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Douglas S. Meade (edited by), *In Quest of the Craft. Economic Modeling for the 21st Century*

In Quest of the Craft

Economic Modeling for the 21st Century

Edited by
Douglas S. Meade

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INTRODUCTION

Douglas S. Meade

As this new century progresses, outlines of a new world economy are taking shape. Globalization, technology and financial innovations continue to grow at an ever more rapid pace. China is poised to become the world's largest economy, but is also expected to rebalance to consumption oriented GDP and slower growth. The future of the Euro area is not clear, but slower growth seems to be all but certain, with financial troubles that survive the great crisis. The U.S. is showing signs of resurgence, but with a vanishing middle class, and much of the income gains going to the top percentiles.

How can we best understand the dynamics driving the differential rates of economic growth, competitiveness, and trade? The macroeconomic modeling approach is certainly useful, as it can tell a powerful story with a minimal amount of data. However, to understand many of the key questions confronting the different world economies, such as productivity, growth, investment and trade, industry analysis is valuable, and interindustry modeling has much to offer. This approach not only illustrates linkages from the demand side, but also can capture the cascading effects of relative price changes.

Linkages between countries are extremely important, and the nexus of trade and finance has become more intertwined and complex in recent years. Sectoral models can be linked through bilateral trade flows. Grasping the changing patterns of these flows of merchandise and services trade can help one to understand how a country's growth can stimulate that of other countries. Alternatively, it can explain how recession in a large country such as the U.S. can spread to Europe and beyond.

For several years, the INFORUM group has focused on the development of national level models that seek to combine the best features of the macroeconomic and interindustry modeling, to answer questions such as these. Since 1993, Inforum national partners have met annually at a World Conference to present papers and discuss modeling issues. The first conference was in Rennes, France in 1993 and the previous conference was held in Listvyanka, Russia at Lake Baikal in 2013. The XXII INFORUM World Conference was held in Alexandria, Virginia in September 2014, and this volume contains a selection of papers presented during the sessions of the conference. Some of the papers are devoted to specific modeling topics or policy issues, and others are oriented to the building of models.

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A prominent paper is the first contribution by Bardazzi and Ghezzi, who are developing a new version of the bilateral trade model (BTM) that is used to link the international INFORUM models through trade flows. The authors provide a valuable survey of the taxonomy of trade models that have been developed by various economists, and highlight the special position of BTM as a central modeling framework linking individual models of different countries which may be potentially of quite different structure, sectoring schemes, and level of complexity. This will be version 3 of BTM. The first version was created by Douglas Nyhus starting in the 1970s, growing out of his PhD thesis work, and the second version was developed by Qiang Ma in 1996 and further extended by Qing Wang.

Both Bardazzi and Ghezzi are students of Maurizio Grassini, who presents a critique of factors content and trade in value-added models. The new international trade database developed by Bardazzi and Ghezzi provide a rich environment for testing such theories. Closing the first section is the paper of Shirov and Yantovsky, who investigate the potential benefits of trade relations between the EU and the Eurasian Economic Union, and also make a quantitative estimate of potential costs of Russian sanctions, on both Russia and the EU. This is a very important topic, and an example of the potential benefits that a system of linked models can offer. Although the previous versions of BTM did not include Russia, it will be included in BTM 3, and will be able to offer insights on energy and other trade with Russia.

The framework of the interindustry macroeconomic model is particularly useful for the study of questions of energy supply, demand, and pollution. The section on energy and environment begins with the paper by Plich on the situation of shale gas extraction in Poland. This paper explores the outlook for shale gas production in Poland in several alternative scenarios using the Polish IMPEC model, out to 2050. Note that Poland is one of the European countries most likely to develop shale gas in the midterm horizon. The next paper is by Sasai and the Japanese team, and uses the JIDEA model to study the effects of abandoning nuclear power in Japan. The effect on the price of electricity and the demand for fossil fuels is considered, and the authors also study the ripple effects of the higher prices on other producing sectors. The paper by Suslov looks at the prospects for renewable energy in Russia. In general, the results are pessimistic for renewable energy development, due partly to the rich endowment of fossil energy resources in Russia, but also because of institutional barriers and lack of infrastructure. However the large surface area of Russia potentially provides opportunities for solar, wind, geothermal and small scale hydropower development. Tagaeva and Gilmundinov discuss ways to improve environmental policy in Russia. They discuss the current set of taxes and incentives in place in Russia, and then present some alternatives. This section is rounded out by a paper by Mullins and Nkosi on using the South African INFORUM model Safrim to calculate the macroeconomic impacts of GHG mitigation. South Africa has a relatively high carbon to

GDP ratio, due to the prevalence of coal-fired power generation. The paper provides a valuable description of the Safrim model, and how it can be applied to do a detailed analysis of mitigation of GHG emissions at their source.

Demographic projections are very important for the understanding of long-range forecasting of personal consumption, and an important context for the study of the labor market, education issues, and pension, retirement and medical policy. The next section includes a paper by Manprasert discussing the estimation of a new demographics-based consumption system for Thailand. He has developed an INFORUM model for Thailand, and is now in the process of updating and extending that model. The paper by Stöver and Wolter from the German team is on the impacts of ageing on the level and structure of private consumption in Germany. Potapenko describes a model for projecting long-term demographic changes in Russia, and gives insight into the modeling techniques used for this type of study.

A wide variety of policy studies are presented in the next section. Meade describes using an employment projections model to explore the requirements for skilled and educated labor in Tanzania. This study is an example of building an INFORUM model for an underdeveloped country for which not much data are available. Such a model can be very useful as a tool for understanding labor force issues. Latvian fiscal projections and analysis are detailed in the paper by Ozolina, Auzina-Emsina and Pocs from the Latvian team. Joubert and Nkosi present an analysis of the macroeconomic impacts of the South African broiler industry. Two policy areas of Russia are explored by Gilmundinov and Bozo. Gilmundinov presents a GE-IO model, still under development, which is used to model impacts of fiscal and monetary policy on the Russian economy. Bozo's paper develops a taxonomy of influences on the supply and demand of various industries related to macroeconomic factors, and applies this to estimating the effects on the sectoral structure of Russia.

The final section of the volume focuses on new model developments. An exciting new model from the Russian team at Rosneft describes the development of the World Economic Dynamics (WED) model, and describes specific analysis of energy sectors. Su and the Taiwan team describe an application with the new Taiwan model called INFORTW. Savchishina and Serebryakov provide updates of the development of two models of Russia, the Russian Interindustry Model (RIM), and the Russian National Accounts model (RuNA). The closing paper of the volume is an introduction to the modeling of Turkey, with the new Turina model.

This collection of papers supplements earlier volumes that have presented papers from other INFORUM world conferences. The last volume published was entitled *Development of Macro and Industrial Methods of Economic Analysis*, and was edited by the team at Novosibirsk, presenting papers from the Baikal conference. It will be quite interesting to see what the next conference in Thailand will offer.

INTERNATIONAL TRADE

TOWARDS A NEW INFORUM BILATERAL TRADE MODEL: DATA ISSUES AND MODELLING EQUATIONS

Rossella Bardazzi[a], *Leonardo Ghezzi*[b]

1. Introduction

The recent global crisis affected output, but the decline in international trade was even sharper, almost twice as big, so that in the literature it is referred as the Great Trade Collapse (Baldwin 2009; Bems *et al.* 2012). Trade flows have transmitted the crisis through the world economy where international trade networks are much more intricate and coordinated than in the past, involving a greater number of countries, firms, and products. In the early aftermath of the crisis several countries considered using trade policy instruments – such as non-tariff measures – to protect their domestic production (OECD 2010, UNCTAD 2010). However these 'emergency' trade measures have increasingly been dominated by governments' commitment to openness and to rely on bilateral and regional free trade agreements in order to stimulate their exports. All these relevant economic issues require a clear understanding of the possible positive and negative effects not only on the economy as a whole and on aggregate macroeconomic variables but especially on specific industries and commodities. This type of quantitative analysis can be pursued with several analytical tools and data. Recently, as microdata have become more available, a growing interest in the use of firm-level data to study the determinants of trade flows is developing[1]. On the other hand, macroeconometric models have a long-standing and remarkable tradition as a tool for analyzing the international transmission mechanism of shocks and policies and for forecasting their effects[2]. Indeed, there has been extensive development of international models linking several economies

[a] University of Florence.
[b] IRPET.

[1] See Cernat (2014) as a summary of the main arguments in favour of this line of research.

[2] Whitley (1992) and Welfe (2013) provide useful descriptions of the development of macroeconometric models. International trade modelling within these structural models and, in particular, the construction of multi-country models are analysed in specific chapters of these volumes.

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through trade flows in the past few decades. Since their first stage of development in the 1970s much progress in data quality and availability as well as in computer capabilities has occurred. However, building and maintaining international multi-country models is still a daunting task.

In this paper we present a newly developed version of INFORUM Bilateral Trade Model (BTM). After a brief survey of a selection of multi-country models to compare their main characteristics and their potential in explaining and forecasting international phenomena, we focus on describing the international system of macroeconomic multisectoral country models which has been developed at INFORUM (Interindustry Forecasting Project at the University of Maryland). The main features of BTM are (i) a detailed disaggregation of commodity classification, (ii) the econometric estimation of import shares, and (iii) the linking system between national models. The high level of disaggregation in trade flows is particularly useful for fully capturing the complex interrelations between economies and to investigate issues of international competitiveness as well as for simulating the detailed aspects of trade policies which are often tailored to specific commodity categories. As we explain in our survey of the related literature, trade shares are computed and used in many multi-country models. However, exogenous assumptions are dominant in modelling trade shares and trade flows, either with parameters assumed from existing literature or with exogenous hypotheses on the behaviour of these shares. Conversely, in BTM import shares are endogenous, econometrically estimated as a function of a set of explanatory variables at the commodity level. Finally, the linking system of national models through BTM enables understanding the transmission channels of shocks via international trade to detailed industries at the national level where country models are designed so that they mirror the specific characteristics of the national economic systems.

To exploit the potential of this analytic framework, detailed data at the commodity and bilateral level must be compiled. Alternative data sources are available at the international level and they are selected and used in this study to build a specific database of bilateral trade flows. Commodity-level shares for the trade module of the international system are calculated and some figures are then presented and discussed. Our preliminary work has been to build a dataset with bilateral trade flows. In order to complete the estimation procedure of the import share equations we need additional information concerning commodity prices for exports, and sectoral capital stock as explained by the theoretical framework of our model. Since this is the next step of our research, this study should be considered as a work in progress.

The paper is organized as follows. In Section 2, some criteria for a taxonomy of applied trade models are selected to highlight their main features and their potential in dealing with complex policy issues. Then a selection of these models in the literature is presented according to these classification criteria. The INFORUM international system of models and BTM are presented in Section 3. As this system has been developed since the 1970's, several versions of BTM are analytically explained. The new dataset which is built for this study is described in Section 4. Finally, preliminary results are presented (Section 5) and some conclusions are drawn in Section 6.

2. Applied models of international trade flows: related literature

Links between economies in multi-country models are potentially of four forms: through trade, through financial variables such as interest rates and exchange rates, through prices and finally, through flows of production factors. In his survey on European multi-country models, Whitley (1992) argues that the transmission of shocks through trade links is relatively weak while exchange rate and interest rate links are more effective in producing spillovers through linked economies. If this conclusion were true at the beginning of the 1990s, after more than twenty years of globalization and after the recent financial crisis, we would argue that trade links have grown in relevance and therefore deserve attention in modelling. In this work we present a system of models linked through international trade, therefore we focus on related literature regarding empirical models of international trade flows.

2.1. A selection of classification criteria

Multi-country models can be classified according to specific characteristics with regard to (i) the level of trade flows aggregation, (ii) the theoretical approach, (iii) the integration between country models and, (iv) the geographic coverage. Although other modelling features could be identified to further differentiate modelling approaches, we consider these as the key aspects.

Official statistics on trade are usually available both at the macro level and disaggregated by commodities. More recently the emergence of new micro datasets on firms and customs transactions have presented a number of challenges to existing international trade theories: even within narrowly-defined industries, a substantial heterogeneity of firms exists and microdata on enterprises have enabled the study of linkages between internationalization and characteristics of enterprises more deeply.[3] However, these data can be mainly used for specific studies and

[3] Recent theories of firm heterogeneity relate firm productivity to trade participation. Theoretical contributions of Melitz (2003), Bernard *et al.* (2003) develop models with heterogeneous enterprises according to which a positive relationship between globalization and productivity can be observed (for a recent survey on this approach see Bernard *et al.* 2007).

are not well suited to build a linked system of country models as their characteristics limit their scope in terms of units, time span and geographic coverage.

As for the aggregate/disaggregate trade statistics, we can first distinguish between multi-country models based on total export and import flows – or at most a very limited aggregation of commodity groups – and models which use commodity-level information capturing the heterogeneity of goods within trade flows. The latter modelling approach allows one to investigate issues of competitiveness with detailed information and this feature is particularly useful for fully describing the complex interrelations between economies and also for simulating the detailed aspects of trade policies which are often tailored to specific commodity categories.

The theoretical approach characterizes both the national models which are linked into an international system and the linkage equations as well. As for the first aspect we can follow the usual distinction between structural econometric models and computable general equilibrium (CGE) models or, more recently, DSGE models (Dynamic Stochastic General Equilibrium). The first approach has a very long tradition also in multi-country model systems dating back to the Cowles Commission research stream. Either macro-econometric and CGE models can be static or dynamic but they differ deeply in several characteristics such as the use of econometric estimation, the economic theory underlying agents' behaviour, and the time horizon of the simulation exercises. The intersection between the first dimension – related to trade flows disaggregation – and the modelling approach produces several categories of models which include macro (aggregate) models, multisectoral models, input-output+econometric models (West 1995).

Multi-country modellers have to consider whether to assume a similar specification across different country models or to allow specific characteristics and country features to be taken into account. In most multi-country models, the models of individual economies are simplified and exclude some mechanisms and feedbacks which are usually found in national stand-alone models (see Bryant 1988; Whitley 1992). Reasons behind this choice are manifold: size – in terms of total number of equations – is a relevant issue, as well as the need to compare national models which share the same theoretical foundations. Moreover, most multi-country models have been developed with a specific objective in mind: to investigate transmission of shocks and effects of inter-country links, to capture both the direct and the indirect effects (feedbacks) of domestic and external shocks and policies which cannot be evaluated with a single national model. Therefore this specific emphasis often comes with a cost in terms of detailed characteristics at the country level to facilitate the analysis of global economic issues. However some examples show that this is not always the case: an alternative approach is to combine independent national models through an international trade model. The national models may share a common theoretical approach but they are tailored to fit the peculiarities of the accounting system and the economic structure of each country considered in the system thus allowing a better interpretation of economic phenomena. This is one of the main features of the model presented in this paper which can be better referred to as an 'international system of national models' rather than a multi-country model because a large emphasis is on the structural and institutional characteristics of each economy as well as on linking the models.

As mentioned above, a key modelling characteristic involves the linkage of the national models to the international system. Most multi-country models compute world trade by aggregating all import demands and export supplies of individual countries into a single global pool. These models can be defined as 'multilateral' as they allow the single country models to be linked through international markets variables – such as foreign prices and world demand –, but bilateral flows between individual pairs of countries cannot be traced. Global consistency must be ensured by applying either restrictions on parameters or scaling procedures[4]. Other models represent trade on a bilateral basis. In this case trade linkages are performed by directly connecting the import demand of a country to the export demand of its trading partners. Obviously these bilateral trade flows are not stable over time: an additional challenging task is to investigate the determinant of these changes and to be able to forecast their behaviour into the future.

Finally, as regards the geographic coverage of multi-country models some of these may cover a specific group of countries which share some institutions, agreements or a currency – such as the Euro area, the European Union, or the G7 countries – others may concern economies which are linked by strong trade relations or that are thought to be satellites of an 'anchor' country such as the United States[5]. If the international system is created by linking already existing national models, the number of countries may vary and be dictated by the development of the single-country models. The limit in terms of countries interacts with the level of detail to represent the functioning of each economy and the disaggregation in terms of economic activities (sectors) and trade flows.

According to these classification criteria, in the following paragraph we analyse some selected applied models of international trade which are summarized in Table 1.

[4] One must also ensure consistency of data definitions and concepts across economies linked in a multi-country model.

[5] A further development is represented by models about a group of countries which are treated as a single open economy (this is the case of QUEST, the model of the Euro area members built by the European Commission).

Table 1 – Selected applied international trade models.

	Aggregation	Theory	Linkage	Geography
Project LINK	Macro	Traditional structural econometric model	multi-lateral	100 Countries
MULTIMOD	Macro	Augmented w/ Rational Expectations and Supply side features	multi-lateral	21 countries + ROW
INTERLINK	Macro	Augmented w/ Rational Expectations and Supply side features	multi-lateral	OECD countri-es + 3 groups (ROW)
GTAP	Multi-sector	CGE (representative agent's maxim.; Armington Assumption)	bi-lateral	Database with 129 Regions
G-CUBE	Multi-sector	DSGE	bi-lateral	Database with 129 Regions
MSG2	Multi-sector	DSGE	bi-lateral	Database with 129 Regions
E3ME	Multi-sector	E3 – Multisectoral Econometric model	multi-lateral	21 world regions
FIDELIO	Multi-sector	Hybrid	bi-lateral	EU Countries

2.2 A survey of applied trade models

A pioneer international system of national models was Project LINK, developed in Philadelphia in the early 1970s by the LINK Center, led by L.R. Klein. The Project LINK grew enormously from 7 to over 100 countries in 1987. In Project LINK, country models had different structures being elaborated by national units (annual and quarterly) (Ball 1973; Jorgenson, Waelbroeck 1976). Country models were linked by commodity flows (4 groups), a matrix of trade shares was computed and systematically updated (Klein, Van Peeterssen 1973). Export prices were endogenously determined by mark-up equations in the country models, whereas import prices were weighted averages of the export prices of partner countries. The LINK system was designed on the side of imports which were determined for each model from behavioural equations where real imports are a function of real national income, domestic and import prices, the exchange rate and other variables. Then exports were determined by imports through trade matrices. The market shares varied as a function of relative export prices and other non-price factors captured by a trend variable. Although the ideal way to link economies together was recognized to be through bilateral trade flows, this method was deemed to be not practicable for LINK mainly because of scarce statistical information and for the large number of variables necessary to explain the behaviour of bilateral trade flows (Hickman 1973).

International organizations such as IMF, OECD and the World Bank are a natural setting to develop multi-country models both for data accessibility and for issues they deal with. Indeed the first version of MULTIMOD (MULTI-region econometric MODel) dates back to 1988 (Masson *et al.* 1988) and has now reached Mark III generation (Laxton 1998). MULTIMOD is a dynamic multi-country model which includes country models for each of the seven largest industrial countries, an aggregate group of 14 smaller industrial countries and two separate blocks for the remaining economies, developing and transition economies. As regards international commodity trade, the IMF's model is a multilateral one where trade flows are disaggregated between oil, non-oil primary commodities and a group of composite goods[6]. Input-output tables for each country are used to estimate import propensities for different components of domestic absorption (private consumption, investment, and government purchases) and for exports and then to create weighted measures of aggregate activity. This is an explanatory variable of the volume of imports as well as the relative price of imports. A pooled estimate of the country price parameters is used as the long-run price elasticity identical across countries. Import prices are determined as weighted averages of other countries' export prices. The specification of export equation is similar to that of imports: explanatory variables are the foreign activity (as a weighted sum of other countries' imports) and the relative price is a real competitiveness index based on export prices of trading partners. Finally, discrepancies are allocated across countries to ensure global consistency of world trade.

The OECD INTERLINK model has been recently updated with a New Global Model (Hervé *et al.* 2011). The model is quarterly with separate country models for the United States, Japan, the Euro area and China, then two blocks of 'Other OECD Europe' and 'Other OECD', finally three other groups for non OECD countries[7]. As the IMF's model, INTERLINK does not take into account bilateral trade flows. Equations for export and import prices of goods and services are described by Pain *et al.* (2005). These can be seen as ones in which firms' pricing behaviour is modelled as a trade-off between the objectives of maximising profits and protecting market shares. Export prices of aggregate goods and services are explained by the price of competitors on export markets expressed in domestic currency and by the GDP deflator in the domestic business sec-

[6] The approach described in the following refers to trade of the composite good. MULTIMOD assumes that oil and non-oil primary commodities are each homogeneous goods with a single world market price. The price of oil is treated as exogenous, while the price of primary commodities is perfectly flexible and varies endogenously to clear the market.

[7] Other non-OECD Asia, Non-OECD Europe and Africa, the Middle East and Latin America.

tor. Similarly, import prices depend on domestic prices and a 'shadow' world price, calculated as the trade weighted average of the export prices of trading partners. Time trends are included in both equations to reflect long-run tendencies. Exports depend on foreign demand, measured as a weighted average of import demands of trading partners, and the prices of exports relative to those of competitors. Imports depend on weighted final expenditures in the importing economy and the price of imports relative to domestic prices. As in the MULTIMOD model, different marginal import propensities for final demand components are allowed[8]. The model includes also stock and flows of foreign assets and liabilities, which are influenced by changes in bilateral exchange rates. On the whole, countries and regions in the global model are linked through international trade variables (volumes and prices), international capital markets and the returns from international capital. Both MULTIMOD and INTERLINK models use single-sector production functions, therefore they preclude any intersectoral effect through international trade.

Several models have been developed at the global level according to the computable general equilibrium approach: a CGE model which has shown an outstanding popularity is the GTAP model (Global Trade Analysis Project) (Hertel 1997), other examples – with some distinctive features – are G-Cubed (McKibbin, Wilcoxen 1999) and MSG2 (McKibbin, Sachs 1991). The GTAP project is a network of researchers using a CGE model and a common global database including IO tables for nearly 129 regions with 57 sectors, production, private consumption, government consumption, investment, exports and imports for a benchmark year[9]. The primary source of global bilateral trade flows is the United Nation's COMTRADE with supplementary information from country data sources. These data are processed to reconcile merchandise trade flows with an approach based on reliability indexes showing which reporting country is more reliable for a particular commodity category (Gehlhar, Wang, Yao 2010)[10]. Given its early emphasis on analyzing multilateral trade liberalization, GTAP has invested a large effort in obtaining a consistent trade dataset where what one country exports, another country must import and the exports of global transport services from individual countries must equal the demand for these same services.

[8] Two constraints are imposed to ensure long run stability. The first is that the long-run elasticity with respect to foreign demands tend to one, otherwise market shares could rise or fall without bound. The second constraint relates to the import elasticities with respect to final expenditures which are also assumed to tend to unity in the long-run.

[9] These details refer to GTAP database version 8.

[10] Discrepancies between the exports reported from one country and the imports reported from another can arise for several reasons: differences in valuation of imports (fob vs cif), differences in reporting years, errors in recording the flows, treatment of re-exports, are a few of these reasons.

The GTAP model follows the Armington assumption (Armington 1969) in the trading sector. Under this approach imported commodities are separable from domestically produced goods: firms first decide on the sourcing of their inputs and then, according to the resulting composite import price, determine the optimal mix of imported and domestic goods. Imported goods and domestically produced goods are combined in a composite nest for both private and government consumption and the elasticity of substitution between these two commodities is assumed to be *equal across uses*.

An important guiding principle in building a multi-regional GTAP model has been that of symmetric production and utility functions across regions. As stated by Hertel (2013), although the choice of linking country/regional models which differ in their specifications could better reflect specific national features, «in practical terms, the asymmetric approach has never really worked in the global modelling context» (p. 826). It is argued that asymmetry in regional models would create problems in model solution, debugging, interpretation and analysis. Consequently, the GTAP multi-regional model shows no differences in regional behaviour except those relative to cost and revenues shares, the parameters in consumer demand and in the model closure which is at the discretion of the user. Therefore, the interaction between a global database including also behavioural parameters and standardized regional models dictates the structure of the GTAP multi-regional model.

Results of these models are particularly sensitive to assumptions about substitution elasticities. In particular, with regards to the modelling of international trade, price elasticities play a crucial role. The GTAP database includes[11] the Armington elasticities of substitution between domestic and imported goods[12] and another set of parameters concerning the elasticities of substitution among imports from different origins[13]. Finally, it is assumed that for each commodity all agents in all regions display the same substitution elasticity.

[11] The source substitution elasticities were based on an econometric work for one country, New Zealand, up to version 6 of GTAP database. More recently, new econometric estimates have been produced by Hertel *et al.* (2007) using import data for seven different countries and have been included in the new version of the database. These new parameters show much greater sectoral variation than the previous ones with striking differences for some commodities such as natural gas where the elasticity firstly assumed was 5.6 while the new parameter is 34.4. These parameters are assumed for all regions in the model, including European countries which are not present in the originating study.

[12] For each commodity within each region, the domestic-import mix is determined separately for each industry and for each final demand component (private consumption, government consumption and investment).

[13] The origin of imports is determined separately for intermediate usage (considering all industries together) and for each final demand component.

G-Cubed and MSG2 are two multi-country models which combine the CGE approach with real business-cycle models and modern macroeconometric models[14]. Whereas MSG2 is a single-sector dynamic inter-temporal general equilibrium model, G-Cubed has a sectoral disaggregation[15] and several country disaggregations although all version of G-Cubed are global[16]. Both MSG2 and G-Cubed are based on explicit optimization of consumers and firms. In contrast to standard CGE models, inter-temporal optimization is assumed and time and dynamics play an important role. Following the Armington (1969) approach as in GTAP, goods produced in different regions are considered as imperfect substitutes. The aggregate imported good is itself a CES composite of imports from individual countries with a specific elasticity of substitution between imports from different countries. All agents in the model are constrained to have identical preferences over the origin of goods. Finally, inter-temporal budget constraints are imposed on each country: trade deficits must be repaid in the future by trade surpluses and trade imbalances are financed by flows of assets between countries (asset markets are assumed to be perfectly integrated across regions).

Notwithstanding many similarities identified so far in the treatment of international trade between G-Cubed and the standard CGE approach as in the GTAP model, G-Cubed model builders state that many of their model's parameters are determined by estimation rather than calibration standing in the middle of the spectrum between «theoretical versus data intensive» (McKibbin, Vines 2000). However, substitution elasticities – which are crucial parameters in this neoclassical theoretical approach – are estimated using a time series of input-output data aggregated for 12 sectors only for the United States (McKibbin, Wilcoxen 2013). As for other countries (or regions) time-series of input-output data are difficult to collect, substitution elasticities within individual industries are imposed to be equal across regions to those estimated for the US. Share parameters are the only regional-specific parameters and are derived from GTAP database.

The global dimension of some issues has stimulated the construction of internationally linked models. Climate change and related policies are a good example where interdependencies between environment and the economy need to be tackled at the multi-country level as policies are also designed at the global or regional level and, moreover, the global economy may be important in determining a policy's effects on trade-exposed in-

[14] G-Cubed model builders argue that their modelling approach is also closely related to the dynamic stochastic general equilibrium models appearing in the macroeconomic and central banking literature (McKibbin, Wilcoxen 2013).

[15] There are several versions with different sectors depending on the question being analyzed: two sectors (macroeconomic issues), six sectors (trade and growth issues), 12 sectors (energy and environmental issues).

[16] The standard version includes United States, Japan, Canada, New Zealand, Australia, Rest of OECD, China, Eastern Europe and the Former Soviet Union, OPEC, and the Rest of the World.

dustries. The awareness of these issues has led to the development of large-scale energy-environment-economy (E3) multi-country models which are best suited for analyzing this unavoidable global issue. These models have great potential to inform the policy-making process and this value has been recognized in the research funding of large-scale global models by many national and international organizations. Within this framework, international trade flows must be modelled.

GINFORS (Global INterindustry FORecasting System) is an E3 model with global coverage developed by GWS (Institute for Economic Structures Research, Germany)[17]. As a member of the INFORUM international group, this research group has transferred the experience of building an internationally-linked system of models in the field of energy and environment empirical analysis. Besides the energy-related modules[18], what is more relevant for the aim of this study is the key role of a bilateral trade model which is the heart of GINFORS. The trade data are the result of merging OECD and UN COMTRADE data: the sectoral classification is 25 commodities and one service sector covering all OECD countries, the EU-25 and 16 other major trading partners. National economic models are distinguished into two types: standardized macro-models for all countries and input-output models for a more limited number of countries for which IO tables were available. Therefore the link between commodity trade flows and specific industries can be performed only for these selected economies. A schematic representation of the trade model is presented by Lutz, Meyer, Wolter (2005). Inputs to the trade model are represented by vectors of imports and export prices for 25 commodities which are provided by the country models as well as the total demand for service imports. The trade model produces export vectors and import price vectors (and service exports) at the commodity level and these are returned to the national economic models. Trade share matrices are computed for every commodity and every importing country. These import shares are used to allocate imports of each country to the exporting partners (computing export demands) and as weights to determine import prices which are a weighted average of the export prices of trading partners. Consistency of the global trade and national models is achieved: global imports and exports have to be identical[19].

For those countries having no input-output model, an aggregate import function is estimated with GDP and relative import price as explanatory variables. Import prices are given from the bilateral trade model and aggregated to calculate a price for total imports.

[17] For more information on this research institute see www.gws-os.de.

[18] GINFORS includes Material Input Models (MIM), Land Use models (LUM) and Energy Emissions Models (EEM).

[19] This consistency is achieved within the balances of payments of the single modelled countries and that of the region Rest of the World within the model.

The price elasticity of nominal import shares is exogenously assumed to be 0.5. Therefore if export prices increase by 10 per cent, the nominal trade share increases only by 5 per cent while in real terms trade decreases by the same amount (Lutz, Meyer, Wolter 2005). This hypothesis is assumed uniformly across all commodities and all countries and it smoothes over the transmission effects of shocks and policies from national models through international trade. Therefore, each commodity trade share between an importer and an exporting country is a function of the exogenous price elasticity, the export price and the import price.

Another characteristic which must be stressed is the standardized approach to modelling national economies[20]. Indeed the primary aim of this system is to represent the global economy for energy forecasts and simulations. Therefore a schematic representation of each country model is best suited for this task while energy-environmental modules need to be well-developed[21].

E3ME is another multi-country model which belongs to the group of integrated energy-economy models to investigate the interactions between the economy, energy system and the environment. It has been developed by Cambridge Econometrics (UK) and like GINFORS, it is a large-scale econometric model with a high level of disaggregation (Barker *et al.* 2011b). There are two different versions of the model which share a similar design but with different geographical coverage: E3MG is the global version of E3ME which is focused on European economies. The model is disaggregated into 43 industrial sectors and 21 world regions. International trade is an important feature of the model: exports and imports represent the linkage between countries and the transmission channel of economic effects within the area. The treatment of international trade[22] is not based upon bilateral trade flows: the basic assumption is that there is a European pool and global pools where trade is taking place and the export and import equations represent each country's exports into these pools and imports from them. The export and import equations have a similar structure with price and income effects. For the income effect, external demand is the weighted sum of domestic demand for the commodity in other countries[23] where weights are taken from bilateral trade matrices. These weights are assumed to measure trade intensity between regions

[20] Macro-models are based upon OECD and IMF data, while input-output tables are taken from OECD and Eurostat, with integration from national sources as well.

[21] GINFORS is currently undergoing extensive revision and update within the framework of international research projects. However, the model has been extensively used in the present version to study various environmental and energy issues as documented by Ekins and Speck (2011), Lutz, Lehr and Wiebe (2012), and Lutz and Meyer (2009 a,b).

[22] This description is based upon information concerning the E3ME model version 5.5. revised in 2012. For further updates and model documentation see the website.

[23] In E3ME a distinction between intra- and extra-EU trade is implemented.

and therefore they represent a proxy of the economic distance between countries. Other proxies are included to help capturing the role of innovations in trade performance – such as spending on R&D – and also an additional synthetic variable to take into account of the European internal market programme from the second half to the 1980's and increasing above one after the introduction of the euro[24].

GINFORS and E3ME models are structural econometric multisectoral models which, albeit relevant differences in modelling international trade as explained above, share some important common features in modelling the economy with the INFORUM international system of models presented in this paper. These are (i) the multisectoral representation of the economic system, with input-output tables at the core of their database; (ii) the use of econometrically-estimated behavioural equations; (iii) the distinctive dynamic path of the economy as the models are solved annually and can show business cycles; (iv) the 'bottom-up' approach: macroeconomic totals are obtained from industry-level variables to achieve substantial disaggregation. Some, but not all, of these features are shared also by the CGE modelling framework. However, relevant differences between these approaches are underlined by Almon (1991), Lutz *et al.* (2005), Barker (2004), Barker *et al.* (2011 a, b).

Besides the widely used trade data produced by the United Nations and Eurostat, a new set of data has recently been built based upon input-output tables with the aim to study the phenomenon of trade fragmentation between advanced and emerging economies which has characterized the evolution of international trade in the last couple of decades. Production processes are now internationally fragmented and this has given rise to the view that commodities are made in global value chains. This concept refers to the phenomenon of increasing shares of intermediate inputs in total trade flows and it has well been recognized that, for including trade in intermediate goods, supply and use tables and/or input-output tables are necessary. Therefore a new global database has been built and increasingly used since its first release, under the WIOD (World Input-Output Database) project. This research has produced a time series of harmonized industry-by-industry IOTs for 40 countries[25] plus the Rest of the

[24] The model has been used in several studies concerning energy/environmental policies and is described in several contributions (Barker *et al.* 2009a, 2009b, 2011a, 2011b). A new version of the model, E3ME-Global, is under construction. The E3ME-Global model will integrate a global database into the main model structure and provide the same capabilities as both the existing E3ME and E3MG models. The new version is expected to include, among others, a better treatment of international trade with bilateral trade between regions which is missing from the present version.

[25] The list of countries includes 27 EU countries and 13 other major countries in the world (US, Mexico, Canada, Brazil, Russia, India, Indonesia, China, South Korea, Australia, Turkey, Taiwan and Japan).

World for the period 1995-2011, and some satellite socio-economic and environmental accounts (Timmer 2012; Dietzenbacher *et al.* 2013). This data is being used to produce several new indicators and measures to re-think international competitiveness but it also represents a good statistical database to build multi-country models. A first example is FIDELIO (Fully Interregional Dynamic Econometric Long-Term Input Output) model for the EU27 which has recently been developed by the European Commission's Joint Research Center (Kratena *et al.* 2013). FIDELIO is a dynamic econometric input-output model using the WIOD database. It is 'full' because it comprehends a complete macroeconomic model with consumption, production, trade, labour market and environment. It is 'interregional' because it models trade flows by country, by commodity and by user. It is also 'dynamic' in the sense that inter-temporal optimization is applied to personal consumption modelling while investment is derived from optimal capital stock. Finally, FIDELIO is an 'input-output' and demand-driven model although it is more flexible than a standard IO model because factor demand and trade are endogenous. The model builders assert that FIDELIO shows also some similarities with CGE models in assuming rational agents under institutional constraints and it is inspired by the 'Jorgenson philosophy'[26] in the sense of calibrating the model with parameters taken from econometric work.

Bilateral trade between the EU countries and with the Rest of the world is distinguished with bilateral trade matrices which provide the starting values for the trade shares containing the information about the origin and destination of each commodity. This information is used to estimate trade elasticities accounting for price substitution effects in the intermediate use of commodities imported for different countries while for final uses the Armington approach is applied (i.e. the total import shares of consumers depend on domestic and import prices). The partner-specific import demands are computed from total import demand using the base-year trade shares and the Armington elasticities. Finally export demands are obtained from the endogenous trade flows between the regions as the sum of import demands from trading partners plus exports to the Rest of the World.

This survey of the main international economic models which are actively used and under development provides some insights about the main characteristics of these tools. In all these models there is some use of input-output tables and bilateral trade matrices: these are the main reference to gather information at the industry and/or commodity level of trade and its relationships with economic activities. However, in most models these detailed data remain in the background as they are used to build weights to form some indicators or propensities to use in behavioural equations. Then the analysis is mostly carried out at the aggregate level or with a very

[26] The main reference is the IGEM model for the US economy (Goettle *et al.* 2007).

limited level of disaggregation: industries become large sectors, commodities are transformed in composite goods. The task of managing a large set of country-level information and simultaneously a large number of commodities and sectors leads to compromises and usually a preference is towards keeping a large representation of countries. Even the latest developments of datasets with world input-output tables are not yet exploited in multi-country modelling.

On the other hand, exogenous assumptions are dominant in modelling trade shares and trade flows. Either with parameters assumed from existing literature or with exogenous hypotheses on shares behaviour, modelling trade shares turns out to be a challenging task.

3. The INFORUM international system of models

3.1 General features

As explained by Whitley (1992), a common approach in modelling international trade flows in multi-country models is to determine the import demand of each separate economy using a standard function where imports are explained by a measure of price competitiveness, domestic demand and various proxies for long-run trends in import penetration. This is indeed the approach which was adopted by the LINK Project and also by INFORUM (Interindustry Forecasting at the University of Maryland)[27] when, at the end of the 1970s, a first linking of national models was designed. The difference between project-LINK and INFORUM was the level of sectoral detail used in the latter. The main purpose of the project developed at the University of Maryland was to build a model of international trade featured by a satisfactory commodity detail so that national input-output models may be linked (Nyhus 1975). As explained by Almon (1991), country models built according to the INFORUM approach share the use of input-output tables as the main core data, a common accounting structure (given by dual pair of Leontief equations) and a common software that facilitates the linkage with similar models of other countries. However, behavioural functions are not centrally determined and estimating techniques may be different: each model should be designed by national researchers as to represent as close as possible the underlying economy.

The international trade module of the INFORUM international system was built well in advance of many of the national models that were to be linked, except for the US national model which is the pioneer of this fam-

[27] INFORUM was founded in 1967 by Clopper Almon to build interindustry-macroeconomic models which combine an input-output structure with econometric equations in a dynamic and detailed framework. These tools are defined by West (1995) as input-output+econometric models.

ily of models, but as early as the beginning of the 1970s researchers in other countries began to cooperate in building similar models for their own economies and the international trade linking system was built with the group rapidly growing. As clearly stated by Almon (1991), an INFORUM model «is an internationally-linkable, dynamic, interindustry model which imitates as closely as possible the way the economy behaves. It is intended for both public policy analysis and business forecasting» (p. 2). Some of these characteristics need to be stressed for the purpose of our analysis about international trade linkages. Since its first building each national model should be thought as to be 'internationally-linkable' therefore the emphasis on the common software is due to its use for the linking mechanism: similarity in software implementation is fundamental to ease the operation of the international system. Secondly, each country model is an 'interindustry model': the economy is represented at the industry and not at the aggregate level, macroeconomic variables are built up from sectoral variables (bottom-up approach). Therefore this multisectoral approach is a distinctive feature that characterizes the linkage system as well, even though country models need not to be identical in their sectoring plans. The input-output core of the models allows one to capture the direct effects of changes in the final demand for exports as well as the effects of trade flows of intermediate and primary resources being used by industries as production factors. Finally, INFORUM models are intended to be well suited for 'policy analysis and forecasting'. The aim is not only to describe the economy but also to forecast, therefore economic variables involved into the international system need either to be forecasted or exogenously determined for the forecasting horizon.

3.2 INFORUM type-I International system of models

The first linking system of INFORUM country models recalls the standard approach described at the beginning of this section with the main important difference being the disaggregation at the industry level.

The pioneer INFORUM international system was built by Nyhus (1975) and a central position was occupied by the trade module as shown in Figure 1, also because it was constructed before many national models that should be linked. The figure suggests, in the words of its author (Nyhus 1975), a solar system with the trade model as a sun … (that) 'draws' imports and absolute domestic prices to itself and 'radiates' exports and world prices back in return. The system focuses on forecasting trade among the US and nine of its major trading partners[28].

[28] The national models included in the INFORUM type I are USA, Japan, Canada, UK, Netherlands, Germany, Belgium-Luxembourg, France and Italy. A small and stylized model for the rest of the world was introduced into the system.

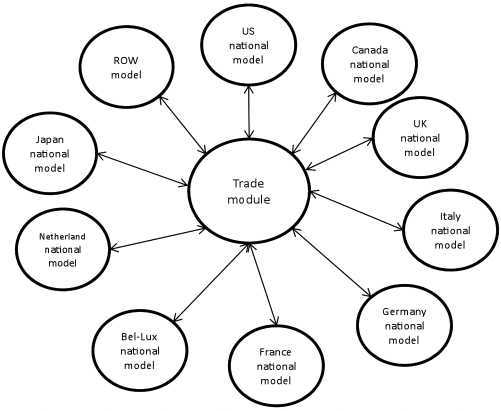


Figure 1 – INFORUM Type-I International System of Models

More specifically, each national model contains equations which determine domestic prices, and imports at the sectoral level. Two vectors of domestic prices and import demands are passed to the trade module which collects this information and, after an iterative process of solution described in detail below, vectors of country-specific foreign demand and market clearing world prices are computed and passed back to the national level where they are used as explanatory variables in the import and export functions. As this system is aimed also at forecasting, sector-specific vectors of foreign demand, domestic prices and world prices are obtained by running each country model in the forecasting period with exogenous variables assumed at the national level.

A rich set of data is required for the trade module. The first choice during the Seventies was to use OECD instead of United Nations data, essentially because the first organization, unlike the second one, applied a standard classification to all countries. From this source bilateral trade flows were used and total exports for the rest of the world were calculated using the imports of each reporting country (member of OECD) from all the partners (160 countries in the world). Data were aggregated starting from 4-digit SITC classification to build a 120 sectors classification used in the trade module. Prices used in the trade module were domestic prices collected from the national models and for the exchange rates INFORUM researchers opted for US Dollar as numeraire and collected data from IMF.

The heart of the trade module is a square trade share matrix M, with as many rows as countries in the system, obtained using imports for each country. S_{ij} is a generic element of the trade share matrix M and is computed as:

$$S_{i,j,t} = {}^{M_{i,j,t}}\!\!\Big/_{M_{\cdot,j,t}}$$

where $M_{i,j}$ is the import of country j from the origin i and $M_{\cdot,j}$ is the total import of j. Viewed from the country of origin, $S_{i,j}$ is the proportion of goods in the *jth* market. Obviously, two constraints should be satisfied in every year of the simulation: (i) each $S_{i,j}$ should not be negative; (ii) the sum of all the $S_{i,j}$ in the *jth* market should be equal to one. As the shares are not stable in time, an important feature of the model is to explain and predict the evolution of M matrix. The basic equation used in INFORUM type I trade module is

$$S_{i,j,t} = S_{i,j,0} \cdot P_{i,j,t}^{b_{i,j}} \quad (1)$$

where $P_{i,j,t}$ is the relative price of the origin country i in market j and $b_{i,j,t}$ is a parameter to estimate. The relative price[29] is a ratio between the domestic price in i (adjusted with the exchange rate), $P_{e,i,t}$, and the world price as seen from the country j of destination of the flows, $P_{w,j,t}$. To ensure the adding-up condition (global export equal global imports), the world price is defined as follows

$$\sum_i S_{i,j,0} \cdot P_{i,j,t}^{b_{i,j}} \equiv 1 \quad (2)$$

Equations (1) and (2) are the key elements of the whole system and parameters $b_{i,j}$ should be estimated[30] in the equation (1) so that equation (2) holds.

Additional factors may affect the evolution of trade shares. In the INFORUM type-I model all these factors are collected in the trend term that is added to (1). The introduction of this term poses a tricky problem. In order to satisfy the adding up condition, first of all, the time trend has been introduced as a linear trend added to the logarithmic version of (1), then it has been estimated using residual of (1) imposing the sum of all the trend rate of growth is equal to zero. Finally, to avoid that in the forecasting period some of the bilateral flows could become larger than total imports in the destination market (and some other bilateral flows could be negative), a 'slow down' time variable has been introduced[31].

The connection between the trade module and the country models occurs through import and export equations of country j (for each commodity). National imports are a function of domestic demand and a rela-

[29] In practical terms, domestic prices used in the formula of relative prices are defined as a weighted average of the present price and the four-year distributed lag of prices. The system of weights varies among different commodities.

[30] The author verifies the failure of linear procedure and so the solution of this problem is obtained using a non-linear least squares estimation method. The equation is non-linear with respect to b-parameters because they enter both in the numerator and denominator of the relative price.

[31] This factor has been named 'Nyhus trend', from the name of the author who first formulated it, Nyhus (1975). This time-trend is cumulated from the complement to 1 of the trade share element, so that as this gets larger the variation of the time variable gets smaller and slows down.

tive price term, defined as the ratio between the world price obtained in the trade model and domestic prices. The import equation of country *j* is represented as follows:

$$m_{j,k,t} = \left(b_0 + b_1 d_{j,k,t}\right)\left(P_{w,j,k,t}/p_{j,k,t}\right)^{\eta}$$

where the subscript *k* refers to the commodity and *t* to the year. The domestic demand *d* is defined as domestic production plus imports minus exports, *p* is the commodity domestic price while $P_{w,j}$ is the world price from the trade module. The domestic price is endogenously estimated in each country model by the input-output price equation. All estimated parameters b_0, b_1 and η, are country and commodity specific. Thus the link inside the INFORUM type-I was through the world price and no bilateral trade flows were calculated at the end of the simulation.

Exports depend on foreign demand (other countries imports) and on the price of competitors. Both equations have a nonlinear form so that both the price elasticity and the marginal imports (exports) per unit of demand would remain constant at different level of demand. The form of the export equation is quite similar:

$$e_{j,k,t} = \left(b_0 + b_1 fd_{j,k,t}\right)\left(p_{j,k,t}/pf_{j,k,t}\right)^{\eta}$$

Here the foreign demand *fd* is the weighted sum of imports for all countries involved in the system for that commodity using export shares by country as weights. The foreign price *pf* is a weighted price of competing exporters adjusted by the exchange rates. In this system exchange rates are assumed exogenous[32].

Given the restricted (and variable) number of linked country models, the system is open and there is no need for consistency of imports and exports at the world level although attention is paid to country trade balances.

3.3 INFORUM type-II system: The Bilateral Trade Model

The INFORUM-type I International System was developed during the Seventies and the Eighties and carried out up to the middle Nineties, when a significant change in the approach to perform the international linkage was implemented. The main feature of the type-I version of the INFORUM international system was the high disaggregation of trade flows, which is a unique characteristics of this linking system, for 10 countries. However, this system does not produce bilateral trade flows, therefore the model has

[32] Several reasons are put forward by Nyhus (1991) to support this assumption: the lack of interest rate equation in some country models, the high volatility of exchange rates, the preference to use the exchange rate as a scenario variable.

been further developed in that direction. INFORUM type-II international system is a Bilateral Trade Model (BTM) and it is presented by Ma (1996) as «a unique international and general equilibrium framework that is particularly suited to address quantitatively sector- and country-specific issues» (p. 5). BTM is estimated using a bilateral database, WTDB, released by Statistics Canada. This database provides high quality and up-to-date information on commodity trade flows at the world level and makes the bilateral model genuinely 'global'[33]. From these data, bilateral trade flow matrices for 120 commodity groups are built. Each matrix has a number of rows and columns which are related to the 60 countries. If the BTM database is ready to accommodate this large number of countries, the present working version is tailored to the existing country models in the system[34].

BTM works as represented in Figure 2. The model receives sectoral imports from each country model and allocates them to the exporting countries within the system by means of import share matrices computed from the trade flows matrices. Imports from a country by all its trading partners equal the country's exports. This balance is obtained at the commodity level. Summing across the importers then yields the exports by country and commodity. These estimates are then used in the country models as indicators of exports. In addition, BTM gives the importing country information on its import prices by commodity.

Figure 2 – Overview of the INFORUM international linking system.

Thus, the key difference from the previous approach described by Nyhus (1991) is the use and modelling of import-share matrices. First of all, imports and prices by commodity, and capital investment by industry are estimated by the country models and then are passed to the trade module: import of country *j* is the 'level' factor; domestic prices

[33] The raw dataset has been submitted to two aggregations. One concerns the commodity classification where the large number of commodity flows has been reduced to 120 trade flows. The second is geographical: the number of trading countries has been reduced from 200 to about 60.

[34] The USA, Mexico, Canada, Japan, South Korea, China, Taiwan, United Kingdom, France, Germany, Italy, Spain, Austria, and Belgium, two areas comprised by the rest of the OECD countries and the Rest of the World.

and capital investment are key elements of the share equation. Three explanatory variables enter the share equations for each element: relative prices, relative capital stock and a Nyhus time-trend. The basic equation is the following:

$$S_{i,j,t} = \beta_{i,j,0} * \left(\frac{P_{e,i,t}}{P_{w,j,t}}\right)^{\beta_{i,j,1}} * \left(\frac{K_{e,i,t}}{K_{w,j,t}}\right)^{\beta_{i,j,2}} * e^{\beta_{i,j,3} \cdot T_t}$$

The first term captures price competitiveness as expressed by the ratio between the effective price of the good in question in country *i* (domestic price of exporter) in year *t*, P_{eit}[35], and the commodity-specific world price as seen from country *j* (importer) in year *t*, P_{wjt}[36]. The relative capital stock is meant to be a proxy of non-price factor competitiveness such as quality and technology improvements. K_{eit} is built from capital investment data as an index of effective capital stock in the industry in question in the exporting country, defined as a moving average of the capital stock indices for the last three years to allow for lagged effects, while K_{wjt} is the same index of world average capital stock as seen from the importing country[37]. Finally, other non price factors –such as preferences, habits, and trade restrictions – are assumed to follow a time trend, the so-called 'Nyhus' trend, T_t, which is added as an exponential to the share equation. Parameters β_{ij0}, β_{ij1}, β_{ij2}, β_{ij3} are estimated using a logarithmic functional form.

Ma (1996) estimated equations for over 19,000 trade flows. Shares different from zero were individually examined for their plausibility through-

[35] This is defined as a moving average of domestic market prices for the last three years and not five as in the type-I version. The price is corrected using exchange rates.

[36] The commodity-specific world price is defined, as it was in the Type-I, as a fixed-weighted average of effective prices in all exporting countries $P_{wjt} = \Sigma_i S_{ij0} P_{eit}$, where the trade shares for the base year are assumed to sum to unity to satisfy the homogeneity condition.

[37] The world average capital stock, K_{wjt}, is defined as a fixed-weighted average of capital stocks in all exporting countries $K_{wjt} = \Sigma_i S_{ij0} K_{eit}$, where the same constraint is applied to the fixed weights S_{ij0}. It should also be noted that in any forecast period each trade share must be non-negative, and the sum of shares from all sources in a given market must add up to 1 (i.e. $\Sigma_i S_{ij} = 1$ for all j and t). The non-negativity condition is automatically satisfied through the use of the logarithmic functional form, but the adding-up condition is not. Therefore, a procedure should be found to modify the forecast trade shares so that the adding-up condition is met. Estimates of all the *n* shares are made separately and subsequently adjusted to meet the adding-up condition. In this way, the forecast shares in each market will satisfy both the adding-up condition and the non-negativity condition. In scaling the forecast shares to meet the adding-up condition in each import market, those with the best fits will require less adjustment than those with poor fits. One way to tackle the problem is to use the standard errors of the estimated equations as weights. Thus, the adding-up condition in each import market is imposed by distributing the residual in proportion to the standard error of each estimated share equation.

out the sample period together with the routine forecast horizon. This procedure was carried out annually in order to anticipate any implausible behaviour of the model.

As suggested by Nyhus, the use of domestic prices in the formulation of import share equation means that the trade module Type-I, and also the initial version of Type-II, ignored the role of tariffs on the bilateral flows of trade. Obviously, the existence of tariffs alone is not sufficient to affirm that domestic prices are unable to capture the 'price effect'. If tariffs decline gradually in a uniform way in all countries (for example this is what happened in the EEC and after the Kennedy Round between EEC and USA) the domestic price could still be a good indicator of price competitiveness. In recent years, new countries joined the international trade market and this hypothesis of a uniform behaviour of tariffs is not credible anymore. In order to consider a non-neutral role of tariffs the trade module should be modified including the effective bilateral tariffs imposed by the importer against the exporter. Wang (2000) included bilateral tariff rates into the import share equations modifying the relative price as in the following equations

$$S_{i,j,t} = \beta_{0,i,j} * \left(\frac{P_{e,i,t} * (1+\tau_{i,j,t})}{P_{w,j,t}}\right)^{\beta_{1,i,j}} * \left(\frac{K_{e,i,t}}{K_{w,j,t}}\right)^{\beta_{2,i,j}} * e^{\beta_{3,i,j} * T_t}$$

and

$$P_{w,j,t} = \sum_i S_{i,j,0} * P_{e,i,t} * (1 + \tau_{i,j,t})$$

where $\tau_{i,j,t}$ is the tariff rate applied by the importer j on the exporter i at time t[38].

This international system of models (Type-II) has been used for several studies as documented on the INFORUM website[39]. At present the interlinked multisectoral models concern countries in Western Europe, East Asia, and Central-North America[40]. Therefore the geographic coverage is not global: this feature is explained by the prominent role of each country model which is not standardized and simplified as in most multi-country models. Moreover, trade in services and international financial flows are not covered by the linking system. On the other hand, peculiar features of this approach are the meaningful representation of bilateral trade flows and

[38] In his original work Wang (2000) assumed that the bilateral tariff structure is constant over the period of estimation since time series data for tariffs was not available.

[39] See inforumweb.umd.edu.

[40] Country models exist for Germany, France, Spain, Austria, United Kingdom, Belgium, Italy, China, Japan, South Korea, Taiwan, Canada, US and Mexico.

the commodity-level analysis as opposed to pooled aggregations, as well as the econometric estimation of import shares at a very high level of detail (120 commodities) which is an outstanding characteristic of this approach.

Although the INFORUM-type II International System shows a satisfying industry/commodity classification and explicit modelling of trade shares which are essential features to understand competitiveness issues at the international level and the contemporary fragmentation of production processes, this system could be further improved as regards the geographic coverage, the trade of services and the international financial flows which are not yet modelled in the system. Therefore an INFORUM-type III international system is under development where a new geographic coverage is considered including countries which have become major trading partners at the global level[41], equations are going to be upgraded and import shares re-estimated, and trade in services is included within the same modelling framework described above.

4. Data

4.1 Source of trade data

International trade represents a large part of the world economy, therefore related reliable information is important both for public and private decision-makers. Beside commodities, during the last two decades international trade in services has increased substantially to represent a share of about 20 per cent of total world trade. Therefore trade flows on both goods and services are considered here.

Informative data to shed light on this global phenomenon are collected by a few international organizations and they satisfy needs of different users in a variety of ways: several classifications and evaluation methods are used, introducing nominal values or quantity measures, and distinguishing different motivations behind the flows[42]. The original raw data are generally collected by national statistical offices or other national authorities involved in this task and then are passed on to international organizations such as Eurostat or the United Nations Statistical Division to be harmonized for international comparisons. Different tasks correspond to different organizations and this is the essential reason to justify discrepancies in datasets coming from alternative sources. Our final task is to create a bilateral trade dataset to be used in an international system of multisectoral models to substitute the currently used bilateral database, WTDB – originally released by Statistics Canada – which has been discontinued. To

[41] The list of countries is presented in Table A3 in the Appendix.

[42] Datasets collect information on imports and exports distinguishing among final exports/imports, re-exports/imports, transit goods.

this purpose, we considered selected suitable data sources: EU – COMEXT and UN – COMTRADE. The main reason for this first selection lies both in the high commodity disaggregation which is essential for our modeling framework and in the country coverage which allows to collect information for all country models included in the INFORUM international system.

The data on trading merchandise by EU member states collected by Eurostat (Comext dataset) concern outward flows from EU countries towards both member and non-member States and inward flows from outside the Union towards EU members. Theoretically, the aim of an international trade database should be to record all flows of goods and services changing the available amount of resources within a country, but there are difficulties in converting theory into practice. There are two different types of information collected by Eurostat for the measurement of international trade: a definition of trade considering all goods entering or leaving a member state excluding goods in transit (so called 'general trade'); and a definition of trade (so called 'special trade') considering only goods put into free circulation in the receiving country (for imports) or goods coming from the free circulation in the origin country (for exports). Valuation of trade considers the value calculated at the national borders: for exports, borders are those of the country of origin (FOB value); for imports, borders of the destination country are considered (CIF value). The dataset produced by Eurostat includes also information about physical quantities useful to calculate 'unit value'. The European statistical office also collects data on trade of services within the current account flows of the Balance of Payment. In the production of data on international trade in services the references are the IMF's Balance of Payments Manual and in the United Nations' Manual on Statistics of International Trade in Services. The United Nations follows the same documents to publish the database UN Service Trade which has been compiled since 2003 as is now publicly available in a pilot version.

The United Nations publishes annually[43] the Commodity Trade Statistics Database (UN Comtrade) which is made up of detailed time series of bilateral import and export flows. Information is collected by the UN from national statistical authorities of about 200 countries or areas. Time series included in this dataset concern annual trade data from 1962 (only for few countries) to the most recent year (at present 2012, for some countries UN-Comtrade covers also 2013). UN Comtrade is probably the most comprehensive available trade database and information included in this

[43] The data collection burden is shared between the United Nations and the OECD. The joint process of collection is useful in order to reduce the burden for national statistical offices, and to refine the quality of data and the harmonization of final information. The database is continuously updated. Whenever trade data are received from national authorities, they are standardized by the UN Statistics Division and then added to UN Comtrade.

dataset is detailed with respect to 'type of merchandise'. Data cover the value, in nominal terms, of a transaction between pairs of countries, for a specific year and a specific sector and the quantity, in physical terms, of exported/imported flows. Therefore it is possible to calculate the unit value of each traded good. This dataset is not ideal in terms of coverage, concerning both geographic and time dimension. Indeed missing data for a specific country in a specific year can occur even if trade has taken place. This is a problem for studying the evolution of trade across time in a specific country or a larger region. Moreover, different areas do not necessarily share the same classification in the same years, therefore it is challenging to compare trade flows at a very detailed sectoral level. Nevertheless, to the best of our knowledge, this database is the most comprehensive and up-to-date source of information about trade flows. These considerations suggested us to use both data sources and to combine data for imports flows included in the Comext dataset for all the European countries with the information we get from the UN for all countries in the rest of the World. With this approach we are confident to maximize the quality of the statistical information to be used in the new BTM.

4.2 Disaggregation of trade data

The most common classifications used to describe international trade of commodities are the Harmonized System (HS) and the Standard International Trade Classification (SITC). Both National and International Statistical divisions use these classifications to organize a comparable set of information. The highest detail level is achieved using the HS subheadings. In this case a classification with six-digits for more than 5,200 different type of trading goods is obtained. In Europe, Eurostat has decided to develop a deeper disaggregation based on the HS classification. This results in a Combined Nomenclature (CN) with a disaggregation of about 10,000 goods (eight-digits). The detail is so fine that once a year Eurostat must introduce some changes in the definitions in order to ensure a description close to reality.

The HS – and the CN as well – is a multi-purpose classification used both for administrative reasons (customs duty) and for statistical purposes. This classification is based on the idea to consider the nature of goods we want to classify. The same holds for the SITC that was introduced by the United Nations just for analytical purposes and currently is at its fourth revision. Both these classifications are used in the datasets published by Eurostat and the United Nations.

In both databases a third type of classification called Broad Economic Categories (BEC) is available. Unlike HS and CN, this system is used to translate international trade information compiled using SITC codes into end-use categories. The target here is not to highlight the nature of the traded goods but the reason for the buyer to consume these goods. In this sense, the BEC classification is more useful for economic analysis.

The classification system of internationally traded services adopted both by UN and Eurostat is only one: transactions by type of services is classified according to the Extended Balance of Payments Services (EBOPS) Classification. The main breakdown of services includes three broad categories: transportation (all modes: sea, air and other including pipelines), travel, and other services (communication, construction, insurance, financial, computer and information services, royalties and license fees, other business services, personal, cultural and recreational services, and government services). However, data according this detailed classification of services (more than 60 items) is not widely available as most countries report information only for the main service categories.

4.3 Data used for the Estimation of the new INFORUM Bilateral Trade Model

Users interested in studying international trade between countries may collect information from two different perspectives: the point of view of the country of origin of the flows, considering data on exports; alternatively, the point of view of the country of destination, considering data on imports. The choice is not neutral because consistency problems between these two views may arise. Moreover, discrepancies occur even within the same dataset, and they are likely to increase if different sources of information are considered. The dataset built at Eurostat is very comprehensive and up-to-date for all the country members, both as origin and destination of the flows, but it does not cover bilateral flows between pairs of non-members. In this case we should rely on national datasets to fill this gap, introducing additional sources of measurement error difficult to disentangle. For this reason our choice has been to consider as primary source of data the Comext database, using information about import flows for each EU country. Thus, the data cover all possible countries of origin of the flows and all EU destinations. The UN-Comtrade is used to collect information about import flows for all other destinations in the world. Obviously, as much as possible, the coherence of the total amount of trade for a specific destination[44] with respect to the National Accounts for that territory must be checked in order to be sure to reach consistency in the integration of many different national models in the same international system. Our choice has been to use imports as the main source and so exports are calculated by aggregating data of all countries importing from a specific nation[45]. The classification used in the previous version of the INFORUM Bilateral Trade Module was the

[44] Considering just the fourteen countries introduced explicitly in the international system of models.

[45] From UN-Comtrade we consider imports of the first 90 reporting countries, ranked by total imports in 2012 which account for more than 99 per cent of total world imports. See Table A-2 in the Appendix.

SITC and in this new release of the international system we decide to use the same classification for two reasons: *i)* to be closer to the previous model, *ii)* and to avoid some problems in the updating process. Indeed, the HS classification is subject to a complete revision every five years in order to maintain a strict relation with the type of traded goods considering the innovation process. The SITC is more stable and it is subject to revision but not on regular basis. The reason we decide to avoid the BEC classification is that through SITC it is easier to link the trade data with classifications of industries used inside national input-output models linked in the BTM.

5. Data description and some preliminary evidence

According to the United Nation publication[46], the value of world trade merchandise in 2012 was 18.0 trillion, in terms of U.S. dollars. This is the result of a very modest increase (i.e. a growth of less than 0.1 percent) with respect to the previous year in which trade has risen by roughly 20 percent. In 2012 the most important exporter has been China with a total exports of 2,049 billion dollars, followed by the US with 1,500 billion and Germany with about 1,400 billion. The United States has been the larger importer with 2,300 billion dollars, which resulted in a trade deficit of 800 billion dollars, while Germany and China recorded trade surpluses of 250 billion dollars each. As a first approximate check, we observe that the dataset we built combining both UN and Eurostat sources is consistent with these figures.

In order to provide some examples of a first use of the data, in the following graphs and tables there are some snapshots with a breakdown of the world trade by the countries (or areas) of origin and destination we include in BTM, both for total trade and for some specific SITC codes. Table 2 shows that in 2012 developed economies' imports included in our dataset represent 54.7% of total trade (it was 62.3% in 2007), and the rate of growth of these markets as a whole is -1.8% per cent with respect to previous year. For the EU28 as a whole, we observe a growth rate of -6.0 per cent with a consequent collapse of the relevance of this destination market not only at the global level but also with respect to other developed countries. The import share of EU countries all together decreases from a 41.8 per cent in 2007 to 32.6 per cent in 2012. The alarming evidence for the EU is that this period is not just a recession phase but it corresponds to a process of marginalization of this area in the international trade markets.

The dynamics just described for EU countries identifies the effects of a double-dip recession involving most of the European economies in the

[46] 2013 United Nation Trade Statistics Yearbook.

last period. For example, Italy is a less important destination for the world merchandise with a contraction in absolute terms of -10.2 per cent. The recent evolution of this market is well described by the information included in the BTM dataset, and the share of Italian imports with respect to the world is 2.8 per cent, that is a reduction of 0.3 points in terms of shares. The same is true for Spain and, with a less negative emphasis, for France as well.

Table 2 – Total international trade. Rate of growth in current prices.

export								
	2007	2008	2009	2010	2011	2012	avg rate 2007-2012	share 2012
developed	14.7	9.9	-25.8	17.4	16.4	-2.4	3.7	46.2
other country	14.8	21.8	-26.1	27.4	23.0	-0.4	8.3	53.8
Total	**14.7**	**15.5**	**-26.0**	**22.4**	**19.8**	**-1.3**	**6.0**	
UE28	18.3	10.5	-27.1	12.3	17.6	-5.1	3.0	30.4
US	12.0	12.1	-23.3	21.0	17.8	2.0	5.8	8.0
China	20.6	13.9	-18.5	28.1	15.0	3.0	9.2	12.0

import								
	2007	2008	2009	2010	2011	2012	avg rate 2007-2012	share 2012
developed	11.4	11.4	-28.3	18.1	17.1	-1.8	3.2	54.7
other country	20.7	22.4	-22.5	28.4	23.3	-0.6	10.3	45.3
Total	**14.7**	**15.5**	**-26.0**	**22.4**	**19.8**	**-1.3**	**6.0**	
UE28	16.6	12.3	-31.2	13.2	17.2	-6.0	2.0	32.6
US	5.1	7.3	-26.0	22.8	15.1	3.1	3.3	14.0
China	21.2	19.5	-11.6	40.3	25.7	3.4	15.2	10.1

In order to double-check the data, it is useful to analyze some specific sectors. One of the most important, both in terms of dimension and in terms of relevance for the world economy dynamics, is the bilateral trade of petroleum (SITC code 33 at 2-digit level of disaggregation, corresponding to the 23rd sector in the new BTM classification[47]).

Petroleum imports as a percentage of total imports of developed economies continues to increase, with an annual growth rate of about

[47] See Table A-1 in the Appendix for the new BTM classification.

4.9 per cent in 2012. Considering that this is computed in current prices, we know that a major part of this change is due to the dynamics of crude oil prices that in 2012 have grown more than the prices of manufactured goods[48]. Petroleum oil, both crude and refined, is the top exported commodity in 2012 as well with a share of 14.1 percent of total international trade. The information included in our dataset indicates that total imports of this commodity have increased yearly by 8.2 percent on average in 2009-2012.

Figure 3 shows the last ten years evolution of the shares held by 'Middle-Eastern producers' in four different markets (US, China, Italy, and Germany) with different trends in China (the share was less than 15 per cent in 2000, and it was 36 per cent in 2012) and in US (the share is stable between 15 and 20 per cent). According to our data Germany is not dependent on the Middle-Eastern production unlike Italy where the Arabic oil covers more than 20 per cent of oil imports (with a peak higher than 30 per cent in 2011). The German economy is more linked to Russian oil whose share, during the recession, increases up to 38 per cent of the total German petroleum imports (see Figure 4).

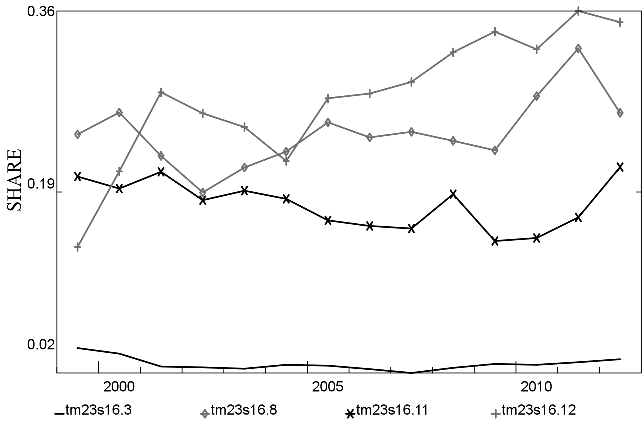


Figure 3 – Crude oil and refined products from 'middle-east producers'[49].

[48] According to UN Yearbook, the ratio between the price index of manufactured goods and petroleum crude oil decrease in 2012 with respect to 2000. Assuming a value of this ratio equal to 100 at the beginning, this ratio was 47 in 2012 confirming that the fuel purchasing power of manufactured goods exports is significantly below its level of 2000.

[49] The graph includes a legend that should be interpreted in this way: tm <sector number> s <origin of the flow> . <destination of the flow>; and so tm23s16.11 is the export of petroleum products (sector 23) from 'middle east producers' (country n. 16) to US (country n. 11).

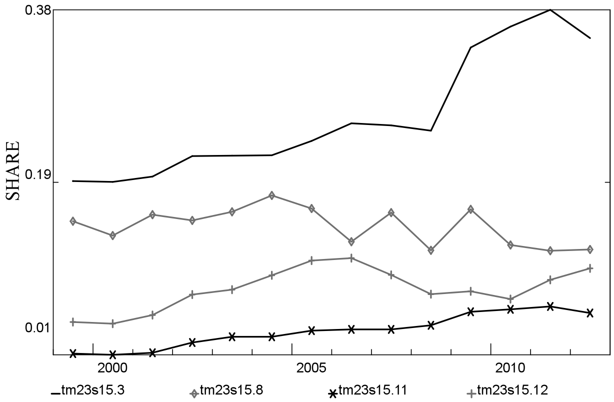


Figure 4 – Crude oil and refined products from Russia.

A remarkable share of global trade is represented by the bilateral flows of machinery and parts thereof. Especially during the initial phase of the financial turmoil that stroke the international economy in 2008-2009, investment goods have been the most affected commodities. We can approximate this category of goods considering the SITC section (1-digit) number 7. According to the new BTM classification this includes commodities from 47 to 55. Machinery as a whole decreases in 2009 both in absolute and in relative terms, with respect to all other commodities. After 2010 the investment decisions in several areas of the world were pushed by a more favorable climate and we find a trace of it in the dataset (see Figure 5).

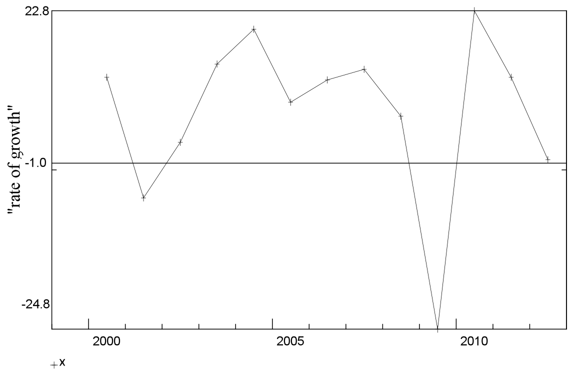


Figure 5 – World trade (imports) of machinery. Rate of growth.

The 'general machinery' item (SITC 2-digit number 74, corresponding to number 50 in the new BTM classification) is made up of pumps, handling tools, heating/cooling equipment: this sector has decreased by -0.8 percent in 2012, a step back with respect to 6.5 percent average annual growth rate in 2008-2011. The share of this sector in total international trade is 3.6 per cent. Germany, China and USA have been the top producers in 2012 as they account for 15.8, 14.1 and 11.3 percent of world exports, respectively. The same countries have been the top destinations for this kind of flows.

In 2012 the value of world imports for 'specialized machinery' (SITC code 72 in 2-digit disaggregation, sector 48 in the new BTM classification) has decreased by -4.8 percent, thus determining, as we can observe in many other sectors, a slowdown compared to the average growth rate in 2008-2011. The most recent value is 380.6 billion dollars, confirming that this commodity accounts for almost 2.3 percent of world trade. Germany, USA and Japan have been the top exporters in 2012 as they account for 16 per cent, 13.2 per cent and 13.1 percent of world exports, respectively. USA, China and Germany have been the top destinations, with respectively 12.1 per cent, 9.4 per cent and 4.8 percent of world imports.

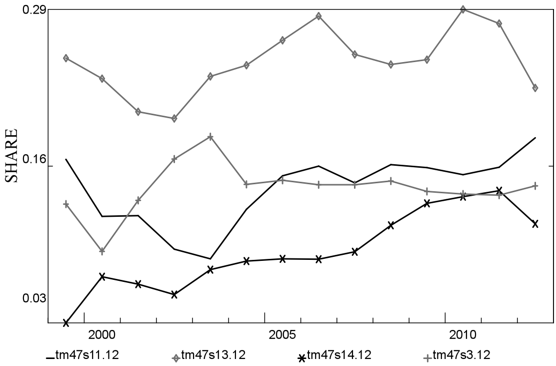
A key role of Germany, USA and Japan as producers is confirmed also for 'power generating machinery' sector (SITC code 71 at 2-digit level of disaggregation, corresponding to the 47th sector in the new BTM classification). As for this commodity, again USA, China and Germany have been the top destinations.

In the last 15 years, the People's Republic of China experienced a massive growth process involving many different components of its productive structure. Considering the huge amount of investment generated in this country during this period it is important to analyze which countries/producers absorbed the Chinese demand for capital goods. According to our dataset, in Figures 6 and 7, we show the evolution of trade shares held by the four largest producers of capital equipment (not considering China).

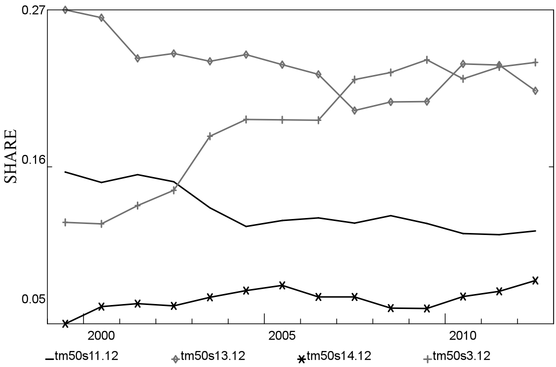
As for power generating machinery, the Chinese market is split among four producers. Japan is the top exporter with a share that grew up to 30 per cent during the initial phase of the crisis (2010, it was 23.6 per cent in 2000) and a drop in the last two years of our data (22.8% in 2012). At the end of 2012 the US power generating machinery sector has reached the share of 18.6, continuing a run-up started at the beginning of the millennium. As for general machinery, the top exporter in China is Germany that overtook Japan during the international turmoil started in 2007-2008. Germany has reached a market share of 23.5 per cent, essentially doubling its weight at the beginning of millennium. The US share in China for 'general machinery' has been stable across the last 8 years included in the graph, after a contraction experienced in 2003-2004. The same evolution marked the share held by Japan. As for specialized machinery we have a different situation: Japan is the top exporter in the Chinese market but, after a period of rapid growth (both in absolute and relative terms), in the last two years, it started to reduce its weight in this market. Germany is in the second position and its share is relatively stable.

Figure 6 – Machinery in China.

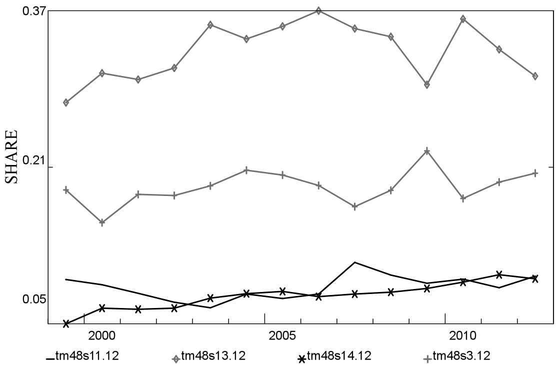
a) Power generating machinery (China imports)



b) General machinery (China imports)



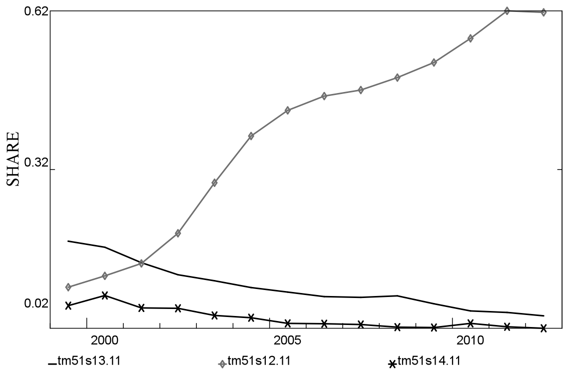
c) Specialized machinery (China imports)



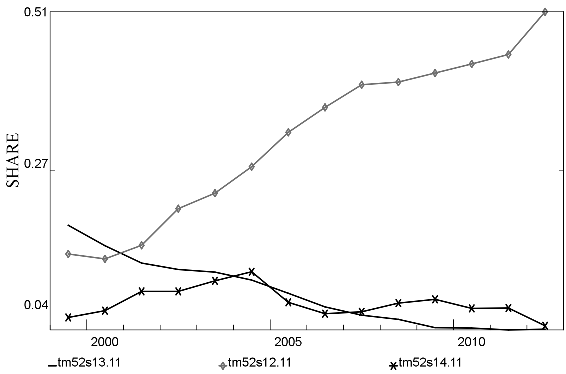
Finally, we test our dataset considering the interindustry relationship between China and the US for some technology sectors. In particular in Figure 7 we show the evolution of the share in the US market of 'office machinery' and 'telecommunications equipment'. As for 'office machinery' (SITC code 75 at 2-digit level of disaggregation, corresponding to the 51th sector in the new BTM classification) the value of world trade in 2012 has increased by 0.5 percent (compared to 1 percent average annual growth rate in 2008-2011) to reach 525 billion dollars, confirming that this commodity accounts for more than 3 percent of total world merchandise trade. US imports represent 23.1 per cent of total trade in this sector and it is the first importer in the World. The graph shows the incredible constant increase in terms of share for Chinese office machinery (and parts thereof) in this market essentially due to the decentralization of production processes outside the US of some important American companies. The same is true for telecommunications. In both commodities the share of China in the US imports is higher than 50 per cent.

Figure 7 – Office machinery and telecommunications.

a) Office machinery (imports in US from Japan, China and Korea)



b) Telecommunications (imports in US from Japan, China and Korea)



Summing up, after a preliminary analysis of these data, we are confident about the quality of our dataset as a reliable source to describe bilateral sectoral international trade. However, as this data is in nominal terms we must use additional information concerning price indexes to compute shares in real terms. Therefore further work is needed for estimating a new version of BTM, both as additional statistics for international trade and for building a dataset of explanatory variables for estimating the equations of the bilateral trade model.

6. Concluding remarks

International trade models represent an indispensable tool to model the transmission at the global level of economic shocks and policies. The recent turmoil which hit economic systems since 2008 revealed that trade was an important channel for spreading not only the effects of the financial crisis, but also for amplifying the effects of public policies in response to negative shocks. Economies are much more intertwined than in the last century due to the fragmentation of production processes, therefore economic modelling must take into account the trade relationships between countries at a bilateral and detailed commodity level.

In general – as shown in our review of related literature – available multi-country models have a limited disaggregation of trade flows and economic activities. Moreover, all of them assume trade shares as exogenous variables either from literature or by making some exogenous assumptions about their behaviour. Modelling trade shares with behavioural equations requires both the specification of a model and the collection of national explanatory variables. Moreover a system of country models should be linked to the international trade block.

In this study we describe the main features of existing multi-regional models, and we compare the Bilateral Trade Model (BTM) built at INFORUM from them. The estimation of bilateral import shares is the main characteristic of BTM, which allows trade to react to changes in both price and non-price factors. These factors are produced by individual country models, each built to reflect the specific features of the national economy, and each linked to the international trade module. At the core of this system lies a specifically built dataset of bilateral trade flows at the commodity level.

Our work shows the advantages and limitations of alternative data sources and the assumptions made to build a dataset as such. Preliminary evidence of our work in progress shows that the bilateral commodity trade flows and shares of our dataset are consistent with statistics published by international institutions and therefore they represent a reliable foundation for our further study. In our following work additional variables will be collected to estimate newly specified equations of BTM both for commodities and services. These estimated values will be integrated in the international system of country models to simulate and forecast the effects on trade of policies and economic shocks.

Appendix

Table A.1 – SITC 2 digits and BTM commodity classification.

BTM code	SITC rev 4	DESCRIPTION	BTM code	SITC rev 4	
1	0	LIVE ANIMALS	34	56	FERTILIZERS (OTHER THAN THOSE OF GROUP 272)
2	1	MEAT	35	57	PLASTICS IN PRIMARY FORMS
3	2	DAIRY PRODUCTS	36	58	PLASTICS IN NON-PRIMARY FORMS
4	3	FISH	37	59	CHEMICAL MATERIALS AND PRODUCTS, N.E.S.
5	4	CEREALS	38	61	LEATHER, LEATHER MANUFACTURES, N.E.S., AND DRESSED FURSKINS
6	5	VEGETABLES AND FRUIT	39	62	RUBBER MANUFACTURES, N.E.S.
7	6	SUGARS, AND HONEY	40	63	CORK AND WOOD MANUFACTURES (EXCLUDING FURNITURE)
8	7	COFFEE, TEA, COCOA, SPICES	41	64	PAPER, PAPERBOARD AND ARTICLES
9	8	FEEDING STUFF FOR ANIMALS	42	65	TEXTILE YARN, FABRICS, MADE-UP ARTICLES, N.E.S.
10	9	MISCELLANEOUS EDIBLE PRODUCTS	43	66	NON-METALLIC MINERAL MANUFACTURES, N.E.S.
11	11	BEVERAGES	44	67	IRON AND STEEL
12	12	TOBACCO	45	68	NON-FERROUS METALS
13	21	HIDES, SKINS AND FURSKINS, RAW	46	69	MANUFACTURES OF METALS, N.E.S.
14	22	OIL-SEEDS AND OLEAGINOUS FRUITS	47	71	POWER-GENERATING MACHINERY AND EQUIPMENT
15	23	CRUDE RUBBER	48	72	MACHINERY SPECIALIZED FOR PARTICULAR INDUSTRIES
16	24	CORK AND WOOD	49	73	METALWORKING MACHINERY
17	25	PULP AND WASTE PAPER	50	74	GENERAL INDUSTRIAL MACHINERY AND EQUIPMENT, N.E.S.
18	26	TEXTILE FIBRES (OTHER THAN WOOL)	51	75	OFFICE MACHINES
19	27	CRUDE FERTILIZERS, AND CRUDE MINERALS (Excluding Coal, petroleum)	52	76	TELECOMMUNICATIONS
20	28	METALLIFEROUS ORES AND METAL SCRAP	53	77	ELECTRICAL MACHINERY
21	29	CRUDE ANIMAL AND VEGETABLE MATERIALS, N.E.S.	54	78	ROAD VEHICLES
22	32	COAL, COKE AND BRIQUETTES	55	79	OTHER TRANSPORT EQUIPMENT
23	33	PETROLEUM, PETROLEUM PRODUCTS AND RELATED MATERIALS	56	81	PREFABRICATED BUILDINGS; SANITARY, PLUMBING, HEATING AND LIG
24	34	GAS, NATURAL AND MANUFACTURED	57	82	FURNITURE
25	35	ELECTRIC CURRENT	58	83	TRAVEL GOODS, HANDBAGS AND SIMILAR CONTAINERS
26	41	ANIMAL OILS AND FATS	59	84	ARTICLES OF APPAREL AND CLOTHING ACCESSORIES
27	42	FIXED VEGETABLE FATS AND OILS	60	85	FOOTWEAR
28	43	ANIMAL OR VEGETABLE FATS AND OILS, WAXES	61	87	PROFESSIONAL, SCIENTIFIC AND CONTROLLING INSTRUMENTS
29	51	ORGANIC CHEMICALS	62	88	PHOTOGRAPHIC APPARATUS AND OPTICAL GOODS
30	52	INORGANIC CHEMICALS	63	89	MISCELLANEOUS MANUFACTURED ARTICLES, N.E.S.
31	53	DYEING, TANNING AND COLOURING MATERIALS	64	93	SPECIAL TRANSACTIONS AND COMMODITIES NOT CLASSIFIED ACCORI
32	54	MEDICINAL AND PHARMACEUTICAL PRODUCTS	65	96	COIN (OTHER THAN GOLD COIN), NOT BEING LEGAL TENDER
33	55	ESSENTIAL OILS AND RESINOIDS AND PERFUME MATERIALS;	66	97	GOLD, NON-MONETARY (EXCLUDING GOLD, ORES AND CONCENTRATE

Table A.2 – UN Reporting Countries, Ranked by Total Imports ($) in 2012.

Rank #	Reporter Code	ISO Code	Country	Value	Cum Imports	Cum Shr(%)
1	842	USA	USA	2,333,805,232,960	2,333,805,232,960	13.5
2	156	CHN	China	1,818,199,227,571	4,152,004,460,531	24.1
3	276	DEU	Germany	1,173,287,645,484	5,325,292,106,015	30.9
4	392	JPN	Japan	885,843,334,518	6,211,135,440,533	36.0
5	826	GBR	United Kingdom	689,137,011,265	6,900,272,451,798	40.0
6	251	FRA	France	663,268,639,629	7,563,541,091,427	43.9
7	344	HKG	China, Hong Kong SAR	553,486,468,741	8,117,027,560,168	47.1
8	410	KOR	Rep. of Korea	519,575,597,289	8,636,603,157,457	50.1
9	528	NLD	Netherlands	501,134,302,479	9,137,737,459,936	53.0
10	381	ITA	Italy	489,104,116,138	9,626,841,576,074	55.8
11	699	IND	India	488,976,378,496	10,115,817,954,570	58.6
12	124	CAN	Canada	462,369,244,562	10,578,187,199,132	61.3
13	56	BEL	Belgium	437,882,665,741	11,016,069,864,873	63.9
14	702	SGP	Singapore	379,722,888,523	11,395,792,753,396	66.1
15	484	MEX	Mexico	370,751,407,489	11,766,544,160,885	68.2
16	724	ESP	Spain	325,835,176,357	12,092,379,337,242	70.1
17	643	RUS	Russian Federation	316,192,918,041	12,408,572,255,283	71.9
18	36	AUS	Australia	250,464,794,398	12,659,037,049,681	73.4
19	764	THA	Thailand	247,575,852,399	12,906,612,902,080	74.8
20	792	TUR	Turkey	236,544,494,245	13,143,157,396,325	76.2
21	76	BRA	Brazil	223,149,128,347	13,366,306,524,672	77.5
22	757	CHE	Switzerland	197,786,932,195	13,564,093,456,867	78.6
23	458	MYS	Malaysia	196,196,618,679	13,760,290,075,546	79.8
24	360	IDN	Indonesia	191,690,908,079	13,951,980,983,625	80.9
25	616	POL	Poland	191,430,111,658	14,143,411,095,283	82.0
26	40	AUT	Austria	169,663,240,578	14,313,074,335,861	83.0
27	752	SWE	Sweden	162,709,210,820	14,475,783,546,681	83.9
28	682	SAU	Saudi Arabia	155,593,039,024	14,631,376,585,705	84.8
29	203	CZE	Czech Rep.	139,726,823,793	14,771,103,409,498	85.6
30	704	VNM	Viet Nam	113,780,430,859	14,884,883,840,357	86.3
31	710	ZAF	South Africa	101,610,607,331	14,986,494,447,688	86.9
32	348	HUN	Hungary	94,266,239,000	15,080,760,686,688	87.4
33	208	DNK	Denmark	92,296,840,060	15,173,057,526,748	88.0
34	579	NOR	Norway	87,320,955,424	15,260,378,482,172	88.5
35	804	UKR	Ukraine	84,656,666,978	15,345,035,149,150	89.0
36	152	CHL	Chile	79,461,529,006	15,424,496,678,156	89.4
37	703	SVK	Slovakia	76,859,351,793	15,501,356,029,949	89.9
38	246	FIN	Finland	76,089,021,011	15,577,445,050,960	90.3
39	376	ISR	Israel	73,112,080,000	15,650,557,130,960	90.7
40	620	PRT	Portugal	72,292,573,376	15,722,849,704,336	91.2
41	642	ROU	Romania	70,259,718,629	15,793,109,422,965	91.6
42	818	EGY	Egypt	69,865,551,868	15,862,974,974,833	92.0
43	32	ARG	Argentina	68,507,490,489	15,931,482,465,322	92.4
44	608	PHL	Philippines	65,349,780,522	15,996,832,245,844	92.7
45	372	IRL	Ireland	63,100,436,769	16,059,932,682,613	93.1
46	300	GRC	Greece	62,341,250,081	16,122,273,932,694	93.5
47	170	COL	Colombia	58,087,854,461	16,180,361,787,155	93.8
48	12	DZA	Algeria	50,369,390,586	16,230,731,177,741	94.1
49	112	BLR	Belarus	46,404,389,200	16,277,135,566,941	94.4
50	504	MAR	Morocco	44,789,781,626	16,321,925,348,567	94.6
51	398	KAZ	Kazakhstan	44,538,070,815	16,366,463,419,382	94.9
52	586	PAK	Pakistan	43,813,262,458	16,410,276,681,840	95.1
53	604	PER	Peru	42,274,273,542	16,452,550,955,382	95.4
54	554	NZL	New Zealand	38,242,730,516	16,490,793,685,898	95.6
55	566	NGA	Nigeria	35,872,509,437	16,526,666,195,335	95.8
56	100	BGR	Bulgaria	32,743,133,695	16,559,409,329,030	96.0
57	440	LTU	Lithuania	32,237,640,017	16,591,646,969,047	96.2
58	634	QAT	Qatar	30,787,000,000	16,622,433,969,047	96.4
59	705	SVN	Slovenia	28,382,568,378	16,650,816,537,425	96.5
60	512	OMN	Oman	28,117,622,531	16,678,934,159,956	96.7
61	218	ECU	Ecuador	25,196,517,284	16,704,130,677,240	96.8
62	442	LUX	Luxembourg	24,010,950,967	16,728,141,628,207	97.0
63	422	LBN	Lebanon	21,146,549,423	16,749,288,177,630	97.1
64	191	HRV	Croatia	20,834,262,292	16,770,122,439,922	97.2
65	400	JOR	Jordan	20,691,383,705	16,790,813,823,627	97.3
66	233	EST	Estonia	19,750,324,256	16,810,564,147,883	97.5
67	214	DOM	Dominican Rep.	19,200,466,024	16,829,764,613,907	97.6
68	688	SRB	Serbia	19,013,236,444	16,848,777,850,351	97.7
69	188	CRI	Costa Rica	18,355,992,786	16,867,133,843,137	97.8
70	144	LKA	Sri Lanka	17,884,922,005	16,885,018,765,142	97.9

Table A.3 – BTM country list.

1	Rest of the World
2	France
3	Germany
4	United Kingdom
5	Spain
6	Austria
7	Belgium
8	Italy
9	Canada
10	Mexico
11	US
12	China
13	Japan
14	South Korea
15	Russia
16	Middle-East Oil producers
17	Rest of the Eurozone
18	Rest of the EU28

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FROM FACTORS CONTENT TO TRADE IN VALUE ADDED

Maurizio Grassini[a]

1. Introduction

Two Swedish economists – Eli Hechsher and Bertil Ohlin – extended David Ricardo's theory of comparative advantage. Their theoretical development – nowadays known as the HO theorem – is fully rooted in the neoclassical paradigm. The rationale of international trade is investigated between two countries which have different factors endowments. Both countries share common technologies and consumer preferences. The theorem proves that if the goods produced are mobile while production factors are immobile, the two countries are better off abandoning autarky and getting positive gains from trade. Originally specified for two countries, two immobile factors and two mobile products, this model was subsequently enriched, extending the number of countries, the number of products, the compensation of the factors and many other aspects. In other words, although strictly within the neoclassical niche, the original HO model has been implemented for a better representation of the real world.

However, any insights developed from the original HO framework were obtained without a single piece of evidence being offered for many years. When the statistics on international trade were produced and first made available by the UN statistical office, the empirical evidence of economic theories, such as that based on the HO model, required the remarkable processing of raw trade data. Leamer (1995) gives a significant description of the work done to match the 'hopelessly detailed' trade data compared to that required for testing international trade theories developed from the HO model, as well as the data organization performed to shape the country economic structure required by such theories.

To prove the empirical accuracy of the HO framework is not straightforward. Trade patterns may have a variety of causes. Trade patterns may reflect the path towards equilibrium stated by the HO model. But it is clear that structural changes can take place in each country reshaping the trade flows independently of heterogeneous factor endowment. For example, in the process of the Eastern Enlargement of the European Union, the Cen-

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tral and Eastern European candidate countries faced a remarkable phase of trade diversion and industrial restructuring and diversification. When such a remarkable structural change takes place, trade statistics are not suitable for testing a 'static' prediction (or long run equilibrium) such as that offered by the HO model. Furthermore, Grubel and Lloyd (1975) revealed relevant inter-industry trade flows among industrialized countries together with sectoral import-export flows growing faster than sectoral output. So, on the basis of the Grubel-Lloyd observation, the fundamental HO model prediction (which reflects David Ricardo's basic example) turns out to be rejected.

Namely, whatever the forces driving the process of globalization, international trade takes place not only because of factor endowment. Nevertheless, the legacy of the HO model is still used to support a recent brand of research.

This legacy involves the notion of 'factor content'. Leamer (1995) suggests a system of equations to explain a number of models (called 'theorems') based on the basic HO model. Among these equations, Leamer writes $q = A^{-1}v$, where q is the vector of output, A is the input-output matrix, v is the vector of factor supplies. Now the inverse of matrix A reveals that A is a non-singular square matrix which implies that vectors q and v are the same size, being the case of the equal number of products and factors specific to the basic HO model. The above equation is defined as «the inverted form of the factor-market equilibrium condition equating the supplies of factors (v) to the demands for factors (Aq)». Hence, this equation is a one-to-one mapping between factors and outputs. In other words, the HO model allows us to convert output into factors and vice versa. As a result, product trade flows may be converted into factor trade flows. Even if factors are immobile, once transformed into products they become mobile.

Unfortunately, the production processes implied by this equation are very primitive; in fact, intermediate factors destroyed during the production process are not allowed for. Picking blackberries from wild bushes in the countryside may require only manpower; fishing by hand or using a simple capital tool like a harpoon or raking clams with a rake does not require intermediate commodities; but even the use of a fishing pole requires intermediate products: the bait. At first glance, it is hard to think of an economy characterized by production processes of this kind engaging in international trade.

Furthermore, Leamer introduces another equation which deserves to be quoted: $w = A'^{-1}p$, where w is the vector of factor returns and p is the vector of commodity prices. This equation «which translates product prices into factor prices, is the inverted form of the zero-profit conditions equating product prices (p) to production costs ($A'w$)». This statement will be referred to later on.

2. The impact of the Vanek prediction

Many years after the publication of Ohlin's book, which publicized the HO model, and after its widespread description in many international economics textbooks, Vanek (1968) developed a formula which was considered suitable to make the HO model testable. This contribution represented an important bridge between the purely theoretical structure of the HO model and the observable world. At that time, the world of international trade began to be observed and, consequently, a number of studies were aimed at evaluating the ability of the HO model to describe the real world.

As a result of Vanek's contribution, the Hechsher-Ohlin-Vanek (HOV) model is now referred to for empirical research aimed at testing the HO model prediction. The Bowen, Leamer, Sveikauskas (1987) paper is among the most representative research investigations reporting testing of the 'factor abundance theory'. They wrote that «HO propositions that trade reveals gross and relative factor abundance are not supported by» the data they specifically processed to test the HOV prediction. The results of this paper were used to affirm, on the one hand, that the HOV theory should be rejected and, on the other, that the 'experimental design' (trade data used) deserved a better arrangement. Leamer (1995) confirms that every test of the HOV prediction has been negative or inconclusive because, he says, «Demonstration of the accuracy of the HO model requires a clear linkage of trade patterns with factor proportions». Waiting for a better specification of the 'clear linkage', spoken of by Leamer, the basic relation he used to explain a number of theories built on the HO model – $q = A^{-1}v$ – was judged inadequate to investigate factor endowment in international trade. Meanwhile many economists involved in empirical research in international trade became aware that the HO theoretical model structure deserved some improvements. Davis and Weinstein (2003) comment: «how to incorporate traded intermediate into factor content studies remains an important area for future research» but in this regard Trefler and Zhu (2010) affirm: «we do not know what the Vanek-relevant definition is for the case where there are traded intermediate inputs and» – they add – when there are also «international differences in the choice of techniques».

In order to evaluate these proposals, HO basics have to be taken into account. The original HO model presented in a standard international economics textbook develops its prediction assuming that two countries have a) identical technologies, b) constant returns to scale and c) common tastes but differ in their relative factor endowments (see, for example, Markusen, Melvin, Kaempfer, Maskus 1995). The merit of such a limited set of theoretical hypotheses is the analytical elegance of the proof developed within the neoclassical economics niche. Unfortunately, as noted (Trefler and Zhu 2005) the HOV 'factors endowment prediction' was consistent with a large class of models. Hence, before continuing to test the Vanek prediction, an identification problem needs to be tackled. In order to make a model identifiable, its specification must be less general; it must include peculiarities making the model distinguishable from any other model on the basis of the available statistical observations.

The proposal to incorporate intermediate consumption into the factor content studies entered the theoretical modelling specification of most

HOV prediction research. Trefler and Zhu (2005), planning to make the introduction of intermediate inputs consistent with the Vanek prediction, proudly announced: «Thus, our paper is unexpectedly related to the growing literature on outsourcing and vertical production networks». This project will be achieved, they declare, using «a new data set» given by input-output tables. This passage shows the (supposed) link between the old research aimed at testing the HOV model with a new brand of research where the 'factor content' of trade is replaced with 'value added content'.

This connection is clear in a number of papers (for example, Trefler and Zhu 2010) and Dietzenbacher and Los (2010, 2012)) which begin with a homage to the Vanek prediction, but the attention immediately shifts to input-output tables, the new data set for measuring the value added (not the factor content) in trade.

3. The present analytical framework

In a joint note, the OECD and the WTO wrote down concepts and methodologies to define and compute 'trade in value-added'. Apart from the example of the iPod Apple assembles in China which presently appears as the essential quotation to declare that the value-added content of a product is the matter dealt with in the paper, the OECD-WTO note contains highlights on the 'conceptual framework'. Some of them very intriguing, almost a puzzle, such as the following:

> Consider an economy *i* that produces only two products *a* and *b* for export, with product *a* exported to country *j* for further processing before being re-imported into country *i* for use in the production of *b*. Let's assume that 100 units of *a,* with value 200, are produced and exported and then used in the production of 100 units of product *c,* with value 300, that are in turn used in the production of 100 units of *b* that are exported with value 400. Let's further assume, for simplicity, that each unit of *a* is produced entirely in country *i;* in other words no intermediate inputs are directly or indirectly sourced from abroad. Let's also assume that apart from the intermediate imports referred to above all the value-added in *b* is also generated in country *i* only.
>
> Following (I) above, it is at least, in theory, possible to show that the 100 units of *a* generated 200 units of domestic value-added (in country *i*) and the 100 units of *b* generated 300 units of domestic value-added (in country *i* – 200 from the production of *a* and100 from the final step in the production of *b*). We know that total gross exports in the economy were equal to 600 (200 of *a* + 400 of *b*), which to some extent overstates the contribution of overall trade to the economy, but simply summing the value-added contribution at the product level (the value-added generated by *a* – 200 – and the total value added generated in producing *b* - 300) will also overestimate the significance of trade in this context, as the overall value-added generated in the economy

> through the sale of both *a* and *b* is only 300; reflecting the fact that of the 300 units of value-added generated through the production of b, 200 units reflect the embodiment of product *a*, whose value-added is separately shown under the production of *a*.

After such a demanding analysis, the OECD-WTO note continues with the following comment:

> In practice of course we will never have the level of detail needed to conduct a value-added decomposition for all individual products in the way theorised above, so it will be necessary to use aggregated data. A pragmatic approach to doing this is by exploiting Input-Output tables, which are readily available in many (notably OECD) economies.

In other words, input-output tables represent the data set where relationships between outputs and value-added should be sought.

In the «framework for the measurement of trade in value-added terms» contained in the OECD-WTO note, among the key problems of the current trade statistics, the following concern the economic significance of value added in general and value added in the input-output tables:

> One final issue, that the OECD intends to tackle as part of its medium term work programme, concerns the need to go 'beyond value-added'. Value-added (in footnote*: It also includes 'other taxes and subsidies on production', i.e., those taxes and subsidies that are unrelated to the quantity, price of volume of goods and services produced.*) in a National Accounts sense reflects the compensation of resident labour, capital, non-financial assets and natural resources used in production. However, measuring flows of value-added reflects only part of the 'global trade' story. The fragmentation of production processes often involves fragmentation within a multinational enterprise. In that sense part of value-added, or at least part of what is referred to as operating surplus in the National Accounts, may be repatriated to the parent company. This may be a straight forward transfer from the affiliate to the parent (recorded as profit repatriation) or it may reflect payments for the use of those intellectual property products that are not recognised as produced assets in the National Accounts. Either way the point is that even estimates of value-added in trade may not provide the full picture of the importance of trade to an economy. Increasingly what also matters is where the value-added ends up. In this context it is important to recognise that the delineation of intellectual property products into those that are referred to as 'produced' (e.g. software) and those that are referred to as 'non-produced' (e.g. trademarks) makes a significant difference.

Cervantes and Fujii (2014) insist on this point: «We should consider that when exports are undertaken by foreign companies, the gross operating surplus can be remitted, to a greater or lesser extent, to the country of origin from which investment originated».

And write: «We hope to determine the sector and the country in which income (output), associated to the value of final consumer goods, was generated».

Being aware that:

> The limitations of the proposed study involve ignoring the reason that lead to changes in the distribution of value added around the world. This is because, on the one hand, value-added coefficients can change in accordance with: specific conditions of supply within each domestic economy: the ways wages for employed labor are determined; processes of accumulation of human capital; market power; and other factors. On the other hand, in the aggregate, it may be the characteristics of demand that lead to changes in generation of value.

From these quotations, 'factors content' and 'value added' are clearly not synonymies. In an input-output table, industry value added is a bundle of items. For instance, in the Eurostat system of national accounts, industry value added is composed of wages, social security, indirect taxes on production, provisions, subsidies and operating surplus which in turn includes a large variety of 'other incomes' and 'profits'; in particular, profits are not equal to zero as usually assumed in any theoretical model based on neoclassical theory, as in the case mentioned above by Leamer (1995).

'Factors content' is meant as a real magnitude while 'value added' as a whole must be measured in current value and it is not straightforward to conceive its real content. Meade (2006) gives a detailed description of methods used to calculate real value added in input-output tables; he recalls that «Though value added is income, real value added does not represent the purchasing power of that income». In the framework of the *Double Deflation* approach «Real value added may be regarded as a sub-function *g(K,L)* of a production function *f(K,L,M)*. If the conditions for separability do not hold, it is not clear what this method measures» (Meade 2006). Even if the conditions of separability hold, the sectoral value added should be divided between labor and capital; labor can be seen behind wages, but it is hard to see capital supporting all the rest of value added; relevant components of the operating surplus are dependent on 'market power' (Cervantes, Fujii 2014) and on the economic cycle (Grassini 2011). Furthermore, social securities, provisions, indirect taxes and subsidies on production and wages are variables which are strongly influenced by economic policies.

Almon (2009) tackles the double deflation trouble directly from the account identities (the input-output table) which statistical offices use to deduce sectoral value added at a constant price. His judgement is a clear censure: «Double deflated value added is a statistic which should never be calculated; and, if calculated, should never be released; and, if released, should never be used if there is anything more reasonable available».

From the account identities, total final demand is equal to total value added, so that the deflated total final demand (GDP) is equal to 'deflated' total value added once the same 'total' final demand deflator is applied. Sectoral value added has no economic meaningful deflator; hence, at present, only value added in current prices appears to be utilizable when following the "chains" of international trade.

4. The analytical structure

The analytical structure begins with the Leontief equation:

$$q = Aq + f \qquad (1)$$

then net exports are divided into exports and imports

$$q = Aq + f - m \qquad (2)$$

At this point the final demand can be still exogenous, but imports must be considered endogenous. Besides the Leontief equation, import equations may appear; constrained within linear algebraic tools, import equations may take the form (OECD-WTO 2013) of

$$m = Dq \qquad (3)$$

where D is a diagonal matrix with imports/outputs sectoral ratios along the diagonal.

Equations (2) and (3) do not represent an economic model of any interest. In the absence of behavioural equations (no matter if econometrically estimated or simply 'calibrated'), this model implies that the ratios of sectoral imports to sectoral output is constant. Namely, the model assumes that sectoral imports elasticity with respect to corresponding sectoral output is equal to one. No import substitution or penetration is allowed. No structural changes coming from international trade may be investigated by means of such a model.

The analytical structure presently proposed by 'trade in value added' researchers is based on a step back from the Leontief equation (which is a model) to a system of accounts developed from input-output tables.

Equation (2) is rewritten emphasizing the supply side (left) and the use side (right)

$$q + m = Aq + f \qquad (4)$$

The use side is then divided into two parts: the part supplied by domestic output and that supplied by foreign output:

$$q = A_d q + f \quad (5)$$
$$m = A_m q \quad (6)$$
with $A = A_d + A_m$

The distinction between supplies is applied to 'the rest of the world' too. Exports are imports of the rest of the world; hence, considering the import coefficients matrix of the rest of the world, A_{m_row}, and its total output, q_{row}, equation (5) becomes

$$q = A_d q + A_{m\_row}\, q_{row} + f \quad (7)$$

leaving in f the domestic demand plus exports directed to the final demand of the rest of the world.

Besides the import coefficients matrix of the rest of the world there is the 'domestic coefficient matrix' of the rest of the world, A_{d_row}, and the final demand f_{row}; hence, equation (6) can be completed as follows

$$q_{row} = A_m q + A_{d\_row}\, q_{row} + f_{row} \quad (8)$$

Equations (7) and (8) represent the core of the research aimed at transforming foreign trade on commodities (and services) into trade in value added. A_{d_row} and A_{m_row} can be split into as many countries as required.

Following the above analytical structure based on the framework of input-output tables, Cervantes and Fujii (2014) notice that:

> the world becomes a 'closed' economy with two destinations for output: intermediate consumption or final consumption. Information is organized in a *world input-output table*, for *S* number of industries and *N* countries, so that, from right to left, we see the distribution of output from sector *i*, of country *p*, as intermediate consumption of each of the industrial sectors within the country in question and those of the rest of the world; similarly we see the destination of final output as household consumption, government expenditure or investment in *N* possible countries of destination. Further, from top to bottom, we can observe the 'origin' of output of sector *j* and of country *p*, in accordance to the content of raw materials that originates in sector *i* and in country *p*, plus domestic value added.

This tongue-twister description of the workhorse supporting this brand of research has a pictorial representation in terms of the following matrix notation which stems from the above description of its analytical structure. matrix A

$$A = \begin{bmatrix} A_{11}A_{12}A_{13} \dots\dots\dots A_{1N} \\ A_{21}A_{22}A_{23} \dots\dots\dots A_{2N} \\ \dots\dots \\ A_{p1}A_{p2}A_{p3} \dots\dots\dots A_{pN} \\ \dots\dots \\ A_{N1}A_{N2}A_{N3} \dots\dots\dots A_{NN} \end{bmatrix} \qquad (9)$$

is the technical coefficient matrix where A_{pp} is the coefficient matrix of domestic inputs for country *p* and A_{ij} is the coefficient of import inputs of country *j* supplied with the output of country *i*. And

$$q = \begin{bmatrix} q_1 \\ q_2 \\ q_3 \\ . \\ . \\ q_p \\ . \\ . \\ q_N \end{bmatrix} \quad \text{and} \quad f = \begin{bmatrix} f_1 \\ f_2 \\ f_3 \\ . \\ . \\ f_p \\ . \\ . \\ .\ f_N \end{bmatrix} \qquad (10)$$

both of dimension *NxG* (where *G* is the number of sectors in each input-output country table), are vectors of outputs and final demands; vector *f* is composed of household consumption, government expenditure, investment and exports of final consumption goods and services; vector f can be expanded as follows

$$f = \begin{bmatrix} f_{11} + f_{12} + f_{13} \dots\dots\dots + f_{1N} \\ f_{21} + f_{22} + f_{23} \dots\dots\dots + f_{2N} \\ \dots\dots\dots \\ f_{p1} + f_{p2} + f_{p3} \dots\dots\dots + f_{pN} \\ \dots\dots\dots \\ f_{N1} + f_{N2} + f_{N3} \dots\dots\dots + f_{NN} \end{bmatrix} \qquad (11)$$

where f_{pp} is the final demand of country p supplied with domestic output of country *p* and f_{ij} is the final demand of country *j* supplied with exports from country *i*.

The world as a 'closed economy' can be represented (using (9), (10) and (11)) by means of the Leontief equation

$$q = Aq + f \qquad (12)$$

At present, the value added located in any country input-output table is connected with the trade flows as described, for example, in a recent World Bank working paper by Francois, Manchin, Tomberger

(2013) and proposed as a methodological instrument in the OECD-WTO note (2013).

The measurement of the linkage starts from the Leontief equation and its solution: $x = (I - A)^{-1}f$. The connection of these flows belonging to the real side of any input-output based model is established by means of a vector of value added shares, $v_j = V_j/q_j$, where V_j is the total value added for sector j.

Given V, vector of value added by industry, and v, vector of value added shares by industry, the relationship is:

$$V = \hat{v}\,q \qquad (13)$$

where $\hat{v}$ is a diagonal matrix with the value added shares along the main diagonal, establishes the relationship between industry output and industry value added. This is basically the yardstick for linking value added to any final demand component. As shown in Bouwmeester, Oosterhaven, Rueda-Cantuche (2012), the value added by industry embodied in the final demand components is defined as follows;

$$V = \hat{v}\,x = \hat{v}(I - A)^{-1}\,f = \hat{v}(I - A)^{-1}(f_1 + f_2 + \cdots f_k + \cdots + f_K) \qquad (14)$$

with

$$V_k = \hat{v}(I - A)^{-1}f_k \qquad (15)$$

the value added embodied in the *k-th* final demand component. The relationship between industry output (as well as any final demand component) and value added is then applied to the world 'closed economy' described in (12).

Then, given the 'international input-output table' (from (9), (10) and (11))

$$\begin{bmatrix} q_1 \\ q_2 \\ \vdots \\ q_N \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} & \dots A_{1N} \\ A_{21} & A_{22} & \dots A_{2N} \\ \vdots & \vdots & \ddots \ \vdots \\ A_{N1} & A_{N2} & \dots A_{NN} \end{bmatrix} \begin{bmatrix} q_1 \\ q_2 \\ \vdots \\ q_N \end{bmatrix} + \begin{bmatrix} f_{11} + & f_{12} + & \dots + & f_{1N} \\ f_{21} + & f_{22} + & \dots + & f_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ f_{N1} + & f_{N2} + & \dots + & f_{NN} \end{bmatrix} \qquad (16)$$

the 'solution' in terms of countries' final demand is

$$q = \begin{bmatrix} q_1 \\ q_2 \\ \vdots \\ q_N \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} & \dots B_{1N} \\ B_{21} & B_{22} & \dots B_{2N} \\ \vdots & \vdots & \ddots \ \vdots \\ B_{N1} & B_{N2} & \dots B_{NN} \end{bmatrix} \begin{bmatrix} f_1 \\ f_2 \\ \vdots \\ f_N \end{bmatrix} = Bf \qquad (17)$$

Following (15) and using the (NxG)x(NxG) diagonal matrix of value added shares

$$V = \begin{bmatrix} \hat{V}_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \hat{V}_N \end{bmatrix} \tag{18}$$

the allocation of sectoral value added to final demand components is performed by means of the following matrix.

$$VB = \begin{bmatrix} \hat{V}_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \hat{V}_N \end{bmatrix} \begin{bmatrix} B_{11} & B_{12} & \dots B_{1N} \\ B_{21} & B_{22} & \dots B_{2N} \\ \vdots & \vdots & \ddots \; \vdots \\ B_{N1} & B_{N2} & \dots B_{NN} \end{bmatrix} = \begin{bmatrix} \hat{V}_1 B_{11} & \hat{V}_1 B_{12} & \dots & \hat{V}_1 B_{1N} \\ \hat{V}_2 B_{21} & \hat{V}_2 B_{22} & \dots & \hat{V}_2 B_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \hat{V}_N B_{N1} & \hat{V}_N B_{N2} & \dots & \hat{V}_{NN} B_{NN} \end{bmatrix} \tag{19}$$

Matrix *VB* is now the «basic measure of the value-added shares» (Koopman *et al.* 2012) for any manipulation designed to reveal where value added is formed and where it reaches its final destination; of course, whatever the index created from the 'world closed economy' represented in (12), it stands on the economic meaning of (or the economic information contained in) the *VB* matrix[1].

5. *Concluding remarks*

Although value added associated with final demand components may be based upon different approaches (see Grassini 2011), this branch of research seems to stem mostly from Belke and Wang's (2005) very detailed paper.

These authors planned to develop 'innovative measures of openness towards bilateral trade'. They observed that «The *degree of openness to trade* indicates the importance of international trade linkages for a country», but the most «widely applied ("traditional") openness indices are not able to accurately calculate the degree of trade openness». So that «In clear contrast to the mainstream», they correct 'the traditional concept by expressing trade in value-added terms instead of gross terms', and proudly affirm that 'The innovative actual openness concept is able to reflect the different structures of production among countries since the value-added created by trade is forecasted on the foundation of a sound theory of production'.

Expressing trade in value-added terms has now become a new mainstream. Originally, trade in 'value-added terms' was considered the other face of trade in 'factors content'. Now this link seems to be drastically weakened[2]. At present, this brand of research appears largely organized

[1] The 'double counting' problem (see for example Dietzenbacher and Los 2012 and Koopman *et al.* 2012) is here intentionally not considered.

[2] Johnson and Noguera (2012) claim to have proved «a general point: the em-

under the conceptual framework posed in the OECD-WTO note (2012). From the overview of the literature on trade in value-added contained in this note, Johnson and Noguera (2010) and Koopman *et al.* (2011) appear to be the outstanding contributors in the field. These contributions focus on the relationship between gross exports (or output) and value added. Although such a relationship is studied on the basis of an input-output table for a given year (which turns out to be a 'base year'), the value added unit of measure is not taken into account. Indeed, it is also ignored in the OECD-WTO project where such statistics will be computed from input-output tables in different and distant years. This point is crucial for addressing within a clear statistical context the «possibility for the System of National Accounts (SNA) to accept the concept of value-added trade without dramatically changing current customs data collection practice [in order to] provide a feasible way for international statistical agencies to report value-added statistics (Koopman *et al.* 2011)»[3].

The shift from 'factor content' to 'trade in value-added' is characterized not only by the choice of the data set. The difference between the research methodology used to assess the 'factors content' in the wake of the Vanek prediction compared to that regarding the 'trade in value-added' shown in the OECD-WTO note is more important. The methodological approach in the field of factor abundance theory is clarified in the abstract of Bowen, Leamer, Sveikauskas (1987)'s paper:

> The Heckscher-Ohlin-Vanek model predicts relationships among industry input requirements, country source supplies, and international trade in commodities. These relationships are tested using data on twelve resources, and the trade of twenty-seven countries in 1967. The Hecksher-Ohlin propositions that trade reveals gross and relative factor abundance are not supported by these data. The Heckscher-Ohlin-Vanek equations are also rejected in favour of weaker models that allow technological differences and measurement errors.

Getting predictions from a theoretical model, collecting data to test such predictions, defining alternative hypotheses, working in the framework of statistical inference, looking for correlations, detecting explanatory variables, sentencing the theory 'true' or 'false', rejecting a model in favour of other models and so on, is a methodology at present totally ignored by the research programme described in the OECD-WTO note.

The 'trade in value-added' methodology is strictly related to a linear algebra manipulation of input-output tables. The researcher in this field

pirical shift from factor content to value added content embodies a deeper conceptual shift in how we think about trade».

[3] OECD, World, WTO, Eurostat, UNSD and UNCTAD assimilated and translated such invitations in the title of the workshop organised on 21 September 2010: «new metrics for global value chains».

acts believing that the input-output table may help reveal new economic statistics[4] and even new accounting identities[5].

Furthermore, the researcher intentionally ignores the difference between the concept of 'factors content' which is basically in real terms and the sectoral value-added defined in any input-output table which is inevitably measured in current prices. Nevertheless, value added shares are used to convert gross outputs into value added flows no matter if sectoral outputs are measured in current or constant prices.

At present, no comparison among input output tables in different years has been applied. Considering the economic meaning of value added flows statistics, the bundle of indexes produced within the framework of the OECD-WTO modelling approach have not yet been submitted to any comparison between different years. In other words, at present no structural change analysis appears to be viable.

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[4] Koopman *et al.* (2012) «believe there are many other applications that may affect our understanding of the pattern of global trade if we could improve the value-added trade and domestic content estimates at the sector levels».

[5] See Global Forum "Measuring Global Trade – Do we have the right numbers?", 2-4 February 2011.

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BETWEEN THE EUROPEAN UNION AND THE EURASIAN ECONOMIC UNION

ESTIMATES OF MACROECONOMIC EFFECTS OF TRADE RELATIONS BETWEEN THE EUROPEAN UNION AND THE EURASIAN ECONOMIC UNION

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This article presents quantitative estimates of the possibility to create a free trade area between the EU and Russia in the mid- to long-term perspective and addresses the issues of competitiveness of different sectors of the Russian economy in the context of lowering or total dissolution of trade barriers with the EU. A list of possible issues to be addressed during the creation of an all-encompassing free trade area on the Eurasian continent is outlined. Also estimates of the effects of sanctions on the Russian and EU economies are given.

The development of free trade and competitiveness may become an important source of stable economic growth in the post-Soviet countries. The most important partner of the Eurasian Economic Union (EAEU)[1] countries is the European Union (EU). Consequently, development of trade and economic relations between the two largest unions on the Eurasian space is in line with the long-term economic development goals. At the same time, the economic effectiveness of the liberalization of foreign economic relations is determined not only by the scale of cooperation between the integrating unions, but also by comparability of key parameters of economic development. First of all, this is an issue of industrial efficiency and the related issue of the competitiveness of goods.

Creation of a free trade area between the European Union (EU) and the Eurasian Economic Union (EAEU) involves a search for answers to a number of principal questions, each of which should help form an understanding of the timeliness and viability of such a step.

These questions can be formulated as follows:

1. Could the creation of a free trade area between EU and EAEU stimulate economic development in the space between Lisbon and Vladivostok in the mid- to long-term perspective?
2. What criteria should signify the readiness of EU and EAEU to create a free trade area?

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[1] The treaty of the Eurasian Economic Union creation was signed between Russia, Kazakhstan and Belarus in May 2014.

Douglas S. Meade (edited by), *In Quest of the Craft : economic Modeling for the 21st Century*
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3. Is a step-by-step (sectoral) transition to an FTA possible? What is the possible timeframe for creation of an all-encompassing FTA?
4. How does the process of EU- EAEU FTA creation coexist with other integration processes (US-EU FTA, etc.)?
5. What would be the most important effects resulting from changes in tariff and non-tariff barriers on trade, workforce and cash flows?
6. How would the FTA creation process impact the dynamic and structural characteristics of EU and EAEU countries' development?

No doubt, answers to these questions can be found by means of an integrated macroeconomic multisectoral and cross-country study. At the same time we believe that there are several aspects for which valid assessments can already be made.

In particular, one such aspect is the estimation of a possible time frame for creation of an FTA between EU and EAEU.

At the present time, there are significant differences in the competitiveness level between the EAEU countries (Belarus, Kazakhstan and Russia) and the key EU countries that are only partially compensated for by exchange rates and tariff and nontariff trade barriers.

The low level of sectoral competitiveness in EAEU countries in comparison to their European counterparts would result in a dramatic increase of imports from EU in case of a single-step abolition of all import duties. At the same time the European Union market is less accessible for EAEU goods due to a number of technological requirements and regulations rather than import duties. This means that at present the creation of such a free trade area is disadvantageous to the EAEU countries, because for them it would result in the reduction of production in a number of economic activities. From our point of view, one of the key indicators of readiness of both EU and EAEU to create an all-encompassing FTA is, at the very least, the absence of significant negative consequences of such a move for each party. In terms of economic dynamics this means that mutual removal of tariff barriers between the EU and EAEU should not result in a significant single-step increase of import volumes on the internal markets of EAEU countries. On the other hand, the EU is concerned with keeping the competitive potential of its products on EAEU markets at an acceptable level when the FTA is created.

There are significant differences in the sectoral structure of the EU and EAEU economies. This means that a change in the mutual trade conditions will be accompanied by different levels of impact on different economic activities. In the long run this can lead to significant changes in the sectoral structure. Therefore, there is a need to assess the sectoral effects of creating an EU-EAEU FTA for the whole forecast period.

Although imported goods account for a little more than 20% of the whole Russian commodity market, in several key segments of the internal market the level of import consumption presents a clear threat to Russian manufacturers. For example, the market share of imported goods is more than 55% in textile and garment manufacture, more than 75% in footwear and leather goods, around 50% in the pulp and paper industry, publishing and printing activities, around 50% in chemicals and pharmaceuticals, more than 55% in machinery and equipment, more than 50% in electrical, electronic and optical equipment, and more than 40% on the car market.

In recent years Russia and other EAEU countries developed and financed ambitious programs aimed at upgrading production and designed for high-priority satisfaction of needs of internal markets. The most important programs were focused on the development of machinery production and agriculture.

Consequently, it would be in the interest of the Russian economy if the dissolution of excessive foreign trade barriers would not result in a spike in imports in the most sensitive sectors of the economy and would have no significant negative consequences for overall macroeconomic stability.

Table 1 – Export/import production balances in the key commodity groups in the Russian economy (2013).

	Internal market capacity, USD bln.	Volumes of domestic production in consumer prices, USD bln.	Export, % of production	Imports, % of apparent consumption	EU countries' share in aggregate imports, %
Total (industry and agriculture)	1525.1	1725.0	30.0	20.8	33.2
Agriculture, hunting and forestry	133.6	127.1	6.0	10.5	26.7
Food (including beverages) and tobacco	191.6	173.4	6.1	15.0	34.5
Textile and garment manufacture	23.2	11.2	8.5	56.0	15.2
Leather, leather goods and footwear	7.6	2.2	18.2	75.9	16.8
Chemicals, except pharmaceuticals	57.9	56.0	41.0	42.9	59.3
Pharmaceuticals	22.8	8.9	6.4	63.4	74.9
Machinery and equipment	94.7	53.3	19.8	54.9	49.1
Electrical, electronic and optical equipment	92.3	51.5	11.8	50.8	33.6
Transport vehicles and equipment	149.2	105.3	9.5	36.1	39.7

Source: Rosstat, FCS, authors' calculations

In order to evaluate the gravity of consequences from the removal of foreign trade barriers, we must first determine the most important differences in industrial efficiency levels in Russia and European countries. In general, the level of technological competitiveness of a production operation can be expressed in terms of efficiency of primary resources use. The more added value that can be produced per unit of primary resources, the higher (other things being equal) the industrial efficiency. Moreover, you can get a certain idea of the level of industrialization by comparing shares of added value and intermediate input in the structure of gross output by types of economic activities.

In the current economic environment industrial efficiency is also determined by inter-country cooperation, when more technologically advanced countries lower their operating costs by utilizing the scientific groundwork available to them. Table 2 compares levels of added value in production and efficiency of resource use, giving a sufficiently complete idea of competitiveness of production operations in different countries.

Table 2 – Indicators of production's efficiency in Russia and its trade partners.

	Food	Oil products	Chemicals	Machinery and equipment	Electrical, electronic and optical equipment	Transport vehicles and equipment
	Efficiency of primary resources use (added value to primary resources cost)					
Russia	0,98	0,79	0,79	1,14	1,13	1,27
Germany	0,87	0,13	1,58	2,48	3,72	1,69
Poland	0,86	0,33	0,75	1,57	1,76	1,13
Bulgaria	0,68	0,15	0,48	0,62	1,07	0,58
Finland	1,10	0,19	0,94	1,69	3,92	1,62
China	0,58	0,26	0,36	0,75	0,76	1,17
	Added value share in production structure,%					
Russia	26,8	30,8	31,8	31,9	34,2	23,0
Germany	22,8	4,3	33,8	36,8	38,3	23,2
Poland	23,5	16,3	26,6	33,5	27,7	20,3
Bulgaria	19,3	7,7	23,2	25,2	27,2	27,2
Finland	25,2	9,1	31,6	27,9	24,0	25,3
China	24,3	17,8	20,6	23,0	16,1	19,5

Source: Rosstat, Eurostat, WIOD database, authors' calculations

Analysis of industrial efficiency in Russia and its main business partner countries shows that judging by the current level of costs, Russia retains competitiveness in the area of primary commodities (petrochemicals and chemicals), still holds a competitive edge in food production efficiency over less developed EU countries and has insufficient competitiveness in all machinery production sectors.

In order to further assess the possibilities of development of trade and economic relations between the EU and EAEU it would be prudent to review the main aspects that determined the current level of trade protection of the most important sectors of the Russian economy in recent years.

In general, tariff regulation of imports in the 2000s consisted in a high level of protection in most economic sectors. It soon became clear, however, that such a policy leads to deterioration of industrial capacity and conservation of a low level of competitiveness in a number of critical production activities. Most factories were in dire need of floating capital for production growth and investment resources for upgrading the industrial base. However, due to the high credit rates and absence of a clear industrial policy the sources of required finance for industrial needs were limited. At the same time, customs and tariff regulation measures had only a marginal effect on the level of competitiveness of Russian producers, both on the external and (most importantly) the domestic market.

In 2000-2008 domestic demand (investment and private) had a moderate growth rate exceeding 10%. However, the Russian industries were unable to provide the Russian consumers with adequate amounts of products of acceptable quality. This resulted in a snowballing growth of imports, and the share of imported goods on the domestic market was constantly growing.

Therefore, Russia had to modify its foreign economic policy, and, first and foremost, its tariff regulation policy. In the 2000s, the import duties on a number of investment goods (first of all, on machine tools and other production equipment) were sharply reduced.

The years 2008-2010 saw a significant decrease in import duties on a number of types of technological equipment. A number of imported items enjoyed special 'duty holidays' which resulted in rather fast re-equipment of a number of aircraft and shipbuilding facilities. These measures were carried out as part of the national industrial policy that began to take shape since the mid-2000s.

This policy is based on the understanding that in a number of Russian industrial sectors the growth of production and competitiveness is impossible without the participation of high-profile global players. These sectors include, primarily, such sectors of machine industry as manufacturing of machine tools and technological equipment, cars, agricultural machinery, electronics and communication equipment and household appliances.

In regards to these sectors the state policy consists of creating a maximum possible preferential treatment regime for large international companies organizing production on the Russian territory. A good example is the car manufacturing sector, as for a number of years industrial assembly mechanisms have been successfully working there.

Table 3 – Scenario forecast of Russian economic development.

	2011-2015	2016-2020	2021-2025	2026-2030	2031-2035
GDP growth rates, %	3.0	4.3	3.7	3.4	2.6
Capital investment growth rates, %	6.9	7.2	5.1	4.9	3.1
	2015	2020	2025	2030	2035
GDP per capita, MUSD (prices current)	15.1	20.7	27.1	37.2	45.3
Labor productivity (2010 = 1)	1.23	1.52	1.84	2.18	2.53
Energy intensity (2010 = 1)	0.84	0.70	0.60	0.53	0.46
Electric intensity (2010 = 1)	0.93	0.86	0.79	0.73	0.63
USD exchange rate, RUR	35.7	36.9	38.2	39.5	40.9

Source: Institute of Economic Forecasting Russian Academy of Science

Furthermore, in the framework of gaining access to WTO Russia undertook to gradually lower the level of tariff protection. Agreements stipulate lowering of the average level of custom duties from 11.3% to 6.4% for manufactured goods and from 15.1% to 11.3% for agricultural products by 2020. Consequently, in the period leading to 2020 the level of tariff barriers between the EU and EAEU (which also has a unified customs tariff) will be lowered considerably. Therefore, we can safely assume that during the period of gradual change in customs protection to the ultimate level the creation of an FTA is unlikely, because adjustment of the Russian market to a new competitive environment can cause additional negative processes due to the opening of the customs borders for trade with EU. After that, however, with the general lowering of domestic market protection possible negative effects from creation of an FTA will have considerably less impact.

In order to evaluate the outcomes of the creation of a free trade area between the EU and EAEU for the Russian economy, several scenario calculations were made assuming a change in the level of price protection in a moderately optimistic scenario of Russian economic development[2].

Foreign economic conditions of the forecast presuppose that for the period of 2014 to 2035 the mean growth rate of the world economy will be slightly less than 3%. Under these conditions the growth of oil prices

[2] Calculations were made using the INP RAN predictive analytical complex, the core of which is the CONTO dynamic input-output model. For further information on model instruments see Shirov, Yantovskiy (2014).

is affected by a general decrease in the energy intensity of the global GDP on the one hand, and depends on the worldwide price developments on the other hand. As a result, by 2030 the price of a Urals barrel will be $163. Therefore, foreign economic scenario conditions used for making a forecast for the Russian economy can be described as moderately favorable.

Economic growth rates will be 3.3% p.a. on average in the period from 2014 to 2035.

These comparatively high growth rates will require an outrunning growth of capital investment, focused on upgrading the existing and creating new production capacities as well as productivity enhancement in general. Simultaneously, there will be an increase in the net savings share in GDP from the present level of 21.5% (2012) to 27% by 2025 and a subsequent decrease to 22% by 2035.

This level of investment activity would allow for an acceptable level of growth of industrial efficiency. Particularly, by the end of the forecast period the GDP energy intensity will decrease by 45% compared to the 2013 level, while in the same period productivity of labor will increase by a factor of 2.3.

The scenario also suggests a continuous depreciation of the ruble, providing favorable conditions for exporters while at the same time not worsening the conditions for the influx of capital. As a result, along with an expansion of debt finance, an expansion of the whole range of capital investment financing sources will be achieved, with a gradual decrease in the importance of own and budget resources. Moreover, the lack of significant exchange rate depreciation will promote the upgrade of production capacities by ensuring the necessary amounts of imported machinery and equipment. It should be noted that, retrospectively, depreciation of the ruble has usually occurred when the economy has slowed down, while with a moderately high rate of economic development, the rate was relatively stable. These scenario parameters were also selected because in the case of lower growth and exchange rates the Russian market would be considerably less attractive to European manufacturers due to the lowering of its nominal volume and solvency margin.

It should also be noted that a moderate depreciation of the national currency helps reduce the gap between Russia and the most developed countries in the level of welfare. In the framework of this scenario, by 2035, per capita GDP will be around $45,000 (which could amount to 45-50% of the US nominal per capita GDP). In these conditions we can expect the Russian market to have a significant private and investment demand for European products, especially in the areas of high-tech machine industry and household appliances.

The relatively stable economic dynamics combined with the growth of relative personal income would drive the corresponding demand for consumer and investment goods.

One of the most important indicators determining the impact that FTA creation would have on the share of imports on the Russian domestic market is the level of protection of domestic manufacturers by parity of domestic and world prices and national currency exchange rate. This indicator can be calculated as a ratio of the nominal ruble exchange rate to its purchasing power parity for a selected range of products taking into account the import duties or their abolition. If the resulting value is higher than one, it is assumed that domestic manufacturers have additional price advantages over external suppliers; if it is less than one, then there is no price protection for Russian manufacturers on the domestic market. Calculations shown in the next table clearly demonstrate that domestic textile manufacturers currently have a price advantage over imports from European countries, and can also maintain this advantage over products from Ukraine and Kazakhstan. Russian manufacturers of clothing and footwear will be able to compete with imports from China only if the import duties are maintained.

Domestic manufacturers of furniture and household appliances will keep a significant price advantage over European goods on the domestic market due to the development of industrial assembly. At the same time, the situation continues to be unfavorable for the investment machine industry as domestic manufacturers of machinery and equipment will continue to lose to their European counterparts, while maintaining price protection against products from post-Soviet space and China. We can state that in order to minimize the negative impact of the abolishment of trade barriers Russia and the EU it would be necessary to develop a long-term strategy for investment products. Currently, the Russian producers have no other option than to buy foreign investment goods. Therefore, demand for such imports will be causing certain requirements in the area of balance of payments. Our calculations show that a 50% decrease in investment imports over the course of 10 years in the current conditions and their replacement by domestic products can improve the annual average growth rate by more than 0.5 %. It is this sector where implementation of the 'added value in exchange for technologies' principle can be implemented, intending to use the technological potential of EU countries in exchange for priority market access.

The second important factor affecting the competitiveness of domestic manufacturers is primary resource use efficiency. A significant share of productive facilities constructed during the Soviet period is the cause for the low base characteristics of industrial efficiency. However, putting more new competitive facilities into operation, upgrading the existing ones and culling the least efficient ones would ensure a moderately fast increase in overall efficiency, especially in the sectors without a long reinvestment cycle. The speed of this process will vary by types of activities and will be determined primarily by capital investment.

As the forecast calculations show, if the savings ratio is increased, then several sectors of the Russian economy, first of all, medium-tech sectors of secondary industry would be able to significantly increase (1.8-2 times) their ratio of produced added value to primary resources spent. This is due to the fact that these sectors still carry a high upgrade potential for existing productive facilities. Possibilities of increasing industrial efficiency exist to a lesser extent in low-tech secondary industries (1.3-1.5 times). High-tech productive facilities have a higher efficiency level by default given a

Table 4 – Price protection by exchange rate (exchange rate to PPP).
(1- import duties preserved,2- import duties abolished)

Year	Germany		France		Italy		Ukraine		Belarus		Kazakhstan		China	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Clothing and footwear														
2008	1,05	0,80	0,95	0,72	1,09	0,83	0,68	0,58	0,63	0,53	0,94	0,80	0,80	0,61
2010	1,03	0,76	0,90	0,66	1,03	0,76	0,60	0,51	0,54	0,46	0,98	0,83	0,90	0,67
2013	**1,32**	**0,99**	**1,34**	**1,00**	**1,38**	**1,03**	**0,64**	**0,54**	**0,46**	**0,46**	**1,05**	**1,05**	**0,98**	**0,73**
2015	1,39	1,04	1,42	1,06	1,46	1,09	0,75	0,64	0,54	0,54	1,19	1,19	1,03	0,77
2020	1,38	1,03	1,40	1,05	1,44	1,08	0,92	0,79	0,66	0,66	1,37	1,37	1,02	0,76
2025	1,38	1,03	1,40	1,05	1,44	1,07	1,06	0,91	0,76	0,76	1,50	1,50	1,02	0,76
2030	1,34	1,00	1,36	1,02	1,40	1,04	1,13	0,97	0,81	0,81	1,53	1,53	0,99	0,74
2035	1,34	1,00	1,37	1,02	1,41	1,05	1,20	1,02	0,86	0,86	1,58	1,58	0,99	0,74
Furniture, household appliances and electronics														
2008	1,29	1,03	1,45	1,16	1,47	1,18	0,80	0,68	0,76	0,64	0,99	0,84	0,85	0,68
2010	1,26	1,02	1,37	1,10	1,40	1,13	0,71	0,60	0,65	0,55	1,03	0,87	0,96	0,77
2013	**1,47**	**1,19**	**1,66**	**1,35**	**1,60**	**1,30**	**0,75**	**0,64**	**0,55**	**0,55**	**1,10**	**1,10**	**1,04**	**0,84**
2015	1,55	1,25	1,75	1,42	1,69	1,37	0,88	0,75	0,65	0,65	1,25	1,25	1,09	0,88
2020	1,53	1,24	1,74	1,41	1,67	1,36	1,08	0,93	0,80	0,80	1,44	1,44	1,08	0,88
2025	1,53	1,24	1,73	1,41	1,67	1,35	1,25	1,07	0,92	0,92	1,57	1,57	1,08	0,87
2030	1,49	1,20	1,68	1,37	1,62	1,31	1,33	1,14	0,98	0,98	1,61	1,61	1,05	0,85
2035	1,49	1,21	1,69	1,37	1,63	1,32	1,41	1,21	1,04	1,04	1,66	1,66	1,05	0,85
Investment machine industry														
2008	0,88	0,74	0,96	0,80	0,89	0,75	1,00	0,85	0,83	0,71	0,89	0,75	0,93	0,78
2010	0,83	0,69	0,89	0,75	0,85	0,71	1,03	0,88	0,70	0,60	0,88	0,75	1,02	0,86
2013	**0,93**	**0,80**	**0,95**	**0,81**	**0,95**	**0,81**	**1,19**	**1,02**	**0,62**	**0,62**	**0,88**	**0,88**	**1,06**	**0,90**
2015	0,98	0,84	1,01	0,86	1,01	0,86	1,40	1,20	0,73	0,73	1,00	1,00	1,11	0,95
2020	0,97	0,83	1,00	0,85	1,00	0,85	1,72	1,47	0,89	0,89	1,15	1,15	1,10	0,94
2025	0,97	0,83	0,99	0,85	0,99	0,85	1,98	1,69	1,03	1,03	1,26	1,26	1,10	0,94
2030	0,94	0,81	0,97	0,82	0,97	0,82	2,11	1,81	1,10	1,10	1,29	1,29	1,07	0,91
2035	0,95	0,81	0,97	0,83	0,97	0,83	2,24	1,92	1,16	1,16	1,33	1,33	1,08	0,92

Source: Institute of Economic Forecasting Russian Academy of Science higher share of modern productive facilities. In this context the efficiency growth forecast in this group of industries is quite conservative.

Table 5 – Productivity of primary resources use, times (added value to primary resources spent).

	2012	2015	2020	2025	2030	2035	2020 to 2012	2030 to 2012
Agriculture and forestry, hunting and fishing	1,82	1,85	1,97	2,17	2,43	2,46	108%	133%
Mining operations	2,80	2,83	3,22	3,73	4,50	4,78	115%	161%
High-tech secondary industries[4]	1,31	1,37	1,52	1,73	2,04	2,24	116%	155%
High-level medium-tech secondary industries	0,75	0,81	0,95	1,12	1,37	1,48	126%	182%
Low-level medium-tech secondary industries	0,53	0,57	0,68	0,83	1,06	1,16	128%	201%
Low-tech secondary industries	1,04	1,09	1,21	1,38	1,64	1,70	116%	158%
Electrical energy, gas and water production and distribution	0,94	1,25	1,45	1,53	1,46	1,44	155%	155%
Construction	1,30	1,39	1,62	1,98	2,52	2,38	125%	193%
Wholesale and retail trade, repair works	11,44	12,11	14,10	16,94	21,32	24,22	123%	186%
Hotels and restaurants	3,49	3,61	3,80	4,13	4,70	4,38	109%	135%
Transportation and storage	1,96	2,24	2,98	4,00	5,21	6,92	152%	266%
Telecommunications	8,90	8,91	9,83	11,35	14,17	17,85	110%	159%
Other services	3,48	3,56	3,78	4,26	5,17	5,69	109%	149%
Total	1,85	1,99	2,32	2,73	3,35	3,63	125%	182%

Source: Institute of Economic Forecasting Russian Academy of Science

[3] Hereinafter we use the aggregation of types of activities by the level of their technological development, based on the current OECD methodology. Particularly, *high-tech* types of activities include manufacturing of pharmaceuticals, office equipment and computing hardware, radio, television and communications equipment, medical equipment, measuring equipment, aviation and space equipment, optical equipment and watches. *High-level medium-tech types of activities* include production of chemicals, manufacturing of machinery and equipment, electrical machinery and equipment, vehicles, trailers and semitrailers, and shipbuilding. *Low-level medium-tech types of activities* include crude oil refining, manufacturing of rubber and plastic goods, other nonmetal mineral products, and metallurgical products; metallurgical production. *Low-tech industries* are all the remaining types of activities of the secondary industries.

Demand for imported products arises under the influence of changes in price competitiveness and existing industrial effectiveness, as well as economic dynamics in general. One of the indicators used to assess the ability of domestic producers to compete with imported goods on the domestic Russian market is the share of imports in the total consumption.

According to the projections, a decrease in the share of imports in the described scenario for the Russian economy in general and the sectors of secondary industries most sensitive to its growth in particular will appear no sooner than 2020-2021. It is this period that we consider to be the most opportune for the creation of a free trade area between the European Union and Russia. By 2021-2025, the capacity of the domestic market in terms of per capita GDP (USD) will increase almost 1.8-fold from 2013. This means that European producers will be interested in keeping and strengthening their positions in the Russian market. Therefore, during this period the dissolution of trade barriers can be accompanied both by the growth of the Russian economy and European producers keeping their positions in this market.

Table 6 – Market share of imports (%, 2013 prices).

	2012	2015	2018	2019	2020	2021	2025	2030
Agriculture and forestry, hunting and fishing	4,8	4,8	4,8	4,9	4,9	4,9	4,9	4,8
Mining operations	6,1	6,6	6,7	6,7	6,7	6,7	6,4	6,0
High-tech secondary industries	50,2	49,5	49,1	48,9	48,7	48,7	48,3	47,6
High-level medium-tech secondary industries	34,6	34,3	33,9	33,8	33,6	33,5	32,6	31,7
Low-level medium-tech secondary industries	22,4	23,4	24,2	24,5	24,7	24,7	24,4	24,6
Low-tech secondary industries	29,1	29,6	29,8	29,8	29,6	29,3	28,1	27,0
Electrical energy, gas and water production and distribution	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,5
Construction	5,2	5,2	5,2	5,2	5,2	5,1	5,1	5,1
Wholesale and retail trade, repair works	3,5	3,5	3,5	3,5	3,4	3,4	3,2	3,1
Hotels and restaurants	1,4	1,4	1,4	1,4	1,3	1,3	1,2	1,2
Transportation and storage	7,8	7,7	7,7	7,7	7,6	7,6	7,2	6,9
Telecommunications	11,0	10,9	10,7	10,7	10,6	10,4	9,9	9,4
Other services	1,7	1,7	1,7	1,8	1,7	1,7	1,6	1,6
Total	13,4	13,9	14,0	14,1	13,9	13,8	13,7	13,6

Source: Institute of Economic Forecasting Russian Academy of Science

The calculations provided here show that within the framework of a moderately optimistic scenario of Russian economic development a realistic time frame for creating an EU-EAEU FTA should have a starting date after 2020. The most opportune is the period between 2021 and 2024 when Russian industries would be able to provide for an acceptable level of competitiveness on the domestic market ensuring the share of locally-produced goods on the domestic market. At the same time, the cheapening of investment imports coming from abolition of customs barriers would, with high probability, provide additional support to investment activities in the economy. On the other hand, the EU would get an opportunity to increase its exports due to the general growth of demand in the Russian economy.

Therefore, creation of an EU-EAEU FTA becomes possible immediately after the end of the transition period resulting from Russia's accession to the WTO. In the same period the other EAEU countries – Kazakhstan and Belarus – would also quite probably become WTO members. A gradual decrease in the level of customs protection between the EAEU and EU in the period up to 2020 would offer favorable conditions for creation of a free trade area.

Additional measures aimed at increasing FTA creation efficiency include the development of a unified energy policy guaranteeing the European partners priority access to energy resources in exchange for technologies, inclusion of Russia into added value procuring mechanisms and development of East-West and North-South transport and logistics corridors.

Hitherto, the creation of an FTA between the EU and EAEU was mostly an issue of a distant and highly unpredictable future. Moreover, any tensions rising from time to time over trade and political issues between the EU and Russia move this question down the list of priorities. However, we have a firm belief that this process is inevitable. Russia needs the EU as a sales market and as the most important, nearly non-competitive partner in technological development. Hence, the time has come to move this issue into the realm of practical calculations and negotiations, both on the level of the expert community and the governmental structures.

1. Effects of sanctions on the EU and Russian economies

Deterioration of political and economic relations between Russia and the EU and the introduction of mutual trade restrictions created additional difficulties for the relations between the countries in Eurasia. These restrictions are producing negative impact on economic development both in Russia and in the EU.

From the point of view of economic theory the sanctions are one of the elements of non-tariff barriers in trade. And their purpose is the achievement of definite political goals by economic means. It should be noted basic difference of the current sanctions from similar restrictions imposed in the past on the Soviet economy. Russia today is an important player in the open world economy, with a share of world GDP reaching nearly 3%.

For Russia the most important channels of influence on economic dynamics are: restrictions of funding on the EU and USA financial markets, restriction on dual-use goods trade, reduction in production cooperation, decrease of direct foreign investments from EU countries, growth of internal prices and embargo on access to high technologies in the energy sector.

So far sanctions have had no significant macroeconomic impact on the Russian economy, but they can become an important factor of economic dynamics in mid-term prospect.

The most significant effect in the short and mid-term is connected with restrictions on funding in the European market. It is estimated at US$ 150-200 bln. per year. Russian companies have to raise additional funds for debts repayment by their own sources which could reduce the level of investment activity. The potential decrease in foreign direct investment can be up to US$ 30 bln. per year. The maximum losses from the embargo in the trade of dual-use technologies and a rupture of cooperation are estimated at US$ 20-25 bln. Growth of production costs due to the food embargo and the increase of import prices is estimated at US$ 20 bln. And finally, in the long term (until 2030) the embargo on energy technologies can reduce potential oil production in Russia by 50-70 million tons, in comparison with the base scenario. Thus, the potential impact of sanctions on the Russian economy can be estimated at 8-10% of GDP.

We will consider the main areas in which sanctions have the most negative impact on the Russian economy. In our opinion the most essential risks in the short and medium-term are connected with restrictions on access to European financial markets for the Russian companies and banks.

During 2007-2013 the loans obtained by the Russian non-financial organizations in EU countries summed to more than 1 trillion US dollars. The annual amount of the credits amounted to 150-200 bln. dollars from the USA and EU countries and only during the crisis of 2009 decreased to 80 bln. dollars. Traditionally Russian companies have widely used mechanisms of refinancing for credit debt. It has allowed the reduction of peaks of payments on the corporate credits (for example, the amount of total payments of the Russian economy for an external debt in 2015 is estimated approximately in 125 bln. US dollars). Now such opportunities will be sharply limited. It means that the largest companies will be compelled to finance a debt by their own means, or to resort to opportunities of internal loan financing. Anyway it will have a negative impact both on investment of the largest companies and on distribution of financial resources in Russian economy. The largest holdings will be able to replace external financing with internal, however, for the enterprises of medium and small business availability of loan resources will decrease even more.

If we look at the structure of Russian corporate debt, one observes that the main Russian creditors are in Great Britain, Cyprus and the Netherlands. This allows us to suggest by analogy with direct foreign investments [1] that a considerable part of this debt is connected with re-export of the capital, and a number of the Russian companies hedge risks by means of such credits. Besides, there are possibilities of partial replacement of these credits at the expense of the means received from other directions, such as Asian markets. Nevertheless, the scale of the potential negative influence of this factor on the Russian economy is the most significant and can be estimated at the sum of 150-200 bln. US dollars.

By our estimates the decrease of direct foreign investment will have a significantly less important impact on the Russian economy due to size of their share in total investment so far and also because a considerable part is directly controlled by the Russian companies. However, if sanctions remain in the long-term this factor may become essential restriction for economic growth. In particular, it is necessary to consider that direct investments are often connected with development of hi-tech productions.

In the short and medium-term the important source of compensation for the disappearance of financial streams from the EU countries for Russia will be reserves which are at the disposal of all economic agents. These reserves are rather considerable. By our estimates, in October, 2014 they reached 1,6 trillion US dollars and 280 bln. dollars on deposits of the organizations, 450 bln. dollars accumulated due to export of the capital, 420 bln. dollars of gold and foreign exchange reserves (from which 173 bln. dollars represented means of sovereign funds) consisted of 445 bln. dollars of organized savings of the population. A parallel calculation of the difference between norm of accumulation and norm of saving in the Russian economy for 1998-2013 gives an assessment of reserves in 1,7 trillion US dollars. Certainly, regarding the means which are taken out from the country it is difficult to count high rates of their return to economy. At the same time we consider that total amounts of reserves quite enable the replacement of the disappearance of credits and direct investments from EU countries within 2-3 years. The preservation of rigid sanctions for a longer period will pose a key threat to macroeconomic stability in Russia.

The following important area of sanctions pressure upon the Russian economy is a decrease in the level of cooperation communications and a ban on access to dual-use technologies.

Russia depends on European imports for a wide range of goods, first of all from import of chemical, pharmaceutical products and machinery and equipment. So, European imports satisfy (in value terms) about 50% of the consumption of medicines and nearly 25% of consumption of chemical products.

However, the greatest impact of such sanctions will be had on development of the machine-building complex. Russian manufacturing depends in a critical degree on imports of various type of processing equipment and some other types of machine-building production. For example, approximately 95% of lathe machinery, drilling and pumping equipment is imported. So, in 2013 if to consider natural indicators, imports exceeded production for weaving looms, metal-cutting lathes (including machines with numerical program control) and pumping units for use in oil industry by a factor of about fifteen. Imports of ball and roller bearings in 2013 by exceeded their production by a factor of 1.3. Imports of all types of machinery and equipment from the EU satisfies 20% of internal Russian consumption. Thus the volume of production of mechanical engineering imported from the European countries in 2013 was equal 65 bln. US dollars, or 48% of all European imports into Russia.

For most types of machine-building equipment, the greatest share of imports in 2013 was provided by China. However, the share of machinery and equipment imported from the countries which imposed sanctions was also considerable.

In the cost structure of imports of all considered types of machine-building equipment the share of the countries which imposed sanctions on trade with Russia appears to be the greatest. It is an indirect sign that imports from the countries of the European Union, the USA and Japan are more technologically advanced than imports from China, and occupy the more 'hard-to-replace' niches in the domestic market of Russia.

The Russian economy possesses a high degree of dependence on hi-tech imports. In those sectors where key competencies were lost, competitiveness can only be maintained through these imports.

It is also necessary to consider that in the current conditions a significant amount of the Russian enterprises inputs are imported goods. A considerable part is from EU countries. Analysis made on the base of the cross-country input-output tables WIOD (World Input-Output Database [2]) shows that total losses from the termination of cooperation communications with EU countries can be estimated as much as possible at 15 bln. dollars a year, about 5 more bln. dollars of additional losses will occur from the embargo on deliveries of dual purpose goods. Thus, the maximum assessment of losses from the reduction of cooperation between Russia and the EU can be up to 20 bln. dollars a year. Certainly, Russia will pursue a policy of compensation of these losses due to extension of the program of import substitution; however its realization will demand considerable time. Respectively reduction technological cooperation will pose the greatest threat in the short and medium-term.

One of the key obstacles for the long-term development is the negative influence of sanctions on the energy sector. For oil and gas production in Russia the key threat is posed by the risks connected with the restriction of loan financing in the open market and different technological embargoes limiting possibilities of exploration and production of oil in remote regions (most importantly the Arctic shelf).

As it was already noted, cutting off the largest Russian companies from loan financing will lead to a number of negative consequences. First, there will be a movement of internal loan resources towards the largest companies to replace a lack of external financing. This may lead to the vanishing of credit resources from medium-sized businesses, including all types of economic activities closely related to the mining sector. Thus the the oil sector may have to increase investment using its own funds in direct support of production in shipbuilding, separate segments of mechanical engineering, and services. Second, difficulties obtaining loans in the open market will require a larger volume of resources to service debt that will also negatively be reflected in investment opportunities of Russian enterprises.

The most adverse sanctions scenarios will lead to emergence of particular cutoff levels for projects in oil production possessing the high level of capital intensity. This is especially true for the oil extraction in remote areas, such as the Arctic shelf, and the extraction on hard-recovered (difficult) oil fields. By our estimates such a succession of events can lead to an essential change in the total profile of oil production during the period up to 2030.

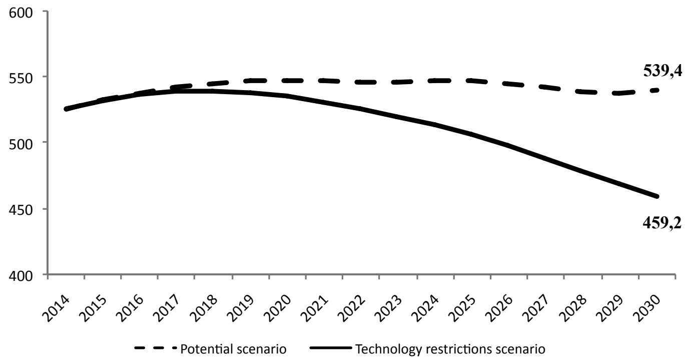

Figure 1 – Forecast of oil extraction in Russia.

In comparison with the potential scenario by 2030 the amount of oil extraction may fall by 15% (80 million tonnes within the considered scenario). An especially large gap in production volumes will be observed after 2025 when the output of old fields significantly decreases, and measures for production maintenance will no longer be able to compensate.

Thus, the greatest threat for the Russian economy in the short and mid-term are sanctions limiting access to financial markets and in the long-term technological restrictions in the energy sector. The total potential influence of sanctions on the Russian economy can be estimated at 8-10% of GDP. However in reality with compensating measures it may be significantly less. At the same time estimates of possible negative consequences of sanctions mean they are as macroeconomically significant.

For the EU in the short-term the most essential losses are connected with a food embargo (US$ 5-7 bln.), decrease of exports to Russia due to decrease in economic activity (US$ 5 bln.) and the fall of ruble exchange rate (US$ 22 bln.). In the mid-term the losses of percentage incomes from credits to the Russian companies (US$ 8-10 bln.), realization of import substitution policy in Russia (US$ 40 bln.), increase of the energy prices on the base of reduced oil supply from Russia (US$ 3 bln.) need to be considered. Thus losses of the EU from deterioration of the relations with Russia can be estimated approximately at 0,75% of the volume of EU GDP.

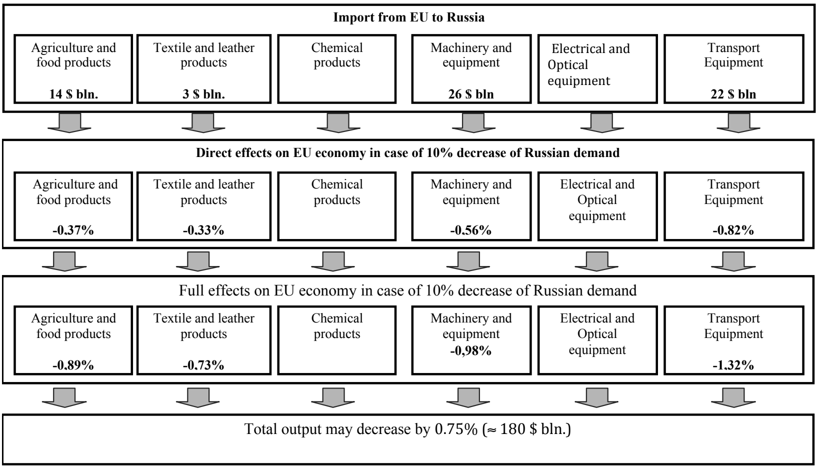

Figure 2

A decrease in the growth rates of the economy of the Russian Federation owing to the imposed sanctions in itself, besides any countermeasures, bears negative consequences for the countries of the European Union. This is because recession in Russia also implies a reduction of internal consumption especially of imported goods. In turn, this implies a reduction of opportunities for export of production of European producers and loss of part of their foreign market. Until recently the Russian Federation imported 14 billion US dollars of production of agriculture and food from the countries of the European ; almost 3 billion dollars from the textile, clothing and tanning; 26 billion dollars of chemicals; ; 64 billion dollars of machine-building, of which 26 billion dollars was for of cars and equipment; 16 billion dollars from electronic, optical and electric equipment; and 22 billion dollars from vehicles and equipment.

Reduction of demand of the Russian economy for production of the European producers by 10 percent will mean potential reduction of outputs owing to loss of a sales market for 0,4% in agriculture and the food industry, 0,3% in light industry, 0,26% in chemical industry. For 0,56% volumes of gross release in production of cars and the equipment, will be reduced by 0,3% in production of electric equipment and for 0,8% in production of vehicles and the equipment.

Nevertheless, the above-mentioned numbers are only the direct effects, which don't include interactions between sectors. Actually a decline in output in any economic activity negatively affects all other sectors of the economy. First of all, reduction of output means also reduction of production expenses, which causes a decrease in intermediate demand for production of other sectors and further reduction of outputs. Next, the fall in production means reduction of wages, profits and tax payments that negatively influences consumption of households, capital investments of business and the public expenditures, that is leads to reduction of final demand – and by that, also to further reduction of gross output.

For an assessment of the full chain of interactions it is possible to use the static model of input-output tables based on the data for the European Union published within the WIOD project. The full effects for the economy of the European Union using on this model is a decrease in production by 0,9% in agriculture and production of foodstuff and drinks, for 0,7% in textile, sewing and tanning production. A similar of decrease in outputs of 0,7% is observed in the chemical industry. Gross output in the production of cars and transport equipment will decrease by 1,32%, production of electric equipment will decrease by 0,65%.

The potential decrease in output in general for the economy of the European Union will be about 0,75% or about 180 billion US dollars.

2. Conclusions

- The low level of economic competitiveness in EAEU countries in comparison to their European counterparts would result in a dramatic increase of imports from EU in the case of a single-step abolition of all import duties.
- The calculations provided here show that within the framework of a moderately optimistic scenario of Russian economic development a realistic timeframe for creating an EU-EAEU FTA should have a starting date after 2020.
- The most negative effects are expected with the continuation of sanctions in the long-term.
- The largest effects from the sanctions are not only the direct, but also the indirect impacts on the economy. The full effects from the imposed sanctions are macroeconomically significant both for Russia and the EU. The potential of negative influences of sanctions on the Russian economy is estimated at 8-10% of GDP, for the economy of the EU countries about 0,5% of GDP.

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ENERGY AND ENVIRONMENT

THE IMPACT OF POSSIBLE SHALE GAS EXTRACTION ON THE POLISH ECONOMY

Mariusz Plich[a]

1. Introduction

The International Energy Information has called 21st century the age of gas (IEA 2011, 2012). This follows the report by U.S. Energy Information Agency (EIA 2011), presenting results of estimates of shale gas resources all over the world. The existence of natural gas in shale deposits is known since the 19th century. However, appropriate technologies enabling the cost-effective production on a commercial scale have been developed only in recent years. Nowadays, downstream companies in many countries all over the world, that were mentioned in the EIA report as rich in shale gas, are exploring shale deposits. The possibility of increasing the domestic supply of gas in those countries has awakened the hope to increase energy security and improve their. Poland belongs to this group of countries.

In this article we try to explore what the possible shale gas extraction in Poland means for the Polish economy[1], precisely: what can be a scale of indigenous extraction of shale gas in Poland and its role in shaping the Polish energy mix as well as how shale gas can affect the Polish energy security and structure of economy. To answer these questions we use an Inforum type model of the Polish economy – IMPEC, which has to be adjusted to include shale gas industry together with some scenarios of its development. In particular, there are several methodological and empirical questions to answer:

- How to reveal the gas industry in the input-output (IO) matrix?
- How to implement a new technology of gas production in the model?
- How will the unit cost of gas production change in the context of new technologies?
- What could be the shape of learning curve in Poland?
- What might be the volumes of gas extraction?

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[1] This task is included as a part of the project titled The prospect of exploitation of shale gas deposits in Poland in light of the 'resource curse' concept. The project is funded by the National Science Center (grant no. 2011/01/B/HS4/04800) and carried out at the Institute of Econometrics in collaboration with the Chair of International Trade of the University of Lodz.

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In the rest of the paper we proceed as follows. In section 1 problems of Polish energy mix and energy security are presented. Section 2 is devoted to the methodological framework, including model construction issues and necessary adjustments. In Section 3, scenarios of feasible shale gas production are discussed. Section 4 presents results of simulations. Section 5 concludes.

2. Shale gas and energy security in Poland

2.1 Factors of energy demand in the Polish economy

External factors

Over the past 20 years there has been a development of technology for extracting gas from unconventional sources. Mastering the technology of horizontal drilling and hydraulic fracturing (see for example Ricardo-AEA 2014, Plich 2013) has opened up the possibility of extracting gas trapped in layers of shale at a depth of 2 to 4 km below the surface. Technology is constantly improving, with longer horizontal laterals, more fracturing (frac) stages per well, more sophisticated mixtures of proppants and other additives in the frack fluid injected into the wells, and higher-volume frack treatments. In addition, multi-well pad drilling reduces well costs. Better technology is having an effect, along with a better understanding of the reservoir and the location of sweet spots (Hughes 2014: 265).

Since 2005, there has been a very rapid increase in shale gas production in the US – in 2014 it was almost 12 times higher, which gives an average over 31% growth rate per year[2]. The US has increased gas production again after a decline since the mid-70s of the 20th century. The maximum gas production achieved in 1973 was exceeded only in 2010, while the share of shale gas reached almost 40% of total production in 2013. Nowadays, gas is very cheap in the US (see Figure 1) and high gas prices on world markets has led US producers to increasingly apply for permissions to US authorities to export LNG. In turn this causes reductions in world's prices of LNG and a noticeable tendency to reduce the differences in prices of natural gas and LNG. Countries dependent on imports of gas more and more frequently pursue a policy of diversification of supply and LNG as an alternative to pipeline transport supply. As a result, there has been a tendency to disconnect the gas prices from oil prices (see Figure 1). This is a new phenomenon. So far, in long-term contracts for the supply of gas by pipelines, prices of gas were associated to oil prices on world markets. This new tendency means that gas market becomes independent of the oil market.

Another phenomenon that has affected the functioning of the gas market has been the reduction of unit costs of production and regasification

[2] Calculations are based on EIA data published at www.eia.gov.

of LNG, which has resulted in a reduction in prices and an increase in turnover, visible since 2000.

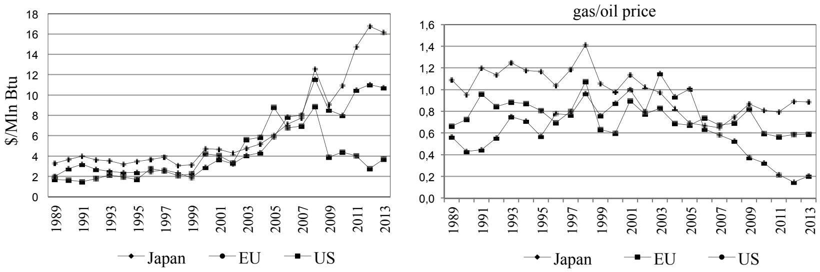


Figure 1 – Prices of gas on different markets. *Source: BP (2014)*

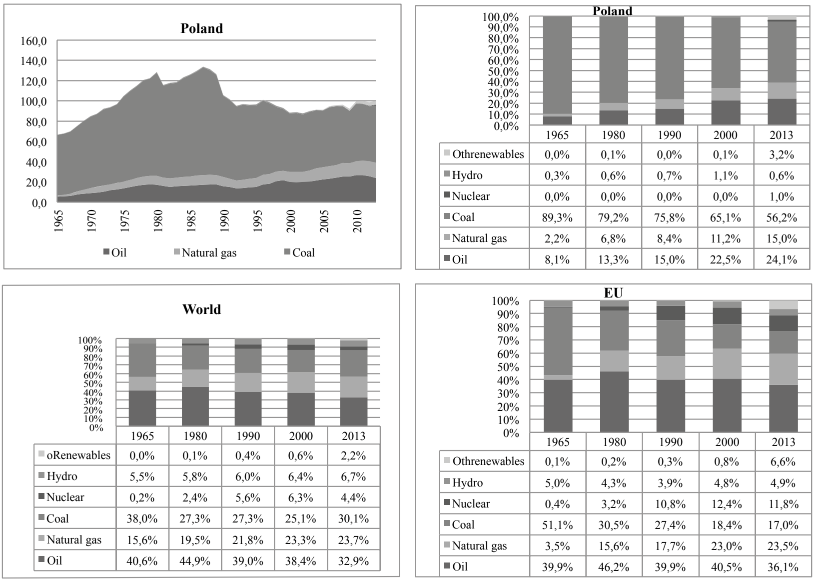
The success of shale gas extraction sector in the US has encouraged EIA to develop and publish a report on natural reserves of shale gas all over the world (EIA 2011). According to the estimates presented in the report, resources of technically recoverable shale gas amount to 208 tcm which is around 50% of conventional gas resources. However, this does not mean that gas deposits hidden in shale, which are fairly evenly distributed across all continents, could be extracted straight away present. Each bed has specific properties that make production on an industrial scale possible only after a number of test drillings. This applies not only to the depth wells of vertical and the length of horizontal drillings, but also the methods of hydraulic fracturing, including the selection of the fracturing fluid components. Each of these elements is a separate factor increasing the uncertainty of achieving cost-effective extraction. A kind of counterweight for these uncertainties is the successful gas extraction in the US and the volume of deposits and their distribution in the world. That is why a significant number of countries see a real possibility to increase their energy security or even to make a profit by exploiting their shale gas deposits.

Internal factors

Poland is in the group of countries indicated in the EIA report as rich in shale gas. According to the report 2.8% of the global shale gas resources are located in Poland. Although the estimates made a year later by the Polish Institute of Geology turned out to be from 5 to 10 times smaller, Poland next to Great Britain is a European leader in the search for shale gas. There are three important reasons for this:

- the high dependence of the Polish economy on coal and lignite;
- Polish obligations as a member of the EU to reduce greenhouse gas emissions;
- relatively small domestic production in relation to the demand for gas in Poland.

All of these reasons are directly or indirectly related to the specific nature of the Polish energy mix dominated by coal (see Boratyński 2015b). In this respect, Poland differs significantly from the EU's and the world economy (see Figure 2). Since the 1950s many economies recognized the advantages of natural gas as an energy source or switched to nuclear energy. The large coal resources in Poland and the strength of the coal lobby slowed down the process of displacement of coal from the energy mix. It is worth recalling that in the 1980s large nuclear power plant project was discontinued, despite a significant level of construction[3].



Poland

	1965	1980	1990	2000	2013
Othrenewables	0,0%	0,1%	0,0%	0,1%	3,2%
Hydro	0,3%	0,6%	0,7%	1,1%	0,6%
Nuclear	0,0%	0,0%	0,0%	0,0%	1,0%
Coal	89,3%	79,2%	75,8%	65,1%	56,2%
Natural gas	2,2%	6,8%	8,4%	11,2%	15,0%
Oil	8,1%	13,3%	15,0%	22,5%	24,1%

World

	1965	1980	1990	2000	2013
oRenewables	0,0%	0,1%	0,4%	0,6%	2,2%
Hydro	5,5%	5,8%	6,0%	6,4%	6,7%
Nuclear	0,2%	2,4%	5,6%	6,3%	4,4%
Coal	38,0%	27,3%	27,3%	25,1%	30,1%
Natural gas	15,6%	19,5%	21,8%	23,3%	23,7%
Oil	40,6%	44,9%	39,0%	38,4%	32,9%

EU

	1965	1980	1990	2000	2013
Othrenewables	0,1%	0,2%	0,3%	0,8%	6,6%
Hydro	5,0%	4,3%	3,9%	4,8%	4,9%
Nuclear	0,4%	3,2%	10,8%	12,4%	11,8%
Coal	51,1%	30,5%	27,4%	18,4%	17,0%
Natural gas	3,5%	15,6%	17,7%	23,0%	23,5%
Oil	39,9%	46,2%	39,9%	40,5%	36,1%

Figure 2 – Polish, EU's and global energy mix. *Source: the author's own elaboration based on BP 2014*

Poland has the resources of natural gas in conventional reservoirs which are used economically. According to the newest estimates in the BP Report (BP 2014) these resources amounted to 115 bcm in 2013, which would suffice for almost 30 years given stable, production levels, as observed in recent years (around 4 bcm – see Figure 3). On the other hand, the demand for natural gas in Poland is constantly growing, which results in an increase in the import dependence of gas. While in the beginning of the political transformation in the 1990s, imports satisfied about 40% of domestic demand, the ratio increased to 75% in 2013.

[3] This is the Żarnowiec nuclear power plant, built in 1982-1990.

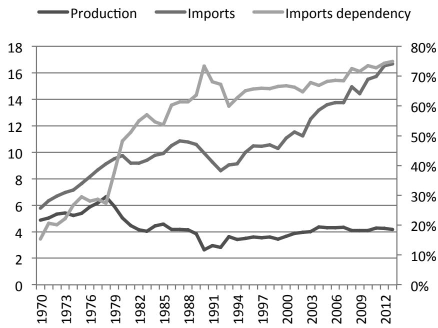


Figure 3 – Supply, demand (left scale) imports dependency (right scale) in Poland. *Source: BP 2014 and the author's own calculations*

The increasing import dependence on gas means a decreasing level of energy security. Another factor causing the decrease in Poland is a small degree of diversification of imports. In 2013, nearly 85% of imported gas was supplied by pipeline from Russia. Other EU countries diversify their supply by importing natural gas by pipelines from Norway, the Netherlands and other directions or importing LNG, mainly from outside of Europe (BP 2014). So far, Poland has not had the infrastructure for regasification to import LNG from Norway, Qatar or Algeria. Currently, construction of a large gas terminal in Świnoujście is under its final phase before launching. Its launch was originally scheduled for 2013, but has been delayed. The LNG terminal will initially import 5 bcm of gas per year, and after the expansion – 7 bcm. This is almost 50% of the annual Polish economy's demand for natural gas in recent years. Startup of shale gas production would additionally contribute to a significant increase in Polish energy security in terms of natural gas. This raises the question of the possible scale of extraction. It depends on a lot of factors, but the size of deposits seem to be the major one.

2.2 Estimates of shale gas deposits in Poland

The history of the last few decades shows that the discovery of energy resources may become an impulse for the development and structural adjustment of economies and changes in their structure. Estimates of gas in the shale layers made by the EIA are very optimistic for the Polish economy, so the questions mentioned in the introduction are justified. In this context, it is worth looking at the economic history of some European countries which faced a similar challenge in the past, in particular the Netherlands and Norway. In these countries, the deposits of natural gas were discovered in the late 1950's (Netherlands) and 1960's

(Norway), and gas exploitation turned out to be an important stimulus for their economies over the following decades. A significant part of the domestic demand for primary energy, mainly production of electricity and heating, has been directed to natural gas, and additionally, the Netherlands is a big exporter of gas to EU countries. In turn, Norway absorbs only a small portion of indigenous gas production, allocating the vast majority to exports.

Estimates by EIA suggested that Poland might be richest European country in terms of natural gas (see Figure 4). Polish resources would be 2.5 times higher than the existing proven reserves of Norway's and 3.5 times higher in comparison with the Netherlands. Both of these countries, i.e. Norway and the Netherlands are currently the largest gas producers in Europe. Recall that currently 75% of the supply of gas in Poland is imported. This raises a question of whether Poland could increase gas production not only to meet its domestic demand, but, like the Netherlands and Norway, through export of large quantities of this raw material could become an important contributor to the EU's energy security?

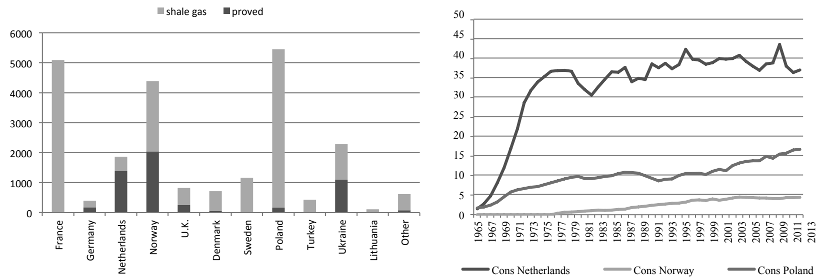


Figure 4 – Resources and consumption (cons) of gas in selected European countries.
Source: the author's own elaboration based on EIA 2011, BP 2014

In recent years Norway has been exporting about 105 bcm of gas per year, while domestic consumption is relatively small – less than 5 bcm – which is approximately equal to the production of natural gas in Poland. The small consumption of natural gas in Norway is due to the fact that the most important component of the energy mix of Norway is the hydroelectric power, which meets about 65% of demand for primary energy.

The Netherlands brings nearly 70 bcm of gas annually, but domestic consumption accounts for more than half of his amount. As a result of the discovery and then the exploitation of gas in the Netherlands in the 1960s of the last century, gas has become an important component of the country's exports, as well as its energy mix. The dynamic growth of gas consumption in the period 1965-1980 (see Figure 4) has meant that until now, its consumption has met almost 40% of the country's demand for primary factors of production (BP 2014).

The examples of Norway and the Netherlands show that if the EIA estimates are confirmed, it is likely that also the Poland could become a significant producer of natural gas in Europe. At this stage, such considerations are purely theoretical or even bordering on fiction. There are several important reasons. First, estimates of the Polish Geological Institute (PGI) report indicate that shale gas resources in Poland may be 5-10 times smaller than suggested in the EIA report (PGI 2012). Second, studies to assess the quality and longevity of the resources require huge investment and are subject to very high risk. Third, the uncertainty as to the applicability of technologies known from the US in Polish conditions (for more information about this and other uncertainties see section 4).

In Poland, despite the above uncertainties, the topic of shale gas has generated hopes for gas sufficiency and a significant increase in energy security by reduction of gas imports from Russia. Recently a new Act on special hydrocarbon tax has been adopted (see Neneman, Kronenberg 2014), proposing investors quite attractive licensing and tax solutions, both on exploration and exploitation phases. There is also much discussion about shale gas as a chance for Polish economy (see Boratyński 2015a). Attention is also drawn (though relatively rarely) on the environmental and social risks associated with the operation of shale (Kronenberg 2014a, 2014b; Stankiewicz, Lis 2015).

3 Method

3.1 Notes on methods used in other studies

Although the economic development of shale gas has a relatively short history, the literature is quite rich. For several years, attempts to assess the impact of shale gas on the economy have been taken with increasing intensity. Initially, they concerned mainly the US, where extraction methods have been developed and extraction on an industrial scale started the earliest. Nowadays one can find more and more publications on other countries, but only those on North America (mainly for the US), are based on empirical data. The other are *ex ante* analysis. That is clear, because only in US a commercial extraction of shale gas has occurred for more than 10 years. The *ex ante* analyses usually refer directly to the North American experience, or are based on assumptions, prepared with the use of North American data. Our research falls within this type.

Lately, systematization of research on the impact of shale gas on the economy has been presented by Boratyński (2015a). He noted that studies on this topic are diverse both in terms of the issues considered and research tools used. The issues concern the effects of linkages of the gas extraction industry with other industries, changes of relative costs and prices, the impact on well-being and development and sustainability indicators.

In the case of partial analyses, the most commonly used approach has been input-output models, while a more comprehensive analysis used approaches based on a suitable extension of input-output models, mainly computable general equilibrium (CGE) or integrated models (also called multi-sectoral macroeconomic models or econometric input-output models). In many cases, an important component of the development of input-output models was the detailed presentation of energy markets, using data from energy balances, which leads to 'hybrid models' in terms of ways of measuring variables (monetary and quantitative approach). Boratyński concludes that interindustry macromodels are in the group of the most successful models in this field.

New publications addressing directly or indirectly the issues of modeling of shale gas impact on economies have appeared recently. In March 2014 a report was published on the effects of mining in the EU. In turn, the book edited by Hefley & Wang (2015) is mainly based on experience with the operation of a number of specific deposits of shale gas in several states of the US, but it concerns a wide range of issues – from economic, regulatory, environmental to socio-demographic. There are more and more studies on countries that are listed in the EIA report as rich in shale gas. This applies not only to those countries that are interested in the production of natural gas from shale, such as South Africa (Wait, Rossouw 2014), the Netherlands (Slingerland, others 2014), Great Britain (Ricardo-AEA 2014; Poyry 2013), but also to those that have declared moratoria to make hydraulic fracturing (which in practice excludes mining of shale gas), such as Bulgaria (KC2 2014) and France (Saussay 2014). These studies demonstrate a growing interest in shale gas all over the world. More and more often uncertainties associated with the extraction have been exposed, and its cost-effectiveness has been questioned (eg. Saussay 2014). However, the studies do not constitute a breakthrough as to the methods of conducting of analyses, and in some cases the methods which were used to carry out the studies are not explained at all.

Based on the literature review Plich (2013) discusses issues which should be taken into account while modeling and preparing scenarios for simulation of shale gas impact on the Polish economy. The conclusions of this discussion are summarized in Table 1.

It must be noted, that from this list, only the items marked in bold were taken into account in the approach presented in this study (see section 3). They were chosen as the crucial elements of the supply side because they affect directly the possible quantities of extraction (investments in drilling), directions for the use of gas (import substitution of indigenous production) and costs of production. Moreover, their inclusion requires special treatment in the model. This is why the model has undergone necessary modifications from its standard specification to take into account the factors set out in the table 1, to enable answering questions posed in this study.

Table 1 – Issues of model building and construction of scenarios for simulation of shale gas impact.

Supply side	Demand side
Investments in • **drilling (depending on life cycle of wells)** • gas storage (proportional to demand) • installations for NG liquefaction (to satisfy possible demand for LNG) • transmission network	Investments in • modernization of existing power plants and CHP to replace coal with natural gas • construction of gas power plants and CHP • distribution network (depends on location of final customers
Decline in imports of gas	Exports of NG or LNG
Unit costs of production of shale gas sector (assumed learning curve)	Energy efficiency of new and modernized power plants and CHP
Financing of investments • public-private • domestic-foreign • crowding out	
Royalties and taxation	
Prices of primary fuels on world markets	

Source: Based on Plich 2013

3.2 Modeling framework

The core IMPEC model

For now, studies on the impacts of shale gas which have been carried out for the Polish economy did not use an input-output model, nor its extensions (see Boratyński 2015a). In this study, analyses will be conducted using the IMPEC model - a macroeconomic multisectoral model of the Polish economy (see Plich 2009). Its main features are:

- use of the Inforum approach to the modeling of the economy (Almon 1991) which means that the model combines input-output with econometric equations;
- the economy is disaggregated into 54 sectors (products);
- a hybrid approach to defining variables, which means that national accounts data are expressed in monetary units and energy data with in natural units;
- the energy model distinguishes 14 energy sources (primary and secondary).

The model includes Leontief's output multipliers. Parameters of the model, representing unit energy consumption have been endogenized - their values result from the assumed energy intensity trends or changes in relative prices of different types of energy. Results presented in this paper are based on the simplified version of the IMPEC model. The main simplification is that final demand is exogenized, which means that the model does not generate final demand components from equations, as it is usually done, but paths of their development are assumed up to 2050. The current version of the model does not include benefits from reducing energy intensity, like energy price decline, multiplier effects associated with consumption, investments and GDP. Imports in sectors of the economy adjust to the volume of production, with the exception of gas mining sector, which will be described in detail below.

In the case of gas, the model allows consideration of the situation in which shale gas is not extracted in Poland (reference scenario) and alternative scenarios which assume different levels of production. The increase in domestic production of gas and the resulting reduction of imports in the model produce additional multiplier effects in the sphere of production. Due to the reduction in imports the rate of Polish energy security measured by share of domestic production in the total gas demand improves.

Revealing 'gas mining' and 'distribution of gas' sectors in IMPEC

The core model is constructed with use of 2005 IO table for Poland. The table uses the Polish Classification of Goods and Services, which corresponds to the EU Classification of Products by Activities (CPA 2002)[4]. In the table, 54 sectors of the economy are distinguished. They are mainly 2-digit sectors (divisions) of the classification, but in some cases divisions are clustered due to statistical confidentiality.

This concerns also the sector of interest, i.e. *mining of oil and gas*[5], which is division 11 (see Table 2). In the 54-sector classification, it is a part of a cluster which consists of divisions 11-14. Although uranium and thorium ores (section 12) are not mined in Poland, production of the other sections in the cluster – beyond oil and gas – is relatively high, particularly of copper ores (section 13) and minerals for the chemical industry and construction (section 14). This is an important argument for the exclusion of oil and gas from the cluster.

Table 2 – National accounts data for IMPEC.

Section C: mining and quarrying	Section E: electrecity, gas, water
Divisions	Divisions
• 10 coal	• 40 electricity, gas, steam and hot water
• **11 oil and gas**	• **40.2 Manufacture of gas, distribution of gaseous fuels through mains**
• 12 uranium and thorium ores	• …
• 13 metal ores	
• 14 other mining and quarrying	

Source: own elaboration

[4] In the end of July 2014 a new io table for Poland were released. It uses a new product classification (CPA 2008). The use of new classification cause that the table is not consistent with IMPEC databank. This causes difficulties in the matrix use for modeling.

[5] There is insufficient data to separate oil form gas production, but it doesn't seem to be a problem since extraction technologies of these minerals are very similar and gas production in Poland forms a clear majority (around 65%) in the sector.

The other sector of interest is *manufacture of gas, distribution of gaseous fuels through mains*. In CPA 2002 it is a 3-digit sector (group 40.2), being a part of division 40 – *electricity, gas, water.* To enable more precise simulations concerning the impact of shale gas on the economy, we decided to reveal division 11 as well as group 40.2 as separate sectors (named here *gas mining* and *gas distribution*, adequately/accordingly). It required making estimations of input and output table structures for the two new sectors. As the result, two additional rows and columns were added to the original 54-sector Polish IO table.

To perform this task, the following additional information was used[6]:

- natural gas supply in quantity units (domestic production and imports);
- natural gas use by final users (sectors) in quantity units;
- prices of natural gas;
- the newest supply and use table for the year 2008 which distinguishes 84 products and 83 activities;
- experts' estimates of cost structure in the two sectors.

Of course it would be better to reveal the gas sector as such, but there is insufficient data to separate oil from gas production. However, this doesn't seem to be problem since extraction technologies of these minerals are very similar and gas production in Poland form a clear majority (around 65%) in the sector. So we can roughly conclude that the characteristics of conventional gas extraction sector in Poland are sufficiently well approximated by the input-output coefficients for the oil and gas sector.

Absorption mechanisms of increased gas supply

Technical possibilities of extraction are not the only condition necessary to start the exploitation of shale gas resources. The others are sales opportunities (existence of demand for the supply) and profitability of production at given prices.

It seems that in the case of gas-importing countries, like Poland, the problem of sales opportunities does not exist, because the emergence of a new source of domestic supply should lead to an imports reduction policy. A limitation to the policy can be long-term gas supply contracts. In trhe case of Poland this concerns contracts with Russia on piped gas, and with Qatar on LNG supply. Nevertheless, in our opinion, crowding out of imports would be the main mechanism of absorption of increase in indigenous gas supply, at least in the beginning years of commercial shale exploitation.

Further improvements of extraction techniques can lead to a reduction in the unit cost of production and, consequently, to lower gas prices. Falling prices will contribute to increases in domestic demand by the substitution (referring to coal, electricity and refined petroleum products) and rebound

6 The procedure of revealing of the two sectors is will be subject of separate paper.

effects. However, the increase of domestic gas demand may be not very high, because of relatively low elasticities of substitution of different types of energy, at least in the short run. Gas infrastructure development is a prerequisite of a demand increase, but this requires investments in a network of pipelines (transportation infrastructure), gas turbines, gas-fired boilers, etc.

In addition to the increase in domestic demand, an increase of foreign demand is also possible. It depends on price competitiveness and transportation infrastructure (again). However, it seems that the increased gas supply will primarily lead to imports reduction, and to increase energy security of the country.

In the model energy use is represented by four sectors: *coal*, *refinery products*, *power and heat*, *gas distribution*. The unit use of energy, represented by rows of IO coefficients, depend on gas prices relative to other energy sources. Falling prices of gas result in decrease of IO coefficients of *coal*, *refinery products* and *power and heat* in all sectors of economy. This concerns also the shares of household expenditures. The decrease is compensated by the increase of coefficients in the *gas distribution* row, so that the sum of the coefficients in the columns remain unchanged. As a result, gas demand increases, and the demand for other energy sources decreases so, that the total energy demand does not change. Shale gas extraction is introduced into the model exogenously and crowds out gas imports.

4. Example scenarios of shale gas production in Poland

Analysis of the literature on the economic effects of the exploitation of shale gas resources has allowed for identification of the issues that should be considered while model building and constructing scenarios (see Table 1). They are classified as purely supply or demand. In this study, attention is focused on key issues of the supply side only. Particularly, two issues related to extraction possibilities are taken into account, namely investments in drilling as well as unit costs of production[7]. In this section we will consider the issues more closely and define parameters and example scenarios of gas extraction in Poland.

4.1 Scenarios of shale gas production volumes to 2050

Parameters

To assess the potential impact of shale gas on the economy, first some projections of feasible production scenarios must be assumed. To do this,

[7] Recall that in the model another issue from the supply side of Table 1 – decline in imports – is taken into account indirectly, because the increase in indigenous gas supply crowds out gas imports.

several basic technical parameters of gas deposits concerning average well and potential of gas plays must be known. The parameters might be estimated based on exploration drillings in areas of potential deposits, which is a time consuming process. For instance, it took five years since the start of exploration in the US Marcellus deposit until the start of commercial production. This type of delay should also be introduced in the scenarios.

Exploration drillings are very risky for investors, especially in case of shale gas deposits, which parameters can be extremely diversified even in the same areas. The greater the number of exploratory drillings, the quicker recognition of the area properties, but on the other hand, the higher the investors losses, if conjectures about possibilities of commercial exploitation of a bed are not proved. However, in case the drillings are successful, they are transformed into operational ones and contribute to a faster start of operation and higher profits.

From a technical point of view, the size of shale gas production from a single well in a given period, is characterized by two parameters (Hughes 2014: 162, also Saussay 2014):

- well quality, measured by production in initial period; (initial productivity);
- rate of well production decline, measured by reduction of productivity after one or more periods, as a percentage of initial productivity (decline rate).

This enables estimation of the production potential of the well in the early stages of production, and in some cases even before the commencement of mining. Experiences concerning the first wells in a play help to estimate the potential future production volumes of the play, based on averaged parameters of first wells and with use of additional characteristics (Hughes 2014: 162):

- rate of field production decline, which is the amount of production that must be replaced each year with more drilling in order to maintain production at current levels;
- number of potential wells in a play which limits number of wells to be drilled in the play;
- rate of drilling, which is determined by the level of capital investment.

It should be noted, however, that the parameters for the different plays and even for the different wells in the same play can be very different and cause inaccurate estimates. Other reasons for inaccurate estimates might be uncertainties of parameters estimated in learning phase of industry and shale plays. In the learning phases, the parameters usually improve in time, due to improvements in technologies of extraction and fracturing (learning of industry) and due to better and better knowledge of explored fields' geology (learning of a play) – see EIA 2014.

In Poland the exploration phase is still in the very beginning stage. According to the Polish Ministry of the Environment as of the beginning of

December 2014[8], in the last four years only 67 wells were drilled in Poland of which in 16 cases horizontal drillings were performed. Hydraulic fracturing was performed in 25 wells, but so far only two companies carrying out explorations (San Leon Energy and BNP Petroleum) reported the results as promising. So far there is no real data for Poland and the situation in other countries excluding North America is very similar – there are no reliable estimates of the parameters of shale gas extraction. This is why in scenarios of shale gas extraction development prepared for reports all over the world for countries from outside North America, parameters based on the American data are used, despite the fact that they have a very high variability as mentioned above.

Scenarios

Some scenarios of shale gas extraction in Poland have already been presented in the report by CASE-Orlen (2012). They have been prepared by scaling US data and recognising that the situation in Poland may differ in key respects. Here we follow the CASE-Orlen scenarios. However, we use a different methodology for the assessment of the results. The CASE-Orlen report uses a macroeconomic model, while we use a model integrating the econometric approach with the methodology of multisectoral analyzes, based on a specially disaggregated, detailed IO table. The other difference is a longer time horizon reaching 2050 compared with 2035 in CASE-Orlen scenarios.

The initial productivity of an average well in Poland is assumed to be 50-60% lower than in the US, i.e. 12 and 15 mcm per year for exploration and operational wells (accordingly). Figure 5 shows the decline rate assumed in the scenarios. The increase in the fourth year seen in the figure, results from additional fracturing after three years of well operation.

It is worth noting here that all the parameters which could have been valid three years ago, now can be out of date in the light of the newest estimates based on US data. Hughes (2014) uses data up to the middle of 2014 for 7 shale gas plays which collectively account for 88% of current shale gas production. The 3-years average well decline rates ranges between 74% and 82% which is significantly more compared with CASE-Orlen assumptions (see Figure 5). Moreover, Hughes (2014) claims that in a long-term forecasts should take into account the steep decline rates and declining well quality as drilling moves from sweet spots to poorer quality rock. Nonetheless, in order to make benchmarking of our study to the CASE-Orlen report – so far the only study on impact of shale gas on the Polish economy – we keep the assumptions unchanged.

[8] http://lupki.mos.gov.pl/gaz-z-lupkow/stan-prac-w-polsce.

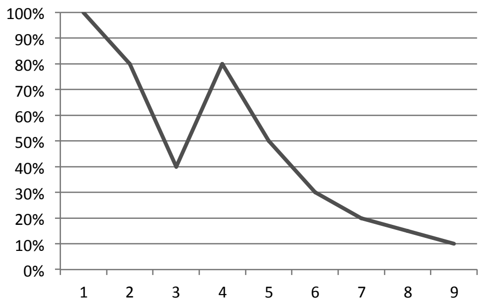


Figure 5 – Distribution of decline rates the 3 scenarios. *Source: the author's own elaboration based on CASE-Orlen report (CASE 2012)*

Following the assumptions made by CASE-Orlen, we use 3 scenarios of shale gas extraction: moderate, significant and huge. They differ from each other in terms of the size of investment in drillings, resulting in different number of operational wells and thus volume of gas production.

Table 3 shows distribution of the number of exploration (E) and operational (O) wells, in various scenarios. In order to maintain comparability with the results of CASE-Orlen and due to the fact that the horizon of simulation in it was 2025, it was assumed that in 2025 the number of wells reaches a maximum, and does not change until 2050.

The assumed number of wells, along with assumptions about the initial productivity and decline rates distribution, enable determination of the volumes of gas extraction for different drilling cohorts, for each year. The left part of Figure 6 shows the moderate variant of gas extraction, disaggregated to the layers representing extraction from subsequent cohorts of wells. The aggregation of extraction of subsequent cohorts for a specific year gives the level of shale gas production in the country in a given year. The right part of Figure 6 presents the total of shale gas extraction for each of the three variants:

1. Moderate (3.5 bcm);
2. Significant (6 bcm);
3. Huge (19 bcm).

In the parentheses the maximum volume of yearly shale gas production is presented. The fourth scenario used in the analyses is a reference (or base) scenario which assumes that there is no shale gas extraction in Poland.

The CASE-Orlen scenarios differ significantly from the EIA scenarios for Poland (IEA 2012) reported by Plich (2013). In the case of optimistic scenario (*Golden Rules Scenario*) unconventional gas production (mainly shale gas) in Poland reaches 30 bcm, ie. almost 60% more than in the Huge scenario in this study.

Table 3 – Distribution of number of wells in the 3 scenarios.

Year	Scenarios (number of wells per year)					
	Moderate		Significant		Huge	
	E	O	E	O	E	O
2015	5	0	5	0	5	0
2016	15	0	15	0	15	0
2017	20	10	20	10	20	10
2018	25	20	25	20	25	20
2019	25	30	25	30	25	30
2020	25	40	25	70	25	70
2021	25	40	25	80	25	80
2022	20	40	25	80	25	130
2023	20	40	25	80	25	180
2024	20	40	25	80	25	230
2025	20	40	25	80	25	280
…	…	…	…	…	…	…
2050	20	40	25	80	25	280

Source: own elaboration based on CASE-Orlen report (CASE 2012)

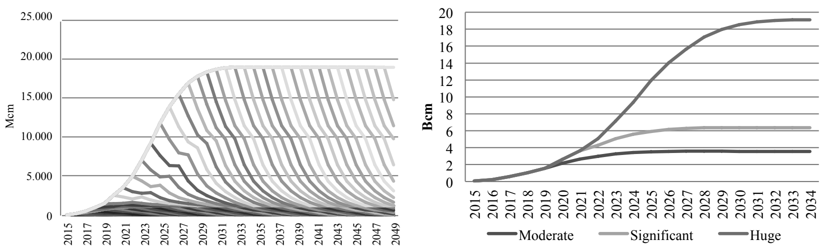


Figure 6 – Scenarios of shale gas extraction in Poland. *Source: the author's own elaboration based on CASE-Orlen report (CASE 2012)*

Considering scenarios of the number of wells needed to reach the assumed volume of gas, a question of investment outlays to implement these plans must be raised. The outlays can be estimated based on information about drilling and completion cost per well. In view of the distant horizon of the scenarios, one should also consider other investment costs incurred in subsequent years, for example relating to additional fracturing or liquidation of the mine after the end of production. The estimates are uncertain because of a wide variation for drilling costs which is dependent on such factors as the well's depth, lateral lengths, number of laterals, and the number of frac stages deployed (Roth 2013). So far in Poland and other European countries the cost of drilling data refer only to the exploration stage.

Therefore, as in the case of productivity, investment outlays per well necessary to start production are determined by scaling the US data, which further increases uncertainty estimates. It is usually assumed that the necessary outlays might be even 50% higher than in the US due to the greater depth of shale deposits.

In this study we follow the investment scenario presented in the CASE-Orlen report with a small difference. While in the report outlays for a well are cumulated in one period before production starts, in our study the outlays are distributed in time. This concerns outlays such as costs of transformation of test drilling into a production well, re-fracking after the first 3 years of production, and the costs of mine liquidation.

Figure 7 presents total investments in Poland for the three scenarios under consideration, as percentage deviations from the reference scenario. From 2015 the investments increase sharply as a result of increasing amounts of drilling and reach a maximum between 2020 and 2027, depending on the variant. In the Moderate scenario the maximum deviation is around 0.5% and in the Huge less than 1.4%. of total investments. After reaching the maximum the deviations decline, which seems obvious because year by year the number of new drilling is fixed and the rest of investments rise with a 3% rate. Although the level of investment does not seem to be very high in relation to total investments, for oil and gas mining investments grow into multiple of the base case.

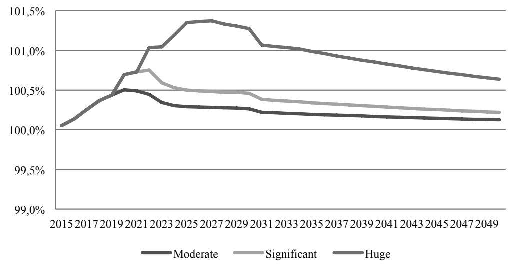


Figure 7 – Deviations of total investments in Poland from the reference scenario. *Source: the author's own elaboration based on CASE-Orlen report (CASE 2012)*

Investments in shale gas sector will lead to demand effects expressed in an increase in demand for investment funds and products as well as supply effects in the form of increased domestic supply of natural gas. Here we assume that these investments will not reduce development opportunities of other sectors by crowding out of their investments.

4.2 Learning curve of technical coefficients of the gas extraction sector

An important element of shale gas production scenarios are the unit costs of extraction. In the model they are shown as technical (input coefficients) of gas and oil mining. They will be a crucial factor in the profitability of shale gas production and the domestic gas price. The upper limit of the domestic gas price is the price of gas on the European market and the price of LNG in the world markets. Relatively low gas prices in the world markets will discourage development of the shale gas industry.

It is obvious that technical coefficients in the sector where new technology is implemented depend on current coefficients representing old technologies and the coefficients of the new technology. The latter will probably change over time, from their maximum level, asymptotically to a minimum level, along a learning curve. To predict coefficients one must have two of the three following components: maximum, minimum and shape of learning curve.

The model assumes a certain minimum ('target') level of unit costs by type. Minimum level means the cost after reaching technology maturity, arising from a learning curve. It has been set using experts' opinions. Experts have assessed shale gas extraction costs by type, in relation to conventional gas production in Poland. The latter were taken from the estimated Polish IO tables, mentioned earlier in this paper.

Using the CASE-Orlen assumptions regarding the cost of shale gas production, learning curve parameters were determined. The shape of the curve is presented on Figure 8. The values on the vertical axis represent multiples of unit cost in relation to the target value. Values on the vertical axis represent unit cost in relation to the target value. As can be seen from the figure, the values of the learning curve after 2025 are close to 1. This means that by that time shale gas technologies in Poland reaches maturity, defined as the stabilization of unit costs at the target level.

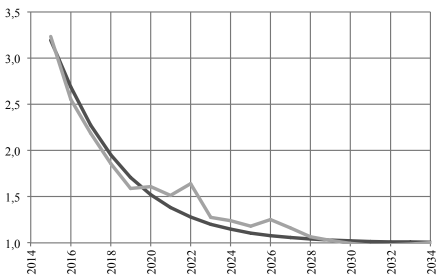


Figure 8 – Learning curve (scenario based and fitted). *Source: the authors's own elaboration based on CASE-Orlen report (CASE-Orlen 2012)*

In connection with use of the learning curve concept, input coefficients of oil and gas sector in the model are determined by the following formula (unit costs - and coefficients of extraction of oil and gas):

$$a_{ijt}^{s+c} = (1 - u_t^s)a_{ij0}^c + l_t u_t^s a_{ijd}^s$$

where:

s: shale gas
c: conventional gas
d: future (minimum) value of coefficient
0: base period of the IO table
a_{ij}^g: IO coefficient for g(as) industry (g is *s* in case of shale gas and *c* in case of conventional gas)
l_t : value of learning curve in year *t*
u_t^s : share of shale gas in output

Note that in the above formula, the coefficients are calculated as a weighted average of coefficients associated with the extraction of shale and conventional gas. Weights are shares of the relevant type of gas in the total volume of gas production. Additionally, shale gas coefficients are reduced in time to the target values according to the learning curve.

5. Results

5.1 Reference scenario

Assumptions in the reference scenario, which remain unchanged also in other scenarios, concern general economic development and changes of situation in energy markets. As to economic development we assume that final demand will develop moderately with an average growth rate of 3% annually.

Assumptions regarding energy markets concern the prices of the four main primary energy sources, i.e. coal, petroleum, gas and electricity. They concern the following issues.

- Average annual improvement of energy efficiency, measured as a rate of decline of technical coefficients of energy use in all energy products (rows of A matrix for energy products mentioned above) equals to 1%.
- Prices of coal, petroleum and electricity rise by 0.8% annually, compared to natural gas. This means that in the perspective of next 35 years the prices of these products will rise by 33.2% compared to gas (in other words, gas will be cheaper by almost 25% compared to other energy sources).
- Taking into account the price elasticities of coal, petroleum products and electricity, which are assumed to be equal to -0.3%, -0.2% and -0,1% respectively, one can observe the effect of substitution of these

energy products by gas. In the perspective of the year of 2050, demand for gas will increase by 9% as the result of substitution of coal, by 5.9% in the case of petroleum products and 2.9% in the case of electricity.

To illustrate the significance of the *reference* scenario assumptions we compare it with 'business as usual situation' (BAU scenario) – see figure 9. The BAU assumes no changes in structures of energy demand and supply in the simulation period. In this case demand for gas increase almost 3 times to 2050 – from 15.5 bcm in 2015 to 41.4 bcm. while in case of *reference* scenario gas demand reaches the amount of 34.1 bcm which is 84% of BAU.

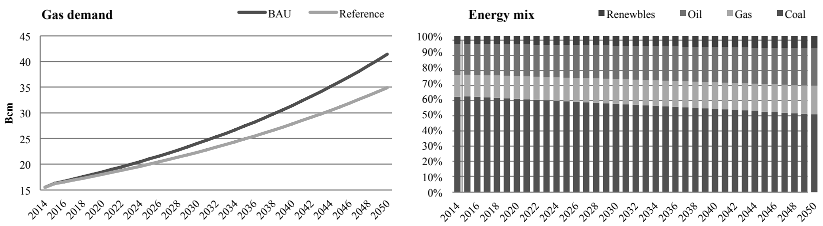


Figure 9 – Energy demand in BAU and reference scenarios. *Source: the author's elaboration*

Bearing in mind maximum volume of shale gas extraction in the *Huge* scenario (20 bcm) it becomes clear that domestic production will not be enough to meet the demand for gas up to 2050. Demand for other primary energy sources also increase but slower. As the result, the share of gas increases from 14% to 18%. Also the share of oil and renewables increases and as a consequence the share of coal in the energy mix decreases from 61% do 50% in 2050.

5.2 Shale gas extraction

Gas extraction is a small sector of the Polish economy, its share in total output has not exceeded 0.07%. It is no wonder, because resources of conventional gas are very limited in Poland and it is not possible to increase production significantly in a long period. Now over 75% of gas demand is satisfied by imports. This is why in simulations we assume that the extracted shale gas amounts will be allocated to the domestic market and will reduce imports. Figure 10 presents basic results of our simulation.

Implementation of the most optimistic (*Huge*) scenario results in a significant increase in gas production in Poland to a level that is sufficient to meet no more than 70% of the demand. After stabilization of production at the maximum level in 2033 it rises again due to the constantly increasing demand for gas. This results in a decrease in the level of self-sufficiency rate to about 52% in 2050.

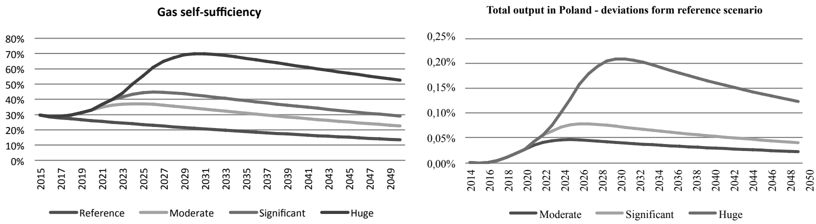


Figure 10 – Results of simulations. *Source: the author's elaboration*

The Huge scenario results in a very rapid increase in the importance of gas extraction sector. Gas production increases over 15 years, more than 4-fold. Around 2030, the share of output in the whole economy deviates from the reference scenario by approximately 0.21%.

The gas production sector is the biggest contributor to the increase in total output. The other are renting of machinery and equipment (0.41%), R & D (0.35%) and land transport (0.17%).

6. Conclusions

The long-term development of the shale gas sector in Poland depends on many external and internal factors, such as world market development and prices of gas, possibilities of adaptation of US technologies to Polish geological conditions, and the size of proved resources of shale gas, which will be recognized within a few years. Despite many uncertainties associated with these factors an important stimulus for shale gas exploration is the prospect of independence from external gas supply and achieving economic benefits. Historical analogies from 50 years ago - the economic success of Norway and the Netherlands in connection with the discovery of gas fields - show that such a scenario could be possible in Poland, had the estimates of shale gas resources from the EIA report published firstly in 2011been confirmed in the course of exploration.

The EIA report has triggered a worldwide interest in shale gas. For most of the countries indicated there as rich in shale gas, studies using different models have been conducted to assess the possible impact of its extraction on their economies. In those studies, scenarios of the development potential of shale gas sector designed for countries that have not yet started mining, especially for European countries, are based on currently available information, which come mainly from the US experience. The approach raises objections, because geological, legal and social determinants of European countries differ significantly from those for the US. Moreover, more and more often it is underlined that even US data is characterized by substantial volatility and it does not decrease with accumulated experience. Therefore, the results of such studies, including this one, are subject to considerable uncertainty.

In this study, like in many other of this type, we use IO data as a core of our model. However, we extend the IO model by adding a number of equations that reflect improvements in energy efficiency and substitution within the energy mix resulting from changing prices. From the methodological point of view the main feature differentiating our study, from similar studies carried out both for Poland and other countries are: the revealing of gas industry (gas mining as well as gas distribution) within the IO table, and the use the learning curve for unit costs of shale gas mining.

Three future scenarios for Poland have been considered. They differ with scale of gas industry development ranging from *moderate*, through *significant* to *huge*. However, the volumes of shale gas extraction under these scenarios are far away from the very optimistic expectations which were characteristic for the first year after the EIA estimates were published. In that time shale gas resources in Poland were treated as a chance for strengthening Europe's energy security. Later these expectations were reduced significantly. Our results shows that even in the most optimistic variant (*huge*) there is no chance for 100% self-sufficiency of gas supply in Poland. This means that gas production in Poland would have only an indirect impact on the European gas market by reducing the demand for gas imports. The impact would be relatively small, because the maximum gas production predicted in the huge variant is about 20 bcm per year, which is less than 4% of the current total demand for gas of the EU countries.

The results also shows that the expansion of gas mining sector in Poland, although important for energy security would have rather little influence on the other sectors of Polish economy. It should be noted that the model used for the study assumes that new investments in gas mining will not increase the level of investment in the Polish economy nor reduce the unemployment. The model also does not contain mechanisms of households adjustments to changes in energy expenditures. Although the results so far show that the response of the Polish economy resulting from the increase of gas production is not very significant these aspects should be included in the next version of the model.

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THE EFFECT OF ABANDONING NUCLEAR POWER ON THE JAPANESE ECONOMY

Takeshi Imagawa, Mitsuhito Ono, Yasuhiko Sasai

After the Fukushima nuclear power disaster, it has become a big issue whether Japan should continue to use nuclear power or not. This issue should be considered not only from the economic viewpoint but also from the perspective of national security, social welfare, environment etc. To discuss this problem more precisely, we will show the result of an economic simulation using the JIDEA (Japan Inter-industry Dynamic Econometric Analysis) model to investigate the effect of abandoning nuclear power on the Japanese economy.

The model JIDEA is based on historical data from 1990 to 2010 and we have made a base line simulation from 2011 until 2030 following the historical trend of the Japanese economy. Against this base line, we made the alternative simulation on the structural change of electricity, totally replacing nuclear power by fossil fuel power from 2014 until 2030. This is the 'Nuclear power zero case'. Compared with the base line, the Nuclear power zero case shows that in 2030, GDP decreases by 1.7% (-77 billion Yen) against the base line level, imports of fossil fuel and natural gas increase by 18.5%, and emissions of carbon dioxide increase by 74.5%.

1. The Assumptions of the Simulation

The main assumption of the simulation are summarized in the box below. In the base line, we assume that the Japanese economy continues to keep nuclear power up to 2030, even after the Fukushima disaster in 2013. The Nuclear zero assumption is to replace all nuclear power by fossil fuel power. In the JIDEA model, the electricity sector is expressed by one column but three separate electricity columns (fossil fuel power, nuclear power and renewable energy) are available in the detailed I-O table. Accordingly, we can calculate how much impact there will be when the entire amount of electricity by nuclear power is replaced by fossil fuel power after 2014 until 2030. In fact, Japanese nuclear power plants have all been shut down after 2014 because of the Fukushima disaster and adding to this shutdown there will be periodic inspection of the nuclear plants. After the Fukushima disaster, the Nuclear Regulation Authority (NRA) was reorganized, and nuclear power regulation will be revised. Only after the NRA authorizes the security of the plant can the nuclear plants be reactivated.

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Thus the reactivation of Japanese nuclear power is getting difficult not only by the change in regulations but also by the increase of political disputes among many political groups and by the opposition of neighboring citizens of the power station. In the future in addition to these old plants' reactivation, 2 new plants are planned to be constructed.

From 2011 to 2013, nuclear power was gradually replaced by fossil fuel power but detailed data on this transition period are not available, hence for the baseline we assumed that electricity is supplied continuously with nuclear power. In the nuclear power zero case, the Japanese import of fuels should increase but we assumed the world supply of fuels is abundant and the price of fuels does not increase because of the increase of Japanese fuel imports.

Base line assumption of JIDEA Model

- Recent year (2011-2013) simulation result is controlled by actual or provisional data published by the government.
- For the electricity sector, shutdown of nuclear power due to the Fukushima disaster or by the periodic inspection are not included.
- The reconstruction budget (2014-2015) for the Great East Japan Earthquake is included.
- The programmed increase of the consumer tax in 2014 and 2015 is included.
- The intermediate input coefficient matrix is extended by historical trend.

The main exogenous variables
- The population forecasted by the National Institute of Population and Social Securities Research is adopted.
- The labor participation rate and labor productivity are extended by historical trend.
- The exchange rate is fixed by 2013 annual average rate.
- Foreign demand and import prices are supplied by BTM[*1] forecast adjusted by recent trade situation.
- Government investment is extended by one year lagged value

[*1] The Bilateral Trade Model is maintained by INFORUM
(The structure of the JIDEA model is explained at <http://www.iti.or.jp/jidea-model.pd> and refer also to <http://www.inforum.umd.edu/>)

By abandoning nuclear power, renewable energy utilization (water, solar, wind, geothermal, biomass, etc.) will also increase, but the actual share of these energy sources in Japan is relatively small, so, we assume these energy sources will continue to increase slowly.

For the replacement of Nuclear power with fossil fuel power, we assume that the fossil fuel power stations have enough capacity, accordingly no new investment is required and no conversion cost is needed. We did not take into consideration the decommission cost of nuclear power or retreatment and the storage cost of nuclear ash.

2. The effect of abandoning nuclear power on the Japanese economy

Since the end of 2012, Prime minister Abe's new economic policy, 'Abenomics' has had beneficial effects on the Japanese economy, as indicated by the stock market or foreign exchange rate. But the additional policy to promote industrial development has not been established yet. The future of the Japanese economy is still obscure.

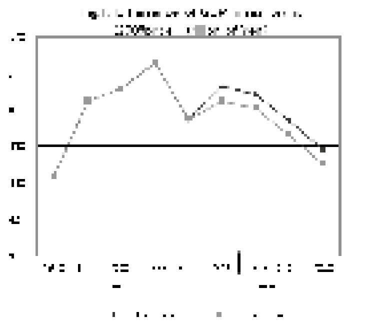
Japanese population passed its peak in 2008 and is now decreasing. Foreign competition is heating up so seriously that Japanese industry tends to invest more in other countries than domestically. These factors have led to the Japanese economy's low growth rate of production and investment.

Under these circumstances, how much effect will there be on the Japanese economy from abandoning nuclear power? Assuming that the replacement of nuclear power with fossil fuel power starts from 2014, GDP decreases by 1.7% (-7.7 billion Yen) from the Base line in the year 2030. The annual growth rate of GDP 2010 to 2030 is -0.18% on the Base line but it declines to -0.27% on the nuclear power zero case, (Table 1, Fig. 1).

Table1 –Differrence of GDP in real term (2005 price, trillion of Yen).

	result					prediction				difference in 2030 (%)	2010-30 average growth rate%
	1990	1995	2000	2005	2010	2015	2020	2025	2030		
a. Base line	443,5	484,5	491,4	505,3	474,6	492,3	488,2	473,7	457,7	-1,69	-0,18
b. Nuclear zero	443,5	484,5	491,4	505,3	474,6	484,5	480,4	465,9	450,0		-0,27
difference (b-a)	0,0	0,0	0,0	0,0	0,0	-7,8	-7,8	-7,8	-7,8		-0,09

Source: JIDEA model data base and its prediction



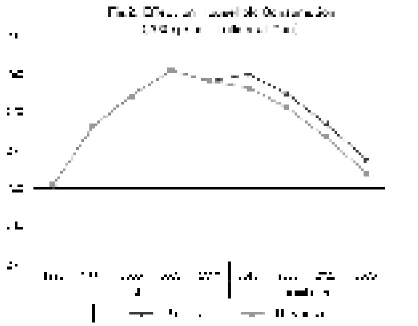
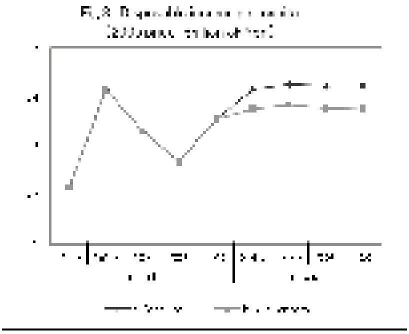


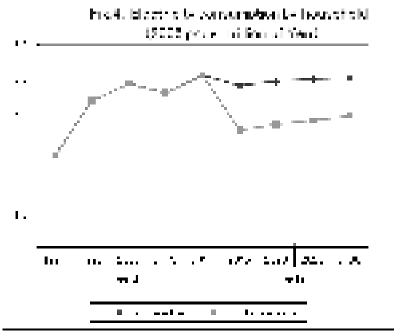
Table2. Effect on Household Consumption (2005 price, trillion of Yen)

		result					prediction				difference in 2030 (%)	2010-30 average growth rate%
		1990	1995	2000	2005	2010	2015	2020	2025	2030		
Consumption total	a. Base line	250,7	266,1	274,3	280,9	278,1	279,9	274,5	266,8	257,7	-1,39	-0,38
	b. Nuclear zero	250,7	266,1	274,3	280,9	278,1	276,3	271,0	263,2	254,1		-0,45
	difference (b-a)	0,0	0,0	0,0	0,0	0,0	-3,6	-3,6	-3,6	-3,6		-0,07
Consumption Electricity (in real)	a. Base line	2,7	4,3	4,8	4,6	5,1	4,8	4,9	5,0	5,0	-22,50	-0,08
	b. Nuclear zero	2,7	4,3	4,8	4,6	5,1	3,5	3,6	3,8	3,9		-1,35
	difference (b-a)	0,0	0,0	0,0	0,0	0,0	-1,3	-1,3	-1,2	-1,1		-1,27
consumption Electricity (in nominal)	a. Base line	3,5	4,5	4,8	4,6	5,2	5,3	5,4	5,5	5,6	5,88	0,37
	b. Nuclear zero	3,5	4,5	4,8	4,6	5,2	5,1	5,4	5,7	5,9		0,66
	difference (b-a)	0,0	0,0	0,0	0,0	0,0	-19,1	-0,7	15,3	33,0		0,29
Consumer price of electricity	a. Base line	1,29	1,05	0,99	1,00	1,02	1,10	1,10	1,11	1,12	-21,40	0,30
	b. Nuclear zero	1,29	1,05	0,99	1,00	1,02	1,47	1,49	1,51	1,53		-0,90

Table 3. The effect on disposable income per capita (2005 price million of Yen)

		result					prediction				difference in 2030 (%)	2010-30 average growth rate%
		1990	1995	2000	2005	2010	2015	2020	2025	2030		
Disposable income in real	a. Base line	2,22	2,41	2,33	2,27	2,35	2,42	2,43	2,42	2,42	-1,92	0,14
	b. Nuclear zero	2,22	2,41	2,33	2,27	2,35	2,38	2,38	2,38	2,38		0,05
	difference (b-a)	0,0	0,0	0,0	0,0	0,0	-3,96	-4,15	-4,39	-4,66		-0,10
disposable income in nominal	a. Base line	2,18	2,44	2,38	2,27	2,34	2,47	2,54	2,59	2,66	-0,27	0,64
	b. Nuclear zero	2,18	2,44	2,38	2,27	2,34	2,46	2,53	2,58	2,65		0,63
	difference (b-a)	0,0	0,0	0,0	0,0	0,0	-0,68	-0,69	-0,70	-0,73		-0,01





Household consumption in real terms decreases by 1.4% (-3.6 trillion Yen) from the base line in 2030. At the same time the consumption of electricity decreases by 22.5% (Table 2 and Fig. 2). The main reason for the decrease in household consumption is the reduction of per capita disposable income in real terms which will reach 2.42 million Yen in 2030 in the Base line but 2.38 million Yen in the case of Nuclear zero. This is a 1.9% decrease (Table 3, Fig. 3). The cause of shrinking disposable income is the increase in the electricity price, which leads all industries to reduce production.

The difference of household electricity consumption between the Base line and the Nuclear zero case is smaller by 1.3 trillion Yen in 2015 and by 1.1 trillion Yen in 2030, which is due to the higher electricity price in the Nuclear zero case (Table 2).

The effect of the nuclear zero case on GDP (-1.7%) is larger than on household consumption (-1.4%). This indicates that the influence on industry is much more than on households. The share of electricity consumption in households out of total consumption is 1.8% in 2010 and it increases a little to 1.9% in 2030.

The diminution of electricity demand is caused by the higher price of electricity. Since we assume that the fuel import price does not change, the cause of the price increase is due to the conversion of nuclear power to fossil fuel. In fact, there is a possibility that some part of nuclear power may be replaced by renewable energy but the portion of renewable energy in total electricity is relatively small (7.6%, of which 90% consists of water power). It is difficult to estimate how much the ratio of renewable energy utilization will increase. Therefore we assume it grows according to the historical trend. In fact the ratio is increasing so rapidly in recent years that our assumption for the long-term trend may be underestimated.

When nuclear power is replaced by fossil fuel power, the demand for fuel should increase. The fuel supply to Japan almost all comes from for-

Table 4. The effect on import (2005price trillion of Yen)

		result					prediction				difference in 2030 (%)	2010-30 average growth rate%
		1990	1995	2000	2005	2010	2015	2020	2025	2030		
Total	a.Base	46,1	55,6	62,8	72,5	73,8	83,9	89,1	92,6	95,9	1,82	1,31
	b.Alt	46,1	55,6	62,8	72,5	73,8	85,5	90,7	94,3	97,6		1,41
	b-a	0,0	0,0	0,0	0,0	0,0	1,6	1,7	1,7	1,7		0,09
Commodity	a.Base	21,8	28,9	35,6	44,0	47,1	55,5	60,1	63,3	66,3	-0,48	1,72
	b.Alt	21,8	28,9	35,6	44,0	47,1	55,2	59,8	63,0	65,9		1,70
	b-a	0,0	0,0	0,0	0,0	0,0	-0,3	-0,3	-0,3	-0,3		-0,02
Service	a.Base	9,2	9,2	9,7	10,8	10,3	11,8	12,4	13,1	13,7	-0,74	1,44
	b.Alt	9,2	9,2	9,7	10,8	10,3	11,7	12,4	13,0	13,6		1,41
	b-a	0,0	0,0	0,0	0,0	0,0	-0,1	-0,1	-0,1	-0,1		-0,04
Fuel	a.Base	10,9	13,4	13,2	13,5	12,6	12,6	12,4	12,1	11,8	18,54	-0,34
	b.Alt	10,9	13,4	13,2	13,5	12,6	14,6	14,5	14,2	14,0		0,52
	b-a	0,0	0,0	0,0	0,0	0,0	2,0	2,1	2,1	2,2		0,85
Share of fuel import	a.Base	23,7	24,1	21,1	18,7	17,1	15,0	14,0	13,1	12,3	16,42	
	b.Alt	23,7	24,1	21,1	18,7	17,1	17,0	16,0	15,1	14,3		

Remarks; a. Base means 'the base line', b. Alt means 'Nuclear zero case'.

Table 5. The Effect on Prices (Base 2005)

		result					prediction				difference in 2030 (%)	2010-30 average growth rate%	
		1990	1995	2000	2005	2010	2015	2020	2025	2030		%	b-a
CPI	a.Base	0,941	1,007	1,023	1,000	0,996	1,055	1,091	1,111	1,136	1,41	0,66	0,07
	b.Alt	0,941	1,007	1,023	1,000	0,996	1,068	1,104	1,125	1,152		0,73	
GDP deflator	a.Base	1,006	1,044	1,054	1,000	0,982	0,995	1,010	1,027	1,050	1,52	0,34	0,08
	b.Alt	1,006	1,044	1,054	1,000	0,982	1,009	1,025	1,042	1,066		0,41	
Total import price	a.Base	0,995	0,785	0,862	1,000	1,015	1,090	1,133	1,175	1,215	1,65	0,90	0,08
	b.Alt	0,995	0,785	0,862	1,000	1,015	1,105	1,150	1,193	1,235		0,99	
Fuel import price	a.Base	0,647	0,365	0,584	1,000	1,292	1,697	1,819	1,936	2,048	0,00	2,33	0,00
	b.Alt	0,647	0,365	0,584	1,000	1,292	1,697	1,819	1,936	2,048		2,33	
Electricity domestic demand price	a.Base	1,286	1,046	0,989	1,000	1,021	1,098	1,098	1,106	1,117	36,44	0,45	1,57
	b.Alt	1,286	1,046	0,989	1,000	1,021	1,466	1,479	1,501	1,524		2,02	
Electricity producing price	a.Base	1,286	1,046	0,989	1,000	1,021	1,098	1,098	1,106	1,117	36,44	0,45	1,57
	b.Alt	1,286	1,046	0,989	1,000	1,021	1,465	1,479	1,501	1,524		2,02	

eign countries and imports of fuel in 2030 increase by 18.5% from the base line. But Japanese total imports increase only by 1.8%. The share of fuel imports in 2030 is 12% but the share in 2010 was 17%, so the share itself decreases. That is the reason why the increase in total imports is relatively small.

In the Nuclear power zero case, nuclear fuel imports should also be zero but the share of nuclear fuel demand in Japan is so small (0.052%) that we don't take this into consideration.

Under these conditions, Table 5 shows how much the Nuclear zero case affects prices. The domestic demand price of electricity increases by 36.4% in 2030 compared with the base line but the consumer price increases only by 1.4%. The annual average increase of the consumer price in the Base line from 2010 to 2030 is relatively low (0.66%) but in the case of nuclear zero it goes up to 0.73%. As we indicate above, we assume the import price of fuel does not change in both cases and Japan does not export or import any electricity, accordingly the electricity price of domestic demand is almost equal to the producer's price. The annual average increase of domestic demand price from 2010 to 2030 is 0.45% on the Base line and it goes up to 2.02% in Nuclear zero case.

Changes in intermediate coefficients caused by replacement of nuclear power to fossil fuel power introduce complicated effects on the production of all other industries. First, the change in input materials to produce electricity affects the production of their supplying industry. Adding to this, the change of combination of input materials increases the price of electricity. Electricity is a basic input required by all industries and its price increase affects the price of all other industries. The consequence of this price increase is that all industries should readjust their demand for their inputs. These ripple effects are causes of the changes in production (Table 6).

In the Nuclear power zero case, the shift to fossil fuel power makes the production of mining and of petro-coal product increase rapidly and the medical-health care sector slightly increases but all other rest of the industries decrease their production (Table 6).

Looking at Table 6, the deviation is larger in the total service industry (-1.26%) than manufacturing industry (-0.94%). But it should be noted that total service industry contains the electricity sector which has the largest deviation ratio of all the industries. If the electricity sector is removed, the deviation ratio of the service industry is -1.09%.

It may appear strange that the deviation of medical and health care service has a positive sign instead of minus, that is to say, the production of this sector increases after abandoning the nuclear power. The reason for this phenomenon is that the price of this sector is determined by public authority and not affected by market mechanisms and even if the prices of other sectors has increased, the price of this sector stays same, and is not affected by electricity cost, accordingly the relative price of this sector decreases and the demand of this sector increases.

Table 6. The effect on Production (2005price, Trillion of Yen)

		result					prediction				2030 deviation ratio %	2010-2030 percentage contri-bution to increse	2030 electricity input ratio
		1990	1995	2000	2005	2010	2015	2020	2025	2030			
Total industries	a.Base	846,820	906,017	921,936	961,620	890,517	939,677	948,200	938,974	931,385	-1,17	-100,0	2,8
	b.Alt	846,820	906,017	921,936	961,620	890,517	929,078	937,667	928,278	920,476			3,6
Agriculture, fishery, etc.	a.Base	14,591	14,018	13,080	12,287	11,739	11,468	11,189	10,877	10,606	-1,58	-1,5	1,8
	b.Alt	14,591	14,018	13,080	12,287	11,739	11,326	11,044	10,721	10,438			2,4
Mining	a.Base	1,818	1,310	1,300	1,008	0,738	0,608	0,528	0,429	0,335	4,78	0,1	2,0
	b.Alt	1,818	1,310	1,300	1,008	0,738	0,622	0,543	0,444	0,351			2,7
Manufacturing total	a.Base	301,226	301,306	294,210	304,682	285,637	299,554	293,036	280,657	270,090	-0,94	-23,2	2,3
	b.Alt	301,226	301,306	294,210	304,682	285,637	296,756	290,415	278,091	267,561			2,9
Food, beverage	a.Base	37,222	39,521	37,624	35,889	35,052	34,315	33,038	31,580	30,309	-2,21	-6,1	2,3
	b.Alt	37,222	39,521	37,624	35,889	35,052	33,729	32,447	30,951	29,639			3,1
Textile	a.Base	13,358	9,571	6,981	4,375	3,098	2,445	1,989	1,652	1,387	-1,15	-0,1	2,3
	b.Alt	13,358	9,571	6,981	4,375	3,098	2,413	1,964	1,633	1,371			3,0
Wood, pulp, furniture	a.Base	17,214	16,796	14,688	12,830	10,318	9,770	9,186	8,492	7,904	-1,39	-1,0	6,6
	b.Alt	17,214	16,796	14,688	12,830	10,318	9,642	9,068	8,379	7,794			7,3
Chemicals	a.Base	22,681	24,238	26,395	27,487	27,471	28,557	29,089	29,069	29,207	-0,60	-1,6	1,8
	b.Alt	22,681	24,238	26,395	27,487	27,471	28,382	28,920	28,897	29,031			2,0
Petro & coal Prod.	a.Base	14,018	17,624	17,233	16,920	16,041	15,727	15,242	14,553	13,926	1,95	2,5	3,1
	b.Alt	14,018	17,624	17,233	16,920	16,041	15,993	15,516	14,825	14,197			4,0
Rubber, Plastics	a.Base	13,352	13,180	13,407	13,636	12,006	12,353	12,152	11,633	11,189	-0,93	-1,0	4,9
	b.Alt	13,352	13,180	13,407	13,636	12,006	12,239	12,043	11,526	11,085			6,2

		result					prediction				2030 deviation ratio %	2010-2030 percentage contri-bution to increse	2030 electricity input ratio
		1990	1995	2000	2005	2010	2015	2020	2025	2030			
Glass, cement, etc.	a.Base	9,589	8,758	8,151	7,156	5,622	5,889	5,934	5,691	5,425	-0,72	-0,4	3,3
	b.Alt	9,589	8,758	8,151	7,156	5,622	5,845	5,893	5,651	5,386			4,1
Iron & steel	a.Base	26,681	27,112	24,056	25,314	23,779	25,304	24,466	22,997	21,732	-0,78	-1,5	3,2
	b.Alt	26,681	27,112	24,056	25,314	23,779	25,087	24,271	22,816	21,563			4,2
Non-ferrous metal	a.Base	7,470	7,141	7,574	7,330	7,002	6,557	6,176	5,610	5,105	-1,10	-0,5	3,0
	b.Alt	7,470	7,141	7,574	7,330	7,002	6,482	6,109	5,548	5,049			4,0
Metal prod.	a.Base	20,491	21,124	17,722	16,363	12,831	13,312	12,818	11,892	10,994	-1,36	-1,4	1,5
	b.Alt	20,491	21,124	17,722	16,363	12,831	13,130	12,651	11,734	10,844			2,1
General Machine, etc.	a.Base	23,664	20,145	20,003	22,501	18,528	23,579	23,240	22,276	21,373	-0,96	-1,9	1,4
	b.Alt	23,664	20,145	20,003	22,501	18,528	23,316	23,005	22,057	21,167			1,9
Electric Machines	a.Base	31,018	37,553	42,044	47,054	51,168	52,119	51,255	49,335	47,701	-0,96	-4,2	1,5
	b.Alt	31,018	37,553	42,044	47,054	51,168	51,539	50,729	48,845	47,245			2,0
Transportation equip.	a.Base	45,450	41,495	42,266	53,016	48,908	54,875	54,192	52,435	51,156	-0,65	-3,1	2,2
	b.Alt	45,450	41,495	42,266	53,016	48,908	54,576	53,888	52,119	50,821			2,9
Precision equip.	a.Base	4,168	3,783	3,761	3,723	3,434	3,568	3,449	3,288	3,131	-0,96	-0,3	2,4
	b.Alt	4,168	3,783	3,761	3,723	3,434	3,530	3,415	3,256	3,101			3,2
Other Manufact.	a.Base	14,850	13,266	12,306	11,088	10,377	11,186	10,810	10,153	9,551	-2,96	-2,6	2,5
	b.Alt	14,850	13,266	12,306	11,088	10,377	10,853	10,496	9,855	9,268			3,0
Service total	a.Base	529,187	589,382	613,345	643,642	592,406	628,049	643,448	647,013	650,354	-1,26	-75,4	3,3
	b.Alt	529,187	589,382	613,345	643,642	592,406	620,374	635,665	639,021	642,128			4,3

(Table 6 continued)

		result					prediction				2030	2010-2030	2030
		1990	1995	2000	2005	2010	2015	2020	2025	2030	deviation ratio %	percentage contri-bution to increse	electricity input ratio
Construction	a.Base	97,365	87,864	78,445	63,237	48,941	48,085	49,331	47,119	43,985	-0,89	-3,6	3,2
	b.Alt	97,365	87,864	78,445	63,237	48,941	47,665	48,923	46,719	43,593			3,2
Electricity	a.Base	11,203	15,361	17,439	15,783	15,964	16,561	17,085	17,307	17,556	-7,74	-12,4	1,8
	b.Alt	11,203	15,361	17,439	15,783	15,964	15,017	15,592	15,874	16,198			2,2
Gass	a.Base	1,521	2,034	2,462	2,894	2,873	3,033	3,087	3,101	3,108	-0,61	-0,2	12,5
	b.Alt	1,521	2,034	2,462	2,894	2,873	3,018	3,071	3,084	3,089			16,0
Water, sewage	a.Base	7,549	7,691	7,862	8,306	7,430	7,912	8,062	8,003	7,959	-1,66	-1,2	5,7
	b.Alt	7,549	7,691	7,862	8,306	7,430	7,806	7,948	7,881	7,827			7,5
Commerce	a.Base	80,611	93,884	94,193	106,709	92,022	96,330	93,735	89,717	85,786	-1,71	-13,4	0,8
	b.Alt	80,611	93,884	94,193	106,709	92,022	94,829	92,263	88,248	84,323			1,0
Finance	a.Base	28,579	33,939	35,650	41,587	35,249	37,338	37,721	37,404	36,968	-1,05	-3,6	9,1
	b.Alt	28,579	33,939	35,650	41,587	35,249	36,977	37,357	37,028	36,578			11,8
Real estate	a.Base	56,141	62,848	64,794	66,206	68,516	69,892	68,786	66,814	64,416	-0,71	-4,2	3,4
	b.Alt	56,141	62,848	64,794	66,206	68,516	69,514	68,384	66,385	63,961			4,5
Transportation equip.	a.Base	39,692	41,733	38,206	40,784	38,683	39,593	39,002	37,625	36,264	-0,74	-2,4	2,3
	b.Alt	39,692	41,733	38,206	40,784	38,683	39,318	38,734	37,357	35,997			3,1
Communica-tion	a.Base	8,452	10,328	19,509	20,037	22,047	25,790	28,694	31,242	33,763	-0,89	-2,8	1,5
	b.Alt	8,452	10,328	19,509	20,037	22,047	25,608	28,479	30,987	33,461			2,1
Information	a.Base	13,127	13,248	20,445	25,899	27,776	32,649	36,227	39,601	43,316	-1,16	-4,6	4,5
	b.Alt	13,127	13,248	20,445	25,899	27,776	32,288	35,832	39,157	42,813			5,9

(Table 6 continued)

		result					prediction				2030 deviation ratio %	2010-2030 percentage contri-bution to increse	2030 electricity input ratio
		1990	1995	2000	2005	2010	2015	2020	2025	2030			
Government service	a.Base	19,794	31,307	34,465	38,536	26,307	28,481	28,934	28,488	27,832	-4,36	-11,1	8,6
	b.Alt	19,794	31,307	34,465	38,536	26,307	27,253	27,713	27,269	26,618			11,2
Education, Research	a.Base	31,148	35,308	35,347	36,292	32,007	32,975	32,750	31,871	31,099	-0,64	-1,8	4,0
	b.Alt	31,148	35,308	35,347	36,292	32,007	32,761	32,544	31,669	30,900			5,2
Medical and health care	a.Base	28,207	41,853	42,214	50,211	54,013	59,977	63,774	66,491	69,032	0,02	0,1	0,8
	b.Alt	28,207	41,853	42,214	50,211	54,013	60,023	63,807	66,514	69,044			1,1
Other public	a.Base	4,158	4,479	4,010	5,031	4,529	4,658	4,755	4,838	4,922	-0,24	-0,1	0,5
	b.Alt	4,158	4,479	4,010	5,031	4,529	4,647	4,744	4,827	4,910			0,7
Business service	a.Base	42,354	46,207	55,348	64,617	63,047	73,044	81,551	89,385	98,292	-1,48	-13,3	2,3
	b.Alt	42,354	46,207	55,348	64,617	63,047	71,993	80,395	88,094	96,841			3,0
Personal service	a.Base	51,921	53,543	56,643	52,022	47,881	46,854	45,515	44,039	42,501	-0,08	-0,3	3,9
	b.Alt	51,921	53,543	56,643	52,022	47,881	46,841	45,494	44,010	42,465			5,1
N.E.C.	a.Base	7,365	7,755	6,313	5,491	5,121	4,877	4,439	3,968	3,555	-1,27	-0,4	0,6
	b.Alt	7,365	7,755	6,313	5,491	5,121	4,816	4,385	3,918	3,510			0,7

Remarks: JIDEA model has 73 sectors and in this table, we aggregated them into 34 sectors.

Table 7. The effect on Employment (Thousand)

		result					predict				difference in 2030 (%)	2010-30 average growth rate %	
		1990	1995	2000	2005	2010	2015	2020	2025	2030			b-a
Total	a.Base	65.821	68.547	68.249	66.701	65.662	65.817	65.555	64.981	64.398	-0,18	-0,10	-0,01
	b.Alt	65.821	68.547	68.249	66.701	65.662	65.699	65.440	64.865	64.280		-0,11	
	b-a	0,0	0,0	0,0	0,0	0,0	-11,8	-11,5	-11,6	-11,8		-0,01	
Total manufacturing	a.Base	13.654	12.541	10.800	9.816	9.663	9.456	9.112	8.703	8.328	-0,44	-0,74	-0,02
	b.Alt	13.654	12.541	10.800	9.816	9.663	9.408	9.069	8.664	8.291		-0,76	
	b-a	0,0	0,0	0,0	0,0	0,0	-4,8	-4,3	-4,0	-3,7		-0,02	
Total service	a.Base	46.415	50.144	52.104	52.020	51.210	51.766	52.062	52.105	52.087	-0,05	0,08	-0,00
	b.Alt	46.415	50.144	52.104	52.020	51.210	51.744	52.038	52.080	52.061		0,08	
	b-a	0,0	0,0	0,0	0,0	0,0	-2,2	-2,4	-2,5	-2,7		-0,00	
Electricity	a.Base	162	170	180	167	164	164	163	162	160	-0,07	-0,12	-0,00
	b.Alt	162	170	180	167	164	164	163	162	160		-0,12	
	b-a	0,0	0,0	0,0	0,0	0,0	-0,0	-0,0	-0,0	-0,0		-0,00	

Remarks; Total contains Agriculture & fishing etc. and Mining. Total service contains Construction, Electricity, Gas, Water.

Table 8. The Effect on Labor Productivity (2005=100)

		result					predict				difference in 2030 (%)	2010-30 average growth rate %	
		1990	1995	2000	2005	2010	2015	2020	2025	2030		%	b-a
Total	a.Base	89,2	91,7	93,7	100,0	94,1	99,0	100,3	100,2	100,3	-0,99	0,32	-0,05
	b.Alt	89,2	91,7	93,7	100,0	94,1	98,1	99,4	99,3	99,3		0,27	
Total manufacturing	a.Base	71,1	77,4	87,8	100,0	95,2	102,1	103,6	103,9	104,5	-0,50	0,46	-0,02
	b.Alt	71,1	77,4	87,8	100,0	95,2	101,6	103,2	103,4	104,0		0,44	
Total service	a.Base	92,1	95,0	95,1	100,0	93,5	98,1	99,9	100,4	100,9	-1,21	0,38	-0,06
	b.Alt	92,1	95,0	95,1	100,0	93,5	96,9	98,7	99,2	99,7		0,32	
Electricity	a.Base	73,3	95,4	102,7	100,0	102,7	106,7	110,8	113,2	115,8	-7,67	0,60	-0,40
	b.Alt	73,3	95,4	102,7	100,0	102,7	96,8	101,2	103,9	106,9		0,20	

To examine more precisely the effect on the sectoral production, we calculate the difference of production in 2010 and 2030 sector by sector and again calculate the difference of this difference between the base line and the Nuclear zero case. Dividing this second difference by total of this second difference, we name this ratio 'Percentage contribution to increase' (Table 6).

The percentage contribution to increase amounts are all minus except mining, petro & coal product and medical & health care because of the increase of electricity price. To see more detailed effects on production by each sector, we arrange the sectors in order of absolute value of 'the percentage contribution to increase'. Then the order of affected sectors are as follows; commerce, business service, electricity, government service, food & beverage, information, electrical equipment, real estate, construction, finance, transportation equipment, communication, other manufacturing, petro & coal products, transportation service, general machines, education & research, chemicals, iron & steel, agriculture & fishing, etc.

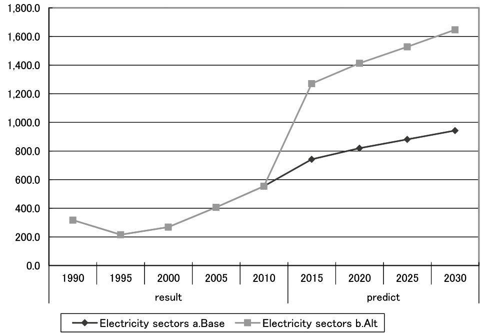
Employment also decreases because of the production decrease. In 2030 employment in the Nuclear zero case is 118 thousand less than in the base line, which is a 0.18% decrease. In manufacturing, it decreases 37 thousand (-0.44%) and the total service sector decreases 27 thousand (-0.05%). In the electricity sector, we assume that conversion from the nuclear power to fossil fuel power goes rapidly and smoothly, the employment change is very small (Table 7).

Following the decrease in production and employment, total labor productivity of all industries in 2030 decreases by 0.99%, manufacturing decreases by 0.5% and services by 1.2% (Table 8). The decrease of labor productivity in the electricity sector is relatively high, at 7.7%.

Table 9. The change of CO2 Emission in both case Mt

		result					predict				difference in 2030 (%)	2010-30 average growth rate %
		1990	1995	2000	2005	2010	2015	2020	2025	2030		
Electricity sectors	a.Base	317,6	215,4	268,3	406,2	554,6	742,8	819,9	881,4	943,5	74,6	2,7
	b.Alt	317,6	215,4	268,3	406,2	554,6	1.271,0	1.413,3	1.528,3	1.646,9		5,6
	b-a	0,0	0,0	0,0	0,0	0,0	528,1	593,4	646,8	703,4		2,9

Fig.6. The change of CO2 Emission in both case (Mt)



Finally, how large is the effect of abandoning nuclear power on the environment? The fossil fuel power increase causes the increase of carbon-dioxide emissions. We have already made a report on «the Prediction of CO2 emissions up to 2020 in Japanese economic activities»[1] at the INFORUM World Conference (2010) held at Hikone in Japan. Applying the same method, we estimate the emissions of CO2 from the electricity industry, and compare the amount of CO2 by the Base line and by the Nuclear zero case. Abandoning nuclear power and converting it to the fossil fuel power, CO2 emissions increase by 1.646 thousand ton (74.6%) in 2030.

3. Comparing with the result of other institutes

In April 2013, the Central Research Institute of Electric Power Industry (CRIEPI) published a report on «the outlook of industrial structure and energy situation until 2030». The report clarifies three forecasts of «stan-

[1] http://www.inforum.umd.edu/papers/conferences/2010/JIDEA_CO2.pdf.

Table 10. Comparison the result with CRIEPI model

	JIDEA			CRIEPI		
	2000-2010 average growth rate	2010-2030 average growth rate		2000-201 0average growth rate	2010-2030 average growth rate	
		Base line	Nuclear zero		Base line	Nuclear zero
GDP in real term	-0,35%	-0,18%	-0,27%	0,71%	1,15%	1,09%
Production by Manufacturig industry	-0,30%	-0,28%	-0,33%	-0,23%	1,21%	1,13%
Production of service industry	-0,35%	0,47%	0,40%	0,24%	1,10%	1,04%
Employment	100,0	98,1	97,9	100,0	95,2	94,8
	(2010)	(2030)	(2030)	(2010)	(2030)	(2030)
Price index of electricity	100	109,4	149,2	100	138,5	152,4
	(2010)	(2030)	(2030)	(2010)	(2030)	(2030)
Demand for electric power	-0,88%	0,48%	0,07%	0,56%	0,36%	0,30%
Emission of CO2	7,53%	2,69%	5,59%	6,27%	4,19%	10,34%
Fuel price index	100	158,1	158,0	100	233,9	233,9
	(2010)	(2030)	(2030)	(2010)	(2030)	(2030)

dard case», «the good World economy and low Yen case» and «the stagnant World economy and high exchange rate case». CRIEPI is specialized for electric energy research, and its report follows details of effect on Fukusima disaster and thereafter actual situation of nuclear power station.

Since we are not in the position to obtain the types of detailed information used in that report, our forecast is based on the industrial structure before the Fukushima disaster, when nuclear power supplied 30% of all electric power. On this base, from 2014 (actually Japanese nuclear power plants are all shut down) we assume that the part of nuclear power is replaced by fossil fuel power and after that year, no nuclear power plants are reactivated.

The CRIEPI model is different from our model not only in the model setting as mentioned above but also in the database, the model structure and assumed conditions. These differences are summarized in the following table. Though the comparison of both sets of model results may be meaningless, the comparison itself shows many different perspectives of the Japanese electric energy situation, so we dare to put here the comparison table as Table10. The case we selected for comparison is the 'standard case' of CRIEPI.

Table 11. Main differences of Assumption; JIDEA & CRIEPI

	JIDEA	CRIEPI
Database	1990-2010 timeseries I-O tables aggregated 73sectors	macro data of national account, world energy market, energy statistics, local economy, electricity statistics
Model Structure	Bottom up type model based on timeseries I-O tables, estimate the component of final demand and value added sector by sector. The intermediate coefficient extended by historical trend. Import and export are estimated using the BTM prediction. The fuel sector is aggregated in one sector. For CO2 estimation, the material matrix 2010 is used for conversion of monetary base to material volume base.	Top down model using macro economic data, combining government budget with macro economy. In this main model, the sectorial industrial production and energy demand are estimated. Intermediate coefficient is extended by recent industrial situation. Regarding the energy, energy source competing model is used to analyse demand of each fuel,
Assumption for economic forecast	Per capita disposable income stays in low level because of diminishing population, increasing aged population. The export which was onece the driving force ofJapanese economy, is stagnant as annual growth rate of 0.6% from 2010 to 2030 because of foreign competition and the shift of production facilities to abroad.	Instead of shrinking and aging population, activating women power, the work force will not be short. With the good world economy, export increases at the rate of 3.2% from 2010 to 2030. Increasing replacement demand makes public investment increase Helped by deduction of corporate income tax, GDP increases anualy by 1.1%.
Exchange rate	1$=96.795Yen in 2013 and fixed until 2030	1$87. 8Yen in 2010. From 2010 to 2030 annual depreciation rate is 0.1%.
Energy price (Crude oil import price)	From 2010 to 2030 estimated annual growth rate is 2.3%.	From 2010 to 2030 annual growth rate assumed 4.4%.
Nuclear power station operating ratio	The historical change from 1990 to 2010 continues its trend until 2030. For the Nuclear power zero case, from 2014 intermediate input coefficient of electricity is changed to replace nuclear power production to fossile fuel power. The fossil fuel power input coefficient does not change but keeps its historical trend.	After 2014, the nuclear power station is reactivated step by step and the stations reached to the end of service period stops its operation. The new nuclear power stations such as Shimane No.3 and Ohma start to activate. In 2030, nuclear power occupies 30% of total electricity production. In the case of Nuclear zero, after Summer of 2013 all nuclear power stations stopped. In the Nuclear zero case, the fuel structure assumes LNG : coal=1: 1.
Renewable energy	Same as growth of electricity, it reaches 1.102 times of the base year level in 2030 .	The solar electricity becomes 7.57 times of the base year 2010 level in 2030, the window power is 2.46 times.

Between the forecast of JIDEA and CRIEPI there are relatively wide differences in the average annual growth rate of GDP in real term or industrial production. This is because of the difference of assumptions for the performance of Japanese economy or the forecast of the world economy.

The period of historical results is from 2000 to 2010 and both models should show the same value but actually they are different. These differences are due to the database adopted by each model. In the JIDEA model, the database is from historical I-O tables and CRIPI is based mainly on the national account macro data.

In the electric price there is a big difference. JIDEA assumes that the fuel import price increases annually by 2.3% from 2010 to 2030. CRIEPI assumes a higher rate of increase. The price of JIDEA is the domestic demand price derived from I-O data but the price of CRIEPI is based on actual Yen/Kwh data.

The estimation of CO2 emissions depends on many conditions such as the ratio of nuclear power, forecast of renewable energy, etc.

On the scenario of the Base line, our model assumes that the nuclear plants continue their production following the historical trend. In CRIEPI's estimate, it includes the plan to construct new nuclear power plants and decommission of the plants which have reached the end of their service life, and it assumes that a half of them are still active in 2030. Though both models make the same assumption that nuclear power stops from 2014, their result is different. JIDEA estimates a higher effect of abandoning nuclear power on CO2 emissions.

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RENEWABLE ENERGY SOURCES IN AN ENERGY ABUNDANT ECONOMY: A FOCUS ON RUSSIA*

Nikita Suslov

1. Energy sector of Russia: high output and inefficient use

Consistent with an endowment of great natural energy wealth, the fuel and energy industrial complex[1] (FEC) of the Russian economy is comprised of more than 40 thousand enterprises. While this is a rather small share of all production units involved in the economy, accounting for only 0.8%, the energy complex amounts to almost 20% of total economic production and 45% of industrial production. The FEC provides no less than 43% of government budget revenues and about 70% of total currency earnings from foreign trade.

The official sources of statistical data provided by Rosstat[2] do not include specific information on the volumes of fixed assets in different spheres of the economy, but they do provide fixed capital investments in constant prices and these can be used to compute capital stocks. According to our estimates, and despite a relatively small amount of enterprises, the FEC owns about a quarter – 24.9% – of the country's fixed assets and nearly two thirds of all industrial assets. This estimate is understated since it does not include the capital concentrated in pipeline systems. According to the forecast of socio-economic development of the Russian Federation for the period up to 2030 developed by the Ministry for Economic Development, the share of FEC investments in 2011 was 32 % (Russian Statistical Yearbook 2012). Perhaps, the difference between this figure and our estimate based on Rosstat data can be explained by the investments in pipeline transportation.

What is the volume of FEC fixed capital in absolute terms? According to estimates based on cross-country data for 2010, the ratio of fixed assets as measured in constant prices to the country's GDP was about 5.5 to 1.0. Thus, with total current price 2010 Russian GDP of RUB 45.2 billion, fixed assets at replacement cost, including property of households, should be about RUB 300 billion. A quarter of that total was RUB 75 billion, implying that value of capital stock in the FEC sector is notably greater than annual GDP.

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[1] This concept coincides with the energy sector of the economy.

[2] Russian Statistical Agency.

Douglas S. Meade (edited by), *In Quest of the Craft : economic Modeling for the 21st Century*
ISBN 978-88-6655-819-4 (print) ISBN 978-88-6655-820-0 (online),

Table 1 – Russian Energy Sector in the World Economy in 2011.

	Volume	World position	Share in the World	Net exports
Oil, mill. t	517	2	12,9	246
Gas, bill. cubic m	677	1	20	196
Coal, mill. t	334	6	4,3	99
Energy from HPS, bill. kW-h	170	4	6,2	
Energy from NPS, bill. kW-h	168	5	4,8	
Petroleum products, mill. t	240	3	6,3	111
Electric Energy, bill. kW-h	1036	4	4,8	17
Energy production, mill. oil. equ.	1315	3	10,0	592
Energy consumption, mill. oil. equ.	731	3	5,6	
Renewables (RE), mill. oil equ.	17,7		1,34	
RE without HPS, mill. oil. equ.	3,5		0,25	
GDP, $ bill. PPP	2376	6	3,0	
Population, mill.	142,9	9	2,06	

Source: Rosstat RF, IEA, and IMF

The Russian energy industry is one of the world's largest, producing 20% of global natural gas, 13% of oil, more than 6% of oil products, more than 6% of hydro-power and almost 5% of world nuclear energy. Table 12 shows that in millions tons of oil equivalent, 46% of the total output is exported. With GDP of Russia amounting to only 3% of the world economy, total FEC output accounts for 10% of world energy production, while consumption is 5.6%.

The FEC sector is therefore very important to the Russian economy as it provides power for industrial production, creates markets for the goods and services of other industries, supports scientific and technical progress, and underpins the living standards of the general economy. It is important to stress, however, that the sector generates an immense amount of economic rent, that is, income above and beyond that necessary to pay production costs including those needed to pay for capital investments. Rents in the oil and gas industry were an important prop to the existence of the Soviet Union. The disappearance of those rents following a two-fold drop in oil prices from 1980 to 1985 contributed greatly to the Union's disintegration at the end of the decade. In many respects, rent income explains the rapid growth of the Russian economy during the first 8 years in the 21st century. Also, rents are sure to remain an important element for economic growth in the long term.

Calculated on the basis of production accounting and world oil prices, the rent created by hydrocarbon production was USD 400 billion (Ickes, Gaddy 2011) in 2010. At the current exchange rate this value is more than a quarter of GDP. Unfortunately, a considerable part of this income was not spent effectively. Only about USD 120 billion showed up in the government budgetary sphere (Suslov 2012), and most of this amount was used as indirect (hidden) subsidies for other inefficient economic sectors. The rest of the rent disappeared 'into the shadows' and much has been sent abroad. Thus, the major task today is to increase the amount of rent that is invested back into the economy including in the FEC sector. Such a task will be made even more difficult by recent falls in the relative prices of oil and gas, because investments in energy and utility sectors take a long time to be realized.

Energy use in Russia is also very inefficient. While Russia's income per capita income is about 34% of that in the United States, its per capita energy consumption is about 70% compared to America's (Table 2). Russia's climate is more severe compared to most other countries, so one might expect per capita energy consumption to ultimately increase to levels similar to Canada and Finland. However, Russian energy consumption per GDP (in PPP units) is two times higher than that in the USA, one and a half times higher than in such northern countries as Canada and Finland, and three times higher than in the developed European countries and Japan. Research show that severe climatic conditions only partly contribute to such a big difference in energy consumption per unit of GDP (Bashmakov, Borisov, Dzedzichek, Gritsevich, Lunin 2008; Suslov 2005, 2007).

These differences indicate that there are structural inefficiencies of energy use in the Russian economy including obsolete technology, decrepit production facilities which waste much of the energy produced, and management failure. In general, the abundance of energy means that there is a lack of incentives to invest in energy saving technologies and other measures. In particular, the development of renewable energy sources (RES) is very hampered. The excessive energy intensity of the Russian economy puts into doubt not only sustainable economic growth but also the possibility of economic growth *per se*.

Table 2 – Energy Consumption in Russia and Other World Economies in 2010, USA=100%.

	Per capita			Per GDP	
	GDP PPP	Energy use	Electricity use	Energy use	Electricity use
Canada	83	104	126	125	152
Czech Republic	54	60	60	112	110
Finland	74	97	109	131	146
Germany	76	56	54	74	72
Greece	63	36	38	57	60
Israel	62	44	56	71	91
Japan	72	55	62	76	87
Netherlands	85	70	50	81	58
Russia	**34**	**70**	**52**	**209**	**154**
Sweden	82	79	116	96	141

Calculated using WB & IEA data.

2. Renewable energy: though desirable but for now is disappointing

From this perspective, it seems clear that the development of alternative energy sources can become an important factor for decreasing energy cost per unit of output. Russia, with its population amounting to 2% of the world's population, produces and consumes only about 1,3% of global renewable energy production. If we put aside large scale hydropower – a traditional source of electricity generation especially widespread in Siberia and in the Far East – the share of Russia in both production and consumption of renewable energy (without hydroelectric power plants) falls to an insignificant value of 0.025 %.

Figures from Table 3 testify to the fact that the role of renewable energy in Russia is insignificant. Even including hydropower, per capita production of renewable energy resources, at 0.12 tons of oil equivalent (toe), is half the average in the world, and a third of the OECD average. Also, production of alternative energy in Russia appears to be just a fraction of that in countries as Finland, Norway, Denmark, Canada and the United States, not to mention Iceland which consumes its own energy mostly produced from renewable sources (Table 3). At first sight, the per capita production renewable energy in Russia is about the same as in the United Kingdom and Japan against 0.10 toe and 0.15 toe, respectively. However, since total energy production is so much larger than in these countries, the Russian share of renewable energy production is much larger than in these countries.

Table 3 – Renewable energy (RE) in the world and selected world economies, tone of oil e., 2011.

	Per capita energy output	Per capita energy use	Per capita RE output	RE share in energy output, %	RE output to energy use ratio, %
Australia	13,63	5,65	0,29	2,10	5,06
Canada	12,02	7,40	1,33	11,04	17,93
Denmark	3,80	3,25	0,55	14,43	16,84
Finland	3,25	6,61	1,73	53,14	26,13
Germany	1,52	3,83	0,38	25,19	10,04
Iceland	15,45	18,42	15,45	100,00	83,83
Ireland	0,38	2,83	0,16	40,82	5,52
Japan	**0,41**	**3,65**	**0,15**	**37,80**	**4,23**
Netherlands	3,82	4,60	0,19	4,88	4,06
Norway	41,64	6,00	2,55	6,12	42,50
Spain	0,68	2,69	0,29	43,31	10,96
United Kingdom	2,07	3,00	0,10	4,85	3,34

	Per capita energy output	Per capita energy use	Per capita RE output	RE share in energy output, %	RE output to energy use ratio, %
United States	5,70	7,00	0,43	7,61	6,20
World	1,91	1,89	0,25	12,89	12,98
OECD Total	3,13	4,31	0,35	11,09	8,05
Russia	**9,20**	**5,12**	**0,12**	**1,35**	**2,43**

Source: OECD

Moreover, RES in Russia include only hydro, geothermal and solid biomass. Solar, wind and other bio sources are insignificant. Table 4 shows that Japan takes the leading position in the use of geothermal and solar energy, and it also uses such sources as wind and municipal waste. Wind power is more widespread in other OECD countries, especially in Europe. Biological motor fuel production is also popular, with Europe specializing in biofuel while North America prefers ethanol. Many countries worldwide have started to recycle municipal waste, but it is not widespread in Russia.

Table 4 – Structure of renewable energy produced by sources (%) in 2011.

	Russia	Japan	OECD Europe	OECD Total	World
Hydro	80,42	36,63	23,41	27,94	17,64
Geothermal	2,53	12,70	6,58	7,64	3,87
Solar Photovoltaics	0,00	2,27	2,09	1,16	0,31
Solar Thermal	0,00	2,10	1,51	1,49	1,08
Tide, Wave and Ocean	0,00	0,00	0,02	0,01	0,00
Wind	0,00	2,01	8,47	6,61	2,19
Renewable Municipal Waste	0,00	3,19	4,95	3,24	0,87
Solid Biomass	17,05	40,54	41,29	38,27	68,91
Landfill Gas	0,00	0,00	1,57	2,08	0,53
Sludge Gas	0,00	0,00	0,69	0,34	0,09
Other Biogases	0,00	0,56	3,34	1,53	0,90
Biogasoline	0,00	0,00	0,92	6,63	2,06
Biodiesel	0,00	0,00	4,29	2,61	1,02
Other Liquid Biofuels	0,00	0,00	0,86	0,42	0,50
Total of Renewable Energy	**100,00**	**100,00**	**100,00**	**100,00**	**99,96**

Russia is world leader in the production of pellets (more than 2 million tons a year), but these are mostly exported to European countries. Their use in Russia is restrained by administrative and economic barriers. Russia is also successfully developing tidal power plants based on original domestic technologies. A number of the Russian companies are also turning attention to the development of large-scale photo-electric converters technology, which again is mainly export-oriented.

The dead-end situation with production and use of green energy in Russia is especially concerning given the breakthroughs of its application abroad. By the end of 2008, the capacity of electric power generating plants using nontraditional RES (without large hydroelectric power stations) reached 280 GW, and in 2010 it exceeded the capacity of all nuclear power plants -340 GW. By the end of 2009, the total capacity of 150 thousand wind power plants produced about 159 GW of power. In 2009, wind power plants (WPP) with total capacity of 39 GW were put into operation, increasing capacity as compared to 2008 (120 GW) by 32%. In 2011, WPPs generated 416.8 TW-h of electric energy, up from 324 TW-h of 2009.

Total world capacity of photo-electric converters increased by 7GW in 2009 reaching 21.3 GW, with the growth of global sales increasing more than 50%. In 2011, total annual output of the converters was 58.7 TW-h compared to 23.9 TW-h in 2009. Total capacity of biomass power plants in 2009 was 60 GW, and the annual electric power output from them exceeded 300 TW-h. The total capacity of geothermal power plants exceeded 10,7 GW, with electric power output being 62 TW-h annually. Total thermal capacity of solar heating systems in 2008 reached 145 GW (i.e. more than 180 mln. m^2 of solar collectors); more than 60 million houses in the world use solar hot water supply, with annual growth rates in excess of 15%.

The production output of biofuels in 2008 exceeded 79 billion liters per year (about 5% of annual world consumption of gasoline), with bioethanol production at 67 billion liters and biodiesel at 12 billion liters a year. Compared with 2004 this production represented a six fold increase in the production of biodiesel, and a doubling of bioethanol. In 2011, the world production and consumption of biofuel exceeded 50 billion liters, which is more than one percent of the world market for liquid fuels.

At present, across 30 countries there are more than 2 million thermal pumps with a total thermal energy output of more than 30 GW utilizing natural and waste heat to provide heat and cooling buildings. Today, in Russia, there are only several hundred installed heating pumps.

Further development of alternative energy generation in Russia would not only reduce the fossil fuel intensity of production, but it would help develop new resources for economic growth in remote areas. The fact is that two thirds of the Russian territories with the population of 20 million people are not covered by the centralized power supply networks. As a rule, these remote regions have the highest prices for fuel and energy (10-20 rubles per kW and more). For the most part these regions are energy deficient because of a lack of both fuel resources and energy delivery. Similar to energy importing countries, energy security is still a very urgent problem for such regions. Moreover, despite being one of the world's largest gas producers, only about 50% of urban and about 35% of rural settlements have access to piped natural gas. Where such gas is not available coal and oil products are mainly consumed, and these are major sources of local environmental pollution.

Finally, continuous growth of energy and fuel prices plus growing costs of centralized power supply have accelerated the development of autonomous (distributed) power production. Over the last 10 years, diesel and petrol generators with unit capacity of 100 kW exceeded the total output of large power plants. While energy consumers understandably seek to provide themselves with their more dependable sources of electric power and heat, distributed small scale production is usually less efficient compared to centralized production. It is this area that renewable energy can really compete with fossil fuels. Off-grid RES energy supply has proved its economic efficiency in many countries, and distributed production can help avoid the high capital costs associated with laying power lines. In Russia, hybrid wind-diesel systems, biomass boilers, and small hydroelectric power stations should be particularly competitive with traditional fossil fuel technologies.

3. While the RES potential is great, current utilization is still quite small

There is a considerable potential of using renewable energy in the Russian economy. Practically all regions of the country possess, at least, one or another type of resource, and the majority of them have a variety of resources such as small rivers, agricultural and timber industry waste, peat stocks, wind and solar sources, and geothermal areas. In some cases RES operations seem to be commercially attractive in comparison with fossil fuels, especially where deliveries of the latter are expensive and unreliable.

What, however, is the experience of current use of RES in the Russian economy? According to O.S. Popel (2011), the Chairman of Scientific Council of the Russian Academy of Sciences on nonconventional renewable energy sources, Russia has become one of the world leading pellet producer at 2 million tons per year, however, the production is mainly exported to Europe. There are certain positive results in constructing tidal energy devices based on original national design. In addition, there are some companies specializing in the development of large scale production and export of photoelectric converters.

As far as the volume of potential involvement of the RES is concerned, one can find various and often inconsistent data. For example, according to I.S. Kozhukhovsky (2012), the General Director of the Energy Forecasting Agency (APBE), the technical potential of alternative sources of energy could reach about 4600 billion tons of coal equivalent (3320 billion toe). The technical potential is defined as the total energy production from RES which is possible using modern advanced and projected technical means. However, the economic potential of RES production (i.e. where production costs enough return to capital to sustain the necessary investment) is estimated to be only 300 billion tons of coal equivalent (210 billion toe), or about 30% of annual energy consumption in Russia.

The last row of Table 5 shows that according to RusHydro, a holding company which owns the majority of large and medium Russian hydroelectric power stations, the general technical potential for RES electric power generation exceeds 45 trillion kWh, or about 4000 billion toe (Pavlov 2012). This figure is only slightly lower than the figures specified above. RusHydro estimates of economic potential are also much smaller, totaling 1.6 trillion kW-h, corresponding to about 135 million toe. In addition, RusHydro identifies 'industrial potential', which, apparently, refers to the possibilities to use renewable energy in industrial enterprises. Industry can use about 227-342 billion kW-h, which equals to 40-60% of the general power consumption in industry.

Table 5 – Potential of energy production using renewable energy sources in Russia.

	Potential, bill. kW-h		
	Technical	Economic	Industrial
Small HPS (<25 Mh)	372	205	6-10
Wind PS	6517	326	70-90
Geothermal PS	34905	335	40-60
Biomass PS	412	203	90-130
Tidal PS	253	61,6	16-45
Solar HPS	2714	435	5-10
Total	45173	1566	227-342

Source: RusHydro JSC, 2010

The RusHydro report also provides a detailed structure of this potential by renewable fuel type. A large majority of the total potential, or 35kWh out of 45kWh comes from geothermal power stations. The technical potential for wind power is also relatively large. However, the economic potential of geothermal and wind energy is not significantly larger than for other types of RES and is even less than the economic potential for solar energy. In general, biomass, rating low in technical potential, has the greatest industrial potential. Despite high technical potential of solar energy, the possibility of its use in the short run is far from optimistic. Thus, biomass and wind sources seem to be the most promising sources of renewable energies for industry.

In 2011, G.M. Krzhizhanovsky Energy Institute developed the *Program for modernization of electric power industry in Russia for the period until 2020.* It included the data of Table 6, an assessment of RES production by types for electrical energy (i.e. without heat and exported biomass) for the year 2010. These figures include small hydropower plants with the power capacity of less than 25 MW. The figures show that in 2010 the use of all renewable energy sources for electricity generated only about 5889.4 billion kW-h which equaled to 0.6% of total output[3]. Solar energy for electricity production in Russia is not used (though in some areas solar collectors are used for heating the dwellings). Wind and tidal power plants use is insignificant, and hydropower and biomass constitute only slightly more than 1% of the total.

Table 6 – Summarized data on electricity production from renewable energy sources (RES) in Russia, 2010.

Types of RES	Generation capacity, MW	Power generation, mill. kW-h	Share in economic potential, %
Wind ES	13,2	14,2	0,04
Small HPS (<25 Mh)	700	2800	1,37
Geothermal PS	81,2	474	0,14
Solar PS	0	0	0,00
Tidal PS	1,1	1,2	0,00
Biomass PS	520	2600	1,28
Total	**1315,5**	**5889,4**	**0,46**
Share of RES in total electricity production, %	0,57	0,58	

4. Reasons why Russia lags in developing RES: economic noncompetitiveness, institutional failure, and lack of infrastructure

Why is RES use so insignificant in Russia? Generally speaking, there are several serious reasons:

- many RES projects are noncompetitive in the existing market environment in comparison, especially against sources from fossil fuels;
- institutional barriers especially a lack of market regulation for stimulating RES use in electric power and the absence of both federal and regional programs to support large-scale use of RES;
- lack of infrastructure required for successful RES development within the electric power industry, including an insufficiency of scientific background, a lack of information on the costs and benefits of potential renewable energy sources as well as authentic database on the realized projects; an absence of normative, technical and methodical

[3] According to another source in 2011 the volume of electricity production from RES increased up to 8,4 bill. kW-h. or about 0,8% from the total generation, which equaled to 1058 bill. kW-h. State Program of the RF “Energy efficiency and energy development in Russia”, p. 162.

documentation and the software necessary for design, construction and operation of RES power plants, insufficient staffing and mechanisms for using public resources for the development of RES electric power.

According to the International Energy Agency (see Figure 1)[4], the cost of RES electric power produced Russia on average is much higher than in other countries; these difference are especially notable in the cases of solar, geothermal and wind energy. Russia has an advantage only for small hydropower. Yet the production cost of one kilowatt-hour at traditional power plants are generally lower than abroad becuaser of cheaper fossil fuels, a high share of cogeneration, and favorable conditions for large scale hydro generation. Thus, the competitive conditions for RES development in Russia are much less favorable than in the leading countries of the world.

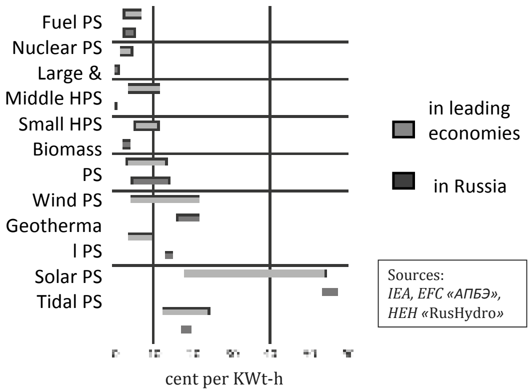

Figure 1 – Electricity Production Cost in Leading World Economies and in Russia, 2007.

The institutional environment in the Russian electric energy sector has been formed mainly by two federal laws:

- the Law *On Energy Saving and Raising Energy Efficiency* of November 23, 2013;
- the Federal Law *On Electric Energy Sector* (revised) of March 26, 2003 N 35-FL.

These laws support the use of RES by providing:

- the possibility to set feed-in tariffs or markups for RE;
- state guarantees and budget compensations for the access to grid;

[4] Prospects of RES in Russia, <http://www.protown.ru/information/hide/7941.html> (date of access: 09.12.2013) (Перспективы возобновляемых источников энергии в России).

- obligations for the electrical distribution companies to purchase all renewable energy produced (e.g. using green certificates).

However, the specified possibilities for RES development are not realized in practice. A key factor is an extremely lengthy and expensive certification procedure. For example, in Belgorod, a leading company developing RES[5] – a well-established company with strong lobbying power – waited a year to receive certification for a pilot solar power station. As a rule, local grids are reluctant to connect to RES plants due to their unstable character and low quality of the energy produced (Table 7).

Table 7 – Energy Capacity Utilization at Power Plants (%).

Fuel PS in Russia	52,9
Large Hydro PS	40
Small Hydro PS	~ 45
Wind PS	~ 25-40
Solar PS	~ 20

5. Government promises to support RES and what is expected

An important feature of Russian society is that most companies and organizations perceive «government advisory recommendations» as directives. From this perspective, the formation of expectations and forecasts for RES development is greatly influenced by the Federal Decree of January 8, 2009 No. 1-p «The main directions for state policy to improve energy efficiency from renewable energy sources for the period up to 2020». The specified document established that «the state policy in the sphere of energy efficiency from renewable energy sources is an integral part of energy policy of the Russian Federation and determines purposes, directions and activities of the state bodies and public authorities for the development of energy industry from renewable energy sources». The decree assigned to the Russians Ministry for Energy the responsibility of coordinating the activities of Federal executive authorities in implementing the policy.

The main objective of the state policy is to increase energy efficiency of national economy by introducing high technologies and innovative equipment. Also, the document establishes target indicators of RES as a share of

[5] The solar station in Belgorod was put into operation on October 1, 2010 by 'AltEnerg'; its peak rated power accounts for 100 kW. It is a pilot plant with different prototypes of equipment. There have been introduced 1320 modules of two types: amorphous and polycrystal, with a total active surface of 1230,2 square meters.

electricity production: for 2010 -1,5%, 2015 -2,5% and 2020 -4,5%. The last figure assumes that capacity of electricity generation in 2020 will amount to approximately 14700 MW, while electric energy production in the year will reach 50 billion kW-h.

Private-state partnerships are expected to finance the implementation of the RES policy. The government means to support the enterprises producing energy from renewable energy (except for hydroelectric power stations of more than 25 MW) by means of:

- establishing and regularly adjusting the size and validity periods for markups to the market energy wholesale electricity/power price to determine the subsidy to RES;
- obliging the wholesale electric energy buyers/consumers to purchase the specified volume of electric energy from RES;
- improving legal regimes for the use of natural resources in construction and operation of electricity generating plants/facilities based on RES.

The government has promised «to use the mechanisms for providing additional support of renewable energy sector in compliance with the budget legislation of the Russian Federation».

The Federal Decree of January 8, 2009 No. 1-p also establishes the following measures to increase the network and infrastructure support for the development of electric energy production from RES:

- improve scientific, engineering and other technological services in the support of development, production and consumption of renewable energy;
- utilize the potential capacity of domestic industry for the specified purposes;
- create and develop and information environment and an consulting engineering network to support for the development of RES;
- develop a normative, technical and methodical documentation for the design, construction and operation of RES power plants;
- stimulate RES electric energy use among consumers.

At the same time, the Russian government initiated the design of two more state programs aimed at facilitating RES development – the State Program of the Russian Federation 'Energy efficiency and energy development' adopted in 2013 and «The program to modernize the electricity sector of Russia for the period until 2020» which has not been adopted yet. Both programs contain similar measures to promote RES development and, judging by the contents, they generally correspond to the Federal Decree of January 8, 2009 No. 1-p. However, they both focus mainly on the existing realities in the sphere of renewable energy production, i.e. weak competitiveness, high institutional barriers and insufficient infrastructure, they are therefore, they are less optimistic in the target parameters. For instance, the modernization program provides for the installation of only 4400 MW of installed RES capacity by 2020. The 'Energy efficiency and energy development' program goes even further and provides for installation of about 9000 MW of power capacity over the period until 2020, which will make it possible to increase the RES generation share of electric energy to 2.5% by then.

Another document – 'General scheme of allocation of electric power facilities for the period up to 2030' – was developed by Energy Forecasting Agency (APBE) and approved at a government meeting of the Russian Federation on June 3, 2010 also concerns RES development. However, the measures specified in this proposal do not seem to be sufficient to achieve the targets and indicators set forth in the Federal Decree adopted on January 8, 2009 No. 1-p. This document offers two scenarios of the dynamics of RES input capacities – basic and maximum.

Table 8 – The Structure of RES Installed Power Generation Capacities according to 'General layout of electric power facilities for the period up to 2030' (%).

		By 2030	
	2010	Basic	Maximum
Total in ths. kW	1315,5	7400	15600
Wind ES	1,0	26,6	48,9
Small HPS (<25 MW)	53,2	27,4	20,5
Geothermal PS	6,2	4,1	2,9
Solar PS	0,0	0,0	0,0
Tidal PS	0,1	0,2	0,1
Biomass PS	39,5	41,7	27,6
In Total	100,0	100,0	100,0

Table 8 shows that according to the basic or the minimum scenario only 6.1 million kW of generation capacity will be installed, whereas the maximum scenario envisions 14.3 million kW of capacity. These less optimistic forecasts are made on the basis of regional planners' suggestions, and the government measures that would be used to support the RES targets still remain unclear.

The minimum scenario suggests that there will be a 5.6 fold increase in the use of RES as power generation capacity is installed, while the maximum one presupposes a 12 fold increase. But even in this case, the share of RES in the total power generation capacity in Russia will not exceed 4,0-5,0%. Wind power plants are expected to make the highest contribution to RES capacity increment, while biomass and small hydro power plants will take the second and the third positions. At the same time, the share of biomass and small hydro energy power plants in the total RE will decrease to the advantage of wind energy. Thus, wind energy is highly likely to be the main direction of RES development in our country.

The prospects for the development of wind energy in Russia draw special attention from experts. Non-government organizations and independent experts are developing a special program – 'The general scheme of allocation of wind power facilities in Russia for the period up to 2030' (Nikolayev 2013). In this document, the technical potential of for wind power generation in 2020 and 2030 is estimated to be 7 and 30 GW, respectively. Annual wind power outputs could reach of 17.5 in 2020 and 85 billion kW-h in 2030, figures which considerably exceed those estimated in the more general and already accepted program 'General scheme of allocation of electric power facilities for the period up to 2030'. Taking into account world-wide experience, the most cost-effective wind farms with power capacities of 30-50 MW consisting of modern wind turbines of 2-3 MW each have been selected as a basis for development of electric power in Russia. The wind farms are proposed mainly in areas where the production costs are lower than thermal power plants (using gas and coal), with the use efficiency coefficients of installed capacity of wind farms exceeding 30% (Nikolayev, Ganago, Kudryashov 2008).

6. Some model analysis

Undoubtedly, the competitiveness of RES largely depends on the microeconomic environment, that is, the circumstances in a certain district including the types and quality of existing energy sources, regional energy needs, and especially the availability and the cost of traditional resources. The most important parameters, of course, are the average costs for RES.

To assess the consequences and efficiency of distribution of various production technologies and energy consumption, IEIE SB RAS[6] use and economic inter-regional and inter-sectoral forecast model, which includes the energy sector of the economy containing energy products in physical units based. The OMMM-Energy framework (optimization in a multi-sector multi-district model), developed on the basis of a well-known model proposed by A.G. Granberg, is included in the multi-sector multi-region model (MRIO) (Granberg 1973). It is a composition of two sub-models for time periods of 2008-2020 and 2021-2030. The dynamics of investment is modeled as a non-linear function adapted with the help of linearization techniques.

The model covers 45 products including 8 energy products: crude oil, gas, coal, heavy petroleum products, light petroleum products, products of coal processing, electricity, and heat. It also includes non-energy sectors which support energy production: drilling for oil and gas, energy production equipment manufacturing, pipeline transport, transportation, and pe-

[6] Institute of Economics and Industrial Engineering of Siberian Branch of Russian Academy of Sciences.

troleum chemistry. MRIO also incorporates 6 large regions of Russia: the Europe, Ural, Tyumen, Western Siberia, Eastern Siberia, and the Far East.

The model includes features of energy production and consumption, which distinguishes this model from a canonical OMMM:

- oil and gas reserves are monitored: The annual output to volume of reserves ratio is fixed in the model, in other words, output growth follows investment in reserves;
- diminishing returns to scale in oil and gas extraction sector are included;
- substitution between different kinds of energy is considered: 20 types of technologies to produce heat and electricity in each region are incorporated.

The model makes it feasible to evaluate complex consequences and efficiency of policy measures in the sphere of energy production, processing and consumption. Earlier studies applied it to evaluate the economic consequences of:

- concentration of energy-intensive production in Southern Siberia;
- gasification in Southern Siberia;
- reduction in energy intensity of production in national economy;
- introduction of heat pumps technology in different regions.

The annual market for compression heat pumps in Russia is estimated to be 40-55 million tons of coal equivalent. According to the calculations conducted with the help of OMMM-Energy, spreading compression heat pumps can bring about a significant reduction in energy intensity, displacing fossil fuels combusted at traditional heat plants. At the same time, the capital intensity of the economy increases because 1) heat pumps are more expensive compared to traditional heat producing engines, 2) additional electricity generation capacity is needed since heat pumps are highly electricity intensive, and, 3) additional gas pipelines could be needed.

Our calculations suggest that heat pumps are efficient in Siberia under at a level 4 transformation coefficient[7], while they are efficient in the European regions of Russia under the transformation coefficient of level 5. This difference is explained by the fact that the electricity required to power the pumps is cheaper in Siberia than in the Western part of Russia.

The latest calculations carried out on the basis of the OMMM-Energy model were aimed at identifying the economically justified cost thresholds for installed RES electricity generation facilities. We have found that given estimate long-run *average* market conditions, this cost limit is about USD 2100 per 1 kW. At the same time, the obtained assessment of marginal cost of power appeared to be slightly lower than the average expected price on

[7] Transformation coefficient is a technical characteristic of *compression* heat pump technology showing a ratio of heat provided by an engine to the electricity consumed to run it; both of them measured in comparable units.

electricity generation from RES which in the State Program of the Russian Federation 'Energy efficiency and energy development' is established at the level of RUB 75 thousand per 1 kW. This fact proves that RES development in Russia requires special attention and support from the government.

7. Summary

1. In general, renewable energy sources are not currently competitive with traditional energy technologies which use abundant fossil, nuclear and hydro energy sources. It is therefore doubtful that RES in Russia will ever play a role as important as in Europe, Japan, North America, and elsewhere.
2. However, there exist certain favorable conditions for RES development. For example, an extremely large surface area provides opportunities for solar, wind, geothermal and small scale hydro resources. There are regions where RES based technologies are already competitive and as time goes by RES promises to become even more advantageous.
3. In order to facilitate RES development, the Russian government should develop and implement substantial measures to support energy production from RES. Current Russian legislation provides the possibility to set preferred feed-in tariffs, promises of government support for subsidized grid access, and obliges network companies to purchase all the RES produced (e.g. using green certificates).
4. The main reason why current institutional regulations are not working well is an extremely lengthy and expensive certification procedure. As a rule, local grids are reluctant to connect to RES plants due to their unstable character and law quality energy.
5. Electricity and capacity supply contracts, which guarantee investment return on a competitive basis, would help greatly to promoting RES, but the required legislation has not yet been developed.

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WAYS TO IMPROVE ENVIRONMENTAL POLICY IN RUSSIA*

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1. Introduction

The latest world economic crisis made quite evident the full measure of the scantiness and frailty regarding the existing world economic model. Ignoring the social and ecological aspects of development as well as stereotypes of maximum consumption standards has led to a crisis coupled with global negative consequences. The modern type of economic development can be characterized as technological. This type of development has distinctive features such as exhaustion and over-exploitation of natural resources, enormous pollution and waste products, as well as economic damage caused by environmental degradation.

Clearly, environmental issues are very important for Russia as it is one of the most polluting countries in the world. Russia accounts for 13% of total world emissions of major hazardous substances (solid substances, sulphurous oxide, nitrous oxide and carbonic gas). Nonetheless, the Russian economy spends intolerably little on these goals. The proportion of environmental protection investment in total national investments is about 1.2%-to 2.6 % per year, in comparison with developed countries where this figure ranges from 6% to 25%. The growth rate of Russian environmental protection investment in 2013 constituted 76.2% of the 1995 level. The growth rate of the current environmental costs in 2013 constituted only 38.5% of the 1995 level. This situation in the field of environment protection costs has determined the dynamics of employing the production facilities for sewage treatment, trapping and liquidation of hazardous substances in waste gases. For example the amount of environment equipment put into operation is being reduced. For instance, if in 1990 the capacity of facilities put into service for sewage treatment amounted to 2 million cubic meters per day, in 2011 it was only 0.7 million cubic meters per day. In addition to that, installations for trap-

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ping and liquidation of hazardous substances in waste gases accounted for 16.4 million cubic meters per hour in 1990 and 9.7 million cubic meters in 2011. So, there is obviously a necessity of increasing ecological expenditures.

2. Russian pollution taxes

The fundamental question is where we should find additional financial sources to improve the environmental situation in the country. First, it is necessary both to increase centralized investments and create incentives for enterprises to construct environmental protection facilities. The main task is to improve the economic mechanism of environmental management. Our ecological legislation is not perfect. Enterprises find it more profitable to emit harmful substances rather than invest in pollution abatements. According to the opinions of the leading economists and ecologists, ecologization of the tax system is necessary. The current level of pollution taxes does not provide for the necessary amount of investment or cover current expenditures for the purpose of pollution abatement. To make matters worse, pollution taxes are declining quickly in real terms because of inflation. In 2011 costs increased from the level of 2003 by 2.83 times, whereas the index of pollution taxes was only 193%. In developed countries there is currently an increase in the rates of environmental taxes with the collected amount being 1% of GDP (in Russia it is 0.03%-to 0.04 % of GDP), despite the fact that the standards of pollution charges are 10–to 100 times higher for various ingredients (see Table 1).

Table 1 – Pollution taxes for SO_2 and NO_x (euro per ton) in 2005.

Country	Pollution taxes	
	SO_2	NO_x
Czech Republic	28	22
Estonia	3,52	8,5
Poland	85	85
Slovakia	22,7	18,2
Slovenia	14	-
Finland	17,1	-
France	27,4	38,1
Italy	53,2	105
Russia	2,6	5,5

The current system of pollution taxes needs to be refined and improved to develop standards for environmental charges. Modern economic science has developed several approaches.

The *first approach* suggests that payments for pollution should be based on an economic assessment of the damage due to contamination. Damage assessments should provide an evaluation of direct and indirect economic and environmental losses in monetary terms as a result of negative environmental impacts. However, the implementation of this approach entails certain difficulties due to the lack of agreed methods to assess damages. In a number of studies an attempt was made to provide such an evaluation which showed that at present enterprises in the Russian economy cause environmental damage to such an extent that they are not able to compensate for it. According to the results of research conducted at the Institute of Economic Forecasting of the Russian Academy of Sciences, the overall damage to Russia's environment is over 10%.

The *second approach* is based on assessing the ability of society to allocate resources for activities to protect the environment. The total amount of environmental charges is determined by the amount of environmental costs in the previous years and the forecast of their possible and appropriate growth. All estimated payments are distributed among the polluting industries in accordance with the amount of damage, taking into account the harmfulness of pollutants and the local environmental situation. In practice it is the second approach which is applied in Russia now.

The *third approach* is based on the estimation of costs needed to avoid environmental protection expenditures. This approach currently has no obvious practical application because of the difficulties in the assessment of such expenditures.

The *fourth approach* allows for calculating the size of pollution taxes based on the value of net resources required to clean up polluted resources, making it possible to bring the contents of the resource pollutants to the level of a maximum permissible concentration. This method is almost out of use due to its complexity (for example, it cannot be applied for air).

The third approach has been used by researchers of the Institute of Economics and Industrial Engineering of the Siberian Branch of the Russian Academy of Sciences (Institute of Economics and IE SB RAS) to estimate the necessary size of pollution taxes.

3. A dynamic input-output model of the Russian economy with an ecological block

The method considered in this paper makes it possible to avoid the main difficulties in the implementation of the third approach, i.e. it enables estimation of the costs of preventing pollution of water and air resources. The assessment of the environmental protection costs was carried out according to the results of predictive calculations using the dynamic input-output model (DIOM) of the Russian economy with an environmental protection block (EP block). This model complex has been developed in the Institute of Economics and IE SB RAS. Fig. 1 presents a brief scheme of this model complex.

In addition to n elements which denote the traditional sectors of the economy, m elements which represent natural resources, are allocated here. A one-to-one correspondence is expected between each of these elements and the areas of environmental protection (air protection, water conservation, etc.). At this stage of our research, one natural resource is studied – atmospheric air. For environmental activity, reproduction processes of the main environmental funds and the formation of environmental costs are modeled into the DIOM (Dynamic Input-Output Model). The EP block describes the tangible indicators of ecological processes. The pollutants generated during the production process, is determined by the amount of manufactured goods in the traditional sectors of economy (X_i). Thus, this model system allows us to forecast the level of pollution formation in industrial production depending on the economic development of Russia with the help of coefficients of pollution generation per unit of gross production output. Estimates of expenditures for reducing air pollution help determine volumes of pollution trapping. The difference between formation and pollution trapping gives us the amount of emissions.

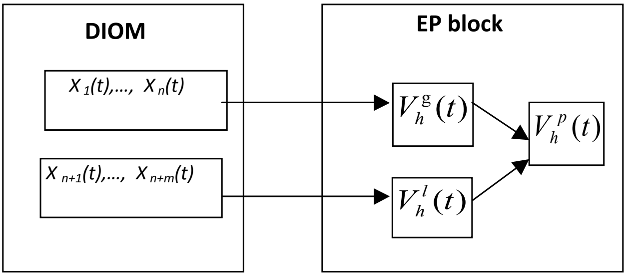

Figure 1 – A brief diagram of the DIOM with an EP block.

This is a description of the EP block:

$x(t) = (x_1(t),\ldots,x_n(t),x_{n+1}(t),\ldots,x_{n+m}(t))$ – vector of gross outputs, where

$x_i(t)$, $i = 1,\ldots,n$: gross output of industry i in the year t
$x_{n+h}(t)$, $h = 1,\ldots,m$: current environmental protection cost for natural resource h

The level of pollutants generated in the production process is described by the formula:

$$V_h^g(t) = \sum_{i=1}^{n} w_{ih}(t)x_i(t) + D_h(t), \text{ where}$$

- w_{ih}: coefficient of pollutant *h* generation (amount of polluted natural resource *h*, referring to the manufacturing of a unit of production of industry *i*);
- D_h (t): output of pollutant *h* (volume of pollution or destruction of a natural resource) in a household.

The amount of current environmental protection costs for natural resource *h* or product of environmental protection industry *h* is determined by the equation:

$$x_{n+h}(t) = \sum_{i=1}^{n} v_{ih}(t)V_{ih}^{1}(t), \quad V_{h}^{1}(t) = \sum_{i=1}^{n} V_{ih}^{1}(t), \quad \text{where}$$

- v_{ih} (t): current cost to recover a unit of natural resource *h* (to destroy or to trap a unit of pollutant *h*) in industry *i*;
- $V_h^1(t)$: the amount of a recovered natural resource (liquidated or trapped pollutant) of type *h*.

The amount of pollutant h (a polluted natural resource), which gets into the natural environment without purification (or by volume of destroyed but not reproduced natural resource), is described by the formula:

$$V_h^p(t) = V_h^g(t) - V_h^l(t).$$

A more detailed description of the economic and ecological units of the model complex is given in the paper [1].

4. *Results of forecast calculations*

The model calculations were based on several scenarios of Russia's economic development in the period of overcoming the global economic crisis in 2013-2020. Tables 2 and 3 show indexes according one of these scenarios. Key factors which will influence Russian domestic markets are the positive consequences of Russia's joining the WTO in 2011, and the Sochi Olympic Games in 2014, and an effective monetary and fiscal policy. The dynamics of key indicators that will affect the Russian economy in 2013-2020 are shown in Table 2.

Table 2 – Forecast key factors of national economy in Russia in 2014-2020.

	2014	2015	2016	2017	2018	2019	2020
Urals price (in USD per barrel)	101.6	103.7	105.7	107.8	110.0	112.2	114.4
Change in GDP (in %)	+2.3	+2.5	+2.8	+3.0	+3.6	+3.9	+4.1
Change in M2 (in %)	+10	+10	+10	+10	+10	+10	+10

Table 3 – Forecast industry outputs in 2014-2020 (growth rate, %).

	2014	2015	2016	2017	2018	2019	2020
Agriculture	102.3	103.9	102.5	102.6	102.7	102.9	103.0
Coal	97.4	104.6	101.8	102.9	103.3	103.8	104.3
Oil	100.9	101.5	101.0	101.0	101.0	101.0	101.0
Gas	100.9	101.5	101.0	101.0	101.0	101.0	101.0
Other minerals	103.7	99.3	102.0	104.0	103.2	103.7	104.1
Food industry	101.6	103.0	103.6	103.1	103.3	103.4	103.5
Light industry	102.2	101.7	104.6	104.8	104.7	105.2	105.6
Logging, wood-working, pulp and paper industry	96.9	91.7	95.4	97.5	96.7	97.3	97.7
Oil products and coke	103.8	102.4	102.0	103.0	102.6	102.6	102.7
Chemical and petrochemical industry	106.5	100.8	105.8	107.7	107.1	107.8	108.3
Other non-metal mineral products	100.8	100.4	100.8	102.8	101.8	102.4	102.9
Metallurgy	99.5	96.4	102.5	101.8	102.0	103.0	103.8
Metal-working industry	101.9	99.0	103.9	104.9	104.5	105.3	105.8
Machine-building industry	104.1	95.8	99.8	105.1	102.9	104.1	105.0
Other products of industry	105.2	101.0	101.5	104.1	103.0	103.4	103.6
Power engineering	102.7	99.9	101.3	102.6	102.1	102.4	102.6
Collection, sewage treatment and distribution of water	102.7	99.9	101.3	102.6	102.1	102.4	102.6
Construction	103.7	102.2	96.4	100.4	98.5	98.5	98.6
Trade	105.6	105.7	102.3	104.3	103.3	103.4	103.4
Transport and communication	104.8	103.8	102.0	103.8	103.0	103.1	103.2
Services	103.0	104.4	101.4	103.7	103.0	103.3	103.6

At the first stage of calculations, Russia's environmental and economic developments, which were subject to increasing volumes of trapped air pollutants, were forecast up to 2020. In the area of air protection, the implementation of the prepared for signing so-called Bali Roadmap (BRM) was simulated (BRM was approved in December 2007 at the UN Conference on Climate Change, Indonesia, and requires developed countries to reduce greenhouse emissions to 60% of the 1990 levels by 2020). Although the document was sabotaged by many countries that are unwilling to be bound by any real commitment, its implementation will be useful for Russia. In 1990 Russian GHG (greenhouse gases) emissions were estimated at 39.599 million tons, and in accordance with the BRM requirements they have to be reduced to 23.760 million tons by 2020. Since greenhouse gases account for 76% of all emissions into the atmosphere, we can estimate the total volume of emissions for 2020 (31.263 million tons).

The estimate received as a result of predictive calculations of the amount of air pollutants produced by different industries and in the national economy as a whole, makes it possible to determine the dynamics of trapping air pollutants in the forecast period in accordance with the objective of BRM. Calculations based on the model complex allow for estimating the total amounts of current and investment expenditures in 2014-2020 (at 2011 prices) to ensure compliance with the specified environmental objectives, i.e. 652.062 billion rubles for the capture of atmospheric pollutants according to the forecast scenario.

Let us estimate the average regional rate of pollution tax and compare these results with those of similar existing rates. We shall proceed from the principle of cost recovery for the destruction of atmospheric pollution based on charges collected. Since records are maintained for a fairly large number of ingredients which enter the atmosphere, let us consider the problem of assessing environmental charges on the example of air-polluting nitrogen oxide, the reduction of emissions of which, along with other greenhouse gases, is assumed by BRM. Since the proportion of this substance among all pollutants in the atmosphere is 13.66%, we will proceed from the corresponding share in the total costs of its capture, i.e. 652, 062.1 million rubles x 0.1366 = 89, 0717.7 million rubles at 2011 prices. These costs were distributed by the federal districts in proportion to the current regional cost structure for the protection of air resources (Table 4, column 1).

Column 2 in Table 4 shows the projected total volumes of regional emissions of nitrogen oxide in 2014-2020 (for all of Russia it is 13.66% out of 186.997 million tons of emissions of air pollutants, that is, 25.544 million tons). We compare the pollution taxes which are estimated based on predictive calculations (column 3 in Table 4) and obtained by dividing the data from column 1 by the data in column 2, with real payment rates at 2011 prices given in column 5. According to the Government Decree of the Russian Federation № 344 of June 12, 2003, the average standard payment for emitting nitrogen oxide is 218 rubles. We used the inflation index of ecological payment (1.93 in 2011 to the level of 2003) and obtained the average standard payment for emitting nitrogen oxide at 2011 prices – 420.74 rubles. Given the lower and upper boundaries of the regional coefficients of the environmental situation and environmental significance (column 4 in Table 4), this base rate of payments was differentiated by the federal district (see column 5 = column 4 x 420.74 rubles). It is obvious from Table 4 that in all federal districts, even the upper limits of the existing rates do not coincide with those in the forecast of the required size of payments for air pollution with nitrogen oxides. In addition, forecasts of payments are more differentiated depending on the environmental situation in each district compared to the actual standards.

Table 4 – Real and model-calculated regional norms of payment for NO_x in 2014-2020 (2011 prices).

	Total environmental cost in 2014-2020 (million Rbl)	Total emission in 2014-2020 (thou tons)	Forecast payment norms (Rbl per ton)	Lower and upper boundaries of the regional coefficients of the environmental situation	Real payment norms (Rbl per ton)
	[1]	[2]	[3]=[1]:[2]	[4]	[5]=[4]x420,7
Central FO	16751.9	2130.1	7864	1.12-1.21	471-509
North-West FO	10266.7	3056.5	3359	1.06-1.33	446-559
South FO	3912.0	843.8	4636	1.23-1.46	517-614
North-Caucasian FO	1213.5	182.6	6646	1.23-1.46	517-614
Privolzhskiy FO	19031.2	3509.7	5422	1.14-1.21	479-509
Ural FO	18093.7	6832.8	2648	1.07-1.18	450-496
Siberian FO	13872.9	7889.8	1758	1.02-1.13	429-475
Far East FO	5929.8	1098.4	5399	1.00-1.20	421-505
Russia	89071.7	25543.7	-		-

5. Conclusion

Thus, the results of the calculations make it possible to assess the extent of increases in payments for environmental pollution in Russia which correspond to world practice. Although most Russian economists and ecologists recognize the need to increase pollution taxes, many oppose this measure, citing the inability of enterprises to pay higher fees for pollution. Of course, the improvement of environmental legislation should occur in a complex interactive way along with improving of the entire tax system. In particular, it is proposed to aim fiscal policy at solving environmental problems with a general decline in direct taxes. In addition, in order to reduce the tax burden, a practice of granting tax reliefs and other financial incentives should be more widely used (offsets of environmental payments in the amount of the environmental costs incurred, provision of favorable loans, state guarantees for environmental loans, schemes of accelerated depreciation of environmental capital stock) to stimulate the implementation of advanced technologies, unconventional energy types, the use of recycled resources and waste management, as well as the implementation of other effective measures to protect the environment. All these measures are obviously an effective means of economic and environmental procedures.

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A PROCEDURE FOR SHOCKING THE SAFRIM MODEL TO CALCULATE THE MACRO-ECONOMIC IMPACT OF GREENHOUSE GAS MITIGATION ON THE SOUTH AFRICAN ECONOMY

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Abstract

In building an econometric model, specifically in this case, the identification of the model framework and the specification of the equations of an INFORUM model receive ample attention in the literature and at conferences. The use of the INFORUM model for forecasting purposes is very clear. However, the identification and the discussion of how an INFORUM model is activated for macro-economic impact analysis is generally lacking. For example, if the impact of a major project, which has forward and backward linkages needs to be calculated, it is not always so clear as to how and where to stimulate the model. The objective of the paper which is to be presented at the 22nd INFORUM World Conference by the authors is to discuss how the South African INFORUM model (SAFRIM) was activated for optimizing greenhouse gas (GHG) emission mitigation options in South Africa.

Currently, the South African economy is mainly operating under the principles of a free market. It can therefore be accepted that the use of scarce resources (labour, capital, natural resources, etc.) is to a great extent applied optimally when financial and economic principles are used as the criteria for optimum growth and development. However, it is also generally accepted that the free market concept has shortcomings, specifically in terms of long-term sustainable economic growth and development as far as its ability to conserve the environment is concerned. To conserve the environment it is necessary that government intervene in certain circumstances to eliminate or reduce the negative environmental impacts of a free market economy. Unfortunately these GHG emission mitigation interventions could have major structural and accompanied price increase effects on the economy which inhibits economic growth and employment creation.

The application of the SAFRIM model is therefore, to assist the decision makers in identifying the GHG emission mitigation options which to a large extent limit the negative impacts on the economy and even in

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certain cases obtain a double dividend namely to limit GHG emissions but still increase the economic growth and employment in the long-term.

Keywords: *INFORUM, Greenhouse Gas Emissions, SAFRIM*

1. Introduction

The most important aspect of a macro-economic impact analysis is the construction of an appropriate model which entails defining the basic underpinnings of the framework of the model, estimating the regression equations (representing important economic functions), and setting of other coefficients and ratios that form an intrinsic part of the model. However, another vital step is developing the methodology and parameters to practically activate the model to calculate the economic impact of a specific programme or project.

The main objective of this paper is to explain how the South African INFORUM Model (SAFRIM) was used to quantify the macro-economic impact on the South African economy of potential opportunities for greenhouse gas (GHG) mitigation. Both the environment as well as economic development is of great importance for South Africa (National Planning Commission for 2030). It is therefore important to compare the positive results of various policies have on the reduction of greenhouse gas emissions with the cost that these reduction opportunities on economic growth and employment.

The structure of the paper is as follows:

- description of the Case Study – South Africa's Greenhouse Gas Emissions Potential Mitigation Analysis;
- overview of the South African INFORUM model (SAFRIM);
- activating the SAFRIM model;
- results of the Case Study;
- conclusions.

2. Description of the Case Study – South Africa's Greenhouse Gas Emission Potential Analysis

The South African economy has industrialized, mainly on the basis of energy-intensive industries helped along with low-cost, coal-fired electricity generation. As a consequence, the country's absolute and per capita greenhouse gas (GHG) emissions are high in comparison to many developing countries. About 83% of South Africa's GHG emissions are derived from energy supply and consumption in comparison to an average of 49% among other developing countries.

Like many developing countries, South Africa also faces a number of social, economic, and environmental challenges. Consequently, South

Africa's approach (Greenhouse Gas Mitigations Potential Analysis, 2013) to mitigating climate change seeks to strike a balance that will enable the reduction of GHG emissions (voluntarily as a good global citizen), whilst maintaining economic competitiveness, realizing the developmental goals, and harnessing the economic opportunities that accompany the transition to a lower carbon economy.

As a responsible global citizen and with both moral and legal obligations under the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol (Kyoto Protocol, 1997), South Africa is committed to contributing its fair share to global GHG mitigation efforts in order to keep global temperature increases below 2°C.

The overall objective of this study has been to present a set of viable options for reducing GHGs in key economic sectors. These sectors were defined as:

- Energy;
- Industry;
- Buildings;
- Mining;
- Transport;
- Waste; and
- Agriculture, Forestry and Other Land Use (AFOLU).

In the table below, a few examples describe what the various sectors are composed of plus proposed measures:

These mitigation opportunities were defined as physical actions that can be taken to reduce or prevent GHG emissions from a given source. For example, this can constitute the implementation of technology improvements within an industrial process or individual industrial facility (e.g. replacement of an inefficient furnace).

A basket of mitigation opportunities were chosen in collaboration with the private sector in South Africa. For all the mitigation options, the financial cost impacts have been assessed against a counter-factual: the existing situation against which a new measure is compared. For example, in considering the water impact of a wind farm, what is of interest is the volume of water used by wind farms compared to the volume used by current power generation mix (primarily coal fired power) for the same level of power generated.

Note that cost was assessed on a Life Cycle Basis. This means that both capital costs associated with construction and de-commissioning (where relevant within the time period) and on-going operating costs were included.

The cost was evaluated on a Net Present Value basis; in other words with future costs discounted at a real rate of 11.3%. The macro-economic impact of the mitigation opportunities were based primarily on these costs (economic surplus) as will be explained later in the paper.

Table 1 – Examples of the composition of the sectors outlined above.

Main Sector	Key Sector	Subsector	Measure
Energy	Energy	Petroleum Refining	CCS - Existing Refineries
	Energy	Petroleum Refining	Energy monitoring and management system
	Energy	Coal Mining	Coal mine methane recovery and utilisation for power and/or heat generation
	Energy	Coal Mining	Process, demand & energy management system
	Energy	Electricity and Heating	Nuclear (PWR)
	Energy	Electricity and Heating	Gas CCGT
Industry	Industry	Primary Aluminium Production	Best process selection for primary aluminium smelting
	Industry	Primary Aluminium Production	Switch to secondary production and increase recycling
	Industry	Ferroalloys Production	Implementing best available production techniques
	Industry	Ferroalloys Production	Replace submerged arc furnace semi-closed with closed type
	Industry	Iron and Steel Production	BOF Waste Heat and Gas Recovery
	Industry	Iron and Steel Production	Top Gas Pressure Recovery Turbine
	Industry	Cement Production	Improved process control
	Industry	Cement Production	Reduction of clinker content of cement products
	Industry	Lime Production	Installation of shaft preheaters
	Industry	Lime Production	Replace rotary kilns with vertical kilns or PFRK
	Industry	Chemicals Production	CCS for new ammonia production plants process emissions
	Industry	Chemicals Production	Revamp: increase capacity and energy efficiency
	Industry	Surface and Underground Mining	Use of 1st generation biodiesel (B5) for transport and handling equipment
	Industry	Surface and Underground Mining	Improve energy efficiency of mine haul and transport operations
	Industry	Pulp and Paper Production	Convert fuel from coal to biomass/residual wood waste
	Industry	Pulp and Paper Production	Application of Co-generation of Heat and Power (CHP)
	Industry	Residential	Energy efficient appliances
	Industry	Residential	Geyser Blankets
	Industry	Commercial/ Institutional	Efficient Lighting
	Industry	Commercial/ Institutional	Heat pumps - Existing Buildings

Main Sector	Key Sector	Subsector	Measure
Transport	Transport	Road	Road - Alternative fuels - CNG
	Transport	Road	Road - Improved efficiency - Petrol ICE
	Transport	Rail	Rail - Improved efficiency - EMUs
	Transport	Rail	Rail - Improved efficiency - Diesel
	Transport	Aviation	Aviation - Biofuels
Waste	Waste	Municipal Solid Waste	Paper recycling
	Waste	Municipal Solid Waste	Energy from waste
Agriculture, Forestry and Other Land Use	AFOLU	AFOLU	Expanding plantations
	AFOLU	AFOLU	Rural tree planting (thickets)

3. Overview of the South African INFORUM model (SAFRIM)

Quantifying the total macro-economic impact of the greenhouse gas mitigation measures was accomplished using the SAFRIM model (Mulder 2006). The main purpose of giving an overview of the SAFRIM model is to better explain how the model was activated.

As you all know, the INFORUM modelling system is macro-economic, dynamic, and multi-sectoral in nature. It depicts the behaviour of the economy in its entirety (i.e. the workings of all the major markets in their inter-related, dynamic existence are accommodated). It therefore lends itself to projecting aggregate gross domestic product (GDP) and all its components as well as the demand categories that determine GDP instantaneously and dynamically.

Another important feature of this macro-economic multi-sectoral model is its bottom-up approach. Using this method, the model mimics the actual workings of the economy in that the macro-economic aggregates are built up from detailed levels at the industry or product level, rather than first being estimated at the macro-economic level and then simply 'distributed' amongst sectors.

The INFORUM system is dynamic from the outset, allowing for projections of the economy as well as to calculate the macro-economic impact of an intervention in an economy such as a programme or new project. Therefore, macro-economic and dynamic multi-sectoral models are well suited for forecasting the baseline projection.

Figure 1 below depicts the dynamic and inter-related workings of SAFRIM. A description of each variable that has to be estimated is shown.

- The model 'loop' begins on the production block side, where the expenditure components on GDP (supply side) are estimated in constant prices. Next, the personal savings propensity is applied to calculate what portion of total household real disposable income will be spent on consumption. From this total figure, the distribution of per-capita consumption expenditures per income group is calculated.

- Exports are usually calculated outside the model (i.e. exogenously) given the dependence of exports on international economic conditions if it used for general forecasting. However, if it is used for macro-economic impact analysis, the model is structured in such a way that exports are endogenous based on world demand as well as relative prices (South African prices relative to the prices of South Africa's trading partners). The investment equations model the substitution (or complementarity) of capital equipment with labour and energy. The scarcity of capital is taken into account as explained above.
- Government consumption and investment expenditures are normally determined outside the model. At this point, after all the final demand categories (except for imports and inventory change) have been estimated, an input-output mathematical solution is applied to jointly and simultaneously determine output, imports, and inventory change.
- Next, the model turns to the important job of forecasting prices at various levels. To start off, all components of value added are calculated, of which the important one is the hourly labour compensation rate by industry, called the 'wage rate'. However, as indicated above, the wage rate is dependent on the availability of appropriately-skilled labour. By multiplying the wage rate with the total hours worked, total labour remuneration per industry is obtained.
- Labour remuneration is the largest component of national income, usually about 60%, and certainly has a major effect on prices. However, it is also important that the various components of capital remuneration are taken into account. Private enterprise gross profits are needed to be able to calculate a number of aggregates namely company taxes, retained earnings, and depreciation of capital assets which make up business savings, which together with personal savings heavily impacts the savings-investment equation in the economy. Furthermore, dividends, proprietors' income, interest income, and rental income generated in the private sector all ultimately contribute to personal income.
- To calculate prices, value added by industry is summed to total value added, and then passed through a product-industry bridge, to obtain value added per product. Once value added at the product level has been obtained, commodity prices are calculated. The import content of intermediate consumption is taken into account here.
- The deficit on the current account of the balance of payments before and after the implementation of the mitigation option was taken as a benchmark to ensure that the economic models adequately capture the need to borrow for and pay back the capital investments. For instance, if the deficit on the current account of the balance of payments amounts to 6% of the GDP in the base case scenario, meaning no changes to the existing energy policies, then for controlling purposes

the deficit in the current account of the balance of payments should not deviate from 6%. This was achieved by increasing or decreasing the prime interest rate.

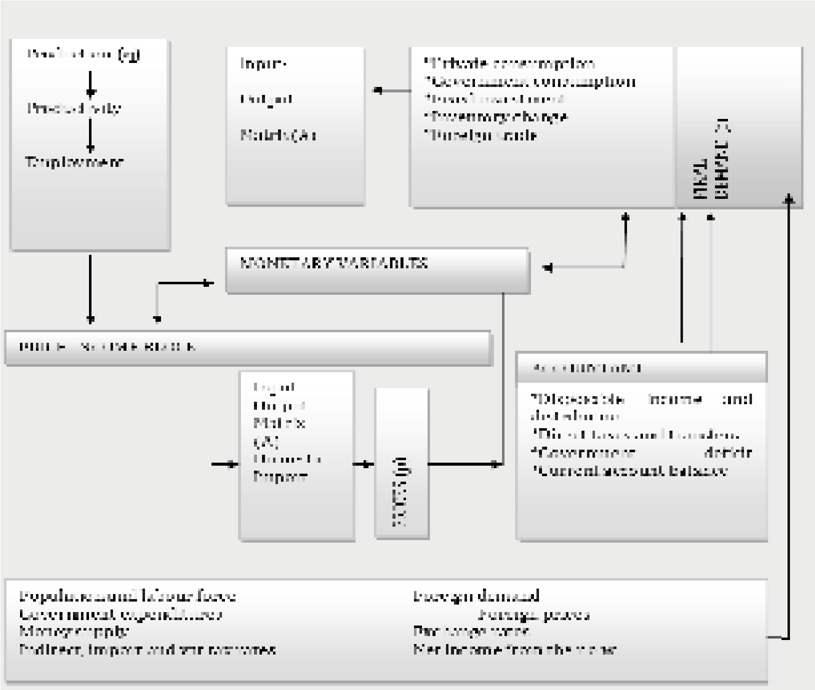

Figure 1 – Dynamic and inter-related workings of the SAFRIM Model.

4. Activating the SAFRIM model

To be able to analyse the macro-economic impact of the GHG mitigation measures, it is essential that a baseline growth forecast of the South African economy should be established. The following section provides information on how a long-term (base) forecast of the South African economy was accomplished.

4.1 Forecasting the Baseline Scenario

It is important to note that the projection of the economy is done over a very long period which stretches the limits of a standard dynamically orientated econometric forecasting model. The assumptions that are usually applied to modelling, such as monetary variables (i.e. interest rates and money supply) as well as short term price fluctuations, which are normally imperative for short- and medium-term forecasting are not that significant in this case. The long-term forecast is much more driven by expected structural developments in the South African economy, specifically regarding the potential of certain sectors ability to export over the longer-term, such as the long-term sustainable exports of iron ore, magnetite, chrome, coal, etc. It is also assumed that South Africa would play a much larger role in the African economy, and will be less dependent on its traditional trading partners, such as Europe and the United States of America. This will also change the structure of international trade, where South Africa will become more dependent on exports of manufacturing goods and services; and less dependent on exports of primary and less processed commodities.

Specific information regarding Transnet's Capital Investment Programme over the medium to long term was also used to get an indication of the export potential of certain sectors (Transnet 2013). However, this information emphasized that a substantial increase in harbour and railway capacity would serve as an essential prerequisite to unlock these resources.

On the other hand, the diminishing role of gold and diamonds in the future development of the economy was also taken into account. Furthermore, fundamental economic imperatives/rules were built into the forecasting scenario, which includes the following aspects:

- there should be an acceptable measure (not exceeding ±4% of the GDP) of balance on the current account of the balance of payments;
- no fundamental obstructions to obtain foreign capital;
- positive growth of the world economy; and
- South Africa's population growth by taking into account the negative effects of HIV/AIDS.

GHG emissions projections developed under this study are based on a targeted level of future economic growth based on the 'moderate growth rate' defined by National Treasury and published in the 2012 draft Integrated Energy Plan (Department of Energy 2013). The projection of moderate growth assumes that the economy will grow steadily, with continued skills constraints and infrastructure bottlenecks in the short- to medium-term. The moderate growth scenario forecasts real growth in Gross Domestic Product (GDP growth) of 4.2% per annum over the medium-term (defined in the draft Integrated Energy Plan as 2015-2020) and 4.3% per annum over the long-term (2021-2050), according to the 2012 Medium Term Budget Policy Statement (National Treasury 2012).

This growth rate could currently be viewed as somewhat on the high side if structural challenges in South Africa, such as the improvement of education; poverty alleviation; and enhancement of income distribution, are taken into account. It is also important to note that the South African economy has grown on the order of 3% to 3.5% since the advent of full democracy, well below the medium growth target of ±4%. A summary of the assumptions for the medium growth scenario are depicted in the Table 2.

Table 2 – Assumptions for the Medium Growth Scenario.

	Input Variable	Parameter Value	Source and Explanation
1	South African population		National Development Plan 2030.
	currently	1,00%	Conningarth increased the population growth to about 2% p.a. over the period.
	long-term, declining to 0.5% by 2030	0,50%	
2	South African inflation targets (SARB objectives between 3.0% and 6.0%)	6,00%	Conningarth Economists.
3	World prices/inflation	3,00%	World Trade Organization (WTO) (short to medium term forecast).
4	Final consumption expenditure by government	3,90%	Conningarth Economists, underpinned by the National Development Plan, 2030. Role of government in South African economy should be in-line with economic growth.
5	Business cycle		Conningarth Economists.
	2013 to 2014	average	
	2015 to 2018	above average	
	2021 to 2025	below average	
	all other years	average	
6	Exchange rate per annum (depreciation of the real effective Rand exchange rate)	-1.7% p.a.	A Manual for Cost Benefit Analysis in South Africa with Specific Reference to Water Resource Development (TT305/07). This real 1.7% is over and above the purchasing power parity theory which means that the Rand will depreciate against its trading partners with this real percentage plus the difference between South African inflation and the inflation of its main trading partners.
7	World economic growth		OECD Economic Outlook Volume 2012/1.
	2013	3,30%	
	2014	4,00%	
	2015 to 2023	4,50%	
	2024 to 2052	4,00%	
8	Current account of balance of payments as percentage of GDP	3,60%	Conningarth Economists. Assumption is based on 10 year average of SARB bulletin. As a rule of thumb, this ratio should be in the order of net domestic investment as percentage of GDP.

4.2 Methodology to activate the model

In broad terms, the impacts of the GHG mitigation measure can be divided into so called backward linkages, forward linkages, as well as balancing the economy according to certain constraints.

4.2.1 Backward Linkages

The backward linkages refer to the economic impact on other sectors of the economy if a specific sector increases its production. This may be expected to translate into a rise in the demand for raw materials, other intermediate inputs, and the remuneration of labour and capital inputs.

The backward linkages originate from two main sources, namely during the construction phase of a project and when the project becomes operational. The construction phase actually entails the establishment of capital assets. For example, in order to generate electricity, a power station (a very substantial capital asset) has to be constructed, which in itself creates economic activities through, for example, additional employment opportunities. The operational impact refers to the creation of economic activities driven by the production process. For instance, generating electricity requires the purchase of raw materials such as coal and the paying of salaries and wages on an on-going basis.

Backward linkages can also change the production structure of the economy due to the implementation of a particular mitigation option, which should therefore be taken into account. For example, if renewable energy options are introduced in lieu of coal-fired power stations, the structure of the economy is altered. Such an event will reduce the need for new coal mines (or extend the life-span of existing ones) which can have a significant negative effect on employment opportunities in that sector.

A technical discussion of how the model was activated for the various backward linkages will follow now:

A. Construction phase (investment impact)

For the construction phase, the model was activated on the following final demand identity (constant prices).

$$fdc = pcec + invc + govc + exc - imc + fdrc + trcc + capex\_tot \qquad (1)$$

Where:
fdc: total final demand
pcec: private consumption expenditure
invc: investment (investment excluding investment in the mitigation measures)
govc: government
exc: exports

imc: imports
fdrc: residual
trcc: transfer costs
capex_tot: total net investment of the various mitigation measures

The investment related to the various GHG mitigation measures were added in the variable capex total on an annual basis over the period 2010-2050. Certain measure's investment is a net figure. For instance, electricity is needed, but can be supplied by the traditional method of coal power stations or by a nuclear power station. The net investment is therefore the results of the investment of the nuclear power station minus that of the coal power station. The investment was broken down to the various assets/commodities (e.g. construction, machinery, and other equipment, transport equipment, etc.) structure of each GHG mitigation measures.

B. Operational impact

The following production formula was used to activate the model for the operational impact (constant prices) on the various economic sectors.

$$outc = (!(I\text{-}AMC) * fdc) + oper\_imp \qquad (2)$$

Where:
outc: total output (production)
! (I-AMC): inverse matrix
fdc: total final demand
oper_imp: total net operational impact of the various mitigation measures

The total net operational impact of the various mitigation measures are added to the production function that is calculated by adding it to the function outc = (!(I-AMC) * fdc). The operational impact is added on a detail sector basis per annum.

C. Changes in the production structure

The default is that the SAFRIM model applies the current structure of production in the country. However, in some cases the large scale of change associated with the mitigation measures will change the structure of production. For this study, the impact on the economy's structure was only incorporated in the case of the energy sector both because of its importance and because of the scale in the shift away from coal-based energy generation measures. These structural changes were made primarily to reduce the importance of coal mining in the South African economy as the increased role of renewables and nuclear power in future will reduce the country's dependence on coal-based power and hence the need to mine coal.

The A matrix, was adjusted on an annual basis to accommodate the changes in the production structure to take into account the influences of the various mitigation measures.

4.2.2 Forward Linkages

In this instance, the forward linkage effect refers mostly to the impact that a specific mitigation option has on the overall competitiveness of the economy. In some cases, the mitigation option's effect can be counterproductive to what is currently in effect and in other cases it is more positive. This effect is largely reflected in the prices of the goods and services produced by a sector, which could have an effect on the international competitiveness of the country. Depending on the price elasticities of the demand for local products, this in turn could have an effect on local production and employment.

The model is activated by the net cost impact on a specific sector's unit production costs. It also rests on the assumptions that if a sector's product price increases/decreases because of the increase/decrease in production cost, this will decrease/increase the price competitiveness of the sector. As such, the price effects are to some extent also determined by the supply-side constraints introduced in the model.

D. Price impact

The additional cost or savings brought about in the economy by the introduction of GHG mitigation measures is added into the model by increasing the value added (current prices) factor per sector where applicable. The identity below explains where it is added in the model.

$$va = lab + gos + itprd - isprd + itprs - isprs + enviro \qquad (3)$$

Where:
va: total value added
lab: compensation of employees
gos: gross operating surplus
itprd: indirect taxes on production
isprd: indirect subsidies on production
itprs: indirect taxes on products
isprs: indirect subsidies on products
enviro: additional costs or savings brought about in the economy by the introduction of GHG mitigation measures.

The next function shows how value added impacts prices in the economy.

$uc = va/outc$ (4)

Where:
uc: value added unit cost
va: value added
outc: output/production (constant prices)

The value added unit cost is calculated by dividing value added by the output of a sector.

$tot\_uc = impr + uc$ (5)

Where:
tot_uc: total unit cost
impr: import unit prices
uc: total value added unit cost

This is an interim step whereby the total unit cost is calculated by adding the import unit price to the unit cost.

$ppi = (tot\_uc) * DPINV$ (6)

Where:
ppi: producer price index
tot_uc: total unit cost
DPINV: domestic price inverse

This formula is calculating the total domestic price (*ppi*) by multiplying the total unit cost by the domestic price inverse.

4.2.3 Balancing constraints

A technical adjustment to the model was necessary to ensure that the empirically measured impact of a mitigation option can be factually compared to a counterfactual outcome. For these purposes, the deficit on the current account of balance of payments as a percentage of the country's overall economic activity (GDP) was taken as a controlling measure demonstrating the ability of the economy to financially carry the burden of a particular mitigation option. For instance, the deficit on the current account of the balance of payments amounts to 6% of the GDP in the base case scenario, meaning no changes to the existing energy policies, then for controlling purposes the deficit in the current account of the balance of payments was constrained to 6%.

In terms of National Accounting Theory, a deficit on the current account of the balance of payments (exports less imports) must be equal to

Table 3 – GDP impact analysis by sector. Average GDP Impact over the period (2010-2050)

Name	Incremental impact						Dynamic impact		Split
	Backward Linkage Impact				Forward Linkage Impact	Net Incremental Impact	Dynamic impact providing for balance of payment adjustment		
	Additional (Net) Investment Impact	Additional (Net) Operational Cost	Impact due to change in Production Structure	Total Backward Linkages	Impact due to Price Change		Impact Before Balance of Payments Adjustment	After Balance of Payments Adjustment	Final dynamic impact
Energy	23488	21461	-5493	39456	-8173	31283	31748	21745	45%
Industry	4397	787	0	5184	160	5343	5403	2371	5%
buildings	1067	1	0	1068	4350	5419	5401	5401	11%
Other Mining	2248	2545	0	4793	2813	7607	7404	7404	15%
Transport	13685	-4345	0	9313	-807	8506	8533	8533	18%
Waste	861	1807	0	2668	-888	1780	1793	1793	4%
AFOLU	155	896	0	1052	-89	963	964	964	2%
Total	45874	23154	-5493	63535	-2634	60901	61246	48211	100%

Note: The difference between the net incremental impact and the dynamic impact (impact before balance of payments adjustment) can be ascribed to the fact.

the deficit on the capital account (savings less investment). Everything being equal, this implies that given the limited pool of the domestic savings, investment in some of the other projects would have to be adjusted downwards to make provision for the required investment and life cycle costs implied by the mitigation option(s). In cases where domestic savings are insufficient to meet the investment needs, the model, simulating the workings of a market economy, will use an increase in the real interest rate to restore equilibrium in the capital markets. The effect of this will be a decrease in overall domestic demand, therefore increasing savings and decreasing other investment (excluding investment in mitigation option in particular).

5. Results of case study

In this section the total macro-economic impact is presented. As already indicated, the impact on only two macro-economic variables has been modelled. They are Gross Domestic Product (GDP) and the impact on employment. Furthermore, only the dynamic impact, after taking into account the manual adjustment on the balance of payments in order to keep the economy's debt ratio at the same equilibrium point, prior to the initiation of the mitigation option, is discussed.

5.1.1 Impact on GDP

The net impact on GDP assuming 100% mitigation is achieved, (the impact of the assessment, minus the impact of the counterfactual) is presented in Table 3.

5.1.1.1 Discussion of GDP results

The analysis using the INFORUM model, incorporating all the mitigation measures applied on average over the programming period (the next 40 years) and taking the current year as the base year, GDP could increase by about R48 billion ($4.8 billion). This constitutes approximately 1.5% of current GDP.

In considering this 1.5% figure, the factors which influence the GDP to change both positively and negatively need to be considered. While backward-linked impacts are mostly positive (driven by capital expenditure and increased operating expenditure associated with the mitigation measures), the forward linkages often give negative GDP changes (driven by increases in relative prices).

The contribution of all the mitigation measures applied in each of the respective sectors to change in GDP is illustrated in Table 3 above. The Energy sector makes the greatest contribution, making up 45% of the overall change in GDP. The mitigation options within Buildings, Mining, and Transport also make significant contributions towards GDP growth.

Table 4 – Employment impact analysis. Results by sector. Average Impact over the period (2010-2050), Change in Number of Jobs.

Name	Incremental impact						Dynamic impact		Split
	Backward Linkage Impact				Forward Linkage Impact	Net Incremental Impact	Dynamic impact providing for balance of payment adjustment		
	Additional (Net) Investment Impact	Additional (Net) Operational Cost	Impact due to change in Production Structure	Total Backward Linkages	Impact due to Price Change		Impact Before Balance of Payments Adjustment	After Balance of Payments Adjustment	Final dynamic impact
Energy	67.243	40.106	-26.299	81.051	-46.741	34.310	40.510	-12.468	-13%
Industry	20.271	5.525	-	25.797	639	26.435	26.760	10.890	11%
buildings	5.914	7	-	5.922	23.863	29.785	29.687	29.687	31%
Other Mining	7.067	3.828	-	10.895	14.756	25.651	24.605	24.605	25%
Transport	46.709	-12.211	-	34.497	-4.179	30.318	30.455	30.455	31%
Waste	3.719	4.075	-	7.795	-4.878	2.916	2.983	2.983	3%
AFOLU	1.371	10.000	-	11.371	-501	10.870	10.869	10.869	11%
Total	152.294	51.332	-26.299	177.327	-17.041	160.286	165.868	97.020	100%

5.1.2 Impact on Employment

The net impact (the effect of the impact assessment, less the impact of the counterfactual) on employment of the various measures is illustrated in Table 4.

The total impact on employment, taken directly from the INFORUM model, is 97,000 jobs based on the standard figures in the model which uses the current structure of the economy in terms of labour intensity.

5.2 Final impact on Projection over Time

Figure 2 displays the trend over time, showing the projected marginal change in GDP in relation to the baseline figures.

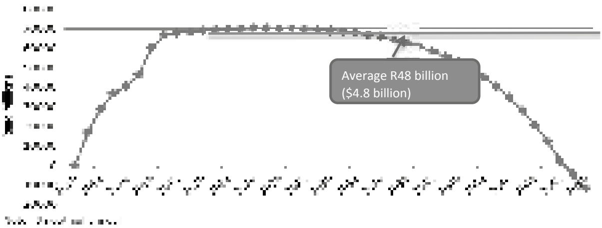

Figure 2 – Marginal impact on GDP.

The average marginal impact on GDP over the period is R 48 million ($4.8 million), with a peak of R 70 million ($7 million) in 2025. The marginal impact in 2010 is zero because no additional mitigation has been implemented yet at the beginning of the projection period.

Considering the shape of the curve, the initial incline over approximately 10 years is caused largely by the investments which are progressively implemented over this period. The decline after 2030 is related to two factors. First, most of the major investments have been made and the negative impacts of relative price increases are felt. Secondly, the measures implemented in the latter years tend to be those which are economically least favourable.

Turning to employment, the marginal increase in employment in relation to the reference case is shown below.

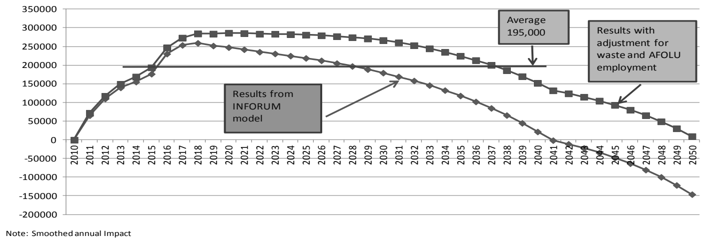

Figure 3 – Marginal impact on employment, assuming all mitigation measures are applied.

Assuming all technically-feasible mitigations are implemented, the overall impact on employment remains positive over the 40 year period, with an average of 195,000 additional jobs created between 2010 and 2050. As with GDP, the increase in the early years is largely driven by new investments. The declining trend of the marginal impact over time is caused due to the fact that several sectoral measures with lower employment benefits are included. But, on balance over the period, employment impacts remain positive; largely because of the labour intensive outcomes of the measures in the waste and AFOLU (Agriculture, Forestry and Other Land Use) sectors.

6. *Summary and Conclusions*

The main objective of this paper was to show how the macro-economic impact of a project or a programme with many facets could be quantified by the SAFRIM model. The use of the model was enhanced by making use of an actual assignment that Conningarth participated in. Specifically, results from the 'South African Greenhouse Gas Mitigation Potential Analysis', commissioned by the Department of Environmental Affairs of the Republic of South Africa, was beneficial.

As far as the results of this Case Study are concerned, the macro-economic impacts of the foreseen mitigation measures can be summarised as follows. Assuming current GDP and employment as a base, the increase in GDP is on the order of 1.5%, while employment should expand 1.2%. The 1.5% means that, on average over the programming period, the GDP will be 1.5% larger than what it is currently. With all mitigation measures included, it can be concluded that it will not have a major impact on the economy. Gains from direct employment and backward linkages are countered by losses due to forward linkage price effects; prices typically increase with increasing costs associated with implementing most measures, without a related gain in revenue.

It can be concluded that the South African INFORUM Model (SAFRIM) is structured in such a way that it enables the researcher to analyze and assess the GHG mitigation case study, to such an extent that the results can be accepted as reliable to a tolerable level of accuracy in terms of economic theory and practice. The proof hereof lies specifically in the fact that the impact of GHG could be decomposed into specific elements. The sign, positive or negative, of the results of the various components conform to expectations.

The INFORUM model also allows the simulation to be closed in terms of the deficit on the current account of the balance of payments (exports less imports) as percentage of GDP, which is also the same as the deficit on the capital account (savings less investment) as percentage of GDP. Before and after the simulation, the deficit on both accounts was therefore the same percentage of GDP. The effect of this was that a decrease or increase in overall domestic demand had to take place to bring the economy in equilibrium and therefore the simulation depicts results that conform to the criteria that the funding capabilities of the economy (overheating the economy) is not exceeded.

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DEMOGRAPHICS AND PERSONAL CONSUMPTION

DEMOGRAPHIC CHANGE AND CONSUMPTION PATTERNS IN THAILAND

Somprawin Manprasert[a]

1. Introduction

Thailand has become a country that consists of a rapidly aging population[1]. A projection from the National Economic and Social Development Board (NESDB), a government long-term planning agency, shows that the Thai population will actually start to decline in 2027. The Thai population in 25 years will be about 1 million persons less than the current population. In 2040, the proportion of elderly people will account for more than 30 percent of Thailand's total population, while children will account for only 12.8 percent.

Several factors have contributed to this trend. Thailand is one of the most successful stories of family planning in the world. Between 1972 and 1995, the population growth rate fell from 3.3 percent per year to 1.2 percent per year. The average number of children per Thai woman declined from 5.8 to 2.2 during the same period. Moreover, implementation of the Universal Coverage (UC) healthcare scheme in Thailand in 2001 has improved life expectancy significantly. From 2000 to 2012, male life expectancy increased from 67 to 71 years, while the female life expectancy increased from 75 to 78 years. Thus, a combination of successful birth control and extending the lifespan has led to this higher proportion of aged people in Thailand.

What are the implications of this aging population on the economy? In fact, the aging population will change the structure of the economy. On the supply side, the population aging leads to lower labor force growth which in turn drags down the long term growth of the economy. On the other hand, patterns of consumer demand will also change, because con-

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[1] This is defined as over 60.

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sumption baskets are different between age groups. Studies of the 'aging economy' and its implication are very important for policymakers. For instance, Ariyasajjakorn and Manprasert (2013) and Bisonyabut (2013) suggest that the aging society in Thailand may cut long term potential growth by as much as 1.0 to 1.6 percent per year. Moreover, in contrast to economies where the aging society emerges after achieving a high income level, population aging set in before Thailand advanced to developed country. Lack of substitute factors of production and insufficient advances in technological progress may lead Thailand into a 'Middle Income Trap.' Policy suggestions include deferral of retirement, increased physical capital investment, improved human capital, and adoption of enhanced technology in production processes. Previous studies found that retirement deferral merely delays the growth slowdown for 10 years. Eventually, Thailand's labor productivity must increase by around 30 percent in order to maintain the current rate of economic growth. Sustainable growth can be achieved only by technological improvement.

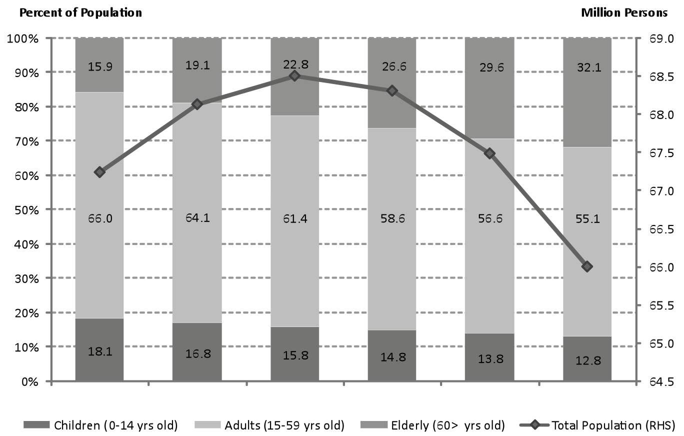

Figure 1 – Projection of Thailand's population and its structure. *Source: National Economic and Social Development Board (NESDB)*

Although previous studies have shed light on the importance of Thailand's aging economy and its impacts, these studies were conducted using only macroeconomic analysis. Because the structure of the economy will change, a study at the interindustry level is required. For example, on the supply side, changing population structure and labor force should affect sectoral activities differently. This is because levels of labor intensity differ among producing sectors. On the demand side, consumption patterns should change because consumption baskets are different among age groups. Analysis at the sectoral level helps us to understand more fully the problem of the aging economy in Thailand.

The Thai Interindustry Dynamic Model (TIDY) is a model that allows us to properly examine effects from the aging economy in Thailand. TIDY has 26 sectors, based on Thailand's Input-Output tables from 1975 to 2000. The model is built in the INTERDYME framework with optimization features. TIDY's consumption functions are purely a time-series demand system (PADS); however, the model takes into account effects from population structure on consumption patterns. The objective of this paper is to estimate consumption equations using surveyed cross-section data and to examine age and demographic effects on the patterns of household consumption in Thailand. The estimation equations follow research by Bardazzi and Barnabani (2001), Bardazzi (2002), and Ding (2006).

2. Household Data and Consumption Patterns in Thailand

The study extensively uses cross-section data from the Socio-Economic Survey (SES) in 2011. The SES is a household survey conducted by the National Statistical Office (NSO) every other year from 1986 until 2006. Since 2007, the survey has been done every year. The survey is not longitudinal – the SES is cross-section data. Yet the data set has rich information on household socio-economic data, which include income, sources of income, consumption by categories, and other household characteristics such as type of residence, area, and characteristics of household members.

Table 1 – Structure of Thai Household by Region.

	Frequency	Percent	Cumulative
Northeast	6.469.751	32,4%	32,4%
Central	4.907.932	24,6%	57,0%
North	3.929.871	19,7%	76,6%
South	2.699.825	13,5%	90,2%
Bangkok	1.965.050	9,8%	100,0%
Total	19.972.430	100,0%	

Source: National Statistical Office (NSO) and author's calculation

The SES surveys about 50,000 households each year. However, the data set also provides weights for each of those representative households. According to the SES survey for 2011, Thailand has about 20 million households with the majority of 6.5 million families, or approximately 32.4 percent, living in the Northeast. Metropolitan areas (*i.e.* Bangkok and its vicinities) have around 2 million households, or approximately 10 percent of the total households in Thailand. By family size, the Thai household average is not large. The majority of Thai households (25.3 percent) have two family members. Family sizes of up to four family members accounts as much as 81.2 percent of overall households. The age of the household head for most households appears to be around 50 to 55 years old.

Table 2 – Structure of Thai Household by Family Size.

	Frequency	Percent	Cumulative
1	2.758.822	13,813%	13,813%
2	5.060.259	25,336%	39,149%
3	4.690.465	23,485%	62,634%
4	3.714.999	18,601%	81,235%
5	2.102.423	10,527%	91,761%
6	1.030.309	5,159%	96,920%
7	421.271	2,109%	99,029%
8	114.655	0,574%	99,603%
9	50.227	0,251%	99,855%
10	14.720	0,074%	99,929%
11	7.850	0,039%	99,968%
12	4.490	0,022%	99,990%
13	1.080	0,005%	99,996%
15	860	0,004%	100,000%
Total	19.972.430	100,0%	

Source: National Statistical Office (NSO) and author's calculation

When examining the consumption patterns in major groups by region of residence, total expenditures in terms of baht per month shows that households in Bangkok consume the most, while families in the North and Northeast have the least consumption expenditures per household, respectively. The total amounts spent by households in these two regions are in fact less than half of those in Bangkok. Overall, we can observe that regions with higher income (*i.e.* Bangkok) generally spend a lower proportion on necessary goods (*i.e.* Food). Bangkok has higher proportion of housing expenditures as well as education and healthcare. There are no clear patterns of expenditure with respect to different regions of residence for Transportation and Communication or Clothing and Footwear.

Figure 2 plots several other demographic factors that might affect the pattern of Thai household consumption expenditures. There is evidence of economies of scale in household consumption when considering family size (top-left panel). Households with larger family size share most of their consumptions with other members as the average consumption per person gradually declines with the size of family, especially durable goods such as Transportation and Communication and Housing and Utilities.

Table 3 – Thai Household Consumption by Region.

		Major Consumption Category by Region					
	(Baht per Month)	Bangkok	South	Central	Northeast	North	Thailand
1	Food	1.002	1.167	995	836	814	932
2	Beverages	89	84	103	55	59	75
3	Tobacco	20	27	25	15	12	19
4	Cloth and Footwear	1.064	775	547	396	410	553
5	House and Utilities	4.138	1.815	1.831	1.031	1.024	1.638
6	Education	820	228	231	132	160	243
7	Health	1.506	755	708	509	537	694
8	Transportation and Communication	6.208	4.367	3.581	2.787	2.546	3.485
9	Recreation	1.641	655	773	392	448	655
10	Others	1.140	589	627	638	595	670
		17.628	10.463	9.422	6.792	6.605	8.963

	(Pecent of Total Consumption)	Bangkok	South	Central	Northeast	North	Thailand
1	Food	5,7%	11,2%	10,6%	12,3%	12,3%	10,4%
2	Beverages	0,5%	0,8%	1,1%	0,8%	0,9%	0,8%
3	Tobacco	0,1%	0,3%	0,3%	0,2%	0,2%	0,2%
4	Cloth and Footwear	6,0%	7,4%	5,8%	5,8%	6,2%	6,2%
5	House and Utilities	23,5%	17,4%	19,4%	15,2%	15,5%	18,3%
6	Education	4,7%	2,2%	2,5%	1,9%	2,4%	2,7%
7	Health	8,5%	7,2%	7,5%	7,5%	8,1%	7,7%
8	Transportation and Communication	35,2%	41,7%	38,0%	41,0%	38,5%	38,9%
9	Recreation	9,3%	6,3%	8,2%	5,8%	6,8%	7,3%
10	Others	6,5%	5,6%	6,7%	9,4%	9,0%	7,5%
		100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Source: National Statistical Office (NSO) and author's calculation

It is plausible that Education is the only expenditure that does not exhibit the economies of scale pattern. The age of the household head also affects consumption spending. Consumption patterns with respect to income and education of household head (bottom panels) are similar. Spending on durable goods increases with higher income and education.

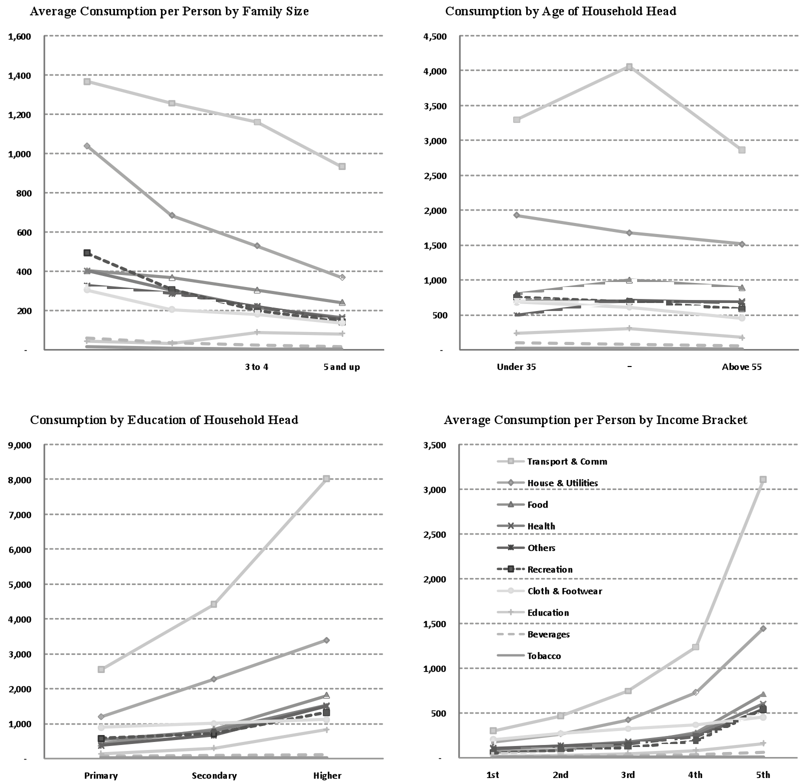

Figure 2 – Consumption Pattern by Family Size, Age of Head, Education, and Income.
Source: National Statistical Office (NSO) and author's calculation

3. The Estimation of Demographic Effects on Household Consumption of Thailand

Previous versions of the consumption functions in TIDY were based on the Perhaps Adequate Demand System (PADS) suggested by Almon (1996). The model was designed to estimate sectoral consumption equations for use in long-term forecasting models; however, previous estimation of TIDY by Manprasert (2004) used purely time-series data. In the present study, we incorporate demographics and population in order to allow us to examine effects of aging on the economy.

The estimation of household consumption with demographic and age effects described in this paper follows Bardazzi and Barnabani (2001), Bardazzi (2002), and Ding (2006). For each consumption good *i* the determinations of household consumption are:

$$C_i^h = \left(b_{i0} + \sum_j b_{ij} Y_j^h + \sum_k d_{ik} D_k^h\right)\left(\sum_g w_{ig} n_g^h\right) + u_i \qquad (1)$$

where

C_i^h: household h's consumption of good i

Y_j^h: amount of household h's per capita income within j^{th} income bracket

D_k^h: the k^{th} demographic dummy variable in household h, represented by a zero or one

n_g^h: number of family members in age group g in household h

u_i : disturbance term with assumption of independently and identically distributed across households for the same product i

The b_{ij}'s, d_{ik}'s, and w_{ig} are coefficients to be estimated, and they represent the marginal propensity to consume in each income bracket, demographic effects, and Adult Equivalency Weights (AEW), respectively. The first bracket on the right-hand-side of Equation (1) explains consumption with income (Piecewise Linear Engel Curve) and other demographic effects, as explained in more detail below. The second bracket takes into account age structure of family members. We identify each person in a household according to 9 groups based on age (*i.e.* age of 0 – 5, 6 – 15, 16 – 21, 22 – 30, 31 – 40, 41 – 50, 51 – 60, 61 – 70, and 71+, where the underlines refer to reference groups). *n* here is number of family member in each age group. This component is included in the equation because households' consumption patterns may differ according to its members age characteristics.

To estimate the Piecewise Linear Engel Curve, the study divided household into 5 income brackets, where each bracket contain exactly one-fifth of total households. Income per capita per month in each bracket is as follow.

$PLEC_0$:	$0 < Y_1 \leq 1{,}950$ baht per month
$PLEC_1$:	$1{,}950 < Y_2 \leq 3{,}288$ baht per month
$PLEC_2$:	$3{,}288 < Y_3 \leq 5{,}300$ baht per month
$PLEC_3$:	$5{,}300 < Y_4 \leq 9{,}167$ baht per month
$PLEC_4$:	$Y_5 > 9{,}167$ baht per month

Demographic characteristics are region (Bangkok, Central, North, South, East, and Northeast), family size (1, 2, 3 – 4, and 5+), age of household head (under 35, 35 – 55, and above 55), education of household head (primary, secondary, and higher), and number of income earners in household (0, 1, 2, more than 2). To avoid the singularity problem in the estimation process, one group of each demographic characteristic is selected as the reference group and is left out of the estimation process. These reference groups are underlined above.

Studies by Bardazzi and Barnabani (1998) and Bardazzi and Barnabani (2001) point out that zero expenditure levels reported in the survey could have different implications than zero consumption levels, especially for durable goods such as cars. For this type of good, people spend money 'once in a while' but consume it continually over a period of time. Therefore, zero entries may not mean zero consumption of service flows from assets purchased earlier. If zero expenditure records represent such special cases of durable consumption, our estimation results could be biased. However, as we show below, this is probably not the case for Thailand.

Table 4 – Percentage of Zero Expenditure by Consumption Goods.

1	Grains and cereals	18,2%	17	Fuel	17,6%
2	Meat and poultry	16,4%	18	Furnitures and textiles	90,9%
3	Fishes and seafood	22,6%	19	Households equipment and maintenance	4,4%
4	Milk, cheese and eggs	22,3%	20	Education	60,2%
5	Oil and fat	19,4%	21	Personal supplies	3,3%
6	Fruits and nuts	33,0%	22	Medical and health care	44,2%
7	Vegetables	15,6%	23	Vehicles purchase	80,8%
8	Sugar and sweets	17,6%	24	Vehicle maintanence and gasoline	16,1%
9	Prepared food and condiments	2,7%	25	Public transportation	78,7%
10	Non-alcoholic beverages	22,0%	26	Communication	7,8%
11	Alcoholic beverages	88,8%	27	Recreation equipment	93,8%
12	Tobacco	76,8%	28	Travelling and restaurants	40,4%
13	Footwears	76,9%	29	Newspapers, magazines and books	86,0%
14	Clothing	52,2%	30	Sports, toys, pets, plants, admission fees	33,5%
15	Other personal effects	45,0%	31	Insurance premiums	12,4%
16	Housing and Water	17,8%	32	Ceremony and career membership	92,1%

Source: National Statistical Office (NSO) and author's calculation

According to Bardazzi and Barnabani (1998) and Ding (2006), choices of methods to estimate this nonlinear equation include simple Nonlinear Least Square (NLS), the nonlinear Probit model, and the Tobit model. The first technique simply ignores zero entries, assuming that zero spending means zero consumption of the goods. The Probit model takes into account that zero entries of spending do not necessarily imply zero consumption. The procedure involves estimating the probability of purchasing the goods given household characteristics. However, an important underlying assumption is that a decision to buy and the amount to spend are separated. To put it simply, by using the Probit model, we assume that people decide first to buy or not to buy; then, they decide how much to spend on the product. The Tobit model similarly accounts for zero entries for spending. However, in using the Tobit model, we assume that the decisions of whether to buy and the amount to spend are made simultaneously.

Table 4 shows the percentage of zero expenditure by consumption goods. We observe that most consumption items which have high percentages of zero expenditure are nondurable goods, such as Alcoholic beverages, Tobacco, Recreation equipment, Ceremony and career membership, and Newspapers, magazines, and books. Therefore, zero expenditure probably refers to zero consumption for these goods. However, durable goods that exhibit a high percentage of zero entries are Furniture and textiles and Vehicles purchases. Yet the average expenditure of non-zero entries of Vehicles purchases for Thai households equals approximately 6,000 baht (or about 200 US dollars). The Thai National Statistical Office (NSO) confirmed that the data actually represent car leasing expenditure and loan payments. Therefore, it may be acceptable to use a simple non-linear regression technique for the present study.

4. Estimation Results

In order to facilitate alignment with time-series data for the PADS estimation, a total of 131 consumption expenditure categories in the SES are consolidated to 32 consumption categories according to the National Account details. Results of nonlinear regression estimation are presented below, where the interpretation for demographic effects, Engel curves, and adult equivalent weights will be briefly discussed. Table 5 and Table 6 display findings of demographic effects in the consumption patterns of Thai households. Plots of Linear Piecewise Engel Curves (PLEC) and Adult Equivalent Weights (AEW) for all 32 consumption goods are included in the Appendix A and Appendix B, respectively.

Demographic Effects

In Table 5, an indication (+) refers to higher consumption levels than the reference region while (–) refers to lower consumption levels. Recall that the reference household lives in the Central region, has a family size of 3 to 4 persons, has two income earners, and has a household head between 35 to 55 years old who attains a secondary level of education. Families in the South consume relatively more seafood as the region is surrounded by the Gulf of Thailand and the Andaman Sea. In fact, the southerners seem to consume a larger variety of food than other parts of the country. On the other hand, northeastern households seem to spend less on almost everything comparing to other parts of Thailand. Bangkokians spend proportionally less for food but spend more on other durable goods such as Housing, Household equipment, and Communication. Spending patterns for other types of goods portray life in the capital city, such as greater expenditure for Prepared food, Fuel, Education, Public transportation, Travelling and restaurants, Newspaper and magazines, and Sports and admission fees.

Estimated effects of family size show the degree of economies of scale. These especially are evident in food consumption and expenditures on nondurable goods. Consumption per person in households with five or more members is significantly lower than that of the reference group (3-4 family members). When the head of household is older than 55 years old, the household seems to consume less food and less nondurable goods, but it spends more on durable goods and services. Expenditures on Medical and health care are also higher for the household with the older household head. It should also be remarked that the opposite consumption patterns are also exhibited by households with younger household heads. Regarding the effects of education level, a household with higher education consumes relatively more. This pattern of consumption appears for almost every good except Meat and poultry, Oil and fat, Vegetables, Alcoholic beverages, Tobacco, Housing and water, and Household equipment and maintenance. Surprisingly, when the number of income earners increases, households seem to consume relatively less.

Engel Curves

Food expenditures are of course are necessary goods. This fact is supported by the estimation results for the Piecewise Linear Engel Curve (PLEC). The first graph in Appendix A is a plot of Grains and cereals consumption, which mainly is rice consumption in the Thai household. The Engel curve clearly shows that consumption increases with respect to income, though at a decreasing rate. Similar patterns are exhibited in Meat and poultry, Fish and seafood, Oil and Fat, Vegetables, and Sugar and sweets. On the other hand, the results indicate that Milk, cheese, and eggs; Fruits and nuts; Prepared food; and beverages (both Non-alcoholic and Alcoholic) are not necessary goods.

Results for semi-durable goods, such as Footwear, Clothing, and Other personal effects, show that these goods are luxuries. Other durable goods and services are also luxuries, including Education, Vehicle purchases, Communication, Recreation equipment, and Travelling and restaurants.

Adult Equivalent Weights

The estimations of the Adult Equivalent Weights (AEW) for 32 consumption goods show reasonable results – the curves are smooth with a peak at some certain age. Plots of these AEW are shown in Appendix B. It is worth recalling that the reference group for the age of a household member is 31-40 years old. Thus, the AEW value of this age group should be equal to 1.0, and for other groups the results show consumption effects in proportion to this reference group.

For rice, and Sugar and sweets, results show a stable AEW while consumption of Meat and poultry, Oil and fat, and Fruits and nuts is increasing with age but peak at 51-60 years old. Thai people seem to continue consuming Fish and seafood and Vegetables as they age. Non-alcohol beverages consumption peaks in the 22-30 age range and then remains high until age of 41-50. Interestingly, similar patterns emerge in the consumption of Tobacco. Thus, people in these age groups are not only drinkers but also smokers. Education expenditure seems to peak at age of 16-21. Actually, this is when Thais finish their bachelor degrees. Spending on Medical and health care keeps rising with age. Consumption of Vehicles peaks at the age range of 31-40; however, maintenance expenditures keep rising until age range of 61-70.

5. Conclusions and Further Work

This paper examines demographic and age effects on patterns of household consumption in Thailand, using a cross-section household survey, namely the Socio-Economic Survey (SES) conducted in 2011. The estimations employed nonlinear regressions with data for 32 consumption goods. Results from the study portray effects of various demographic factors including region of residence, family size, age of household head, education of household head, and number of income earners. Age effects were also examined, where Adult Equivalent Weights (AEW) were estimated for nine age groups.

Still, there is further work to be done. Alternative estimation techniques could be explored such as the nonlinear Probit models. Different periods of cross-section data or even the estimation of pooled cross-section data could be examined.

In fact, when we examine consumption patterns over the long run, there are not only demographic and age effects that matter. Bardazzi (2001) pointed out that 'taste' changes over time and between generations should also be examined. This is called the cohort or 'vintage effects' on consumption patterns. For example, usage of computer and mobile devices in the current middle-age groups will continue as they age, even if the current elderly cohort shows little interest in them. Current younger generations are big consumers of alcohol and tobacco; therefore, expenditures on these products may decline in the future. All in all, these extensions need to be worked on in order to arrive at the plausible PADS estimation for long-term consumption analysis.

Table 5 – Estimated Signs of Demographic Effects on Household Consumption in Thailand.

		Region				Family Size			Age of Head		Education		Number of Earners		
		Bangkok	North	South	Northeast	1	2	5 up	< 35	> 55	Primary	Higher	0	1	> 2
1	Grains and cereals	-11,79	-4,52	5,46	-16,30	-1,35	-0,25	-1,69	-0,25	-1,72	0,24	0,02	10,41	6,53	-2,13
2	Meat and poultry	-18,98	11,58	-0,56	10,95	-14,99	-0,17	-5,04	-5,63	-2,25	1,53	-2,79	2,93	0,59	-3,48
3	Fishes and seafood	-10,96	-4,09	23,99	0,86	-9,72	-2,25	-3,23	-4,89	-1,11	0,53	2,08	5,71	1,13	-2,78
4	Milk, cheese and eggs	-0,28	0,74	0,53	0,15	3,85	1,11	-0,89	-0,23	0,62	-0,14	3,62	0,96	0,74	0,03
5	Oil and fat	-1,40	-1,38	0,66	-2,67	-0,22	0,57	-0,41	0,08	-0,27	0,16	-0,82	0,16	0,19	-0,48
6	Fruits and nuts	-7,76	-8,86	6,30	-8,30	5,47	2,05	-2,02	0,46	-0,61	-2,21	7,40	6,23	2,27	-2,30
7	Vegetables	-11,98	0,40	-1,82	-4,52	-8,06	0,33	-2,52	-1,94	-1,07	1,01	-2,60	4,68	2,26	-2,22
8	Sugar and sweets	-6,71	-4,69	2,85	-4,27	2,77	1,43	-1,31	-0,15	-0,40	0,17	0,56	1,35	0,40	-1,04
9	Prepared food and condiments	20,13	-24,26	-6,24	-13,57	66,91	25,06	-13,17	8,53	-3,59	-12,93	25,32	16,71	12,63	-11,67
10	Non-alcoholic beverages	-8,58	-6,59	-2,66	-7,50	18,30	5,52	-2,40	3,71	-0,19	-0,86	4,39	5,13	2,28	-1,67
11	Alcoholic beverages	-8,09	-4,66	-6,35	-4,92	23,98	4,80	-0,97	2,92	-0,40	-1,03	-3,21	-3,55	-1,79	-0,02
12	Tobacco	-3,36	-4,39	0,91	-2,75	12,95	4,13	-0,23	1,88	-0,26	-0,93	-2,96	-3,61	0,88	0,55
13	Footwears	14,45	0,93	6,46	-2,26	10,65	-5,86	-5,36	2,41	-0,82	-4,21	30,77	-7,69	-1,00	-0,83
14	Clothing	-3,72	2,16	66,35	-8,33	32,73	-30,41	-4,62	12,96	7,82	-14,67	171,54	-11,87	2,52	-8,53
15	Other personal effects	1,68	-6,09	-8,61	-5,19	-18,20	-5,73	8,57	10,16	-1,22	-8,60	21,17	-0,78	3,31	-7,16
16	Housing and Water	255,45	-133,22	-79,31	-110,81	672,51	213,87	-47,38	146,91	-32,88	-28,60	-3,02	183,33	42,28	-1,64
17	Fuel	92,47	-62,57	-56,04	-76,59	-64,86	-37,85	11,32	-27,37	3,77	-23,11	74,97	65,19	32,93	-15,86
18	Furnitures and textiles	7,05	11,37	11,71	13,23	-10,62	-5,87	-0,90	-1,98	0,98	-10,26	5,83	-5,87	-3,54	-4,77

		Region				Family Size			Age of Head		Education		Number of Earners		
		Bangkok	North	South	Northeast	1	2	5 up	< 35	> 55	Primary	Higher	0	1	> 2
19	Households equipment and maintenance	115,29	-20,52	-0,47	-8,98	-56,57	-63,47	-24,89	-44,69	44,96	-56,52	-17,44	-25,35	-27,29	-34,37
20	Education	18,18	-0,95	-2,14	-3,38	-1,49	-6,73	0,71	-4,52	1,94	-1,63	20,45	5,48	1,49	-3,05
21	Personal supplies	22,01	-24,12	-23,19	-21,80	58,79	-6,52	-9,34	4,62	7,46	-14,66	133,15	36,38	15,83	-12,07
22	Medical and health care	81,37	3,97	5,65	-6,03	-6,64	2,92	-5,12	-7,18	6,35	2,48	19,82	11,00	3,63	2,98
23	Vehicles purchase	-276,26	136,33	159,71	255,28	-408,82	-226,19	76,76	-64,29	-98,58	-79,74	141,32	-192,01	-20,72	-53,21
24	Vehicle maintanance and gasoline	-106,07	-50,08	38,61	-78,32	-211,71	-120,91	-0,91	-104,53	-17,77	-76,02	439,29	-96,25	0,29	-26,94
25	Public transportation	149,99	-43,82	-36,90	-34,27	20,43	-11,26	0,02	-20,06	10,79	-23,06	18,57	14,24	6,60	-11,50
26	Communication	106,69	-35,65	-34,21	-46,75	-25,14	-39,93	-1,83	-15,81	12,53	-22,75	155,72	27,25	25,90	-2,83
27	Recreation equipment	3,54	4,53	4,00	3,48	-13,18	-5,94	-0,61	-9,22	0,13	-4,74	13,65	14,76	3,78	-1,76
28	Travelling and restaurants	68,91	-37,09	-38,17	-51,21	93,38	23,12	0,06	17,96	6,67	-17,22	118,01	42,72	-0,05	-2,71
29	Newspapers, magazines and books	9,85	-9,19	-11,27	-11,50	-0,87	-2,51	-0,16	-3,05	2,50	-4,39	23,57	4,64	0,92	-0,84
30	Sports, toys, pets, plants, admission fees	5,79	-13,82	-22,80	-15,67	44,43	7,58	-5,59	-6,88	3,62	-7,31	24,62	7,58	1,32	-5,68
31	Insurance premiums	84,17	-7,04	-81,31	-37,29	-23,42	-21,62	-10,47	-32,30	27,69	-8,55	167,98	-40,48	-1,42	5,21
32	Ceremony and career membership	-2,52	4,92	2,84	12,71	3,27	5,47	-4,07	-9,70	3,14	1,83	0,61	-4,51	1,99	2,29

Table 6 – Estimation Results of Demographic Effects on Household Consumption in Thailand.

		Region				Family Size			Age of Head		Education		Number of Earners		
		Bangkok	North	South	Northeast	1	2	5 up	< 35	> 55	Primary	Higher	0	1	> 2
1	Grains and cereals	(-)	(-)	(+)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(+)	(+)	(+)	(-)
2	Meat and poultry	(-)	(+)	(-)	(+)	(-)	(-)	(-)	(-)	(-)	(+)	(-)	(+)	(+)	(-)
3	Fishes and seafood	(-)	(-)	(+)	(+)	(-)	(-)	(-)	(-)	(-)	(+)	(+)	(+)	(+)	(-)
4	Milk, cheese and eggs	(-)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(+)	(-)	(+)	(+)	(+)	(+)
5	Oil and fat	(-)	(-)	(+)	(-)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(+)	(-)
6	Fruits and nuts	(-)	(-)	(+)	(-)	(+)	(+)	(-)	(+)	(-)	(-)	(+)	(+)	(+)	(-)
7	Vegetables	(-)	(+)	(-)	(-)	(-)	(+)	(-)	(-)	(-)	(+)	(-)	(+)	(+)	(-)
8	Sugar and sweets	(-)	(-)	(+)	(-)	(+)	(+)	(-)	(-)	(-)	(+)	(+)	(+)	(+)	(-)
9	Prepared food and condiments	(+)	(-)	(-)	(-)	(+)	(+)	(-)	(+)	(-)	(-)	(+)	(+)	(+)	(-)
10	Non-alcoholic beverages	(-)	(-)	(-)	(-)	(+)	(+)	(-)	(+)	(-)	(-)	(+)	(+)	(+)	(-)
11	Alcoholic beverages	(-)	(-)	(-)	(-)	(+)	(+)	(-)	(+)	(-)	(-)	(-)	(-)	(-)	(-)
12	Tobacco	(-)	(-)	(+)	(-)	(+)	(+)	(-)	(+)	(-)	(-)	(-)	(-)	(+)	(+)
13	Footwears	(+)	(+)	(+)	(-)	(+)	(-)	(-)	(+)	(-)	(-)	(+)	(-)	(-)	(-)
14	Clothing	(-)	(+)	(+)	(-)	(+)	(-)	(-)	(+)	(+)	(-)	(+)	(-)	(+)	(-)
15	Other personal effects	(+)	(-)	(-)	(-)	(-)	(-)	(+)	(+)	(-)	(-)	(+)	(-)	(+)	(-)
16	Housing and Water	(+)	(-)	(-)	(-)	(+)	(+)	(-)	(+)	(-)	(-)	(-)	(+)	(+)	(-)
17	Fuel	(+)	(-)	(-)	(-)	(-)	(-)	(+)	(-)	(+)	(-)	(+)	(+)	(+)	(-)

		Region				Family Size			Age of Head		Education		Number of Earners		
		Bangkok	North	South	Northeast	1	2	5 up	< 35	> 55	Primary	Higher	0	1	> 2
18	Furnitures and textiles	(+)	(+)	(+)	(+)	(-)	(-)	(-)	(-)	(+)	(-)	(+)	(-)	(-)	(-)
19	Households equipment and maintenance	(+)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(-)	(-)	(-)	(-)	(-)
20	Education	(+)	(-)	(-)	(-)	(-)	(-)	(+)	(-)	(+)	(-)	(+)	(+)	(+)	(-)
21	Personal supplies	(+)	(-)	(-)	(-)	(+)	(-)	(-)	(+)	(+)	(-)	(+)	(+)	(+)	(-)
22	Medical and health care	(+)	(+)	(+)	(-)	(-)	(+)	(-)	(-)	(+)	(+)	(+)	(+)	(+)	(+)
23	Vehicles purchase	(-)	(+)	(+)	(+)	(-)	(-)	(+)	(-)	(-)	(-)	(+)	(-)	(-)	(-)
24	Vehicle maintanance and gasoline	(-)	(-)	(+)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(-)	(+)	(-)
25	Public transportation	(+)	(-)	(-)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(+)	(+)	(-)
26	Communication	(+)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(-)	(+)	(+)	(+)	(-)
27	Recreation equipment	(+)	(+)	(+)	(+)	(-)	(-)	(-)	(-)	(+)	(-)	(+)	(+)	(+)	(-)
28	Travelling and restaurants	(+)	(-)	(-)	(-)	(+)	(+)	(+)	(+)	(+)	(-)	(+)	(+)	(-)	(-)
29	Newspapers, magazi-nes and books	(+)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(-)	(+)	(+)	(+)	(-)
30	Sports, toys, pets, plants, admission fees	(+)	(-)	(-)	(-)	(+)	(+)	(-)	(-)	(+)	(-)	(+)	(+)	(+)	(-)
31	Insurance premiums	(+)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(-)	(+)	(-)	(-)	(+)
32	Ceremony and career membership	(-)	(+)	(+)	(+)	(+)	(+)	(-)	(-)	(+)	(+)	(+)	(-)	(+)	(+)

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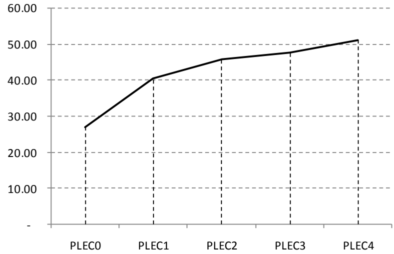
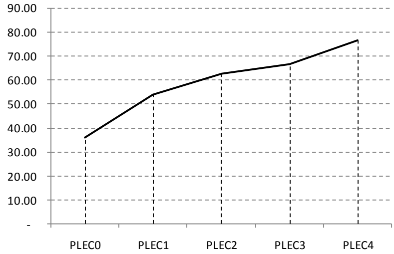
Appendix A: Piecewise Linear Engel Curve (PLEC)

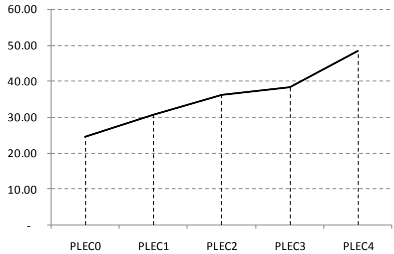
1. Grains and cereals



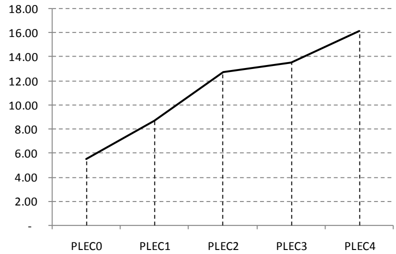
2. Meat and poultry



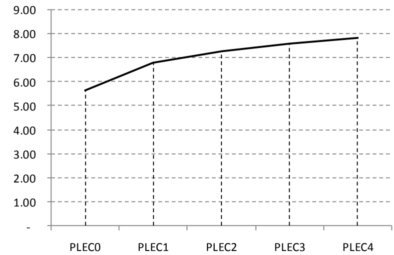
3. Fishes and seafood



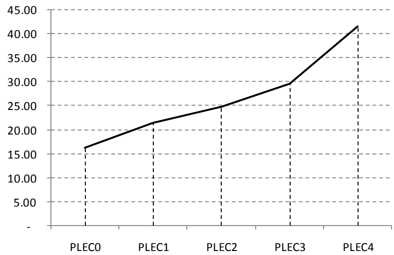
4. Milk, cheese and eggs



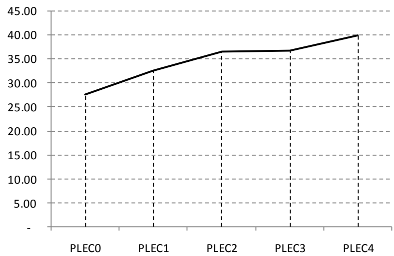
5. Oil and fat



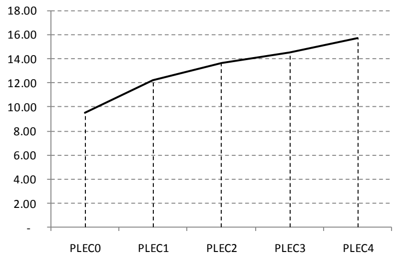
6. Fruits and nuts

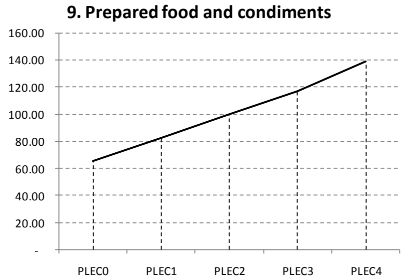


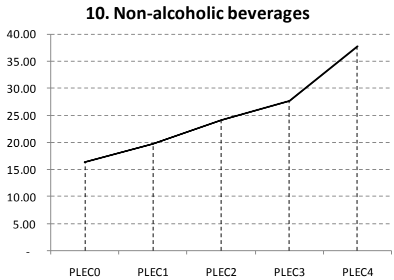
7. Vegetables

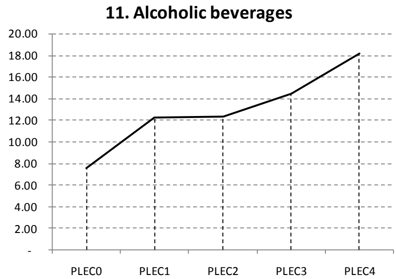


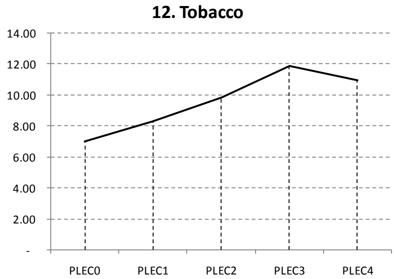
8. Sugar and sweets

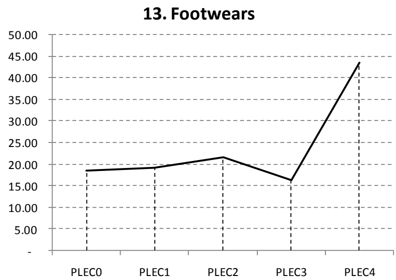


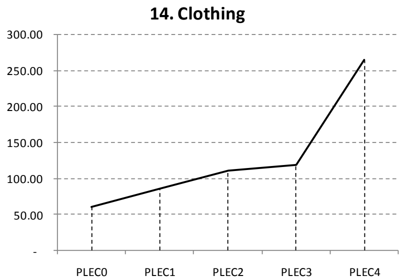

9. Prepared food and condiments
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

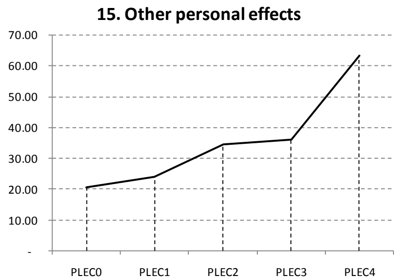

10. Non-alcoholic beverages
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

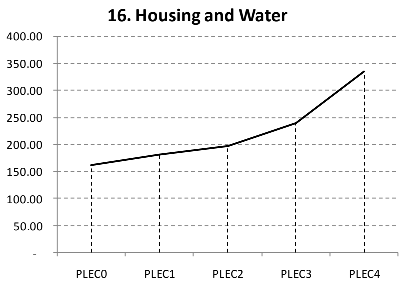

11. Alcoholic beverages
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

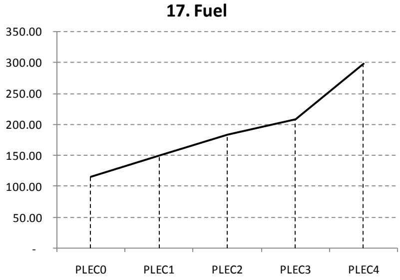

12. Tobacco
14.00
12.00
10.00
8.00
6.00
4.00
2.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

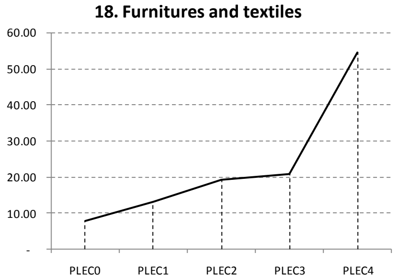

13. Footwears
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

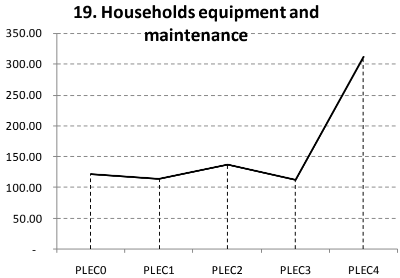

14. Clothing
300.00
250.00
200.00
150.00
100.00
50.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

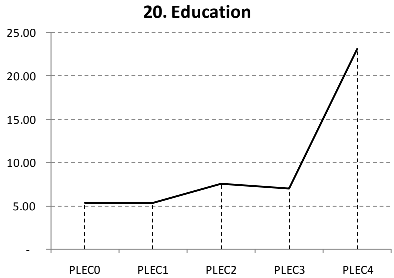

15. Other personal effects
70.00
60.00
50.00
40.00
30.00
20.00
10.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

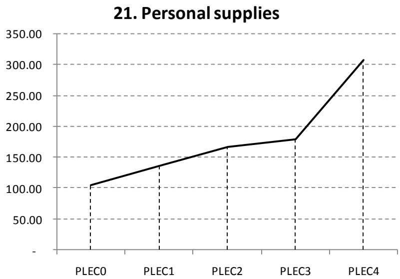

16. Housing and Water
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

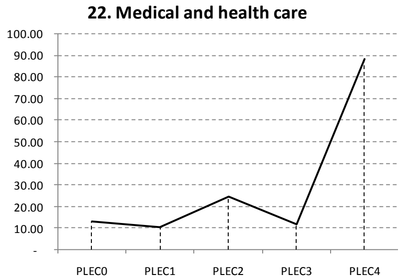

17. Fuel
350.00
300.00
250.00
200.00
150.00
100.00
50.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

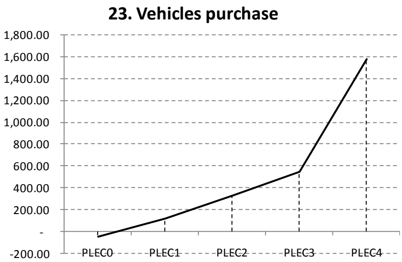

18. Furnitures and textiles
60.00
50.00
40.00
30.00
20.00
10.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

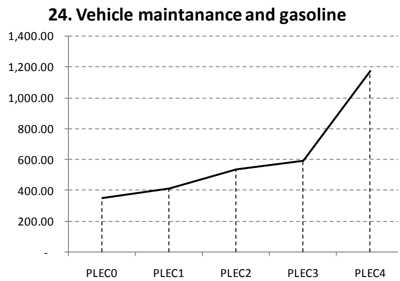

19. Households equipment and maintenance
350.00
300.00
250.00
200.00
150.00
100.00
50.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

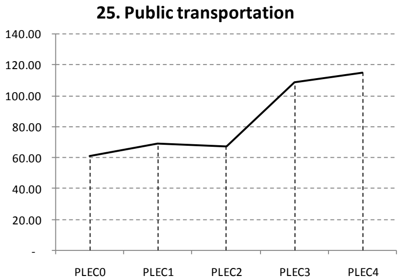

20. Education
25.00
20.00
15.00
10.00
5.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

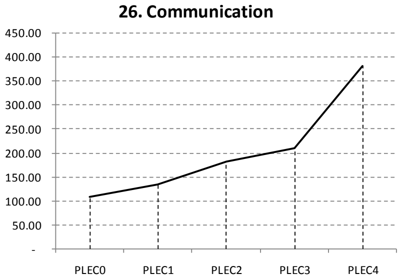

21. Personal supplies
350.00
300.00
250.00
200.00
150.00
100.00
50.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

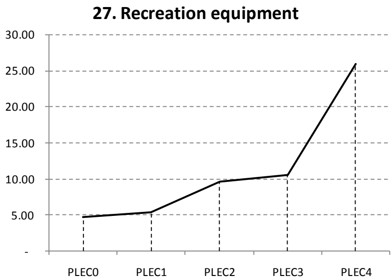

22. Medical and health care
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

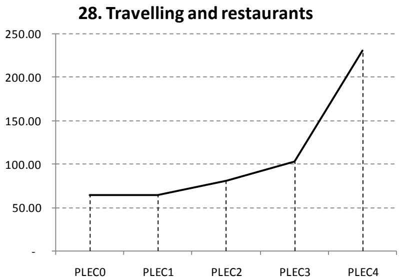

23. Vehicles purchase
1,800.00
1,600.00
1,400.00
1,200.00
1,000.00
800.00
600.00
400.00
200.00
-
-200.00
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

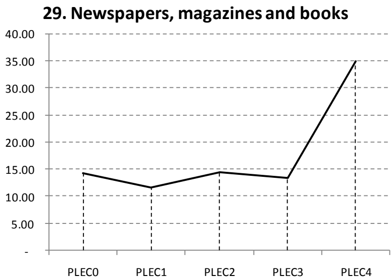

24. Vehicle maintanance and gasoline
1,400.00
1,200.00
1,000.00
800.00
600.00
400.00
200.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

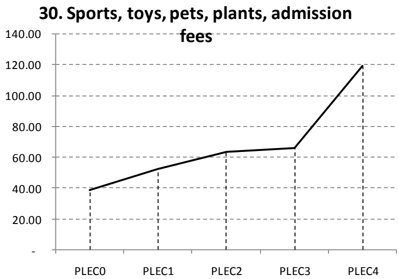

25. Public transportation
140.00
120.00
100.00
80.00
60.00
40.00
20.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

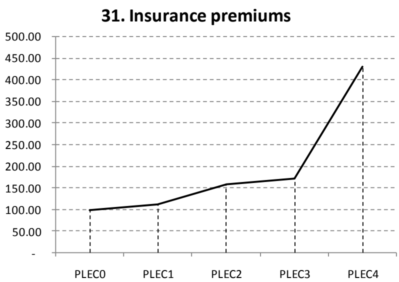

26. Communication
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

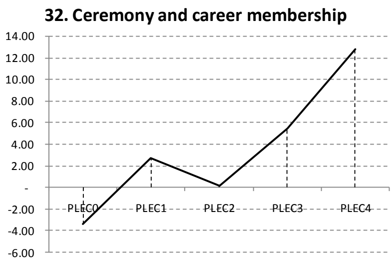

27. Recreation equipment
30.00
25.00
20.00
15.00
10.00
5.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4


28. Travelling and restaurants
250.00
200.00
150.00
100.00
50.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4


29. Newspapers, magazines and books
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4


30. Sports, toys, pets, plants, admission fees
140.00
120.00
100.00
80.00
60.00
40.00
20.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

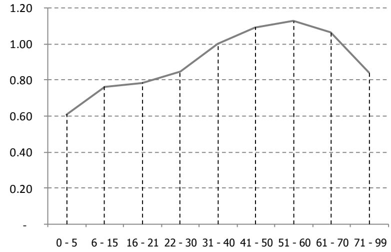

31. Insurance premiums
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
-
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4


32. Ceremony and career membership
14.00
12.00
10.00
8.00
6.00
4.00
2.00
-
-2.00
-4.00
-6.00
PLEC0
PLEC1
PLEC2
PLEC3
PLEC4

Appendix B: Adult Equivalent Weights

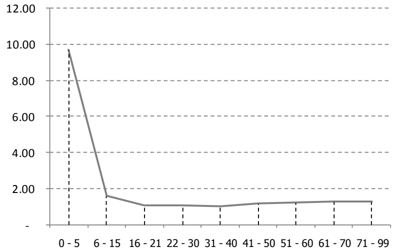
1. Grains and cereals

2. Meat and poultry

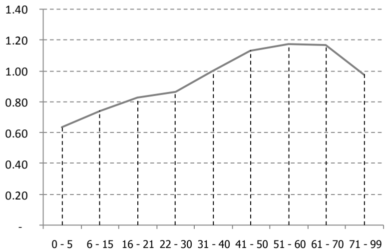


3. Fishes and seafood

4. Milk, cheese and eggs

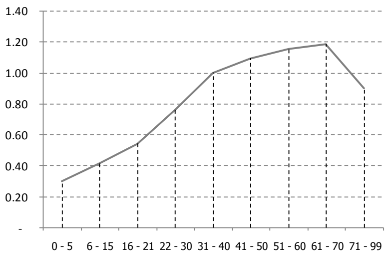


5. Oil and fat

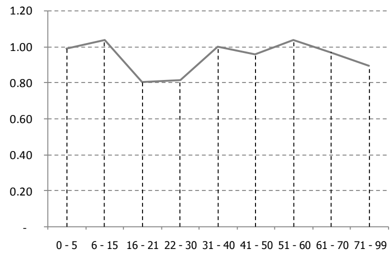


6. Fruits and nuts

7. Vegetables

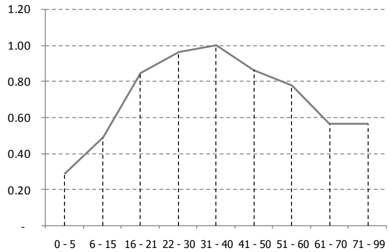


8. Sugar and sweets

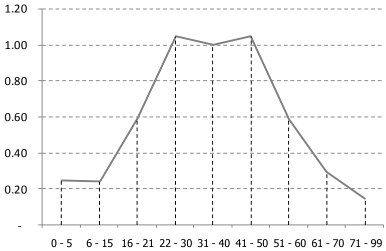


9. Prepared food and condiments

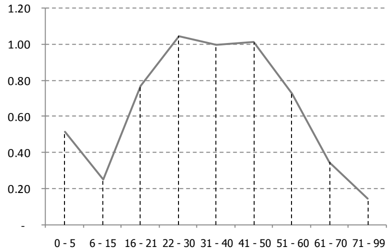
10. Non-alcoholic beverages



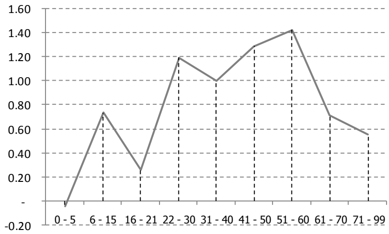
11. Alcoholic beverages



12. Tobacco



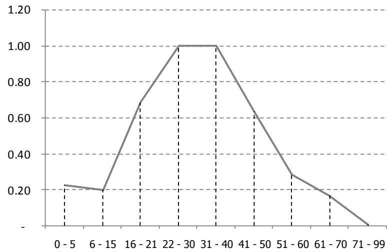
13. Footwears



14. Clothing

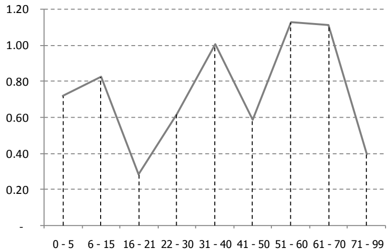
15. Other personal effects

16. Housing and Water



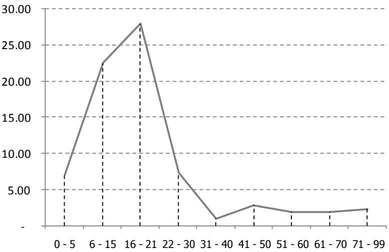
17. Fuel

18. Furnitures and textiles

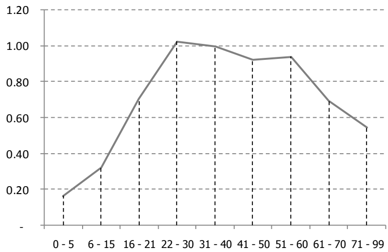


19. Households equipment and maintenance

20. Education

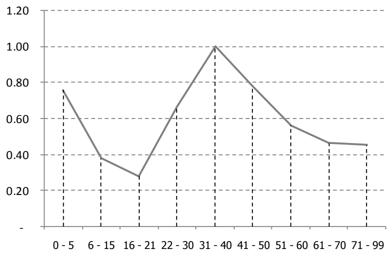


21. Personal supplies

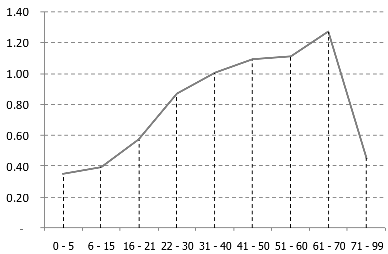


22. Medical and health care

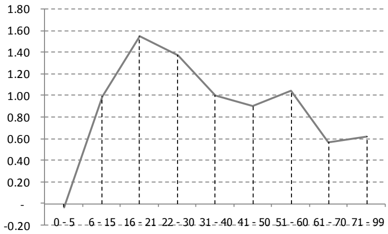
23. Vehicles purchase



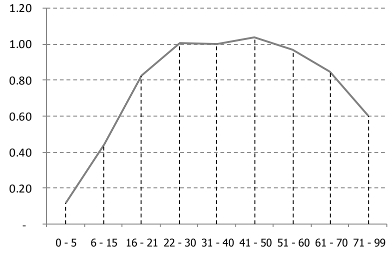
24. Vehicle maintanance and gasoline



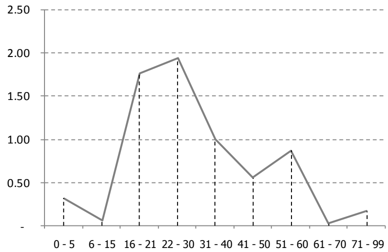
25. Public transportation



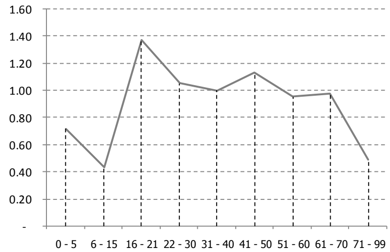
26. Communication



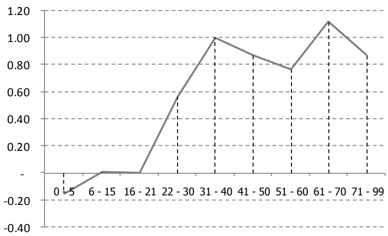
27. Recreation equipment



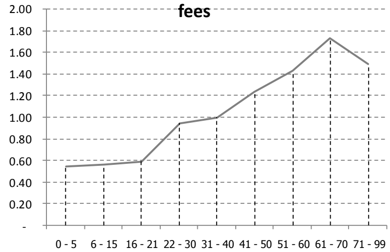
28. Travelling and restaurants



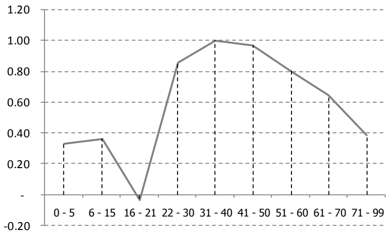
29. Newspapers, magazines and books



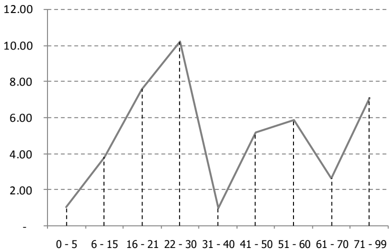
30. Sports, toys, pets, plants, admission fees



31. Insurance premiums



32. Ceremony and career membership



DEMOGRAPHIC CHANGE AND CONSUMPTION - HOW AGEING AFFECTS THE LEVEL AND STRUCTURE OF PRIVATE CONSUMPTION

Britta Stöver, Marc Ingo Wolter[a]

1. Demographic change and consumption

Demographic change alters the population composition regarding age, structure and size. While the overall population grows older and declines over the next decades, the number of households will still increase due to a rise in single households. The ageing process poses a challenge for all economic sectors and affects the economy in many ways. Five main impact vectors of ageing can be identified: public budget, labour market, production potential, goods and financial markets, and exports. The goods and financial markets depend on the level and structure of private consumption. The level is determined by disposable income, and the structure depends on the needs and desires of households. Both change with an ageing population. This paper analyzes the impact of demographic change on the level and structure of consumption expenditures.

To show the economic consequences of ageing for consumption, a scenario analysis is made comparing the ageing German population to a German population with constant age structure and to one with constant size. Our results show that consumption is much higher in an ageing population, mainly due to the fact that overall disposable income is larger. On the one hand savings are lower, but on the other hand wages and salaries increase faster because of growing labour market shortages. With regard to the consumption structure a shift from goods to services can be observed. In particular, the health sector expands rapidly because of a growing number of elderly households.

The rest of the paper is structured as follows. Chapter 2 gives a short overview over the main drivers of demographic change. Chapter 3 introduces the parts in the modelling structure of INFORGE where demographic information is directly considered. Chapter 4 describes the scenario setting and the main results. Chapter 5 concludes.

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2. The main drivers of demographic change

Demographic change affects the economy in five ways (Sachverständigenrat 2011, BMI 2011, EC 2011): (1) Public budget, (2) Labour market, (3) Production potential, (4) Goods and financial markets and (5) Exports. The interdependencies between demographic change and the main addressees are given in Figure 1.

(1) Public budget

Demographic change affects the public budgets from two sides: revenues and spending. The income of pensioners is much lower than that of wage earners. Hence, pensioners pay much lower or no income taxes. In the next years, their number is going to increase relative to the working population leaving the government with lower tax revenues. At the same time, the government has to increase payments – especially for health, long term care and pensions. Some release can be expected in the fields of unemployment and education as the number of unemployed and students is likely to go down. To avoid a budget deficit or to meet the debt brake respectively the government could be forced to increase the contribution rate to the social security system and/or to cut down the administration costs.

(2) Labour market

The ageing process of the German population leads to a reduction in the working population. Though the labour force participation rate is likely to increase further, the size of the labour force is restricted by the size of the population. The German population decline will most probably (re)start in 2015 followed by a reduction in the labour force and labour market shortages.[1] The shrinking labour supply can be partially compensated by labour productivity initialised by further education and innovations. Measures such as improved day care facilities (for children and elderly), inclusion concepts or workplace health promotions facilitate to raise the potential of growing labour force participation rates of women and older working people. Overall, wages are likely to increase and economic activities will be confronted with higher labour costs and a reduced labour supply.

(3) Production potential

The production potential will decrease if the reduction in the labour supply is not balanced by an increase in productivity. A gain in productivity can be achieved by technological progress and/or a higher educational level. The immigration of (highly) skilled workers can ease the labour market shortage and increase labour supply.

[1] The population decline in Germany started in 2006. From 2011 to 2014 high immigration rates brought the process to a halt and resulted in an increase of nearly one million people. The European crisis and the comparably stable labour market in Germany made this possible.

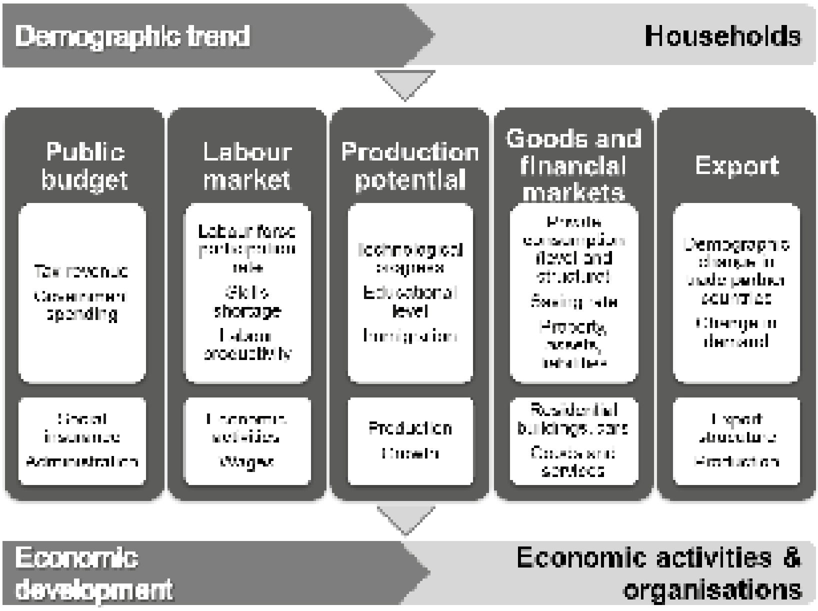

Figure 1 – Overview over drivers and impact of demographic change. Source: own figure based on Sachverständigenrat (2011), BMI (2011), EC (2011).

(4) Goods and financial markets
Goods and financial markets are affected by private consumption, saving behaviour and the accumulation of property and wealth. The level and structure of consumption depend on the age structure, number and size of private households. Due to demographic change the number of older one- and two-person-households will increase.[2] Their consumption behaviour – total expenditures and distribution of consumption purposes – gain importance compared to that of other household types. A shift towards services is very likely (Sachverständigenrat 2011, p. 7). Production output has to be adapted to the changing demand structure. With regard to the saving behaviour, pensioner households show lower, but still positive saving rates than households in working age.[3]
Financial and real estate markets will be under pressure if large age groups (e.g. the baby boomer generation in Germany) liquidise their

[2] The age of the household is defined by the age of the household member with the highest net income.

[3] According to the life-cycle hypothesis (Fisher 1907, 1930; Ramsey 1928; Modigliani, Brumberg 1954; Ando, Modigliani 1963) the saving rates should be negative or lower with the beginning of the retirement. In countries with extensive social security systems the reduction in the saving rate is smaller.

property income in order to finance their retirement. Supply and prices of the housing market as well as interest revenues thus change with the demographic situation.

(5) Exports
The ageing process is not a regional phenomenon but can be found in most other countries as well. As a consequence, the worldwide consumption structure changes, giving more weight to the needs and preferences of older households. This leads to an alteration in the composition of traded goods and services as well. The trade related industries in Germany – though not directly affected by the domestic consumption – need to adapt to the internationally changing consumption behaviour.

3. Demography in the model INFORGE

INFORGE (INterindustry FORecasting GErmany) is a macro-econometric input-output model for Germany developed by GWS according to the INFORUM principles of modelling (Almon 1991). The model has been used for economic forecasts, projections and scenario analysis in many projects and studies (e.g. An der Heiden *et al.* 2012; Helmrich *et al.* 2013; Stöver 2013). It is established among European input-output models (EUROSTAT 2008: 527) and is well documented (Ahlert *et al.* 2009).

INFORGE is annually updated and often combined with modules for specific questions and objectives (e.g. Maier *et al.* 2013; Ulrich *et al.* 2012; Drosdowski, Wolter 2012). Thus, analyses related to energy and environment, labour market disaggregated by occupation and qualification, world trade or regional aspects can be conducted. It also provides opportunities to analyse a wide variety of socio-economic issues on the aggregate level and to generate numerous socio-economic indicators related to private and public consumption or wage and capital income. This also includes the impact of demographic change on the economy.

Figure 2 gives a (reduced) overview of the model INFORGE. The points indicate parts in the modelling structure where demographic information is directly considered. All other variables / components are indirectly influenced by the interlinking character of the model structure. The stock of the population (size and structure) is exogenously given by the population projection provided by the Federal Statistical Office (2009). This projection determines the number, size and age structure of households. The number of households is important for the housing stocks and the stocks of transport: the number of cars and flats depends on the number of households. Final demand in the components private and government consumption as well as investments is connected to household / population structure and size. Investments include investment in construction that is directly interlinked with new construction and refurbishment of residential buildings. This way it is also related to the housing stocks and the future number of households. With regard to consumption, different needs and preferences of age groups are considered: The demand for clothing e.g. positively depends on a young population while the consumption purposes related to health profit from a higher share of the elderly. Government consumption is mainly affected by demographic change in the areas (COFOG) health, education and social protection. The level of consumption is determined by disposable income and revenues that again change with the population composition. Labour income is much higher than pension payments and income tax revenues grow with the number of employees subject to social security contributions. Finally, the labour market is connected with the population by the size of the labour force giving the labour supply and labour costs.

The changes in final demand and labour markets driven by demographic change affect the economic activities changing intermediate inputs, technologies and unit costs. Thus, changes in the population composition indirectly show up in production and value added as well.

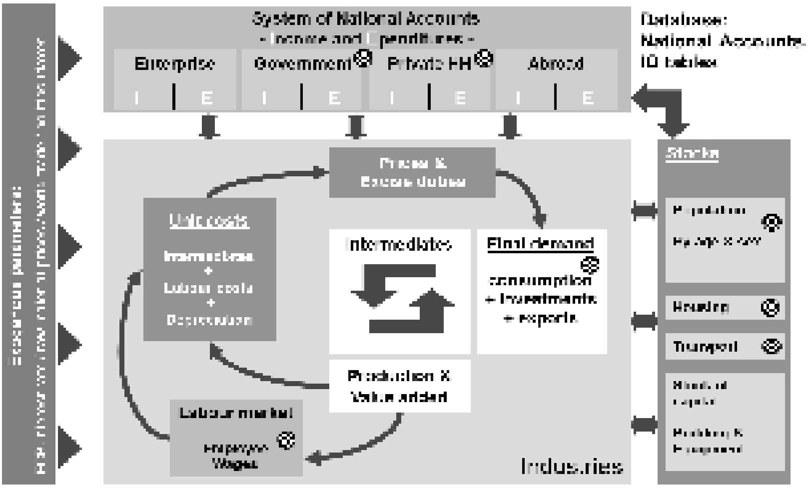

Figure 2 – Overview of the model structure of INFORGE. Source: GWS

4. Consequences of demographic change on consumption

To quantify the impact of demographic change on consumption, a scenario analysis is used. The scenario analysis starts in 2015 and runs until 2030. Four different scenarios were calculated including the reference scenario or baseline. The details about the settings and the results are given in the following sections.

4.1 Scenario settings

The main scenario settings refer to the exogenous level of population. Additional settings are included if they are necessary for the consistency of the model. The population can change in size and structure. The four resulting combinations offer the possibility to discriminate between the effects of quantity and structural effects.

In detail (see Table 1), the baseline or reference scenario (called 'decline & ageing') includes the most probable development given by the official population projection variant 1 migration balance 2 (V1W2) (Statistical Office 2009). Starting with 82.2 million people in 2014, the population decreases by 2.3% (-0.1% p. a.), resulting in 80.3 million people in 2030. At the same time the share of older people increases, leading to an average age of 47 years in 2030. Opposed to that is the scenario 'constant size & constant structure' where the population of 2014 is left unchanged. Therefore the population stays at 82.2 million people with an average age of 44 years throughout the projection period 2014 to 2030. Compared to 'decline & ageing' the population is bigger and younger. The scenario 'constant size & ageing' differs from the reference only in the number of people, leaving the population size as in 2014. The population is therefore larger but ages in the same way. The scenario 'decline & constant structure' keeps the population composition constant (2014) but diminishes in size.

Additional assumptions refer to the development of the labour force participation rates and the rate of social security contributions. Increases in the labour force participation rates – especially for women and elderly – can be observed for the last ten years. In the scenarios with an ageing population it is therefore assumed that the trend continues but at a somewhat lower extent. On the contrary, in the scenarios with constant population composition it is assumed that the willingness to work is constant as well. As the age structure does not change, behavioural changes are unlikely to occur. The adjustments in the social security contribution rates were necessary to avoid huge social security surpluses (constant structure) or deficits (constant size & ageing) compared to the reference scenario. With the different contribution rates it is secured that the balance is equal for all different scenarios.

The comparison of the scenarios with changing population to the scenarios with constant conditions reveals different effects.

(1). The quantity effect: when comparing the scenarios 'decline & constant structure' to the overall constant scenario the main difference is the size of the population. The deviation between both scenarios hence shows the impact of quantity.

(2). The structural effect: the scenario 'constant size & ageing' differs from 'constant size & constant structure' only by the age composition of the population. The deviation quantifies the structural effect of an ageing population.

(3). The total effect: the scenario 'decline & ageing' encompass both the quantity and the structural effect. In comparison to the completely constant scenario the total effect of demographic change can be quantified.

Table 1 – Scenario settings.

Scenarios	Population		Additional adjustments		Effect
	size	age structure	labour force participation rate	social security contributions rate	
constant size & constant structure	status in 2014	status in 2014	unchanged	declining	
decline & constant structure	population projection (V1W2)	status in 2014	unchanged	declining	quantity effect
constant size & ageing	status in 2014	population projection (V1W2)	increasing	increasing	structural effect
decline & ageing (reference scenario)	population projection (V1W2)	population projection (V1W2)	increasing	unchanged	total effect

Source: own table

4.2 Scenario results

Total consumption is higher in an ageing population than in a comparably younger one. Figure 3 shows that the light grey lines, representing the scenarios with ageing, always lie above the dark grey lines, which stand for the scenarios with constant age structure. With regard to the size, more people are better for consumption than less: the continuous lines (decline) always lie under the respective equally coloured dashed line (constant size). With a growing distance to the starting point in 2015 the difference between the constant and the changing population become more apparent as demographic change proceeds.

The distance between the dashed and the continuous line (quantity effect) is smaller than between the two continuous or the two dashed lines (structural effect). Hence the different population composition has a much higher impact on the consumption expenditures than the different population size.

The differences in the private consumption expenditures can be explained by differences in the disposable income, the saving behaviour (propensity to consume) and the consumption structure.

The disposable income and the saving rate are given in Figure 4. It shows that the disposable income (upper illustration) of an ageing population (light grey lines) is higher than that of a non-ageing population (dark grey lines). The employed persons in an ageing population earn higher wages

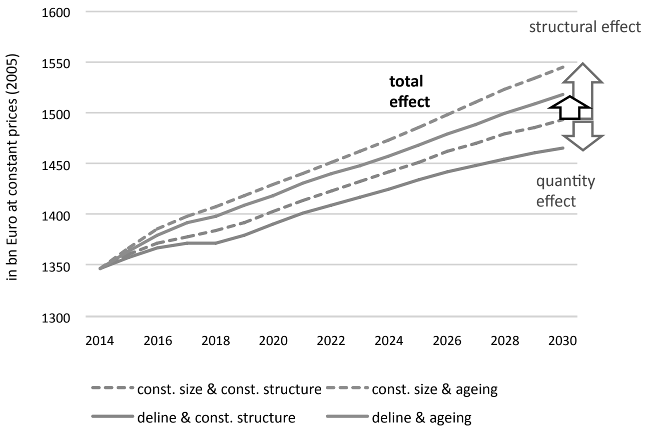

Figure 3 – Private consumption at constant prices (base year 2005). Source: INFORGE, own figure

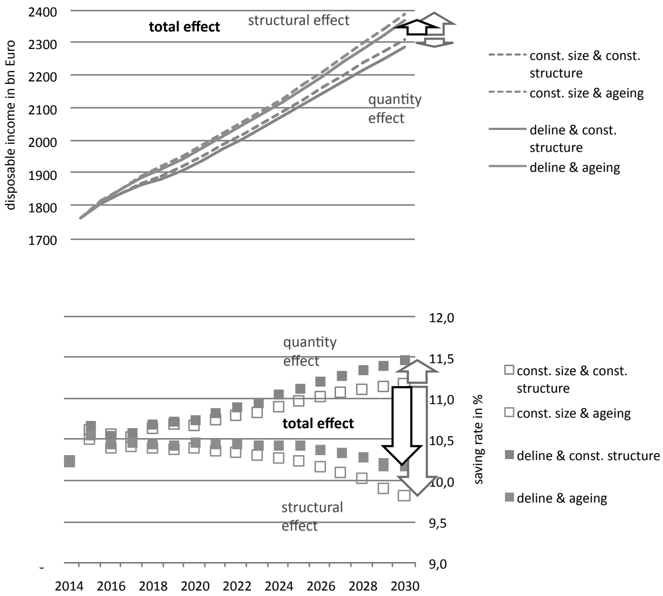

Figure 4 – Disposable income and saving behaviour. Source: INFORGE, own figure

and salaries due to the increasing labour market shortages. Though the comparably low incomes of pensioners gain weight on the overall disposable income, the wage rise more than outweighs the effect. At the same time the saving rate is lower and goes down with a higher and increasing share of older people. Or put differently, older people's propensity to consume is higher. The quantity effect is negative, saying that a declining number of people results in higher saving rates. In terms of total private consumption the effect is relatively small though.

In summary, demographic change has a positive impact on private consumption as ageing private households consume more.

The composition of consumption expenditures also influences total consumption and changes with the different needs of the private households. Table 2 shows the private consumption expenditures by consumption purposes and the deviation from a constant population (in size and structure) for the year 2030.

Table 2 – Private consumption expenditures at constant prices, percentage deviation from constant population in 2030.

private consumption expenditures	2030	percentage deviation		
in bn Euro at constant prices, consumption purposes SEA 2013	const size & const structure	structural effect	quantity effect	total effect
food, beverages and tobacco	198,3	-1,2%	-0,7%	-1,8%
clothing and footwear	71,5	-1,8%	-1,4%	-3,2%
housing, water, electricity, gas, other fuels	340,1	1,7%	-1,5%	0,4%
furnishings, household equipment	87,5	3,1%	-2,5%	0,9%
health	92,0	36,0%	-4,7%	29,8%
transport	169,5	1,5%	-2,6%	-1,0%
communication	55,9	1,6%	-1,6%	0,2%
recreation and culture	160,6	0,8%	-1,9%	-0,9%
education	20,4	1,3%	-4,3%	-2,6%
restaurants and hotels	84,9	2,5%	-0,7%	2,1%
miscellaneous goods and services	212,0	2,6%	-2,1%	0,8%
Total consumption	1493,7	3,5%	-1,9%	1,7%

Source: INFORGE, own figure

The highest differences in consumer behaviour between a comparably young (constant) and an ageing population can be identified for the consumption of health care. The growing number of older consumers (65+) by 30% (const. size & ageing) or 31% (decline & ageing) compared to a status quo of 2014 (const. size & const. structure) implies an increase in health expenditures by 36% and 30% respectively. The need for health care services and products grows disproportionately with increasing age (u. a. Niehaus 2012: 63) and explains partially the increasing importance.

The consumption of health care can be differentiated in 'medical products, appliances and equipment', 'out-patient services' and 'hospital services' whereof the first two hold the highest shares (Table 3). All three sub-categories can profit from demographic change. The highest deviation from a constant population (size and structure) appears in out-patient services according to their highest share. The very high percentage deviations for the 'ageing' scenarios are due to the fact that the growth in health expenditures – that was observable in the past – continues. In the 'constant' scenarios the development slows down. From 1991 to 2013 private consumption expenditures for health grew by 4% p. a. in average. In the projection period (2014 to 2030) the average growth rates are only around 1% p. a. for the constant scenarios but around 3% p. a. for the ageing scenarios. The latter are much closer to the past development.

Table 3 – Consumption expenditures for health at constant prices, percentage deviation from constant population in 2030.

	2030	Percentage deviation		
Consumption expenditures in bn Euro at constant prices consumption purposes SEA 2013	const size & const structure	structural effect	quantity effect	total effect
Medical products, appliances and equipment	30,7	19,0%	-2,1%	17,2%
Out-patient services	45,2	59,3%	-7,3%	48,8%
Hospital services	16,2	2,8%	-2,3%	0,8%

Source: INFORGE, own figure

Other consumption categories that are (according to Table 2) positively affected by the ageing process are 'furnishings, household equipment etc.', 'restaurants and hotels' as well as 'miscellaneous goods and services'. Negative impacts show for 'food, beverages and tobacco' as well as 'clothing and footwear'. The expenditures for 'housing, water, electricity, gas and other fuels' as well as 'transport' seem to be invariant to the ageing effects at first glance. Different sub-groups however depend on the number of households and thus on the demography.

The main positive impact within 'restaurants and hotels' can be assigned to 'catering services' (middle part of Table 4). In the sub-groups related to 'furnishings, household equipment etc.' the two consumption purposes 'Furniture and furnishings, carpets and other floor coverings' as well as 'goods and services for routine household maintenance' profit most from the ageing process (upper part of Table 4). Within 'miscellaneous goods and services' the areas 'personal effects n.e.c.', 'insurance' and 'financial services n.e.c.' can be identified as the consumption categories with the highest positive percentage deviation (lower part of Table 4). The differences between the scenarios for the three positively affected consumption purposes (furniture, hotels/restaurants and miscellaneous) can be mainly explained by the differences in the disposable income and only to a lesser extent by the changing consumption structures. The changes in the consumption expenditures are therefore indirectly caused by demographic change.

Table 4 – Consumption expenditures for furnishings/household equipment, restaurants/hotels and miscellaneous goods/services at constant prices, percentage deviation from constant population in 2030.

	2030	Percentage deviation		
Consumption expenditures in bn Euro at constant prices consumption purposes SEA 2013	const size & const structure	structural effect	quantity effect	total effect
Furniture and furnishings, carpets etc.	30,8	5,6%	-3,6%	2,5%
Household textiles	7,5	1,1%	-4,7%	-3,5%
Household appliances	12,2	1,7%	-0,7%	1,1%
Glassware, tableware and household utensils	6,0	2,0%	-1,6%	0,5%
Tools and equipment for house and garden	8,9	0,9%	-1,1%	-0,1%
Goods and services for routine household maint.	22,1	2,2%	-2,0%	0,4%
Catering services	66,3	2,3%	0,3%	2,9%
Accommodation services	18,6	3,1%	-4,1%	-0,5%
Personal care	31,8	2,9%	-2,2%	1,0%
Personal effects n.e.c.	8,6	4,0%	-2,2%	2,1%
Social protection	24,3	1,9%	-1,6%	0,5%
Insurance	57,6	2,5%	-2,0%	0,8%
Financial services n.e.c.	64,8	3,2%	-2,9%	0,7%
Other services n.e.c.	24,8	1,3%	-1,0%	0,5%

Source: INFORGE, own figure

The case is different for the negatively affected expenditures for 'food, beverages and tobacco' as well as 'clothing and footwear'. A lot of subgroups depend directly on the age distribution of the population. 'Food' and 'non-alcoholic beverages' are solely driven by income and show due to their necessity character nearly no differences between the scenarios (upper part of Table 5). Contrary to that, stimulants ('alcoholic beverages', 'tobacco') and fashion ('clothing', 'footwear') lose their importance in an ageing society (lower part of Table 5). Especially 'clothing' has a relatively high share of 4% on total consumption (2014). However, the products related to stimulants and fashion are scarcely domestically produced (Federal Statistical Office 2014), so that mainly imports are affected.

Table 5 – Consumption expenditures for food/beverages and clothing/footwear at constant prices, percentage deviation from constant population in 2030.

	2030	Percentage deviation		
Consumption expenditures in bn Euro at constant prices consumption purposes SEA 2013	const size & const structure	structural effect	quantity effect	total effect
Food	131,5	0,3%	-0,3%	0,0%
Non-alcoholic beverages	21,4	1,0%	-1,8%	-0,5%
Alcoholic beverages	21,9	-7,1%	-1,1%	-8,0%
Tobacco	23,5	-6,2%	-1,7%	-7,7%
Clothing	61,0	-1,5%	-1,7%	-3,2%
Footwear	10,5	-3,5%	0,2%	-3,2%

Source: INFORGE, own figure

Within the consumption category 'housing, water, electricity, gas and other fuels' the sub-groups 'actual-' and 'imputed rentals for housing' are connected with demographic change: they depend on the number of households (upper part of Table 6). The number of households grows (in the beginning) faster in the 'ageing' scenarios than in the scenarios with a constant age structure. The quantity effect shows when comparing 'constant size & ageing' with 'decline & ageing'. The positive deviation is much higher with a constant population size. The other consumption categories are mainly determined by income and are indirectly subject to demographic change. The highest deviations can be assigned to the ageing scenarios where the income growth is higher.

The two components 'purchase of vehicles' and expenditures for 'operation of personal transport equipment' being part of 'transport' have a connection to the number of households as well. They depend on the stock of vehicles, the registration of new cars and the fuel consumption. These three values are positively affected by an increasing number of households. The 'transport services' depend on disposable income. Taken together, this implies for the different scenario outcomes in the lower part of Table 6 that 'decline' is always below 'constant size' due to the quantity effect and that 'ageing' is always higher than 'constant structure'.

Table 6 – Consumption expenditures for housing and transport at constant prices, percentage deviation from constant population in 2030.

	2030	Percentage deviation		
Consumption expenditures in bn Euro at constant prices consumption purposes SEA 2013	const size & const structure	structural effect	quantity effect	total effect
Actual rentals for housing	101,7	2,7%	-2,5%	0,5%
Imputed rentals for housing	151,7	1,4%	-1,3%	0,2%
Maintenance and repair of the dwelling	10,1	1,8%	-1,5%	0,5%
Water supply and miscellaneous services relating to the dwelling	29,1	0,4%	-0,3%	0,1%
Electricity, gas and other fuels	47,5	1,6%	-0,8%	0,9%
Purchase of vehicles	64,9	1,4%	-3,8%	-2,5%
Operation of personal transport equipment	69,2	2,7%	-2,2%	0,6%
Transport services	35,4	-0,7%	-0,8%	-1,4%

Source: INFORGE, own figure

5. Conclusions

Demographic change affects consumption in three areas: disposable income, saving rate and consumption structure. The disposable income is higher in an ageing population and allows higher consumption expenditures. The propensity to consume is also higher with a higher share of older people and fosters private consumption. Some consumption purposes gain weight due to the changing needs of an ageing population: the consumption expenditures for health, actual/imputed rents and the purchase/operation of vehicles are higher in an ageing than in a comparably younger population. Negative deviations are found for alcohol, tobacco, clothing and footwear.

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THE LONG-TERM DEMOGRAPHIC FORECAST FOR RUSSIA

Vadim Potapenko[a]

1. Introduction

The demographic situation – current and future – is one of the most discussed subjects on the Russian socio-economic agenda. The beginning of depopulation in the 1990s has shocked Russian society and led to an alarmist view on the Russian outlook that is shared by many experts and policy makers. In the mid-term period Russia will face new demographic challenges because of inevitable changes in the population age structure. These challenges are often considered to be one of the main obstacles for sustainable economic growth.

However, to understand the advantages and disadvantages that are provoked by these demographic changes and their influence on society and economy, one should take into account not only the obvious aggregate indicators (population size, the share of 20-64 people in population etc.), but also many different details that determine their values. Besides, one should have the possibility to understand the consequences of demographic changes in a long-term period.

For these reasons detailed long-term demographic forecasts are crucial. But they do come with some problems. In the case of Russia the most popular demographic forecast in the world – the one developed by the UN (2013) – is not very detailed. Demographic estimates of the Russian government have significant disadvantages too. To solve these problems an attempt for creating new long-term demographic forecast for Russia has been made. The results of this work are presented in this paper and they are used as a basis for building the economic forecast in the Russian Interindustry Model (RIM).

2. The UN Demographic Forecast for Russia

The demographic forecast developed by the UN is a very useful database that provides many advantages for demographic research. Neverthe-

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less, it has features which complicate its use. First, even in the most recent version of the UN forecast released in 2013 (United Stations 2013) the historical data end in 2010. All data since 2011 are projections. As a result, nowadays there are some gaps between actual and forecast data.

Secondly, the UN forecast contains only one mortality scenario. This makes the forecast rather inflexible, but in the case of Russia the situation is aggravated by unrealistic assumptions about Russian mortality in the future. The UN forecast methodology says that the mortality model for the former Soviet Union countries including Russia shows tendencies of stagnation or a very slow decline in mortality. But it is fallacious: since the middle of the 2000s Russian mortality has fallen after several decades of stagnation for women and is increasing for men (Figure 1).

Moreover, life expectancy[1] at birth for Russian men in 2013 was 65.2 years, although the UN forecasts this level of mortality only by 2035. The situation with life expectancy at birth for women is similar: in 2013 it was 76.2 years, whereas the UN forecasts this value after 2025. The example shows that model used by UN for forecasting mortality in Russia is not quite appropriate. In this way, using a forecast based on such a model can lead to mistaken conclusions.

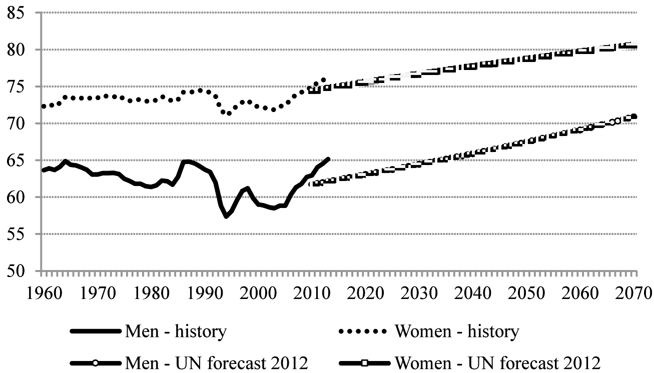

Figure 1 – Life expectancy at birth in Russia, years.

Another feature of the UN forecast that complicates analysis of Russian demography is its specification of scenarios. In spite of the fact that the projections have eight variants, some of them have only theoretical interest, in the case of Russia (these are high-fertility, instant-replacement-fertility, constant mortality, no change and zero-migration variants). The other three variants (low fertility, medium fertility, constant fertility) are

[1] Life expectancy at birth can be considered as an integral indicator of the mortality level.

more reliable, but all of them are based on above-mentioned inappropriate mortality scenario[2] that does not let include even a reliable broad interval of demographic indicators' values.

3. The Past and Current Demographic Situation in Russia

In 1992 the number of deaths in Russia has exceeded the number of births (and the crossing of the graphs was called 'Russian Cross', Figure 2). After this Russian population decreased every year until 2010. In the beginning of 2014 the population was 143.7 mln. persons and births and deaths' graphs again converged. Such population movements are connected both with the current demographic process (fertility, mortality and migration) and with features of the age structure.

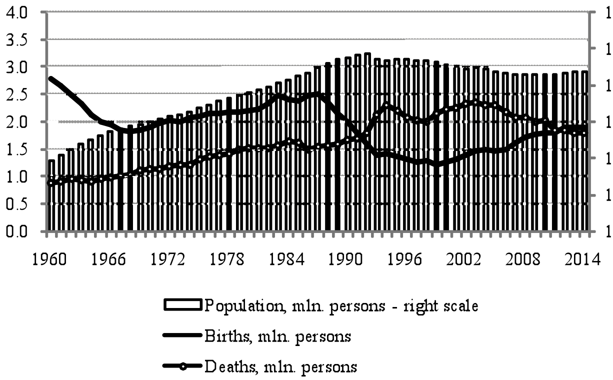

Figure 2 – Population and its natural increase in Russia.

While Russian fertility partly follows trends that are typical for countries of the West, Russian mortality is characterized by special features. Mortality in Europe, USA and Japan has been decreasing in recent decades, but Russian mortality (except age below 20) has stagnated or even risen (see Figure 1). Due to this fact, the life expectancy at birth for men and women is much more lower than in most other Western countries.

A very important peculiarity of Russian mortality is its high level among adults. The difference in life expectancy at birth between Russia in 2013 and USA in 2010 was 11.2 years for men and 4.9 years for women. Decomposition of the difference shows that in the case of men only 0.3

[2] This mortality scenario is used in six of eight variants of the UN forecast. Other scenarios (constant mortality and no change variants) assume that in the future mortality will be the same as in 2005-2010.

years can be attributed to persons at age 0-19, 0.7 years – to persons at age 20-29, and 10.1 years – to persons at age older 30 (Figure 3). For women the values are 0.3, 0.2, and 4.4 years, respectively. In addition, mortality differences at age 60 and above explains 45% of the difference in life expectancy for men and 60% for women. Thus, the high level of Russian mortality is explained by extraordinary mortality for working age and the elderly population.

Nevertheless, some years ago the situation with mortality was much more negative. But since 2005 a rapid decline in the mortality rate has been observed: during 2005-2013 life expectancy at birth has increased by 6.3 years for men and by 3.9 years for women. This growth is almost completely attributable to lower mortality among working age and elderly (Figure 3). This decline in mortality is the most outstanding one for a half a century, and there are encouraging signs that it will continue (detailed analysis of the process can be found in Shkolnikov *et al.* 2013).

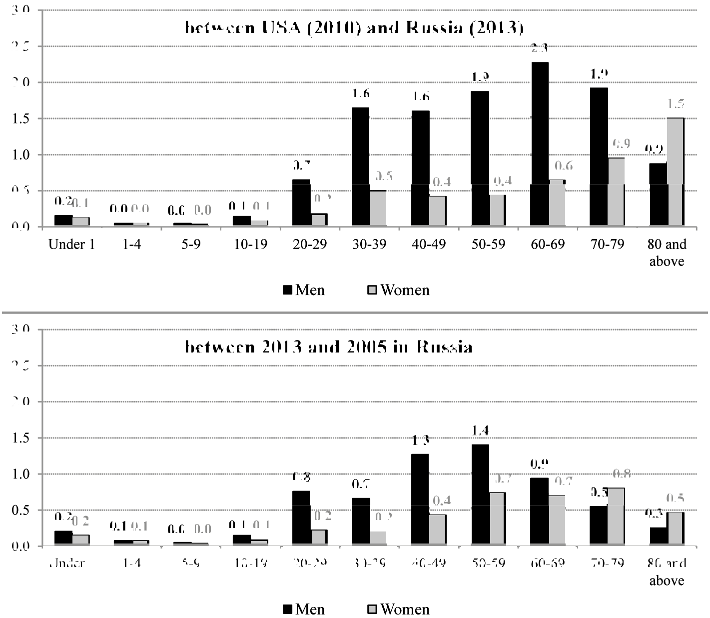

Figure 3 – Decomposition of the difference in life expectancy at birth by age, years.

The most important structural characteristic of the Russian population is the so-called echo of war with Germany in 1941-45 and enormous loss of life during the war. This echo is the reason for the demographic waves that have been observed, as the population in certain age groups has changed cyclically with wide amplitude for a relatively short time interval. Demographic waves have great impact on many different socio-economic processes, which necessitate changes in resource flows to different institutions[3].

The waves can be seen on age pyramids as hollows (Figure 4; compare with the US age pyramid). In spite of the seventy-year period since the war, the hollows are very remarkable in Russian age structure and they determine the socio-economic agenda in many respects. In particular, problems that many experts observe about the demographic situation are connected with this process: in the near future, the working-age population will decrease significantly with a simultaneous increase of the pension-age population.

Another very remarkable characteristic of the Russian age structure is the gap between the mortality of men and women (left-hand side lines of the age pyramids are much shorter for adults than right-hand side). Generally, this is typical when men's mortality is higher than women's, but the Russian difference is uncommonly wide.

Despite these unusual features, the Russian age structure has characteristics that are common for Western countries. First of all, the population of Russia is getting older, similar to the European, American or Japanese population. This process is demonstrated by the long-period change of age pyramids' form: it turns from 'triangle' to 'rectangular'.

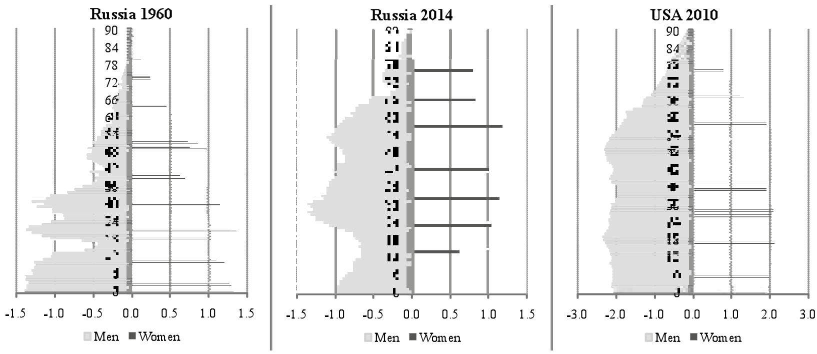

Figure 4 – Population size by age in Russia and USA, mln. persons.

4. Cohort Component Method

The most commonly used method for demographic forecasts – the cohort component method – was applied in this study for forecasting.

[3] For example, the demographic waves affect the number of schoolchildren, requiring changes in school financing, investment in buildings and human capital. The waves are also important for the military, higher education, pension system etc.

The idea of the method is calculation of number of persons at age x at time t on based on the number of persons at age (x-1) at time (t-1). To apply the method one should have scenarios of mortality, fertility and migration. The scenarios are sets of age-specific survival ratios, fertility rates and net migrant flows for every year of the forecast period. Detailed consideration of cohort component method is presented in Preston, Heuveline, Guillot (2001). There are formulas of the method (to simplify notation these ones correspond to women only, but formulas for men are analogous):

$$N_x(t+1) = \left[(N_{x-1}(t) + \frac{I_{x-1}(t,t+1)}{2}\right] * \frac{L_x}{L_{x-1}} + \frac{I_x(t,t+1)}{2} \quad \text{for } x = 1,2, \ldots, 99 \tag{1}$$

$$N_{100}(t+1) = \left[(N_{99}(t) + N_{100}(t) + \frac{I_{99}(t,t+1) + I_{100}(t,t+1)}{2}\right] * \frac{T_{100}}{T_{99}} + \frac{I_{100}(t,t+1)}{2} \tag{2}$$

$$B_x(t,t+1) = F_x * \frac{N_x(t) + N_x(t,t+1) + 0.5 * I_x(t,t+1)}{2} \tag{3}$$

$$B(t,t+1) = \sum_{x=15}^{49} B_x(t,t+1) \tag{4}$$

$$B^f(t,t+1) = B_x(t,t+1) * ShF \tag{5}$$

$$N_0(t+1) = B^f(t,t+1) * \frac{L_0}{l_0} + \frac{I_0(t,t+1)}{2} \tag{6}$$

Where
$N_x(t)$: number of women aged x to x+1 at time t
$I_x(t, t+1)$: number of net female migrants aged x to x+1 between t and t+1
L_x: number of person-years lived by women from age x to x+1
l_0: number alive at age 0 (usually accepted as 100000 or 1)
T_x: person-years lived above age x
$B_x(t, t+1)$: births to women aged x to x+1 between time t and t+1
F_x: age-specific fertility rate in interval x to x+1
$B(t, t+1)$: total births between t and t+1
$B^f(t, t+1)$: number of females births between t and t+1
ShF: share of females births among total births.

5. Modelling of mortality

To build mortality scenarios for the forecast two methods were applied: Murray's method (Murray *et al.* 2003) and Himes-Preston-Condran's method (Himes, Preston, Condran 1994). The former enables us to get approximate values of age-specific mortality rates by one-year age groups through ages 0-85 on the base of two parameters' values. These are the probabilities of dying before age 5 and age 60. The latter is used for the calculation of age-specific mortality rates by one-year age groups above age 85.

The application of the algorithm of Murray's method:

1. Exogenous setting of probabilities of dying before age 5 and age 60 (separately for men and women) and calculation of probabilities of surviving by age 5 and age 60.
2. Calculation of some function of probability of surviving – logits – by formula (7). The calculation is processed both with exogenous probabilities of surviving and with table of probabilities of surviving for all one-year age groups through age 0-85. The table probabilities ('standard' ones) were estimated by the creators of the method.

$$\mathrm{logit}(l_x) = 0{,}5 * \ln\left(\frac{1 - l_x}{l_x}\right) \qquad (7)$$

Where
l_x: probability of surviving by age x ($l_0 = 1$)

3. Calculation of auxiliary coefficients *a* and *b* by formulas (8)-(9):

$$a = \frac{\mathrm{logit}(l_5) * \mathrm{logit}(l^s_{60}) - \mathrm{logit}(l^s_5) * \mathrm{logit}(l_{60})}{\mathrm{logit}(l^s_{60}) - \mathrm{logit}(l^s_5)} \qquad (8)$$

$$b = \frac{\mathrm{logit}(l_{60}) - \mathrm{logit}(l_5)}{\mathrm{logit}(l^s_{60}) - \mathrm{logit}(l^s_5)} \qquad (9)$$

Where
l^s_5 and l^s_{60}: exogenously set probabilities of surviving by age 5 and age 60
and : standard probabilities of surviving by age 5 and age 60

4. Estimation of logits for all one-year age groups through age 0-85 by formula (10):

$$\mathrm{logit}(l_x) = a + b * \mathrm{logit}(l^s_x) - y * \left(1 - \frac{\mathrm{logit}(l_5)}{\mathrm{logit}(l^s_5)}\right) - t * \left(1 - \frac{\mathrm{logit}(l_{60})}{\mathrm{logit}(l^s_{60})}\right) \qquad (10)$$

where

l^s_x : standard probability of surviving by age *x*
y и t: coefficients calculated by the method's authors

5. Calculation of probability of surviving for all one-year age groups through age 0-85 by formula (11):

$$l_x = \frac{1}{e^{2 * \mathrm{logit}(l_x)} + 1} \qquad (11)$$

6. Calculation of age-specific probability of death by formula (12) and then age-specific mortality rates:

$$q_x = 1 - \frac{l_{x+1}}{l_x} \qquad (12)$$

Where
q_x: probability of deaths at age (x, x+1).

The application of the algorithm of Himes-Preston-Condran's method:

1. Calculation of age-specific mortality rates' logits for one-year age groups through age 45-85[4].
2. Estimation of regression coefficients. The dependent variable of the regression is a set of age-specific mortality rates' logits through age 45-85 (calculated before), the independent variable of the regression is a set of 'standard' age-specific mortality rates' logits which are found by the method's authors.
3. Calculation of age-specific mortality rates' logits through age 86-99 by means of estimated regression coefficients and 'standard' age-specific mortality rates' logits through age 86-99 which are found by the method's authors.
4. Transformation of the estimated values into age-specific mortality rates through age 86-99.

6. Mortality scenario

To apply the above described methods for modelling mortality one should have values of the probabilities of dying before age 5 and age 60. The values for forecast period are calculated on the basis of Russian and international mortality data since 1950 (time series of Russia, European countries, USA, Japan, Canada and Australia were analyzed for this purpose by means of *The Human Mortality Database*).

Current Russian probabilities of dying before age 5 are 0.011 and 0.009 for men and women, respectively, and probabilities of dying before age 60 are 0.332 and 0.130. There are large gaps between Russian and Western countries for the values of these variables. In some countries Russian levels were reached many decades ago. Nevertheless, several points should be outlined:

- the decrease of mortality is a general process worldwide;
- after years of stagnation Russian mortality began (since 2005);

[4] While building the forecast the rates are calculated on the basis of Murray's method.

- in many cases the later a country reaches some level of mortality the shorter the period for reaching a lower level (it is demonstrated in Figure 5).

The latter point can be explained by the hypothesis that successful medical, social and other practices which promote the decrease of mortality all over the world. Once they have demonstrated their efficiency, the implementation of these practices is relatively easy.

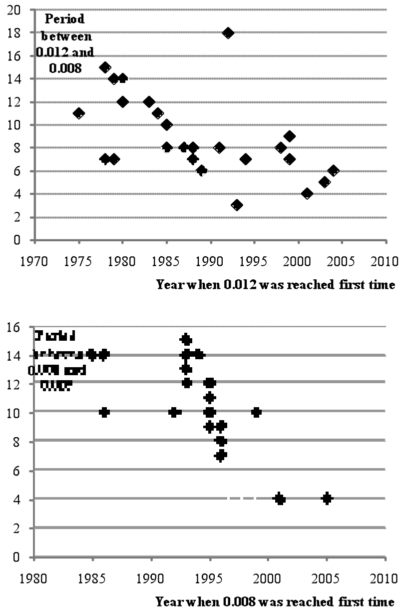

Figure 5 – Patterns of decrease of the probabilities of dying before age 5 for men.
Note 1. Points in the figure correspond to one of 24 considered European countries, USA, Japan, Canada and Australia.
Note 2. The number of points on the right-hand side of the figure is less than in the left-hand side because some countries have not yet reached the probability of 0.005.

The mortality scenario was built with the assumption that in Russia the speed of decrease of considered probabilities of dying will be the same as in other countries which had recently reached some values. For instance, with this approach the gap in the probability of dying before age 5 for men between 0.012 and 0.008 is supposed to be overcome within 5 years (it is the average of periods that recent countries have spent to overcome the gap). Then the international mortality statistics are analyzed to find the period for overcoming gap between 0.008 and 0.005 and so on.

According to this approach, in 2070 the probabilities of dying in Russia will be the same as in some countries of the West and even East Europe nowadays (Table 1). Thus, although the mortality scenario assumes a significant decrease of mortality, in fact it is rather moderate.

Table 1 – Russian probabilities of dying.

	Before age 5		Before age 60	
	Men	Women	Men	Women
1990	0.024	0.018	0.337	0.135
2000	0.022	0.017	0.458	0.175
2013	0.011	0.009	0.332	0.130
2030	0.005	0.003	0.210	0.098
2050	0.004	0.003	0.135	0.058
2070	0.004	0.003	0.099	0.050
Some countries that in 2009-2013 had probabilities of dying the same or lower as Russia is expected to reach in 2070	Austria	Estonia	Canada	Austria
	Czech Rep.	Czech Rep.	Germany	Australia
	Denmark	Finland	Italy	Italy
	Italy	Japan	Japan	Japan
	Finland	Norway	Norway	Spain
	Japan	Slovenia	Spain	Sweden
	Norway	Sweden	Sweden	Israel
	Spain		Ireland	

7. Modelling of fertility

To construct the fertility scenario a method proposed by P. Peristera and A. Kostaki (2007) was applied. The idea of this method is to obtain a set of age-specific fertility rates (fertility curve) by exogenously specifying values of four parameters. These parameters are total fertility rates, modal mothers age and two auxiliary parameters that determine the form of the fertility curve before and after modal mothers age (formula 13):

$$f(x) = T * e^{-\left(\frac{x-M}{N(x)}\right)^2} \qquad (13)$$

Where
x: age
$f(x)$: age-specific fertility rate at age x
T: total fertility rate:
M: modal mothers age (age that corresponds to the highest value of age-specific fertility rates)
$N(x)$: auxiliary coefficient; $N(x) = N_1(x)$ if $x < M$ and $N(x) = N_2(x)$ if $x \geq M$.

8. Fertility scenario

The fertility scenario was based on European countries' trends as Russian fertility follows them with some lag in recent years. The main trend is growth of modal mother's age. It is assumed that after 26 years in 2013 modal mothers age will continue to rise and will reach 28 years in 2025 and 30 years in 2035. By the end of the forecast period its value is set as 31 years. Besides, it is assumed that fertility curve will shift to more symmetrical form (Figure 6) with a fall of fertility among the youngest women and growth of fertility among the older ones.

In the fertility scenario the UN forecast values of the total fertility rate were used (medium fertility variant). According to this projection, the total fertility rate that was 1.71 children per woman in 2013 will be 1.79 in 2040 and 1.87 in 2070.

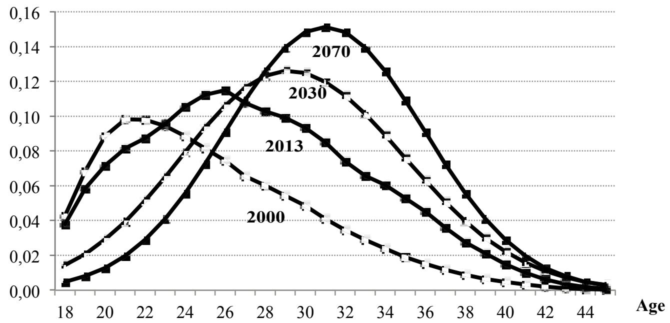

Figure 6 – Russian age-specific fertility rates.

9. Migration scenario

Net migration values are also taken from the UN forecast. It supposes that net migration will decrease from 0.30 mln. persons in 2013 to 0.11, 0.08 and 0.05 mln. persons by 2030, 2050 and 2070, respectively. The age structure of migrants is set constant as in 2013 for whole forecast period.

Generally, these forecast migration estimates may seem understated in view of the fact that Russia borders several unstable less-developed overpopulated countries (Tajikistan, Kirgizia, Uzbekistan), but any migration forecast is debatable . Besides, several million workers from the countries work in Russia now, and continuation of current migration policy (almost free migration to Russia) can lead to serious social tensions. In this way, in the future migration policy will probably become stricter, therefore values from the UN forecast are quite defensible.

10. Results of the forecast

The above described mortality, fertility and migration scenarios form our base demographic scenario. Some results of the forecast with the scenario are presented in Table 2. First of all, after the stabilization of recent years the Russian population will again decrease. The process will begin in 2022 and continue for the whole forecast period. By 2070 the Russian population will be 126.7 mln. persons. The natural increase will be positive until 2016, in 2017-2070 it will become negative again and will fluctuate in the interval -0.5-0.0 mln. persons per year.

Table 2 – The main results of the base demographic forecast.

		2013	2030	2050	2070
Population, mln. persons		143.5	144.0	136.7	126.7
Natural increase, mln. persons		0.09	-0.49	-0.34	-0.53
Births		1.89	1.29	1.49	1.31
Deaths		1.80	1.79	1.83	1.85
Total fertility rate, children per woman		1.71	1.74	1.83	1.87
Modal mother age, years		26	29	31	31
Life expectancy at birth, years	men	65.2	70.6	74.8	77.4
	women	76.3	80.5	84.1	85.0
Population aged 20-64, %		66.2	57.8	54.3	54.4
Population aged 60 (men) / 55 (women) and older, %		23.0	28.6	35.8	34.6

Note. The results in the table take into account the population of Crimea after its reunion with Russia in 2014. Crimea's population was 2.3 mln. persons in the end of 2014.

According to the forecast, mortality will have great decline: in 2070 life expectancy at birth will be 77.4 years for men and 85.0 years for women. The increase in life expectancy for men in 2013-2070 will be 12.3 years, of that only 0.9 year is to be attributed to age 0-19, 1.0 year – to age 20-29, and 10.6 years (or 86% of the advantage) – to age 30 and older. For women the increase in life expectancy for the period will be 8.7 years with an age structure gain that is very similar to men's.

The share of population aged 20-64 will decrease from 66.2% in 2013 to 54.4% in 2070. It is an unavoidable consequence of population ageing. Another consequence of this process is the increase of the share of population of pensionable age (60/55 years for men/women): it will increase from 23.0% in 2013 to 34.6% in 2070. However, the pensionable age in Russia is very low, and there is a sufficient demographic basis[5] for increasing

[5] Life expectancy at pensionable age for Russian women is comparatively very high. In 2013 it was 25.4 years. Moreover, as next decades will be characterized by decrease of mortality, life expectancy at pensionable age for women who have reached the age in 2013 will be higher – its forecast value is 27.1 years.

the pensionable age for women to at least 60 years. The realization of this moderate scenario would decrease the share of population at pensionable age in the whole population by 5 percentage points.

11. The impact of the demographic situation on the labor market

Population ageing and structural demographic shifts will lead to decrease of the working age population – both counted by heads and as share of population. To estimate the influence of the processes on labor market, a forecast of active population and employment should be made. In the long-term age- and sex-specific participation rates demonstrate stability for most ages (except the youngest and oldest ones). For getting the base scenario's approximate forecast of active population Russian 2013 age- and sex-specific participation rates were applied to the forecast population of corresponding age- and sex-groups. To forecast employment, 2013 age- and sex-specific unemployment rates were applied to the estimated active population by age- and sex-groups.

The inevitable trend is a very considerable decrease of active population and employment (Figure 7). But relative indicators are better suited for estimation of the demographic burden on the economy. One of the best such indicators is the ratio of dependents[6] to employed persons. Nowadays the indicator's level is the lowest since the beginning of the 1990s – about 100%. The period 2015-2050 will be characterized by growth of the ratio to 145%, then it will stabilize. Despite the rather fast growth of the ratio, only in the 2040s will level of 2000 be reached. And in the 2000s the value of this ratio was not an obstacle to economic growth.

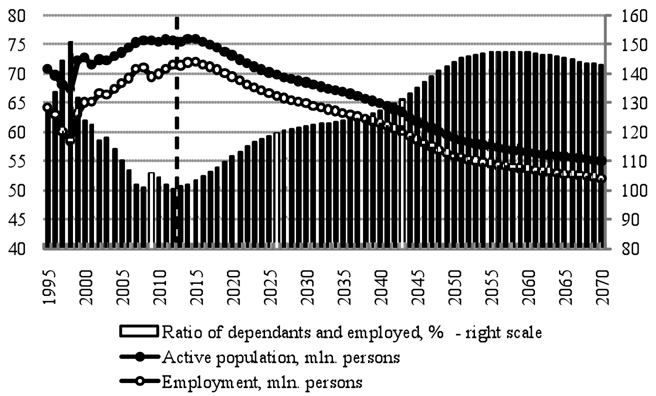

Figure 7 – Some indicators of the labor market in Russia.

[6] Calculated as population minus employed persons.

12. Sensitivity analysis

In reality, the base scenario is perhaps the most likely, but not the only possible outcome, although it seems to be adequate to trends extracted from retrospective data. To understand the future demographic situation more fully one should know the consequences of different deviations from base scenario. We have considered five such deviations – modified base scenarios.

- No migration: the scenario assumes that number of net migrants will be zero for the whole forecast period.
- Low fertility: the total fertility rate will fall to 1.4 children per woman by 2030. Then it will be constant. Three other parameters of the fertility model proposed by P. Peristera and A. Kostaki are assumed to be the same as in the base scenario.
- Constant modal mother's age: it is assumed that the age that corresponds to the highest value of age-specific fertility rates and two auxiliary parameters of fertility model in 2014-2070 will be the same as in 2013. Total fertility rate will be taken from base scenario.
- Slow decrease of mortality: this scenario assumes age-specific mortality rates which are to be reached in the base scenario in 2040 will be reached in 2070. In this case life expectancy at birth for men and women will be 68.7 and 78.9 years in 2040, 72.7 and 82.1 years in 2070, respectively.
- Increase of participation rates: it will be possible that in the long-term the decrease of the active population will stimulate demand for employees that will increase some age-specific participation rates. It is assumed that participation rates at age 15-24 and 55-72 for men and women will increase to current German values by 2030 (Germany is chosen as an example because of its similarity to some demographic features of Russia). The scenario's aim is to estimate a possible reserve for adjusting the labor force deficit.

Sensitivity analysis shows that in the long-term the Russian population forecast has weak sensitivity to changes of such parameters of the base scenario as net migrants flow (downward) and modal mother's age (constant). With the realization of these variants the Russian population will be 135-140 mln. persons in 2040 and 120-126 mln. persons in 2070. With the variants ratio of dependents to employed will be 128-129% in 2040 and 143-144% in 2070 (Table 3).

A significant decline in fertility (as assumed above) will make population 109 mln. persons in 2070. In this case ratio of dependents to employed will be a bit lower than in the base scenario.

A slow decline in mortality will lead to a little faster depopulation in comparison with the base scenario: population will become 135 mln. persons in 2040 and 118 mln. persons in 2070. In this case the ratio of dependents to employed will grow more slowly.

Table 3 – Some results of modified scenarios of the base demographic forecast.

Name of modified scenario	Population, mln. persons			Ratio of dependents and employed, %		
	2013	2040	2070	2013	2040	2070
Base	143.5	139.7	126.7	101.2	127.1	143.1
No migration	143.5	135.3	120.3	101.2	128.9	143.8
Low fertility	143.5	134.9	109.4	101.2	120.1	140.7
Constant modal mother age	143.5	139.8	126.0	101.2	127.8	143.3
Slow decrease of mortality	143.5	134.6	117.9	101.2	123.8	133.9
Increase of participation rates	143.5	139.7	126.7	101.2	110.2	125.0

In the event that the increase of participation rates is realized, the ratio of dependents to employed will be only 110% in 2040 and 125% in 2070. Hence, even in the end of the forecast period the indicator will not exceed the level of the beginning of the 2000s.

13. Conclusions

Russia will have some demographic challenges both in the medium- and long-term period. On the one hand their cause is the general process of population ageing, on the other hand – age structure features that determine great demographic waves. The situation is aggravated by the abnormally high mortality level in Russia. It is inevitable that the depopulation process will resume in a medium-term perspective. Simultaneously, the share of working age population will decrease and number of pensioners will rise. The forecast provokes quite reasonable concerns.

Nevertheless, the situation will be far from disastrous. According to our base forecast, by 2070 the Russian population will decrease by 12% and become 127 mln. persons. In this way, Russia will remain the most populous country of Europe. Some structural demographic changes which are likely to happen in Russia in the future have already taken place in certain Western countries without disastrous consequences.

The influence of depopulation and structural changes on the labor market are not unprecedented. The growth of the burden on working people from dependents will not be overwhelming. In summary, Russia can meet future demographic challenges without a significant detriment to social policy and economic development.

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POLICY ISSUES

VISUALIZING HUMAN CAPITAL INVESTMENT NEEDS IN TANZANIA TO 2030

Douglas S. Meade

1. The Setting

Today Tanzania stands at the threshold. Since 2000, the country has seen an acceleration of real GDP growth to about 7 percent. Since Tanzania has a population growth just below 3 percent, this implies that real GDP per capita growth has been over 4 percent. If this growth continues, Tanzania may reach middle-income status by 2025. Signs of major shifts in the structure of the economy are already visible, but change will have to accelerate if this goal is to be met. In many ways, Tanzania has great potential. Situated on the Indian Ocean, it has the potential for active trade with Europe, Middle East, Asia and Latin America and to facilitate trade for many landlocked sub-Saharan African countries. Its fast-growing population translates to a young and rapidly growing labor force. The country is rich in natural mineral and agricultural resource potential, and there have recently been discoveries of offshore oil and gas. Tanzania needs capital to build and improve electric power, ports and transportation infrastructure, and to provide the seed for development of export industries crucial to productive jobs. Luckily, Tanzania has been the recipient of aid from multilateral donor agencies, and has generated significant interest from international investors, in the form of foreign direct investment.

However, if Tanzania is to succeed in realizing its potential, there will need to be a sea change in economic structure and the location of economic activity. As economies grow and diversify, there are fundamental structural transformations at work, reflected in shift of labor out of agriculture and into industry and services. The likely drivers of growth in Tanzania are FDI and domestic investment, revenues from the oil and gas sector, urbanization, and the growth of industries that generate productive jobs. What will be the likely impact of these changes on the type of jobs that will be created and the type of skills that are required for these jobs? Understanding this linkage will help policy makers to devise broad priorities for education and skills development and prepare the education and training system for the likely changes in the job market.

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2. Fundamental Structural Transformations Expected in Tanzania

2.1. Demographics

Due to high fertility (slightly over 5 live births per woman) and a young population (median age of 17.3), Tanzania is also expected to have one of the fastest population growth rates in the world, making it potentially the 6th largest country in terms of population by 2100, rising to 275.6 million, according to the UN's medium fertility projection. According to this projection, Tanzania's population is expected to top 100 million before 2040. Even if actual population growth falls shy of these projections[1], in order to raise the standard of living, GDP will need to grow significantly faster than population.

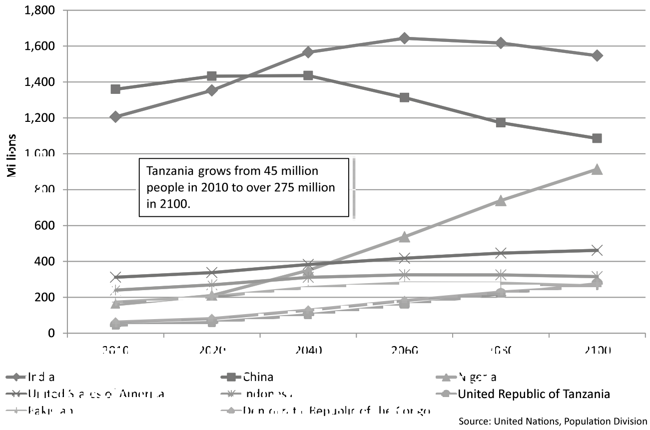

Figure 1 – UN World Population Projections: Top 8 in 2100.

Of particular interest for issues of education and training are the cohort of youth (15-19) and younger workers (20-24). The 15-19 age cohort was comprised of 4.4 million in 2010, and is anticipated to rise to 7.6 million by 2030. The 20-24 age cohort was comprised of 3.8 million in 2010, and is expected to rise to 6.9 million by 2030. The working age population (15 and above) is expected to increase by about 800 thousand in 2015, and at a rate of about 1.25 million per year by 2030.

2.2 Transition from Agriculture

In 2015, about 72 percent of the labor force is employed in agriculture and related activities. In order to sustain recent high rates of GDP growth,

[1] As discussed below, the UN may be on the high side for its fertility estimates for Tanzania. Nevertheless, the number of new entrants to the labor force will be large.

the Tanzanian economy must transform itself, making the transition to a higher share of productive jobs in manufacturing and in services. How rapidly this may occur will be significantly affected by the growth of FDI, successful urbanization and of international donor aid. The employment share of agriculture is projected to fall to 46.9 percent by 2030 in the Base scenario. This is due both to a shift in the sectoral mix of production, as well as productivity growth in agriculture.

2.3 Urbanization

Reflecting a pattern that is occurring in developing countries around the world, urbanization in Tanzania is increasing rapidly. A prime example is the growth of Tanzania's largest city. From less that one million people in the 1990s, Dar es Salaam's population has growth at an average rate of 5.8 percent to reach 4.4 million today, and it is expected to be over 10 million by 2030. The 2012 Tanzania Population Census shows that approximately 15 million Tanzanians (27%) live in urban areas today, compared to 1990, when there were only 4.5 million (18%). About 70% of this urban population increase has been the result of in-migration from other parts of the country. People move from the rural areas because of better educational and employment opportunities, and because the quality of life is perceived to be better. This urbanization brings with it many problems and challenges, particularly for children. It also provides an effective constraint for labor available to the agriculture sector, as this labor must usually be located in rural areas.

2.4 Key Sector Development

Like several other Sub-Saharan African (SSA) countries, Tanzania has experienced high rates of real GDP growth over the last decade, growing in real terms at a 6.7 percent annual average from 2000 to 2013. Although population and labor force grew over this period at 2.3 and 2.5 percent, respectively, aggregate productivity growth (real GDP/employment) has been strong, growing at a 4.1 percent average annual rate. Growth has been driven to a large extent by a boom in the extractive sectors, telecommunications, financial services, and construction[2]. However, structural transformation of the economy has been limited, and the contribution of manufacturing to GDP has declined. Furthermore, productivity growth in Tanzanian manufacturing has been stagnant. The case has been made that if Tanzania is to continue to grow rapidly, it must make a structural transformation to broaden the basis of growth, with focus on industries in which the country has a natural comparative advantage.

A consensus has developed that the focus on individual industries based on the following criteria: 1) export performance and potential for product

[2] Dinh and Monga (2013) has proven to be a rich resource on this topic.

diversification; 2) potential for cost competitiveness; and 3) potential for jobs generation. Tourism would be an example of an industry satisfying the first criterion; leather production would be a prime example of the second, and horticulture and other high value added agriculture would be an example of the third. Additional industries could include labor intensive minerals development and other labor intensive manufacturing industries. Other key sectors include Textiles and apparel, Wood and wood products and Agro-processing.

2.5 Oil and Gas Development

Exploration companies have discovered reservoirs off the coast of Tanzania estimated to contain between 45 and 50 trillion cubic feet of natural gas in the past few years. In 2012, Tanzania produced 33 billion cubic feet of natural gas from regions closer to the coast, all of which was consumed locally. Tanzania is currently pursuing partnership arrangements with multinational companies to help plan the development of drilling rigs, pipelines, gas liquefaction facilities, and increased gas electric power generation capacity.

Total investment is expected to be between \$20 and \$40 billion[3]. These expenditures are expected to take place over a 10 year time frame, perhaps 2020-2030, but there may well be additional follow-on investments. Modeling the impacts of this investment must take account of the fact that most of the capital equipment, and perhaps much of the construction labor, will be imported, although there would undoubtedly be come local economic impacts in the construction phase. However, capital intensive investments of this sort cannot be expected to provide a lot of jobs to Tanzanian workers. A very interesting possibility is the amount of revenue accruing to the government, with which it can pursue investments in education, training and infrastructure development. The oil and gas development may also be fruitful in enabling the development of gas-intensive sectors within Tanzania, such as inorganic chemicals, petrochemicals and fertilizers.

2.6 Foreign Direct Investment

Foreign direct investment (FDI) affects GDP through both the demand and supply-side. On the demand side, the effect includes both direct (investment and construction) impacts, as well as indirect impacts, such as production induced in sectors that supply to the investment or construction industries. In a lesser-developed country such as Tanzania, much of the direct and indirect effects are attenuated, due to the fact that much of the required capital goods must be imported.

On the supply-side, the FDI leads to increased capacity, which is used to generate additional production either for the home market or export

[3] To put these figures in perspective, nominal published GDP for 2013 was \$34 billion, and may reach \$70 billion by 2020.

markets. FDI in each sector is somewhat unique. For example, investment in the retail trade or retail banking sector can be expected to serve mostly the home market, so the investing company must have already had reason to believe that unfulfilled demand for these services existed. Investment in a mining or metals production facility may be made with the intention of promoting exports, as the domestic demand may be small compared to the international demand for these products.

Foreign direct investment (FDI) has apparently played a key role in the rapid GDP growth in the recent period, with FDI increasing at an average annual rate of 15.1 percent from 2000 to 2013, measured in current dollars. As a share of domestic fixed capital formation, FDI has also been large over this period (see Figure 2). The growth of FDI in the projection period is closely related to the development of oil and gas, and attracting FDI to assist in the growth of focus sectors.

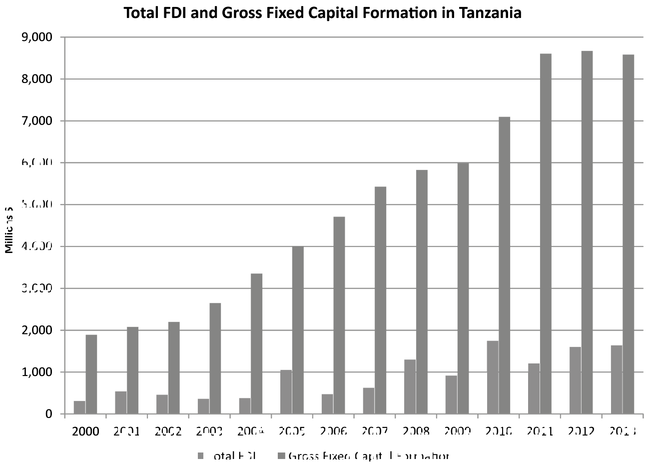

Figure 2 – FDI and Gross Fixed Capital Formation in Perspective.

The goal of this study is to quantify potential alternative trajectories of these six aspects of transforming the Tanzania economy. We will contrast a Base case that continues current trends, with an Accelerated case, where each of the features above (except population growth) occur more rapidly and strongly than in the base case. First, a few words are necessary about the modeling framework used to make these investigations.

3.Uhuru*: An Employment and Skills Projections Model*

A flexible modeling system, called *Uhuru*, has been built for Tanzania that projects employment and skills requirements under different economic scenarios. The model is an *employment projection model*, which links the creation of jobs to the growth of specific industries. The key output of the model is the projection of employment by industry and by occupation, which can be related to required skill or education level. The projection period of the model is to 2030.

The employment projection model is an example of a more general class of models developed by Inforum called interindustry macroeconomic models. A typical Inforum model embodies input-output (IO) relationships at its core, and also produces projections of aggregate variables, such as GDP, consumption, trade and investment. The model uses econometric equations to estimate the determinants of the final demand, value added, employment and other variables.

3.1 How the model works

The *Uhuru* model builds on the accounting structure of the Tanzania National Accounts, which includes Gross domestic product (GDP) and its main expenditure categories, value added and its components, as well as sectoral detail for domestic investment. The model also incorporates an input-output (IO) framework which relates the production in each industry to the demand for its products in other industries, and to exports, consumption, investment and government. The IO framework has been updated to be consistent with the currently published national accounts.

The model solves by the following steps.

1. Making projections of final demand by category at the industry level, including household consumption and private investment, and exports.
2. Use the IO solution to jointly determine output and imports.
3. Project labor productivity by industry, and use this to calculate employment for 9 sectors.
4. Project population by age and sex. Determine the labor force. Calculate unemployment and the unemployment rate.
5. Use employment with the occupational matrix to calculate employment by occupation.
6. Aggregate detailed results to summary macroeconomic variables.

Figure 3 shows some of the directions of causality of key components in the model. With a slight lag, foreign direct investment (FDI) leads to the building of new capacity, which results in increased production, exports and final consumption. While it is being put in place, FDI also stimulates domestic investment. Some of this investment will be provided by domestic production, and some of it will need to be satisfied through increased imports. The patterns of growth of investment, exports, consumption and imports all affect GDP, as well as production by detailed sector.

The employment projections by industry are determined by the growth rate of production in each industry, as well as the productivity growth forecast for each industry. The projections by occupation (and their implications for skill requirements) depend both on the employment projection by industry, as well as the coefficients in the occupational matrix, which we project to change over time.

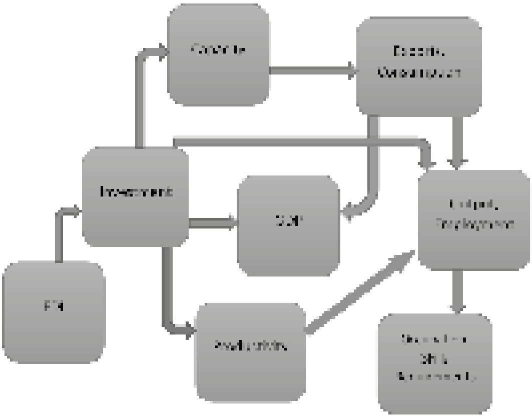

Figure 3 – Chain of Effects of Major Variables.

3.2 The Data

The core of the model is based on the input-output (IO) framework for Tanzania. This IO framework allows for the projection of production in the Tanzanian economy at a fairly detailed sectoral level. This is important for identifying industries which may be recipients of incoming foreign direct investment, as well as for projecting demands for educated and skilled labor. Unfortunately, input-output data for Tanzania are relatively scarce, and one must rely on indirect estimates. For this project, we have utilized the Social Accounting Matrix (SAM) of Tanzania which has been estimated for 2007, at the level of 57 producing sectors, by GTAP. The IO framework has been updated using controls for final demand and value added from the national accounts.

The national accounts data for Tanzania mainland are taken from the latest publication released by the Tanzania National Bureau of Statistics (NBS), with macroeconomic and other accounts updated and revised through 2013[4]. Tables that are used from this volume include tables for GDP by expenditure category in current and constant prices, fixed capital formation by major sector, value added by major sector, value added by category, and national disposable income. Parallel data for Zanzibar

[4] United Republic of Tanzania, NBS (2014).

is obtained from the United Nations[5], and these are combined with the data for the mainland to make estimates for the United Republic of Tanzania as a whole.

An important component of the model database is the estimates of population by age and sex, estimates of labor force, and employment by sector and occupation. Historical population data by detailed age bracket and sex for the model have now been benchmarked to the Tanzania 2012 Census. Since the UN medium fertility projections were higher than the Census, we have used the previous UN low fertility growth rates to move the 2012 population census forward in time. By 2030, the projection is now showing total Tanzania population of 71.6 million, compared to the UN medium-fertility projection of 79.4 million, a difference of nearly 10 percent.

For this study, we have followed the ILO definition of labor force drawn from the population 15 and over. In the *Key Indicators of the Labor Market*[6] (KILM), the ILO publishes their estimates of population, labor force and employment by sex and 10 year age brackets. Their population estimates are based on the UN, and are close to those. To revise the labor force history and projections to be consistent with the Tanzania Census and the revised population projections, we have used the KILM labor force participation rates by age and sex, and applied them to the revised population data. The total labor force estimate for 2012 is now 22.4 million, down from the ILO estimate of 23.5 million. Note that the percentage difference is not as large as that for total population, since we are considering only the 15 and older population, and fertility based revisions affect the estimate of the youth population.

Employment estimates are based on a combination of ILO KILM data and tabulations from the Tanzania Integrated Labour Force Survey (ILFS)[7], and tabulations from the National Panel Survey 2012/3. The headline number is the agriculture employment share which in the NPS-based data is 72.8 percent of the total for 2012. Except for Trade (about 10 percent), the other sectors' shares are small, and similar to those from the 2006 ILFS-based data.

Foreign Direct Investment (FDI) data are derived by combining information from a variety of sources. *fdiIntelligence*, a subsidiary of Financial Times, produces a dataset for Tanzania that is based on a list of individual investments. This source was used to help determine the detailed target industry distribution of FDI. UNCTAD produces the *World Investment Report (WIR)*[8] which shows aggregate FDI by country. Finally, the *Tan-*

[5] UN National Accounts Main Aggregates Database, at <http://unstats.un.org/unsd/snaama/selcountry.asp>.

[6] ILO (2014).

[7] United Republic of Tanzania, National Bureau of Statistics (2007).

[8] UNCTAD (2014).

zania Investment Report (TIR)[9] contains estimates of FDI stock and inflows by major sector, consistent with the totals from UNCTAD. We have used information from *fdiIntelligence* to further disaggregate the *TIR* data.

3.3 The Projection Exercise

A model projection depends on assumptions about exogenous variables, as well as modifications of variables that are normally endogenous to the model. In fact, the key to scenario-based analysis is to understand the changes in assumptions that should be made to implement a given scenario. For example, alternative assumptions may be made about the rate of population growth, world oil and gas prices, government tax rates and spending, or the rate of labor productivity growth by industry. Given these assumptions, the *Uhuru* model shows the resulting changes in production and employment by industry, and the implied demand for labor by occupational type.

The projection exercise used for this study, described in the next section, first posits a Base case scenario, based on a reasonable and conservative extrapolation of current trends and developments. Even in this Base case, as we will see, the share of agriculture in Tanzania is steadily shrinking, urbanization increases, and FDI continues to grow quite rapidly, spurring development of Oil and gas, Minerals extraction, Finance and banking, and Electric power. The Accelerated case assumes a faster growth of the fundamental transformations described above. The differences in results serve as a way of bracketing or bounding possible increases in the demand for skilled labor by 2030.

4. Scenario Development

The *Uhuru* model has been developed to explore several important components of the economic future of Tanzania. Each of these is relevant to an understanding the implications for employment for each industry, and by occupation and skill/education level.

Here are some features of the scenarios.

- The forecast horizon is to 2030, as many of the important structural economic changes considered will take place over this longer time horizon.
- We have examined and refined estimates of population, labor force and employment in Tanzania in light of better and more current survey data. This work is extremely important for making accurate employment projections.
- A careful consideration of FDI by target industry has been made, guided by special characteristics of the alternate scenario. FDI is important

[9] Bank of Tanzania (2013).

as a key driver of the development of new industries, and as a potential for increasing productivity and export potential.

- We have explored the potential development of oil and gas, both onshore and offshore, and what this implies for investment and employment.
- Investigation of the possibility of targeting of key growth sectors, informed by the Tanzania *Country Economic Memorandum* (*CEM*)[10]. These key sectors were highlighted in the *CEM* on the basis of making good use of Tanzania's specific natural resource advantages and current labor supply and skill levels.
- A projection of the increase in urbanization expected in Tanzania, linked to the declining share of agriculture in total employment This has implications for non-agricultural employment, and the concomitant training and skills requirements.

The next two subsections describe the Base and Accelerated scenarios. Refer to Figure 4 for a summary.

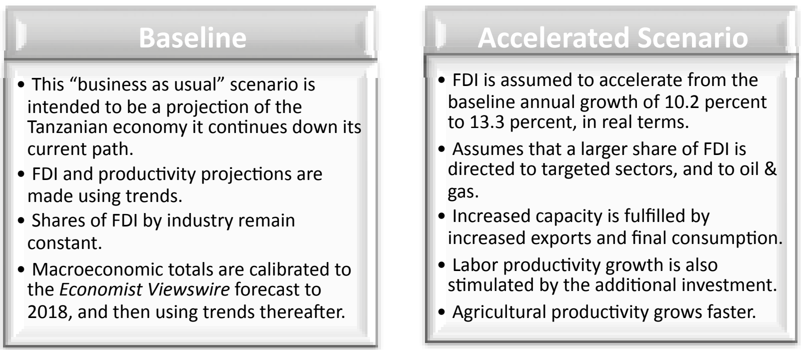

Figure 4 – Comparison of Scenarios.

4.1 The Base Case

The base case is the 'business as usual' case, which is implemented to interpret the future path given current trends. Table 1 shows selected macroeconomic variables from the base case. The last two columns represent multi-year average annual growth rates, from 2000-2013, and 2013-2030, respectively.

In the baseline forecast developed for this study, and presented below, GDP is expected to grow at average annual rate of 7 percent from 2013 to 2030. Population and labor force are expected to grow quickly during the projection period. We expect a slight deceleration of FDI and investment, but an increase in employment growth.

[10] World Bank (2014).

Table 1 – Macroeconomic Summary of the Base Case.

	2000	2013	2020	2030	2000-13	2013-2030
Real GDP Accounts (bil 2005 TzSh)						
GDP	11,639	27,464	45,710	91,408	6.7	7.0
Gross capital formation	1,957	8,791	17,647	41,499	13.0	8.3
Exports	1,556	6,863	11,285	22,446	13.1	6.1
Imports	2,342	11,859	22,117	48,555	13.6	7.8
Population, labor force and employment						
(Thousands of persons)						
Population	34,021	46,248	55,917	71,558	2.3	2.6
Labor force	16,691	23,163	28,896	39,682	2.5	3.2
Employment	15,842	22,249	27,362	37,480	2.6	3.0
Aggregate productivity index	82.8	139.1	188.3	274.8	4.1	4.0
Total Real FDI	315	1,546	3,217	10,030	13.6	10.2

4.2 The Accelerated Case

The accelerated case incorporates faster structural transformations, and investigates the implications for skilled labor needs.

4.2.1 Agriculture and Urbanization

The share of employment in the agricultural sector is determined by 2 factors:

1. the share of agriculture in output;
2. the rate of productivity growth in agriculture compared to other sectors.

The impacts of oil and gas development, key sector development, and foreign direct investment are discussed below. These three aspects of the scenario stimulate the growth in the non-agricultural industries, reducing the share of agriculture in total output.

Time trend equations for labor productivity have been estimated for the 9 aggregate employment sectors (see appendix Table A.2). Average annual productivity growth in the sector Agriculture, hunting, forestry and fishing was 4.6 percent from 2000 to 2012. In the accelerated case, we assume that the labor productivity growth rate in agriculture increases from its historical trend, to an annual average rate 5.9 percent from 2013 to 2030.

The rate of urbanization has been linked to the non-agriculture share of employment through a simple regression equation. This equation is used in the forecast to estimate the rate of urbanization.

4.2.2 Oil and Gas Development

The extractive sectors have generally been the largest recipients of foreign direct investment in Tanzania, taking an average of 45 percent of total

FDI in the period 2000-2012. In the accelerated case, this already large flow of FDI is assumed to increase drastically, as shown in Figure 5. This investment is assumed to ramp up from the base starting in 2020. By 2030, it is $7.1 billion larger than the base case. The cumulative increase in investment we have assumed from 2020 to 2030 is roughly $41 billion in 2005 dollars.

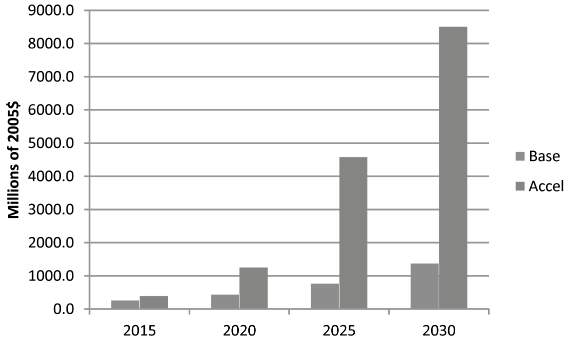

Figure 5 – Oil and Gas Investment Assumptions.

This increase in FDI translates into an increase in gross fixed capital formation in aggregate sector 2 (Mining and extraction). The additional capacity put in place enables an increase of production, some of which is directed to exports, and some to domestic use.

4.3.3 Development of Key Sectors

We assumed additional stimulus to certain key sectors, with guidance from the *CEM* and Dinh and Monga (2013). These sectors are outlined in Figure 6. Stimulus was split between additional consumption and additional exports, or a mix of both, depending on the sector.

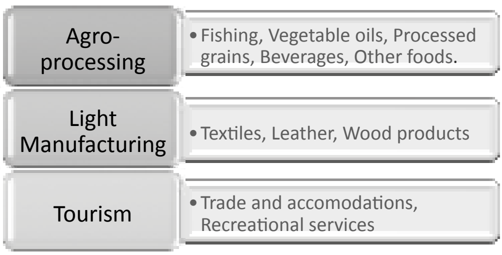

Figure 6 – Summary of Key Sectors.

4.3.4 Foreign Direct Investment

Foreign direct investment increased partly due to increases in the oil and gas sector, and in some of the key sectors above. Aggregate FDI was also increased. Figure 7 summarizes the change in the FDI assumptions for selected years.

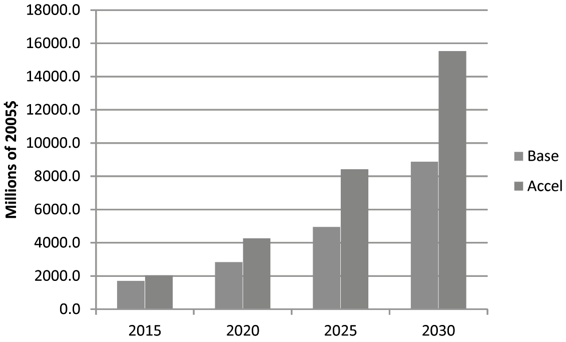

Figure 7 – Comparison of Total FDI Assumptions.

5.Results

5.1 Agriculture and Urbanization

In the accelerated case, agriculture productivity growth averages 6.1 percent from 2015-2030, compared to 4.0 percent in the base case. By 2030, total employment in the agricultural sectors reaches 16.1 million, compared with 20.8 million in the base case.

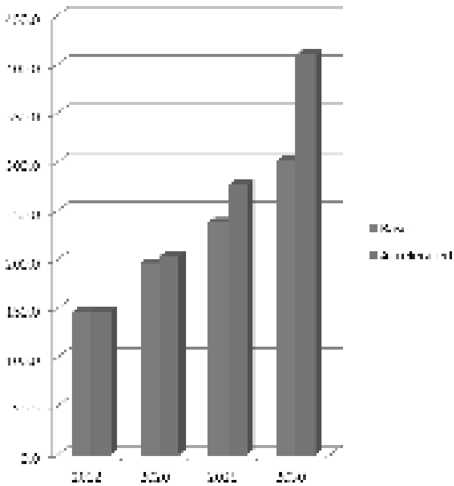

Figure 8 – Agriculture Productivity.

The pace of urbanization picks up considerably, in pace with the reduction in the relative share of agricultural employment. By 2030, the urbanization share is a little over 54 percent in the Accelerated scenario, compared to 48.8 percent in the Base.

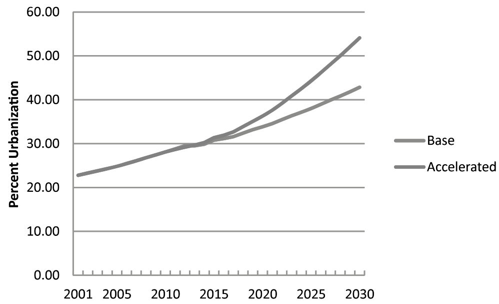

Figure 9 – Urbanization.

5.2 Growth of Key Sectors

Figure 10 compares the average annual growth rate of the key targeted sectors between the Base and the Accelerated case, over the period 2013 to 2030. Note that all of these sectors are growing faster than GDP in the Base case. The increase in growth of this magnitude imply significant differences in the levels of output by 2030 between the Base and Accelerated case.

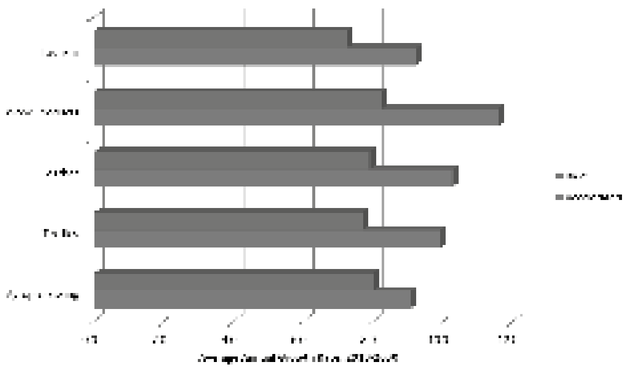

Figure 10 – Increased Growth in Targeted Sectors.

5.3 Oil and Gas Sector

A significant portion of the increase in oil and gas production is expected to be exported. Figure 11 compares exports from the Mining and extraction sector, which includes oil and gas, as well as metals and minerals. In addition to the sizeable increase in exports, there is expected to be increased use of natural gas by industry and households, as gas should be cheaper than in the base case.

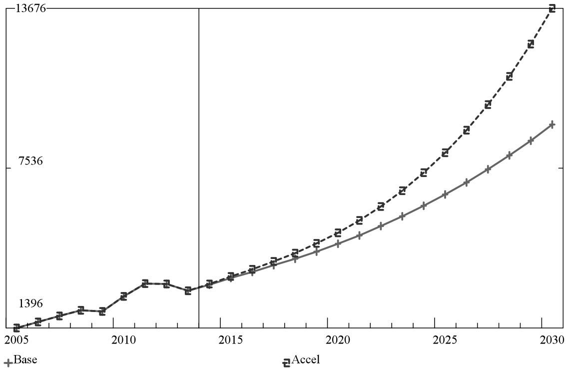

Figure 11 – Exports of Mining & Extraction, Billions of 2005 Tzs

5.4 FDI and Investment

As shown in Figure 3, investment is stimulated directly by an increase in FDI. With a slight lag, the stimulus will be greater than one-for-one. Although some of the goods required to satisfy the additional investment must be imported, there is also a positive impact on domestic industries, resulting in an increase in sectoral outputs and real GDP. This additional output stimulates further investment, through a multiplier effect. Figure 12 is a comparison of total Gross fixed capital formation (investment) in the Base and Accelerated cases.

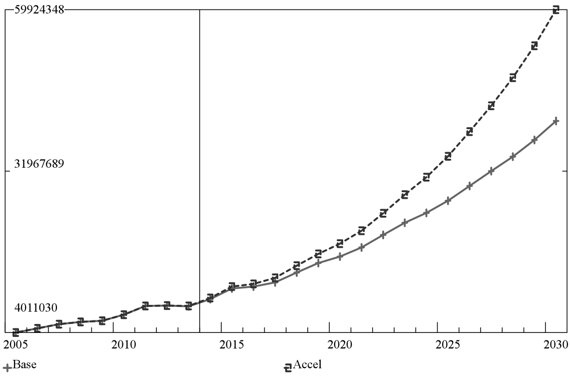

Figure 12 – Gross Fixed Capital Formation.

Figure 13 shows the increase in manufacturing imports in the Accelerated case. Some of this increase in imports is due to increased investment, but some is also due to increased consumption and intermediate purchases.

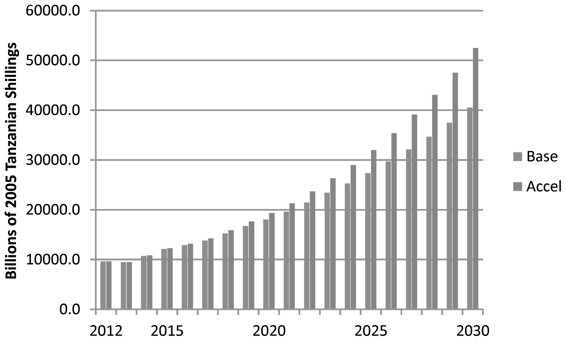

Figure 13 – Manufacturing Imports.

5.5 Employment Results by Sector and Occupation

Differences between additional investment, exports, and final consumption expenditures in the two scenarios lead to different levels and distribution of sectoral output, or production. Production then determines the demand for labor, through the average labor productivity ratio. Differences in employment depend on the total level of production as well as its distribution between labor- and capital-intensive industries. Therefore, stimulus to relatively capital-intensive industries can actually reduce the aggregate labor/output ratio, which works against the job-creating effect of higher output and GDP. Also, about 35 percent of the increases in investment spending leak out as additional imports.

Although not detected in the Tanzanian data econometrically, we have made an additional assumption of an increase in labor productivity with additional capital stock. This assumption is consistent with many cross-country studies relating average labor productivity to capital-output ratios. Without this additional productivity, differences in total employment between the two scenarios would be larger.

The relative levels of employment in each industry affect the employment by occupation through the occupational matrix. Rather than keep a constant matrix in the forecast, we looked to Viet Nam as a guiding development model, and made the occupational shares in the matrix approach those of Viet Nam, reaching the Viet Nam occupational structure by 2030.

The table shows the employment for an aggregation of the occupations by skill level between the 2 scenarios for 2030. The reduction in the agriculture share in the Accelerated scenario results in a reduced share of Skilled agricultural workers and Elementary occupations. We see an increase relative to the base line in all other occupations, but it is particularly noticeable in Managers, professionals and technicians.

Table 2 – Employment Share by Major Sector.

	2012	2030	
		Base	Accelerated
Total Employment	21,764	37,480	38,433
Shares by Major Sector			
1 Agriculture, hunting, forestry and fishing	72.5	58.5	46.9
2 Mining and quarrying	1.0	2.7	7.1
3 Manufacturing	2.9	4.1	4.3
4 Electricity gas and water	0.2	1.4	1.5
5 Construction	1.5	1.9	2.5
6 Wholesale and retail trade, restaurants and hotels	13.0	19.1	21.4
7 Transport, storage and communication	2.1	4.0	4.0
8 Finance, insurance, real estate and business services	1.1	4.3	8.9
9 Community, social and personal services	5.5	4.0	3.5

Percent

Table 3 – Employment by Skill Level.

		2012	2030			
			Levels		Additional Jobs from 2012-2030	
			Base	Accelerated	Base	Accelerated
Total Employment		**21,694**	**37,480**	**38,433**	**15,785**	**16,739**
Managers, professionals, technicians	High skilled	493	3,698	5,608	3,205	5,115
Clerks, service workers, craft and trade workers	Medium skilled	3,768	9,135	11,157	5,367	7,389
Agriculture workers, elementary occupations, operators	Low to medium skilled	17,434	24,647	21,668	7,213	4,234
Percentage Shares						
Managers, professionals, technicians	High skilled	2.3	9.9	14.6		
Clerks, service workers, craft and trade workers	Medium skilled	17.4	24.4	29.0		
Agriculture workers, elementary occupations, operators	Low to medium skilled	80.4	65.8	56.4		

Units: Thousands of Persons

5.6 Education Levels

As shown in Figure 14, a large proportion of the population in Tanzania has either no primary or incomplete primary education (the combined figure is 32 percent). Only 12 percent of the population had completed lower secondary or upper secondary and university in 2010. To determine the relative shortfall of educated workers, the education structure shown above must be projected into the future, preferably for age groups relevant to determining labor force availability.

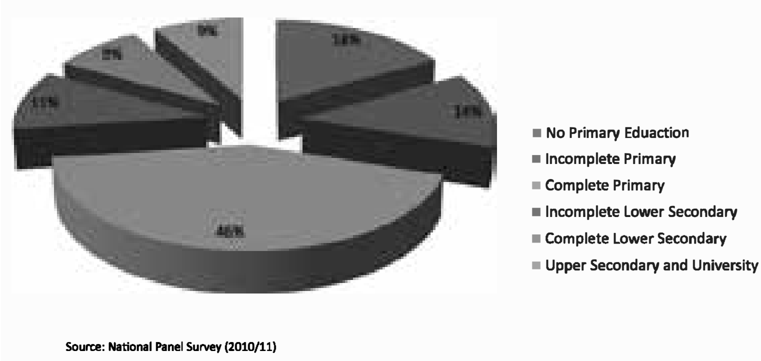

Figure 14 – Snapshot of Education Levels in Tanzania, 2010.

An indicative education attainment module was constructed that allowed for projections of population by educational attainment. Shares of population by 4 age groups were estimated and projected for the following educational attainment categories:

1. No education
2. Attending primary school
3. Completed primary school
4. Completed secondary school or higher

A projection has been made using percentage increases of completion by age group as the driving assumption, with the aim of aligning this education supply to the demand for skilled workers. The results of these assumptions are shown in Table 4.

Table 4 – Estimates and Projections of Population and Educational Attainment.

	2006	2012	2015	2020	2025	2030
Base Case						
Total working age population	21,661	25,203	27,591	32,429	38,266	44,512
No education	5,138	3,556	3,332	2,801	1,908	279
In primary	1,550	1,697	1,827	2,136	2,549	2,876
Finished primary	12,992	16,569	18,212	21,505	25,256	29,550
Finished secondary	1,980	3,381	4,220	5,987	8,553	11,807
Percent Shares, total working age population						
No education	23.7	14.1	12.1	8.6	5.0	0.6
In primary	7.2	6.7	6.6	6.6	6.7	6.5
Finished primary	60.0	65.7	66.0	66.3	66.0	66.4
Finished secondary	9.1	13.4	15.3	18.5	22.4	26.5
Accelerated Case						
Levels						
Finished primary	12,992	16,569	17,997	20,833	23,939	26,877
Finished secondary	1,980	3,381	4,398	6,543	9,900	14,553
Percent Shares, total working age population						
Finished primary	60.0	65.7	65.2	64.2	62.6	60.4
Finished secondary	9.1	13.4	15.9	20.2	25.9	32.7

It is perhaps instructive at this point to compare these projections with the projections of occupational employment, as a check. To this end, certain occupational categories were aggregated into a category called 'Skilled'. The demand for this labor category in each scenario are plotted in figure 15, next to the category 'Finished Secondary' from table 4.

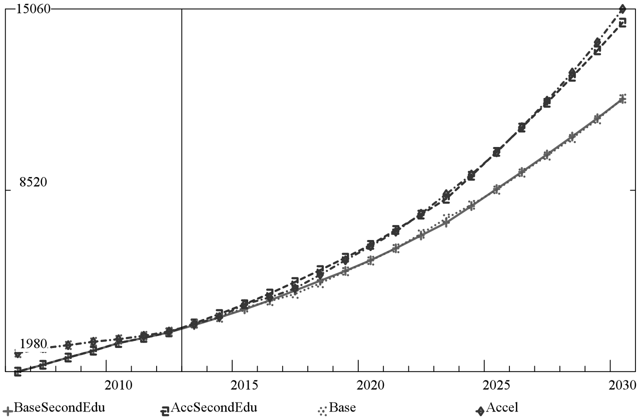

Figure 15 – "Skilled" Occupations vs. Secondary Education Completion (Thousands of Persons).

6. Conclusions and Discussion Points

The framework described here can help economists and policymakers visualize likely and alternative states of the world for Tanzania in the medium- to long-term. What is new about this study is that it brings together diverse aspects of Tanzania's economic future into a consistent, quantitative picture, and allows for the projection of demand for employment by skill and education level to 2030. Using alternative assumptions about education and training investment, future paths of labor supply by skill and education level can be constructed consistent with those assumed investments.

Education policy makers can use these results to help identify needed investments in education and training programs. Such programs require planning and conscious direction of these investments to help develop the skills and education particularly needed in Tanzania for the next ten years and beyond. The model examines the demand side of employment. This information, combined with supply-side assumptions about population and labor force, and education and levels, estimates of possible shortfalls or bottlenecks can be made.

The very nature of this process is uncertain and iterative. Such modeling cannot serve as a forecast or crystal ball. However, the process requires us to make explicit assumptions about features and relationships of the economy that will affect the level and distribution of labor demand by industry and by skill level. Even though the future is uncertain, different possible future states of the world can be modeled to better understand the range of possible implications for labor demand.

The model outputs are inherently quantitative. While this focus on numbers has many advantages, this type of analysis needs to be complemented by broader understanding of the historical, political and geographic context that makes Tanzania unique. It also helps to understand the analogues between Tanzania and other countries that have proceeded on a similar development path.

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Appendix A. Classification Schemas

A1. Detailed Producing Sectors of the Uhuru Model of Tanzania

1	Paddy rice	30	Wood products
2	Wheat	31	Paper products, publishing
3	Cereal grains, NEC	32	Petroleum, coal products
4	Vegetables, fruit, nuts	33	Chemical, rubber, plastic products
5	Oil seeds	34	Mineral products, NEC
6	Sugar cane, sugar beet	35	Ferrous metals
7	Plant-based fibers	36	Metals, NEC
8	Crops, NEC	37	Metal products
9	Bovine cattle, sheep and goats, horses	38	Motor vehicles and parts
10	Animal products, NEC	39	Transport equipment nec
11	Raw milk	40	Electronic equipment
12	Wool, silk-worm cocoons	41	Machinery and equipment nec
13	Forestry	42	Manufactures, NEC
14	Fishing	43	Electricity
15	Coal	44	Gas manufacture, distribution
16	Oil	45	Water
17	Gas	46	Construction
18	Minerals, NEC	47	Trade
19	Bovine meat products	48	Transport, NEC
20	Meat products, NEC	49	Water transport
21	Vegetable oils and fats	50	Air transport
22	Dairy products	51	Communication
23	Processed rice	52	Financial services, NEC
24	Sugar	53	Insurance
25	Food products, NEC	54	Business services, NEC
26	Beverages and tobacco products	55	Recreational and other services
27	Textiles	56	Public Administration, Defense, Education, Health
28	Wearing apparel		
29	Leather products	57	Dwellings

A2. Aggregate Industry Sectors

		ISIC
1	Agriculture, hunting, forestry and fishing	A
2	Mining and quarrying	B
3	Manufacturing	C
4	Electricity gas and water	D,E
5	Construction	F
6	Wholesale and retail trade, restaurants and hotels	G, I
7	Transport, storage and communication	H, J
8	Finance, insurance, real estate and business services	K,L,M,N
9	Government, community, social and personal services	O,P,Q,R,S,T,U

A3. Occupations

1 Legislators, administrators and managers
2 Professionals
3 Technicians and associate professionals
4 Clerks
5 Service workers and shop and market sales workers
6 Skilled agricultural and fishery workers
7 Craft and related trades workers
8 Plant and machine operators and assemblers
9 Elementary occupations

FORECASTING TAX REVENUES IN LATVIA: ANALYSIS AND MODELS

Velga Ozolina, Astra Auzina-Emsina, Remigijs Pocs[a]

1. Introduction

There are many factors and several significant events that influence the development and maintenance of macroeconomic models in the last decades. There are special considerations for the relatively small countries like the Baltic States, and Latvia in particular. The main factors are data availability, changes in statistical classifications and major political decisions. Several of the most important events in the recent history of Latvia are joining the European Union (in 2004), the following period of a fast economic growth, the introduction of the 2nd edition of the NACE classification (since 2007), the global financial crisis (especially sharp and deep for Latvia (2008-2009)), a quick and stable recovery (since 2010) and the most recent one – joining the euro area (in 2014).

Previously decisions regarding the Latvian Macro-Econometric Model were made mostly on how to adjust the model to the new circumstances, but now it is necessary to change the whole dataset and thus the whole model. The recently launched cooperation with the specialists of the Ministry of Finance of the Republic of Latvia is another factor which influences the development of the Latvian Macro-Econometric Model. The Ministry of Finance is the leading institution responsible for the development of fiscal policy and forecasts in the framework of the state budget, including the forecasts of tax revenues and government expenditures. Hence, the major attention must be paid to the tax revenues modeling by tax type.

The aim of the current research is to elaborate new modeling tools for forecasting tax revenues in the mid-term in Latvia. This research includes the analysis of the theoretical and legal aspects of taxation, the analysis of the factors influencing tax revenues and the elaboration of the forecasting tools using monthly, quarterly and annual data of 1995-2014 on tax revenues. In addition, the relations between labor productivity and the economic growth have been investigated in order to reveal the side-effects (in most cases, also unexpected effects) of significant economic fluctuations. This part of the study focuses on the time period 2005-2013 that is

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subdivided into three sub-periods: pre-crisis (period that is characterized with high economic growth rates, wage and costs increase, but slow productivity growth), crisis (negative economic growth, changes in economic structure) and post-crisis (stable high growth rates, productivity increase).

The research results are a valuable resource for the Ministry of Finance of Latvia and other policy makers.

2. Analysis of Data and Legal Aspects

Annual Data

In Latvia, as in other countries, tax revenues account for the major share of government revenues. In 1995 – 2003 taxes formed about 84-90% of all government revenues. After Latvia joined the EU, this share fell slightly to 81-86%, but during the crisis it was only 77-78%.

It should be noted that the tax revenues as a share of GDP or tax burden in Latvia (28.1%) is one of the lowest among the EU countries (see Fig.1). The tax burden is slightly lower only in Bulgaria (27.7%) and Lithuania (27.5%) and it is similar also in Romania and Slovakia (28.5%). On the other extreme, the tax burden is higher than 45% only in Denmark, Belgium and France and it is higher than the EU average (40.6%) also in Austria, Sweden, Italy and Finland.

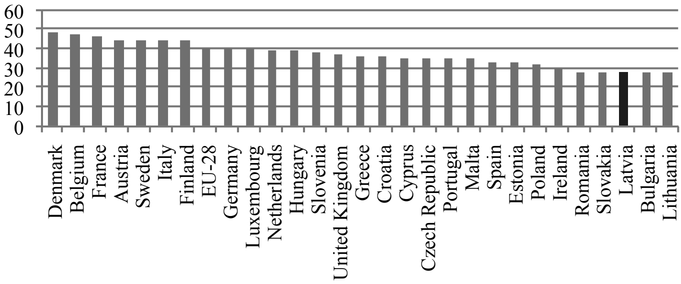


Figure 1 – Tax Burden in the EU Countries in 2012, % of GDP. *Source: Eurostat database*

The most significant taxes (by revenues) in Latvia are social contributions, the value added tax, the personal income tax and the excise duty. The share of social contributions in total tax revenues has fallen from 36.2% in 1995 to 30.3% in 2013, the share of the value added tax fluctuates around 25%, the share of the personal income tax has increased from 16.0% to 20.5% in the respective time period, and the share of the excise duty has fluctuated around 12%. Figure 2 also shows that the dynamics of tax revenues are similar to Latvian economic GDP growth, however the analyzed trends are not exactly the same.

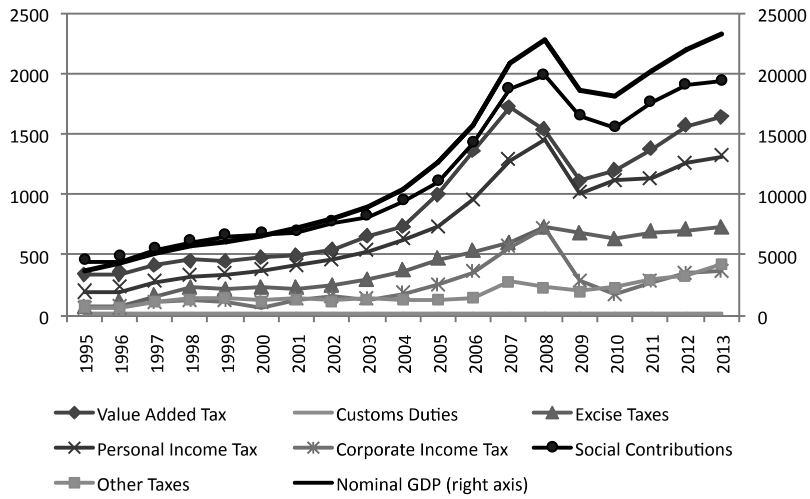


Figure 2 – Tax Revenues in Latvia (ESA95 methodology), m EUR. *Source: Authors' calculations based on CSB database*

The tax revenue data of the Ministry of Finance slightly differ from the statistical data (ESA95 methodology). The reason is that the Ministry uses the national methodology, which is based on the IMF methodology (GFS) (Tkačevs 2011). Both systems are based on similar accounting rules with some slight differences, mostly regarding consolidation (Government Finance Statistics Manual 2001). Generally, the actual tax revenues are taken into account and, if possible, attributed to the time periods when the obligation to pay taxes is created, but in separate cases some flexibility is allowed. The tax revenues should be similar in both methodologies. However, differences can occur regarding the social contributions (related to the pension system) and other adjustments.

For forecasting of tax revenues values were first used from the national methodology. There are several reasons why the national methodology should be preferred. The national data are obtained first and then recalculated according to the ESA95 methodology. The Ministry of Finance needs the forecasts according to the national methodology. The budget surveys in the national methodology are available much sooner than the ESA95 data in the necessary disaggregation. On the other hand, the ESA95 data should be preferred within a macroeconomic model, as other macroeconomic indicators used in such a model are mostly calculated using the ESA95 methodology. In this case, the national data can be used to generate the estimates for the latest data periods, which are not yet available in the official statistics. It should also be mentioned that the statistical databases do not provide detailed information on tax revenues on quarterly or monthly bases. Therefore the national methodology can be used for quarterly and monthly calculations, but the ESA95 methodology – for annual calculations.

The comparison of the revenues of social contributions calculated in the national methodology and ESA95 methodology are presented in Figure 3. Significant differences between social contributions in the ESA95 and the national methodology are related to the 2nd tier – mandatory state funded pension scheme (II pension pillar), which was introduced in Latvia in 2001. A certain proportion of the contributions is transferred from the State Social Insurance Agency to the private insurance companies and thus is not considered a tax (Recording of taxes and social contributions according to ESA95, 2014). At first, all the assets of the II pension pillar were managed by the Treasury. Since 2003 a part of the social contributions has been transferred also to private companies (mainly banks). Beginning with the end of 2007 all the assets of the II pension pillar are being transferred to the private companies, substantially reducing the revenues of the social contributions. The difference in 2008 is comparatively large also due to the fact that 8% of the social insurance rate were transferred to the II pension pillar for participants (total rate was 33.09% at that time). In 2009-2012 the part of social contributions transferred to the II pension pillar was reduced to 2% of the social insurance rate due to the crisis and increasing expenditure on the unemployment benefits. In 2013 – 2014 this proportion is 4%, in 2015 it is planned as 5% and in 2016 – 6% (2nd Tier – Mandatory State Funded Pension Scheme, 2014). The data on the other major tax revenues are almost the same in both methodologies – the ratios of the tax revenues fluctuate closely around 1.

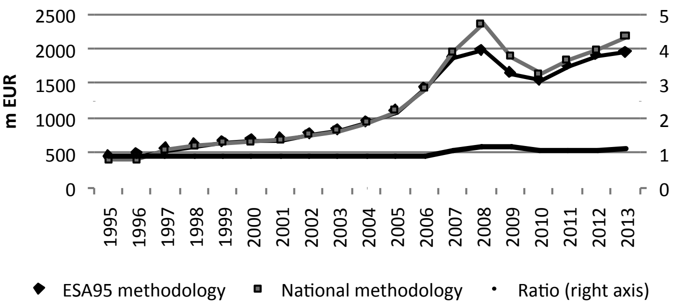


Figure 3 – Social Contributions in Latvia, m EUR. *Source: Authors' calculations based on CSB database and Ministry of Finance.*

The data analysis we have performed indicates that special attention regarding the methodology used to obtain the data has to be paid only in modeling of the social contributions. In other cases the ratios between the values of both methodologies can be used to transform data as needed.

Legal Aspects

The system of taxes and duties in Latvia is regulated by the Law On Taxes and Duties and laws related to the particular types of taxes. These laws include also significant information for modeling and forecasting the tax revenues such as the tax base, the tax rates, the dates of payments etc. Also the changes in the legal acts can be significant and thus also influence the modeling process.

- The main laws in the group of direct taxes are:
- on State Social Insurance;
- on Personal Income Tax;
- Micro-enterprise Tax Law.

Social contributions are paid for all the employees and can also be paid voluntarily by others (15 years old and older, who are not retired). The tax base is the sum of all earnings (usually wages). The social contributions tax rate as well as the proportion to be paid by the employer and the employee have been changed several times. In 2014 the full rate is 34.09%, of which 23.59% is paid by the employer and 10.5% is paid by the employee. There are several categories of persons with lower tax rates; however, these groups are not covered against all risks provided by the social insurance system of Latvia. It should be noted that the social contributions rate should be adjusted, when modeling revenues according to the ESA95 methodology, to take into account the II pension pillar.

The employers pay social contributions once a month till the date set by the State Revenue Service (SRS) (usually in the subsequent month). Self-employed persons and foreigners pay the social contributions each quarter, till the 15th day of the subsequent month. Voluntarily social contributions are paid each month till the last day of the month. The social contributions can also be paid in advance. The share of social contributions paid by self-employees since 2004 is approximately 0.6% of the total social contributions revenues. It means that only a small part of tax payers makes their contributions once per quarter. Thus their contributions should not enhance the seasonal pattern in monthly data very much (if such a pattern exists).

Additionally, the social contributions are paid also within the micro-enterprise tax. The tax base here is the annual turnover and revenues of employees, if they exceed 720 EUR per month. The micro-enterprise tax rate is 9%, if there are 5 employees or less in the enterprise. In the future a 9% tax rate will be applied to the turnover till 7000 EUR, a higher rate will be applied to the remaining part of the turnover up to 100,000 EUR. The rate is 20% for the turnover, which exceeds 100,000 EUR. The micro-enterprise tax is paid each quarter till the 15th day of the subsequent month. 65% of micro-enterprise tax revenues are transferred to social contributions account. As the Central Statistical Bureau (CSB) uses different criteria for the classification of enterprises, it is not possible to determine the significance of micro-enterprises. However, taking into account that the revenues of micro-enterprise tax are relatively small, also the number of tax-payers is not significant both regarding social contributions and personal income tax. For example, in January 2014, the value of the complex taxes (patent fees and micro-enterprise tax) revenues was 2.5 m EUR, the revenues of the social contributions were 148.1 m EUR, the personal income tax revenues – 101.0 m EUR (Valsts kase 2014a).

The personal income tax is applied to various incomes, which are not taxed by other types of income taxes. Initially the tax base included all wages, particular economic activities and economic activities not taxed by other types of taxes. Since 2010 also an income from capital and an increase in capital is taxed. And since 2014 the income of a seasonal agricultural worker is also taxed. The tax base consists of all taxable income during a particular period, from which the untaxed minimum, the eligible expenditures (social contributions, education, donations, private pension schemes etc.) and the tax breaks (for dependent persons, to invalids and politically repressed persons) are subtracted. Till 2008 additional relieves were granted to a specific group of pensioners. Most of these items are determined by the regulations issued by the Cabinet of Ministers and thus change over time.

For a long time the personal income tax rate was stable – it was 25% in 1995 – 2008, then it was lowered, raised again due to the crisis and now it is 23%. It is planned to lower it gradually to 22% in 2016. The tax rate on income from capital and some other specific items is lower. The personal income tax is mostly paid on monthly basis; however there are some exceptions – economic activities (quarterly payments) and capital increase (depending on the scope of increase – each month, each quarter or once a year).

A part of the micro-enterprise tax is transferred to the personal income tax account as well. Depending on the status of the tax payer, the share varies from 34 to 35%. It is paid on quarterly basis.

Each year the tax payers can file a personal income declaration, stating their eligible expenditures and thus qualifying for the refund of overpaid taxes. Persons involved in economic activities have to file the declaration from the 1st of March to the 1st of June (for the previous year) and pay the due taxes or receive back overpaid taxes within 3 month. It should be noted that declaration filing dates have been changed over time. In 1995 the declaration was filed until the 1st of March, from 1996 to 2011 the deadline was the 1st of April. Also the officers since 1996 have to file their declarations compulsory – till the 1st of April (since 2010 from the 15th of February). Others can file their declarations within 3 years after the taxation year.

- The main laws related to the main indirect taxes are:
- since 2013 the Value Added Tax Law;
- before 2013 law On Value Added Tax;
- on Excise Duty.

The value added tax payer is any person that is involved in economic activities. The tax payers can be registered or not registered persons from Latvia, the EU member countries or the third countries. The taxable objects are the delivery and the purchase of goods and services (including exports and imports) for reward. The tax base is the reward for delivered goods or services or the prime cost of production of goods or delivery of services. In the case of imports, also the additional services and the transportation to another EU country, as well as the customs and other duties and fees are regarded as the taxable value. The standard tax rate is 21%. A 12% rate is now applied to the most pharmaceutical products, delivery of medical equipment, special baby products, regular domestic passenger traffic, books and regular press, accommodation, fuel wood and heat for households. A 0% rate is applied to the export of goods, to the import of goods destined to another EU country, to the delivery of a new transport vehicle to another EU country, to the goods sold in tax-free shops etc. The tax exemptions are applied to the universal post services, the majority of medical services, the education services etc. The tax rates and the special conditions have been revised several times since 1995.

The taxation period differs according to the taxable value in the previous period. For registered tax payers it is one month, if the taxable value exceeds 50 000 EUR, half a year, if it is less than 14 228.72 EUR and a quarter otherwise. The tax should be paid within 20 days after the taxation period. The previously paid value added tax for goods used in production process and similar activities, can be deducted from the tax payments. If the excess tax is paid, it is transferred to the subsequent tax periods in 30 days after the tax declaration is filed. In several cases the residents can claim refunds and can get the money in 10 days after the decision is made by SRS. Persons from other EU countries can ask for the tax refunds in case of purchases and imports, if they are registered in another member country and have not performed economic activities in Latvia, but are planning to do them in another EU country (similar rule applies to Norway, Switzerland, Island and Monaco). The procedure takes up to 4-8 months, depending on the necessity of additional information. In the same manner Latvian residents can apply for tax refunds from other EU member countries.

The excise duty is applied to the excise goods – alcoholic beverages, tobacco products, oil products, soft drinks and coffee, natural gas used as a fuel or for heating (with exceptions). As the excise goods are diverse and specific, there are differentiated tax rates for different products. Therefore it is not easy to follow all the changes in tax rates and eventually to take this information into account in order to evaluate the changes in tax revenues. A part of these goods are essential for entrepreneurship and even existence (like heating in winter and fuel for vehicles). Another part can partly be viewed as luxury goods (like alcoholic beverages and soft drinks), the consumption of which depends on the income level. Thus a suitable tax base for excise tax is an indicator characterizing economic activities of the country like GDP. The excise duty is paid on monthly bases or when the goods are available for purchase in 5-15 days after the taxation period or actions stated in the law On Excise Duty.

Seasonality Analysis

The analysis of legal aspects indicates that there could be a seasonal pattern observed in the revenues of some taxes, but it should not be very explicit. The social contributions are paid on a monthly basis and basically depend on the number of employees and wages. Only a small part comes from the micro-enterprise tax, which is paid quarterly. There is a similar situation with the personal income tax. However, in this case the tax payments can be revised after the income declaration is filed. The monthly data on the main indirect taxes (see Fig. 4) show some hints on seasonal patterns in the value added tax and the excise duty revenues, but these patterns are not very stable. The value added tax is paid once a month, once a quarter or half a year. The monthly payments probably dominate; therefore it is not possible to distinguish periods with constantly higher or lower tax revenues. It is interesting to see that the crisis has not influenced excise tax revenues much. On the other hand, it is not a big surprise as about a half of these revenues come from oil products and another 20% from tobacco products (it is hard to give up on both of these things). The excise duty is paid on monthly basis or when the respective economic activities occur, therefore the tax revenues at the beginning of the year are lower than in other seasons.

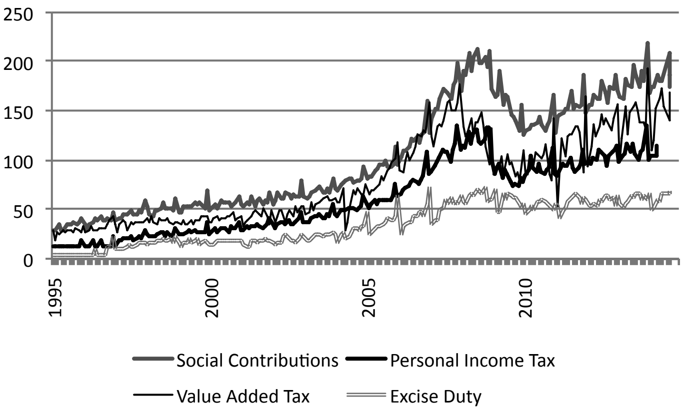
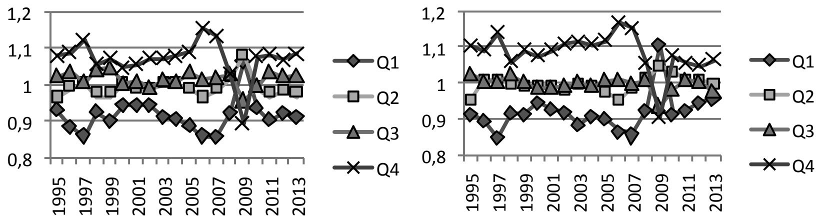


Figure 4 – Revenues of the Main Taxes in 1995 – September 2014, m EUR. *Source: Ministry of Finance.*

In this study, in order to reveal the seasonal fluctuations in tax revenues data, the value of each month or quarter was divided by the average value per month or quarter. These indexes have to be analyzed together with the seasonal patterns in the tax base. For the direct taxes, the main indicators to analyze are wages and the number of employed persons. Wages generally increase with a seasonal pattern, except in 2009. The maximum values are usually reached in July and December, but the lowest values are in February and September. The main factors influencing this pattern are bonus payments (frequently paid at the end of the year) and the vacations (in many cases enjoyed during the summer). In quarterly data it translates as the lowest value in the first quarter and faster or slower growing values in the next three quarters. The pattern in employed persons' data since 2010 is more like a classical cycle – two periods with upward movement are followed by two periods with downward movement. The high season is usually in the 3rd and 4th quarters, but the lowest value is in the 1st quarter. If we take wages together with the number of employees, the pattern is more like the pattern of wages – the smallest value (drop) in the 1st quarter is followed by increased values in three subsequent quarters.

The quarterly pattern of the revenues of the social contributions corresponds to the compound pattern of the wages and employees (see Fig.5a). The only exception can be seen in 2009, when the dramatic and specific changes took place due to the crisis. The values of monthly seasonal indexes in the first month of each quarter are not significantly higher than in other months (except July).



a. Social Contributions

b. Personal Income Tax

Figure 5 – Quarterly Seasonal Indexes of Direct Taxes. *Source: Authors' calculations based on Ministry of Finance data.*

The quarterly pattern of personal income tax revenues is similar to that of the social contributions (see Fig.5b). But in this case, the range of the values has become narrower after the crisis. Probably the main reason why the value of the coefficient in the 1st quarter increases in 2012 and 2013 and the value of the coefficient of the 3rd quarter decreases in the same period is the shift in filing dates of personal income declarations. The monthly pattern of the seasonal indexes for the personal income tax is similar as for the social contributions.

The seasonal patterns of indirect taxes should be analyzed together with the seasonal patterns of GDP and personal income. The general seasonal pattern of nominal GDP is – the lowest value in the 1st quarter followed by the increase in three subsequent quarters and then again – lower value in the next 1st quarter. It should be noted that the pattern is similar before and after the crisis. However, before the crisis the increase in the 3rd quarter was lower and in the 4th quarter – higher than after the crisis. Private consumption has a similar seasonal pattern with a lower growth in the 4th quarter.

The quarterly pattern of the value added tax revenues is not very stable. One of the reasons might be relatively frequent changes in the legal acts both regarding the tax base and the tax rates. Also here monthly pattern of seasonal indexes does not suggest that the quarterly tax payments are a significant part of the tax revenues. The value added tax revenues are comparatively larger only in January.

The quarterly pattern of excise duty revenues is more clear and stable, although since 2007 the seasonal index of the 4th quarter is no longer the highest among others. This suggests that private consumption is a more appropriate tax base for excise duty comparing with the GDP. As the excise duty is paid mostly on monthly basis, the monthly seasonal indexes are fluctuating in a similar manner.

The analysis of seasonal patterns indicate that there is a general trend for the tax revenues to follow the patterns in variables related to the tax bases, therefore the use of seasonal dummies or seasonally adjusted time series may not be necessary in most cases.

3. Productivity and Economic Activity Analysis

Labor productivity is a very powerful factor that affects wages, taxes, profits, investments, technologies etc. Labor productivity has a wide application range, for example, labor productivity can also be used in the analysis and evaluation of business competitiveness in global market. Due to the labor migration and the free movement of labor and capital, it is valuable to analyze these issues in regional level – the Baltic countries, not just national level (only Latvia). (However, it should be stressed that majority of Latvian employees working abroad are employed in the UK, Ireland, Sweden, Norway.) The analysis performed here indicates the regional situation as all three countries have similar economic development pace and history.

The analysis of labor productivity dynamics shows a significant improvement in labor productivity as compared with the average productivity in the EU. It indicates that the economic crisis heavily influenced productivity and technologies applied, which resulted in significant improvements. The data show that in the fast economic growth period (2004-2007) the labor productivity in Latvia was 37-40% of the average level of EU productivity, in Lithuania – 49-53%, but in Estonia – 49-56%. During the crisis (2008-2010) the negative GDP growth rates result in changes in the economic structure. The post-crisis period (2011-2013) is again comparatively stable with productivity increase trend. The analysis of relation between productivity per hour and real GDP growth rate in three research periods argues that the relation between the indicators is unstable. The results indicate that in the pre-crisis period the level of productivity had small or no effect on economic growth rate (see Fig.6), during the crisis the productivity increased while the economies declined, but in the post-crisis period the productivity is higher than previously and it results in stable economic growth with some time lag.

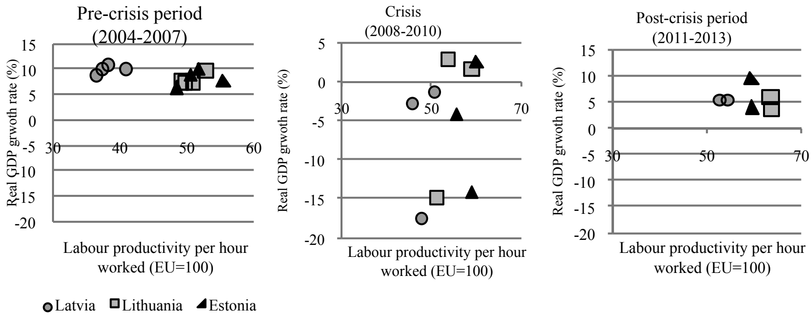


Figure 6 – Labour productivity and real GDP growth rate in pre-crisis, crisis, and post-crisis period. *Source: Eurostat database.*

The data show that in the fast economic growth period (2004-2007) the labor productivity in Latvia was 37-40% of the average level of EU productivity, in Lithuania – 49-53%, but in Estonia – 49-56%. During the crisis (2008-2010) the negative GDP growth rates result in changes in the economic structure. The post-crisis period (2011-2013) is again comparatively stable with productivity increase trend.

The statistical analysis of neighboring EU countries' data shows that the countries, that took policy action and increased productivity during the crisis, experience quicker and more noticeable recovery (including Latvia). As a result, also the profits of companies and corporate income tax revenues increase.

Our analysis is important also from the modeling perspective. We can expect that the relations between the tax revenues and the influencing factors will be relatively stable during pre-crisis and post-crisis period. However, it may be necessary to use some dummy variables during the crisis period. The results of labor productivity analysis in the Baltic countries illustrate also some valuable aspects of the business competitiveness in the global market and its dynamics – in Latvia, we can observe a noticeable improvement of competitiveness that leads to the increase of exports of goods and services (both in money terms and volumes) in the post-crisis period.

4. Methodology

Modelling Approaches

One of two main approaches can be applied when modeling tax revenues. It is possible to use identities, where an effective tax rate or a coefficient characterizing the tax rate, is multiplied by an appropriate tax base. Traditionally the tax base is endogenous and the tax rate – exogenous (Willman, Estrada 2002). Usually in this kind of calculation, a proxy of the tax base is used, and the tax rate is calculated as a ratio of tax revenues and chosen tax base. The second approach is based on estimation of econometric equations. In most cases estimation of econometric equations of tax revenues includes the tax base as the main factor. The advantages of regression equations are connected with the possibilities to use a wider range of influencing factors, including the use of tax rates stated in legislation, as well as various forms of tax relief. Also a mixed approach can be used – identities can be used to calculate the tax revenues, but econometric approach can be used to determine the value of the tax rate coefficient.

Revenues of direct taxes in the models of other countries are calculated both as aggregates and by individual tax types. Revenues of personal income tax and social contributions are often modelled as a single variable, using an explanatory variable which is close to disposable income including taxes (Almon 2004; Willman, Estrada 2002) or total compensation of employees (Schneider, Leibrecht 2006), which is a product of average wages and number of employees, as a tax base. Alternatively these revenues are modelled separately by using previously mentioned (Livermore 2004) and/or other factors. Taking into account the peculiarities of calculation of taxes, in some models the untaxed minimum (Celov *et al.* 2005) and/or social contributions (Kattai 2005) are deducted from the tax base.

For indirect taxes, GDP (Almon 2014) and private consumption (Kattai 2005) are used most frequently as a tax base. Private consumption can be used for calculating excise and customs duties, however, for calculating taxes on production and imports, which have a broader tax base, GDP is more suitable (Almon 2004). Nevertheless, such a choice of factors does not always ensure the best results, for example, in the Austrian model (Schneider, Leibrecht 2006) VAT revenues are modeled depending on private consumption, but fuel tax revenues – depending on GDP. In the model for Ireland (McQuinn *et al.* 2005) domestic demand or the sum of private consumption, government consumption, investments and export is used as a tax base of indirect taxes.

Models and Equations

Within the research, calculations are made in 3 levels – monthly, quarterly and annual. In such a way it is possible to use the modeling experience from the development of the macro-econometric model of the

Latvian economy (Ozolina, Pocs 2013) as well as all the data obtained from the Ministry of Finance. The Ministry of Finance data are used in monthly and quarterly calculations and ESA 95 data are used in annual calculations. It should be noted that the usual procedure in the Ministry of Finance is to use annual macroeconomic projections provided by the macroeconomic analysts to calculate the annual forecasts of tax revenues and then spread the revenues over 12 months. Therefore simple macroeconomic tools with the main macroeconomic indicators as exogenous variables are used for quarterly and annual projections. Monthly data are used only for calculation, analysis and projections of seasonal indexes as there is a need to transform quarterly and annual data to monthly data. Additionally, data of January – July of 2014 are used to measure the precision of obtained forecasts.

At the quarterly level the identity-based approach is compared with the econometric approach. The identities can also be used to determine the necessity of seasonal dummies in econometric equations. In general, the equation (1) can be used for modeling and it involves two exogenous indicators – the tax rate coefficient and the tax rate.

tax_rev = taxr_coef*taxr*tax_base, (1)

where tax_rev – tax revenues,
taxr_coef – tax rate coefficient,
taxr – tax rate,
tax_base – tax base.

The tax rate is the official tax rate stated in laws and regulations and is applied in cases, when a single tax rate dominates (like the value added tax, the social contributions, the personal income tax). In other cases only the tax rate coefficient is used and it is calculated by dividing the tax revenues and the tax base value. Moreover, it is advisable to obtain and predict the values of the real tax rate coefficient, as the tax rate coefficient in nominal terms is often influenced by inflation. If the tax rate is used in equation (1), tax rate coefficient is calculated by dividing tax revenues with the product of the tax base and the tax rate.

Nominal GDP is used for modeling the value added tax and the excise duty revenues (private consumption was also tested, but the values of coefficient were more volatile). The product of nominal wages and the number of employees is used for modeling social contributions revenues. The calculation of the tax base for private income tax revenues is similar to its calculation for tax purposes – we have to deduct non-taxed income from wages and multiply this value by the number of employees and then subtract a share of social contributions paid by employees.

The econometric equations are estimated using similar indicators as those needed for calculation of the tax base. The equation of social contributions revenues is shown in Table 1. Additionally to the tax base and the tax rate multiplication, also the ‘EU dummy’ is used, which once again indicates that the economic development in Latvia is not homogeneous. The higher revenues of social contributions between 2004, when Latvia joined the EU, and 2007 – a period of fast development, can be associated with the higher income of population and willingness to pay taxes voluntarily.

Table 1 – Social Contributions Revenues Equation in G7 for Latvia.

```
SEE    =      12.80 RSQ   = 0.9911 RHO =    0.43 Obser  =   48 from 2002.100
  SEE+1 =      11.82 RBSQ  = 0.9907 DW  =    1.14 DoFree =   45 to   2013.400
  MAPE  =       2.39
    Variable name          Reg-Coef  Mexval  Elas   NorRes     Mean   Beta
  0 TAX_SOC              - - - - - - - - - - - - - - - - -    394.63 - - -
  1 intercept             -15.67795     5.9  -0.04  112.06      1.00
  2 TAXR_SOC*((EMPL*W_NOM*3)/100000)
                            0.82441   929.9   1.03    1.22    492.62  1.007
  3 D_EU                   13.39648    10.3   0.01    1.00      0.31  0.046
```

Where
TAX_SOC: social contributions revenues
TAXR_SOC: social contributions rate
EMPL: number of employees
W_NOM: gross nominal wages, monthly average
D_EU: EU dummy (2004Q2-2007Q4 = 1, 0 otherwise)

The product of the tax base and the tax rate is used as the main factor for personal income tax revenues. However, in this case tax revenues in 2010 have been smaller than expected; therefore a dummy for 2010 is used as well (see Table 2).

Table 2 – Personal Income Tax Revenues Equation in G7 for Latvia.

```
SEE    =      10.34 RSQ   = 0.9841 RHO =    0.14 Obser  =   48 from 2002.100
SEE+1  =      10.34 RBSQ  = 0.9834 DW  =    1.72 DoFree =   45 to   2013.400
MAPE   =       3.24
  Variable name            Reg-Coef  Mexval  Elas   NorRes     Mean   Beta
0 TAX_INC_PERS           - - - - - - - - - - - - - - - - -    246.31 - - -
1 intercept               -15.42434     9.4  -0.06   62.85      1.00
2 TAXR_IIN*((EMPL*(W_NOM-TAX_NMIN))/1000-TAX_SOC*TAX_SOC_E)
                            3.39666   687.7   1.08    2.44     78.20  1.022
3 D_10                    -46.54480    56.2  -0.02    1.00      0.08 -0.157
```

Where
TAX_INC_PERS: personal income tax revenues
TAXR_IIN: personal income tax rate
EMPL: number of employees
W_NOM: gross nominal wages, monthly average
TAX_NMIN: untaxed minimum
TAX_SOC: social contributions revenues
TAX_SOC_E: share of employees social contributions
D_10: dummy for 2010 (2010 = 1, 0 otherwise)

Value added tax revenues are calculated using GDP as the main factor and a time trend as an adjustment factor (see Table 3). Similarly as in case of the social contributions, the "EU dummy" was used as the tax revenues in 2004-2007 tend to be higher as expected. However, in this case the influence of Latvian membership in the EU is not very notable.

Table 3 – Value Added Tax Revenues Equation in G7 for Latvia.

```
SEE    =       0.10 RSQ   = 0.9723 RHO =   0.13 Obser  =   76 from 1995.100
SEE+1  =       0.09 RBSQ  = 0.9712 DW  =   1.74 DoFree =   72 to   2013.400
MAPE   =       1.37
  Variable name           Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
0 LTAX_VAT              - - - - - - - - - - - - - - - - -      5.27 - - -
1 intercept               -2.56866    55.4  -0.49   36.14      1.00
2 @log(GDP_CP)             1.03000   201.5   1.54    1.28      7.89  1.094
3 @log(TIME)              -0.09040     6.8  -0.06    1.13      3.37 -0.143
4 D_EU                     0.09103     6.5   0.00    1.00      0.20  0.063
```

Where
TAX_VAT: value added tax revenues
GDP_CP: nominal GDP
TIME: time trend (1995:1 = 1)
D_EU: EU dummy (2004Q2-2007Q4 = 1, 0 otherwise)

The excise duty revenues are modelled depending on the nominal GDP according to the equation given in Table 4. In this case tax revenues during the crisis (in 2009 and 2010) are higher than might be expected, therefore a respective dummy is used as well.

Table 4 – Excise Duty Revenues Equation in G7 for Latvia.

```
SEE    =       0.08 RSQ   = 0.9767 RHO =   0.06 Obser  =   60 from 1999.100
SEE+1  =       0.08 RBSQ  = 0.9759 DW  =   1.87 DoFree =   57 to   2013.400
MAPE   =       1.25
  Variable name           Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
0 LTAX_EXC              - - - - - - - - - - - - - - - - -      4.70 - - -
1 intercept               -3.29918   170.7  -0.70   42.90      1.00
2 @log(GDP_CP)             0.98389   514.3   1.70    1.39      8.11  0.958
3 D_0910                   0.14311    17.7   0.00    1.00      0.13  0.098
```

Where
TAX_VAT: value added tax revenues
GDP_CP: nominal GDP
TIME: time trend (1995:1 = 1)
D_10: dummy for 2010 (2010 = 1, 0 otherwise)

In order to evaluate whether the econometric equations give adequate results, the Mean Absolute Percentage Error (MAPE) was used to evaluate the precision of forecasts. MAPE values for the whole sample (last observation in IV quarter of 2013) are rather low – 2.39% for social contributions, 3.24% for personal income tax, 1.37% for value added tax and 1.25% for excise duty. However, it is more important to measure the accuracy of forecasts in the next periods. As the data of I and II quarter of 2014 are available (except for personal income tax), forecasts are compared with the actual data and the results of MAPE are given in the Table 5. We see that the econometric equations allow obtaining rather accurate forecasts for the social contributions and excise duty, and reasonably precise results can also be obtained for the personal income tax. However, the value added tax should be forecasted only using the identity-based approach.

Table 5 – Quarterly calculations – precision MAPE.

Tax Type	2014 I	2014 I and II
Social Contributions	3.5	1.8
Personal Income Tax	6.5	-
Value Added Tax	15.4	16.7
Excise Duty	0.7	1.7

After the quarterly forecasts are obtained, they are transferred to the monthly data using seasonal indexes.

Annual models usually reveal medium and long-term trends and relationships among economic variables. Therefore short-term forecasts are not always very accurate. Therefore identities (the same as in the quarterly calculations) are preferred in annual level, if the values of exogenous indicators are reasonably stable and thus predictable.

It should also be added that the tax rate of social contributions was adjusted according to the ESA95 classification in order not to show the part of revenues transferred to the private sector within the II pension pillar. As it was mentioned before, the 2nd tier – mandatory state funded pension scheme was introduced in Latvia in 2001 and at first all the assets were managed by the Treasury. Since 2003 a part and since the end of 2007 all the II pension pillar assets were transferred to private companies (mainly banks). The share of social contributions, which goes to the II pension pillar is generally known. However, not all the employees have to participate in this system. Therefore detailed information on the government budget revenues and expenditures was analyzed to estimate the II pillar rate. The estimated value of the II pillar rate in 2009 is higher than the maximum possible II pension pillar rate. The reason is that social payments were higher in the first part of the year, when 8% points of social contributions rate were transferred to the II pension pillar. So comparatively fewer funds were transferred in the rest of the year, when the share dropped to 2% points. However, the maximum II pillar rate is calculated as a simple average share and thus does not take into account the differences in the tax base. Overall, the estimated II pillar rate values seem plausible.

The final modeling step in annual calculations is to transfer the forecasts from the ESA95 methodology to the national methodology. For this purpose the simple coefficients are used. In case of the social contributions, also adjustments related to the II pension pillar are made. Further the values are transferred in monthly projections using the seasonal indexes.

5. Modelling Results

Estimates of Exogenous Variables

In order to show the ability of the model to perform short-term forecasts, calculations are made for 2014-2015. Thus for the econometric equations we need information about the tax rates and the untaxed minimum of the personal income tax and about several macroeconomic indicators. The values of the exogenous macro variables for 2014-2015 are given in Table 6.

Table 6 – Values of Exogenous Macro Variables in 2014-2015, %.

	2014							2015
Exogenous variables	I*	II*	III	IV	I	II	III	IV
Real GDP growth rate	2.8	2.3	2.3	2.6	2.7	2.8	2.8	2.9
GDP deflator growth rate	1.2	1.2	0.8	1.0	2.4	2.4	2.4	2.4
Nominal wage growth rate	7.5	6.5	6.0	5.0	4.5	4.5	4.5	4.5
Unemployment rate	11.9	10.7	10.7	10.5	10.3	10.1	9.9	9.7
Growth rate of economically active population	-1.1	-0.8	-0.8	-0.8	-0.7	-0.6	-0.5	-0.4

* actual data, calculated based on CSB database

Additionally, for the identities we need information about the tax rate coefficients. The calculated and estimated values of the tax rate coefficients are shown in Figure 7. The beginning of the sample for the direct taxes – the 1st quarter of 2002, is related to the data availability on the number of employees. The patterns of all the coefficients do not show stable seasonal fluctuations. However, the seasonal fluctuations appear in the dynamics of the tax rate coefficient of the social contributions since 2011, which is expected to continue. Also since 2009 the values of the tax rate coefficient of the value added tax in the IV quarter tend to be the smallest. Therefore a similar pattern is chosen for 2014 and 2015.

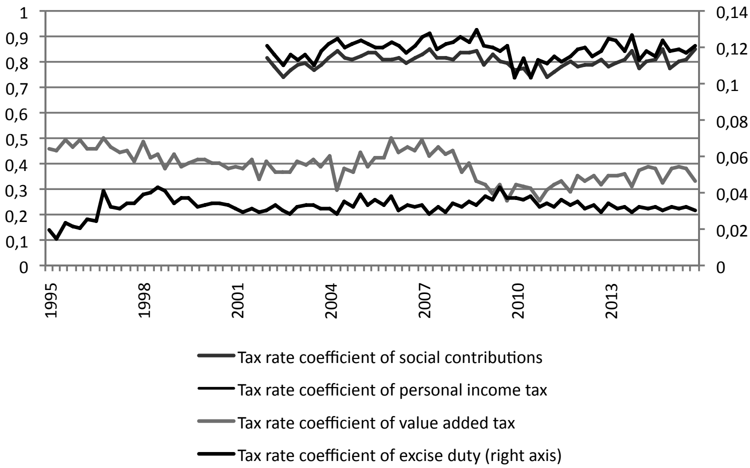


Figure 7 – Dynamics of Tax Rate Coefficients in 1995-2015. *Source: Authors' calculations, 2014 Q3-2015 Q4 – estimates.*

The annual values of the exogenous macro-variables correspond to the quarterly estimates. The calculated values of the tax rate coefficients are shown in Figure 8.

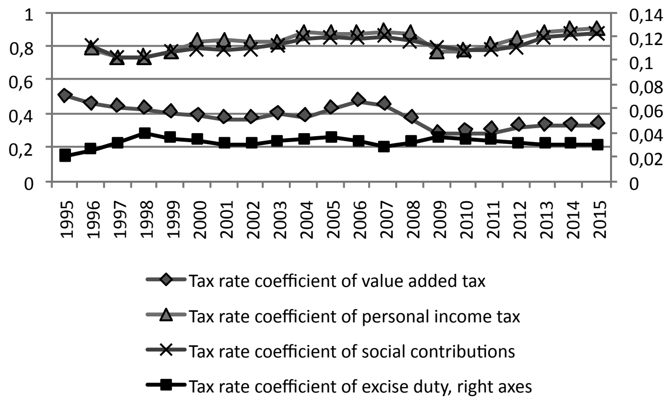


Figure 8 – Dynamics of Tax Rate Coefficients in 1995-2015. *Source: Authors' calculations.*

The trends in the social contributions and the personal income tax are very similar. This is probably related to their interrelation as well as the similar tax base.

Forecasts

All three kinds of models were used to obtain forecasts – quarterly identity and econometric equation and annual identity. The results are given in Table 7. It is evident that for the direct taxes annual identities give relatively higher values in both years, which may indicate that the assumptions regarding the tax rate coefficients are very optimistic. On the other hand, the value of annual identity forecasts of the value added tax in 2014 seems pessimistic. The forecasts of the excise duty are relatively similar.

Table 7 – Forecasts of Tax Revenues in 2014-2015, m EUR.

			2014			2015
Tax Type	Q Id.	Q Ec.	A Id.	Q Id.	Q Ec.	A Id.
Social Contributions	2255.4	2214.4	2317.0	2364.0	2345.5	2454.5
Personal Income Tax	1346.6	1359.5	1440.4	1368.9	1398.0	1467.7
Value Added Tax	1843.1	1833.1	1724.1	1961.9	1812.7	1816.7
Excise Duty	750.6	759.5	749.2	790.3	784.4	776.0

Where
Q: quarterly
A: annual
Id.: identity
Ec.: econometric equation

For the final forecast we decided not to use the minimum or maximum values for the revenues of each tax type. Thus the quarterly identities are used for the social contributions, the econometric equations for the personal income tax, the quarterly econometric equation in 2014 and the annual identity in 2015 for the value added tax and the quarterly identity in 2014 and the econometric equation in 2015 for the excise duty. The final monthly forecasts are shown in Figure 9.

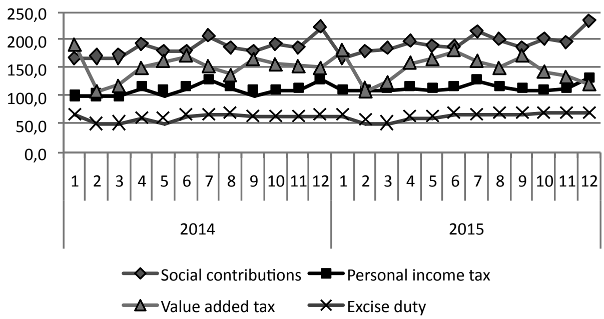


Figure 9 – Monthly Forecasts of Tax Revenues in 1995-2015, m EUR. *Source: Authors' calculations*

The annual forecasts provide insight into the general trends of tax revenues. The monthly forecasts provide useful information for the planning of financial flows.

6. Conclusions

The development of forecasts involves two main issues – the elaboration of an adequate model and the development of plausible scenarios. The use of econometric equations helps to reduce the need for assumptions as these in many cases involve less exogenous variables. The analysis of tax revenues in Latvia shows that the econometric models can be quite precise, but not in all cases (the value added tax). Therefore also the identities should be considered as well.

Special attention should be paid also to the seasonal fluctuations of tax revenues, as the Latvian government needs monthly forecasts for the budget planning. In many cases it depends not only on the fluctuations in tax base or tax payment deadlines, but also on the number of working days, however, it requires additional study.

The choice of additional factors such as dummies related to the particular events or periods of the development have to be considered, especially for a country with dynamic development (both positive and negative) as Latvia.

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MACRO-ECONOMIC IMPACT ANALYSIS OF THE SOUTH AFRICAN BROILER INDUSTRY USING THE SOUTH AFRICAN INFORUM MODEL (SAFRIM)

Christo Joubert[a], *Nomsa Phindile Nkosi*[b]

Abstract

The South African Broiler sector is one of South Africa's most complex and integrated systems. The industry is the biggest agricultural sub sector in terms of value of production which amounts to R37,8 billion ($3.78 billion), 22% of the total value of agricultural production in 2012. South African citizens consumed 36.12 kg of poultry per capita per annum in various formats in 2011. The sustainability of the broiler industry is dependent on a lot of factors, of which maize (mainly yellow), high protein (soya), and unfair international competition play important roles.

The primary objective of this research is to analyse the Macro-economic impact of the South African broiler industry by applying the South African INFORUM model (SAFRIM). The focus will be to analyse various scenarios to aid the further development of the industry. The objective of the scenarios is to compare supporting actions to assist the industry, instead of policies to protect the industry against international competition through import tariffs or other direct import reduction measures.

JEL Classification: C32; C54; D11; D24; D57; D58; F13
Keyword: SAFRIM; Inter Industry Forecasting Model; Broiler; Poultry; Tariffs; Trade

1. Introduction

There is currently an important debate in South Africa regarding the lifting of import restrictions on broilers. The production of broilers is a very important agriculture industry in South Africa. The industry employs an estimated 110,000 people in the primary and secondary sectors. This excludes employment in the feed and other industries. The annual poultry imports for 2010 into South Africa were 265,791 tons, which constituted an increase of 34,488 tons, or 15% more, in comparison with the total poultry imports

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for 2009. Broiler meat accounts for 90.4% of all poultry imports. The value of annual poultry imports (FOB) for 2010 into South Africa amounted to R1,766 billion ($176.6 billion), which constituted a 13% increase or R200 million more in comparison with the value of total poultry imports for 2009.

Although this industry comprises mostly of large scale producers, it is also a product that can easily be produced by small scale farmers and can be used in the agriculture sector as an empowerment and development product for emerging farmers entering the commercial market. This is due to the simplicity of the production process, and the management and the availability of markets specifically in rural areas.

If the lifting of import restrictions on broilers takes place, this will harm the broiler industry with significant effect on employment and poverty alleviation. However on the other side, if broilers can be made available at lower prices due to the lifting of import restrictions, it will improve spending power of the consumers. This project's objective is to calculate the net effect of lifting import restrictions on broilers on the South African economy by making use of the South African Inforum Model (SAFRIM).

The report is divided into the following sections:

- scope of the study;
- the impact of related import restrictions;
- methodology;
- results of Case Study;
- summary and conclusion.

2. Scope of Study

2.1 Increasing Imports

Chicken meat is considered the most affordable source of animal protein. Consumption has grown rapidly through the past decade, driven mainly by increased consumer disposable income per capita. Chicken consumption grew at an average rate 8.4% per annum for the period from 2002 to 2012 (BFAP 2013), domestic production has not matched this growth, resulting in an increasing deficit in the local market (Figure 1), and a trend of increasing imports into South Africa. In 2011 the South African industry produced 1.42 million tons of broiler meat, an increase of only 0.8% from 2010 (SAPA 2012), despite an increase of 3.3% in real per capita consumption from 2010 to 2011, implying that growth in consumption was largely met by imports.

2.2. The South African broiler value chain

The value chain consists of several role players interacting with each other through the system. An illustration of the broiler value chain is provided by Davids (2013) in Figure 2. The commercial broiler industry

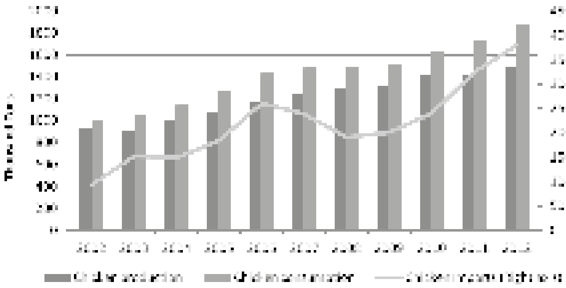

Figure 1 – Production, consumption and imports of broiler meat in South Africa: 2000-2011. *Source: Compiled from SAPA statistics.*

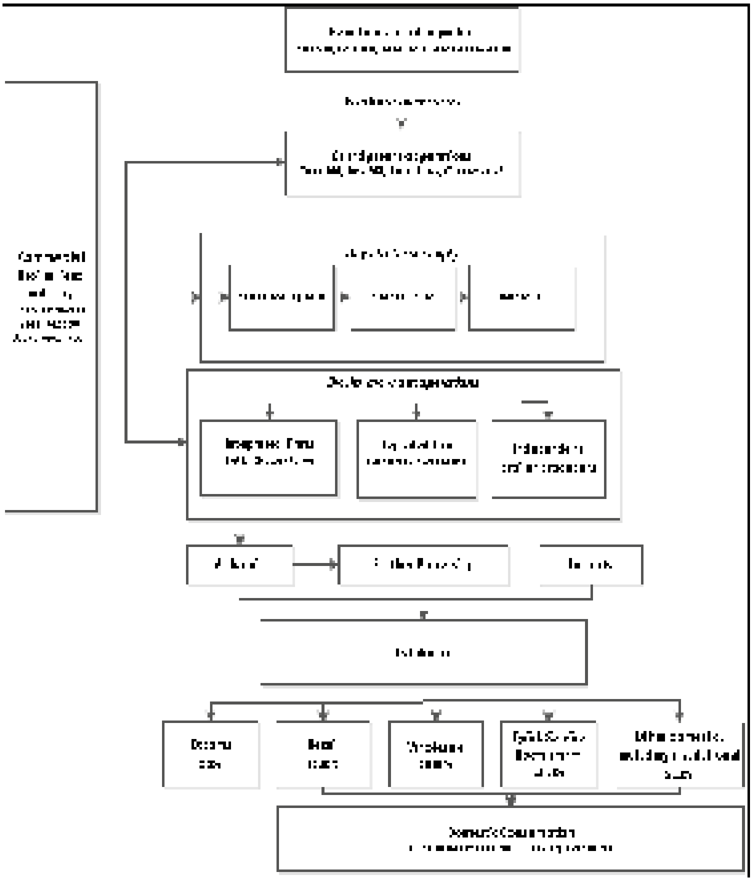

Figure 2 – Diagrammatic representation of a generic broiler supply chain in South Africa. *Source: Davids (2013).*

consists of approximately 275 broiler producers and 231 contract growers, producing exclusively for specific holding companies (SAPA 2013).

2.3. Import protection debate

Since 2008, domestic broiler prices in South Africa have been under pressure due to cheaper imports, while feed prices increased sharply within a particularly volatile environment, resulting in uncertain profitability. Louw et al. (2011) argues that feed prices represent between 60% and 80% of input costs for broiler growers, a figure that was verified in interviews with key broiler producers in South Africa (Davids 2014).

Broiler producers in South Africa have been under pressure for some time, mainly as a result of significant increases in feed costs, combined with stagnant broiler prices. As a net importer of chicken, the industry is integrated into international markets and prices are expected to follow global trends. While feed costs increased by 157% from 2001 to 2012, the chicken price was capped by the increased flow of cheaper imports, resulting in an increase of only 61% through the same period. Thus, the only mechanism for remaining economically sustainable was through efficiency gains, mainly in the form of improved feed conversion rates. As a result of the cost pressures, many smaller producers that do not have integrated feed producers and economies of scale benefits have been unable to stay in production. This has increased concentration levels in a market where the two biggest producers already account for almost 50% of total production. High concentration levels in turn raises concern of uncompetitive behaviour, as illustrated by numerous enquiries from the competition commission (Davids 2014).

At the heart of the recent debates surrounding imports and the dilemma faced by the industry is the issue of competitiveness. While the importance of the broiler industry within the South African agricultural sector cannot be denied, its inability to compete within the global context raises concern regarding its long-term sustainability. At the same time, the cost of increased tariff protection, as well as the segment of the population that is likely to bear the cost makes the issue particularly sensitive. Despite this sensitivity, given its pivotal role in food security and the economy in general, the long-term health and sustainability of the industry must be prioritised.

2.4. Trade regulation in the South African broiler market

South Africa applies import tariffs based on the Harmonised System (HS) eight-digit classification codes. Following an application by the industry, the general duty on imported products was increased in October 2013, as illustrated in Table 1. In addition to the tariffs indicated in Table 1, South Africa applies anti-dumping tariffs for frozen bone-in portions (including leg quarters) originating from the USA. Anti-dumping tariffs for boneless cuts and frozen whole birds originating from Brazil were instituted provisionally for six months from February to August in 2012, while the investigation by the International Trade Administration Commission of South Africa (ITAC) was completed (ITAC, 2012). Upon completion of the investigation by ITAC, the Department of Trade and Industry (DTI) in South Africa did not institute anti-dumping tariffs further.

Table 1 – Import tariffs for chicken meat products applied by South Africa.

HS Classification Code	Description	General Tariff	EU Tariff	SADC Tariff
2071100	Fowls, not cut in pieces, fresh or chilled	0%	0%	0%
2071210	Fowls, not cut in pieces, frozen, mechanically deboned	0%	0%	0%
2071220	Fowls, not cut in pieces, frozen, carcass with cuts removed	31%	0%	0%
2071290	Fowls, not cut in pieces, frozen, other	82%	0%	0%
2071300	Fowls, cuts and offal, fresh or chilled	0%	0%	0%
2071410	Fowls, cuts and offal, frozen, boneless cuts	12%	0%	0%
2071420	Fowls, cuts and offal, frozen, offal	30%	0%	0%
2071490	Fowls, cuts and offal, frozen, other	37%	0%	0%
2071490	Fowls, cuts and offal, frozen, other originating and imported from USA			Anti-dumping tariffs on products originating from the USA: 940 c/kg

Following the industry's application for increased tariffs in 2013, the South African Poultry Association (SAPA), the Association of Meat Importers and Exporters (AMIE) and the Competitions Commission briefed the Portfolio Committee on Agriculture, Forestry and Fisheries on the status of poultry tariffs in South Africa and the possible impact of the proposed tariff increase for poultry imports in 2013. The decision regarding increased tariffs had to weigh the negative effect of increased food prices on consumer welfare with the need to ensure the sustainability of South Africa's largest agricultural sub-sector. Additional considerations related to the segment of the population that consumes chicken products, as well as the argument for self-sufficiency. Ultimately, increased tariff protection would have to allow the industry to improve its competitiveness in the long run. While imports provide competition in an industry characterised by high levels of concentration and integration, the effect of a sharp depreciation in the rand on the domestic chicken price through the end of 2013 highlights the extent to which macroeconomic fluctuations affect prices under a net import situation, further illustrating the importance of sustainable domestic production.

3. Description of Case Study – Impact of Relaxing Import Restrictions

The current average import tariff for the various broiler meat cuts is about 32%. The base for this analysis is that this 32% will be phased out with an impact on the current 2013 production of 11.3%. The current production of broiler is 1,667 million tons which therefore means that local production will decrease by about 188,371 tons and that imports will increase by the same amount. It was further assumed that the relaxing on the import restriction will happen over a 3 year period. Furthermore, it was also assumed that the future production will never be less than the 1,667 million tons of 2013 and that the impact of the relaxing of the tariff, the current import restriction measure, will only have a bearing on future production. It was assumed that the broiler sales growth rate is 4% per annum.

Regression analysis was performed to calculate the production price elasticity of broilers. The 11.3% change in production from 2013 levels due to the 32% change in price relates to the regression analysis. The dependant variable for the regression was the South African broiler production and the independent variables are South African broiler prices per kilogram and time. The regression is performed over the period 1970 to 2013. Below is the technical results emanating from the regression analysis.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.99
R Square	0.98
Adjusted R Square	0.95
Standard Error	139.74
Observations	44.00

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	2.00	34 866 542.20	17 433 271.10	892.74	0.00
Residual	42.00	820 166.00	19 527.76		
Total	44.00	35 686 708.20			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Upper 95.0%*
Intercept	-	-	-	-	-	-	-	-
Price	65.40	14.35	4.56	0.00	36.45	94.35	36.45	94.35
Time	15.79	4.13	3.82	0.00	7.45	24.13	7.45	24.13

Figure 3 – Regression Analysis Results.

According to the regression results, the model has a good fit. It has an R Square of 0.98 which is very close to 1 representing a good fit. The t-stats of both variables are significant, with the price being 4.5 and time 3.8, both more than 2 which is in line with the statistics theory indicating that the variables explain an acceptable relationship between the exogenous and endogenous variables. The positive sign of the price variable indicates that if the price of broilers go up, production will also increase, which is in line with general economic theory. The positive sign of time indicates that the production of broilers in South Africa increase over time.

Taking into account the above assumptions as well as making use of the regression analysis model and based on the current production of broilers in South Africa, Table 2 reflects the direct impact if the import tariff of 32% on broiler imports is relaxed.

Table 2 – Model Inputs – Financial losses to the broiler industry and financial gains to broiler consumers (R Million, 2013 constant prices).

	2014	2015	2016	2017	2018		2031	2032	2033
Investment in the broiler industry	-1 278	-1 329	-1 003	-	-	...	-	-	-
Government income	-403.21	-855.46	-1,232	-1,281	-1,333	...	-2,219	-2,308	-2,400
Production (operational cost and profits) in the broiler industry	-1,131	-2,307	-3,195	-3,195	-3,195	...	-3,195	-3,195	-3,195
Positive price/cost impact on the consumer	-1,647	-2,262	-2,784	-2,895	-3,011	...	-5,013	-5,214	- 5,422

Note: The negative sign (positive price/cost impact on the consumer) of the impact indicates that the cost of broilers for the consumer will decrease. This decrease is in essence actually a positive financial effect for the consumer.

Impacts emanating from the broiler industry as depicted in Table 2 are:

A. Investment: the loss in investment was calculated by multiplying the lower broiler production with the direct capital/production ratio. A capital/output ratio of 1.13 was assumed which means that for every one Rand of output, R1.13 of future investment will be forfeited (see Table 2 for the investment magnitude per annum).

B. Government: government income will also be directly affected due to the phasing out of the customs tariff. The amount is equal to the tariff of 32% multiplied by the total value of imports projected before the removal of the tariff which relates to the base case value of imports (see Table 2 for the impact on government income per annum).

C. Impact on the consumer: The positive impact on the consumer is equal to the additional imported broilers that can be obtained at a lower price (import price). The local production price of broilers is R16,960 ($1,690) per ton while the imports price is R9,600 ($960) per ton. This constitutes a saving for the consumer of R7,323 per ton. The cost savings to the consumer per annum is depicted in Table 2.

4. Methodology

4.1. Framework of the Model

In order to calculate the macroeconomic impact of relaxing the import duties, the South African version of the Inforum Model (SAFRIM) has been used.

The model is multi-sectoral and includes an Input-Output (I-O) Table and accounting which shows the magnitude and diversity of intermediate consumption within the context of the current economic structure. This allows the system to integrate intermediate input prices with sectoral price formation which ultimately determine overall price levels in the economy. This is done through the use of behavioural equations for final demand that depend on prices and output; and functions for income that depends on production, employment, and other variables[1].

4.2 Forecasting the Baseline Scenario

For calculating the macroeconomic impact of the future development of the broiler industry on the South African economy, it is important firstly to do a baseline projection of the South African economy. The baseline projection was based on certain assumptions whereas the most important ones are as follows:

- population growth – 1.5% p.a.;
- world economic growth – 3 to 4% p.a. over the period 2013-2033;
- world prices/inflation – 3% p.a.;
- exchange rate per annum (depreciation of the real effective Rand exchange rate) – -1.7% p.a.

The baseline scenario based on the above assumptions projects a growth rate of ±4% p.a. and is in line with the 'moderate growth rate scenario' defined by National Treasury and published in the 2012 draft Integrated Energy Plan (Department of Energy 2013).

[1] For a more detailed description of SAFRIM, see Mulder 2006.

4.3. Methodology for Activating the Model

A. Construction phase (investment impact)

For the construction phase, the model was activated on the following final demand identity (constant prices).

$$fdc = pcec + invc + govc + exc - imc + fdrc + trcc + capex\_b \qquad (1)$$

Where:
fdc: total final demand
pcec: private consumption expenditure
invc: investment (investment excluding investment in the mitigation measures)
govc: government
exc: exports
imc: imports
fdrc: residual
trcc: transfer costs
capex_b: total net investment of the broiler industry

The investment related to the broiler industry was added in the variable *capex_b* on an annual basis over the period 2013-2033. The investment was broken down to the various assets/commodities (e.g. construction, machinery and other equipment, transport equipment, etc.) for the broiler industry.

B. Government Impact

For the government income loss, the model was activated on the following final demand identity (constant prices).

$$fdc = pcec + invc + govc + exc - imc + fdrc + trcc + gov\_b \qquad (2)$$

Where:
fdc: total final demand
pcec: private consumption expenditure
invc: investment (investment excluding investment in the mitigation measures)
govc: government
exc: exports
imc: imports
fdrc: residual
trcc: transfer costs
gov_b: government income losses from the broiler industry

C. Operational impact

The following production formula was used to activate the model for the operational impact (constant prices) on the broiler sector.

$$outc = (!(I\text{-}AMC) * fdc) + opex\_b \quad (3)$$

Where:
outc: total output (production)
! (I-AMC): inverse matrix
fdc: total final demand
oper_imp: total net operational impact of the broiler industry

The total net operational impact of the broiler sector is added to the production function that is calculated by adding it to the function *outc = (!(I-AMC) * fdc)*. The operational impact is added on a detail sector basis per annum.

D. User Price/Cost Impact

Both the intermediate users (food industry) and the private consumers will benefit from the lower price of imports.

Intermediate users

In this instance, the intermediate user (food industry) will have a cost reduction that will increase its domestic and international competitiveness. This effect is largely reflected in the prices of the goods and services produced by the food sector, which could have an effect on the international competitiveness of the country. Depending on the price elasticity of the demand for local products, this in turn could have an effect on local production and employment.

The identity below explains where the cost reduction is added in the model.

$$fdc = pcec + invc + govc + exc - imc + fdrc + trcc + price\_b \quad (4)$$

Where:
fdc: total final demand
pcec: private consumption expenditure
invc: investment (investment excluding investment in the mitigation measures)
govc: government
exc: exports
imc: imports
fdrc: residual
trcc: transfer costs
price_b: increase in consumer spending power from relaxing the tariffs

5. Results

In this section the macro-economic impact is presented. It is important to note that the results of a non-linear econometric model (which is the case here), differs when the components of the model are run separately (incremental) as compared to running the model components concurrently (dynamic).

As already indicated the impact on only two macro-economic variables has been modelled. They are Gross Domestic Product (GDP) and the impact on employment.

The results of the scenario that depicts relaxing of the import restrictions on broilers are shown in Table 3. The impact is given a per annum average over the total period from 2013 to 2033. Both the results of the Scenario as well as the Baseline is given in the table. The impact is defined as the Scenario minus the Baseline.

Table 3 – Summary of Results for Economic Impact with Gross Value Added (GDP, R Million 2013 constant prices) and Employment (Numbers). (Average impact over the period 2013-2033)

	Additional (Net) Investment Impact (Construction Impact)	Additional (Net) Operational Cost	Government Income Loss	Impact increase in personal disposable income (consumption expenditure)	Total Incremental Impact	Total Dynamic Impact Before Balance of Payments Adjustment
GDP	1	2	3	4	5	6
Scenario	2,531,787	2,530,871	2,530,643	2,536,297		2,533,180
Baseline	2,532,438	2,532,438	2,532,438	2,532,438		2,532,438
Difference	-652	-1,567	-1,795	3,859	-156	742
Employment						
Scenario	16,220,323	16,203,884	16,208,706	16,252,215		16,212,819
Baseline	16,226,233	16,226,233	16,226,233	16,226,233		16,226,233
Difference	-5,910	-22,349	-17,527	25,981	-19,805	-13,414

The following aspects are of importance:

- the net effect in terms of GDP and employment is negative which means that the economy will lose out in terms of economic growth (GDP) and employment creation if the restrictions on the imports of broilers are relaxed. The GDP will increase by R742 million and about 13,414 potential jobs can be lost (see column 6);
- the negative impacts on the economy is created by less investment (column 1, GDP = R-652 million and Employment = –5,910 jobs), reduction in the local production of broilers (column 2, GDP = R-1,567 million and Employment = –22,349 jobs) and the decrease in government income (column 3, GDP = R-1,795 million and Employment = –17,527 jobs); and

- the positive impact on the economy is due to the price reduction of broilers in South Africa and its positive effect on the intermediate consumers of broilers and the private consumers (column 4, GDP = R3,859 million and Employment = 25,981 jobs).

6. Summary and Conclusions

The objective of the analysis was to estimate the macro-economic impact of the relaxing of import restrictions on the broiler industry for the period 2013 to 2033.

The industry is very important for South Africa. Chicken meat can be seen as one of the most favourable and most affordable protein sources for South Africans. The industry is highly integrated into other industries and account for the biggest contribution to agriculture GDP. The industry therefore contributes highly towards food security and food sustainability.

The economic impacts was calculated by making use of a general equilibrium modelling system which is of a dynamic and multi-sectoral nature depicting the economy in a bottom up approach. Macro-economic aggregates are built up from detailed levels at the industry or product level. The various impacts in this analysis are the loss in investment by the broiler industry, reduction in production (operational cost and profits) in the broiler industry, loss of government income from relaxing the import restrictions, and a positive effect on the buying power of the private consumer due to a reduction to the price of broilers.

The results of the scenario show clearly that the positive effects that the consumers will receive due to cheaper broiler prices will be outweighed by the negative effects which will impact the broiler industry. It seems that there is a net gain of R742 million ($74.2 million) in GDP and a reduction in 13,414 jobs.

In conclusion, it can be said that the analysis show clearly that the South African broiler industry should be safeguarded against unfair international competition which can have a significant negative effect on the South African broiler industry. It is important to note that the broiler industry in South Africa is also an industry that is a suitable start-up for upcoming small farmers and the destruction of the industry can have a detrimental effect in terms of poverty alleviation.

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MODELING OF THE IMPACTS OF MONETARY AND FISCAL POLICY IN THE RUSSIAN ECONOMY – USING THE GE-IO MODEL OF RUSSIA WITH AGGREGATE MONEY AND CURRENCY MARKETS*

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1. Introduction

The gradual exhaustion of the raw-export model of economic development in Russia (see, for example, (Baranov 2013) imposes new requirements for government economic policy as well as new demands on economists for the comprehensive study, estimation and scientific substantiation of new alternative models of the Russian economy's development. The extension of economic models constructed for the Russian economy and applied to estimate consequences of different scenarios of economic development is one of the important issues of scientific substantiation of new models of economic development and corresponding priorities in economic policy in Russia. In this regard the issues of the extension of dynamic input-output models which enable getting detailed simulation of economic dynamics and changes in industry structure take on a very important role. However most of the Soviet-era input-output (IO) models of the Russian economy suffer from a well-known restriction which does not allow their application to the simulation of market interrelations and finance flows between sectors of national economy. The extension of dynamic input-output models to consider resource restrictions, mainly sectors' finance restrictions, is another issue for research.

For this purpose, in this paper we present a concept of an extension of a macroeconometric general equilibrium input-output model of the Russian

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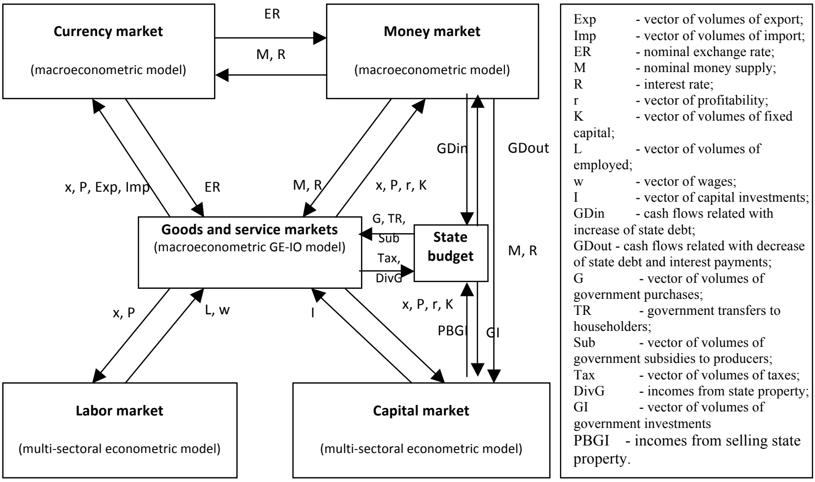
economy with aggregated money and currency markets[1]. The extension allows us to consider macroeconomic and intersectoral relations influenced by monetary and fiscal shocks. Key equations, empirical estimations and applications of this model are also presented in the paper.

2. A Macroeconometric GE-IO model of the Russian economy with Aggregated Markets

A basic version of the macroeconometric general equilibrium input-output model of the Russian economy with aggregated money and currency markets is described in (Gilmundinov 2012). The extension of the model is based on the combination of the macroeconometric input-output approach suggested by C. Almon (Almon 1989), the computable general equilibrium approach suggested by L. Johansen (Johansen 1974) and the neo-classic and neo-Keynesian macroeconomic models used to describe aggregated markets (see, for example, Gali 2008).

The theoretical structure of the extension of the macroeconometric general equilibrium input-output model of the Russian economy with aggregated money and currency markets is shown in Scheme 1. The model includes IO equations for product markets with input-output coefficients to simulate inter-sectoral relations, as well as econometrically estimated equations for aggregate monetary and currency markets and sectoral output elasticities to simulate an intersectoral competition and links between aggregate markets.



Scheme 1 – The structure of a macroeconometric GE-IO model with aggregated money and currency markets and shocks of monetary and fiscal policy.

[1] A basic version of this model is described in Gilmundinov 2012.

In the current version, the core of the model is a macroeconometric GE-IO model with 28 (see equation (1) below). The GE-IO model simulates total outputs for each sector of economy based on the projection of total demand (see equation (2) below) and production capacities (see equation (3) below). Total demand and capacity constraints are based on inward and backward links with macroeconometric models, which describe aggregate markets (the current version has models only for money and currency markets). Links between the GE-IO model and the macroeconometric models of the aggregate markets are based on the endogenization of some key variables of the aggregate markets which influence sectoral variables (interest rate, exchange rate, inflation rates). In the current version of the model we assume only three variables of aggregate markets are linked with total demand (real exchange rate, real wage, and real interest rate).

$$x_{i,t} = \sum_{j=1}^{n} a_{i,j} \cdot x_{j,t} + y_{i,t} \qquad i = 1,\ldots,n \qquad (1)$$

$$Ln(x_{i,t} / x_{i,t-4}) = e_{x_i,ExR\$R} \cdot Ln(ExR\$R_{t-\tau_{x_i}^{ExR\$R}} / ExR\$R_{t-\tau_{x_i}^{ExR\$R}-4}) +$$
$$+ e_{x_i,WR} \cdot Ln(WR_{t-\tau_{x_i}^{WR}} / WR_{t-\tau_{x_i}^{WR}-4}) + e_{x_i,IRR} \cdot Ln(1 + IRR_{t-\tau_{x_i}^{IRR}}) + e_i^0 \qquad i = 1,\ldots,n \qquad (2)$$

$$x_{i,t} \leq Cap_{i,t} \qquad i = 1,\ldots,n \qquad (3)$$

Where

n: number of sectors (n = 28 in the current version)

$x_{i,t}$: total demand for the product of sector i in quarter t in constant prices

$y_{i,t}$: final demand for product of sector i in quarter t in constant prices

$a_{i,j}$: coefficients of direct expenditures of sector j for products of sector i, $i, j = 1,\ldots, n$

$\tau_{x_i}^{ExR\$R}, \tau_{x_i}^{WR}, \tau_{x_i}^{IRR}$: time lags in influence of changing in real exchange rate, real wage, and real interest rate on total demand for product of sector i estimated by constructing regression equations

$ExR\$R_{t-\tau_{x_i}^{ExR\$R}}$: real exchange rate of the Russian ruble to US dollar in quarter $t-\tau_{x_i}^{ExR\$R}$

$WR_{t-\tau_{x_i}^{WR}}$: real wage in quarter $t-\tau_{x_i}^{WR}$

$IRR_{t-\tau_{x_i}^{IRR}}$: average annual real interest rate (deflated with deflator of GDP) for credits for non-financial sector in quarter $t-\tau_{x_i}^{IRR}$

$e_{x_i,ExR\$R}$, $e_{x_i,WR}$, $e_{x_i,IRR}$: elasticity coefficients of total demand for product of sector i to real exchange rate, real wage, and real interest rate, accordingly, estimated by constructing regression equations (see Table 1)

e_i^0: a constant term of the regression equation for total demand for product of sector i

$Cap_{i,t}$: production capacities for total output of sector i in quarter t estimated by constructing of production function.

As it follows from the equations above the current version of the model is mainly the demand-side. More updates for production capacity constraints and other supply-side equations will be presented in the next papers. Notwithstanding this the equilibrium variables of aggregate markets in equations (2) make the model GE type by harmonizing the equilibriums of the different aggregate markets.

Table 1 – Elasticity coefficients of total demand for the product of sector i to the real exchange rate, real wage, and real interest rate for the main sectors of the Russian Economy (in parentheses time lags are specified, in quarters).

	Real exchange rate (Rub in USD)	Real wage	Real interest rate	R^2
Agriculture	-0,06 (1)		-0,19 (3)	0,20
Coal	0,95 (0)	-0,58 (0)	1,16 (0)	0,63
Oil		0,26 (0)	0,30 (0)	0,17
Natural Gas	-0,44 (4)	0,53 (0)	-0,28 (0)	0,78
Other minerals	-0,25 (4)		-0,54 (0)	0,30
Food, beverages, etc.	-0,10 (4)	0,41 (0)		0,63
Clothes	-0,30 (4)	0,51 (0)	-0,26 (0)	0,65
Pulp industry	-0,31 (4)	-0,07 (0)	-0,58 (0)	0,83
Oil refinery			-0,20 (0)	0,25
Chemistry industry	-0,39 (4)	-0,06 (2)	-0,60 (0)	0,61
Construction materials	-0,30 (4)	1,20 (0)	-0,67 (0)	0,79
Ferrous metallurgy	-1,10 (3)	0,36 (0)	-0,96 (3)	0,81
Non-ferrous metallurgy	-0,27 (4)	0,46 (0)	-0,47 (0)	0,68
Metal products	-0,45 (4)	0,46 (0)	-0,50 (0)	0,65
Machinery	-0,57 (4)	0,79 (0)	-1,43 (0)	0,62
Other industrial products	-0,11 (4)		-0,56 (0)	0,71
Energy	-0,13 (4)		-0,34 (0)	0,49
Water supply	-0,13 (4)		-0,34 (0)	0,49
Construction	0,15 (4)	0,75 (0)	-0,75 (0)	0,61
Trade	0,06 (3)	0,67 (0)	-0,43 (0)	0,92
Transport		0,41 (0)	-0,40 (1)	0,53
Communication		0,41 (0)	-0,40 (1)	0,53
Finance and Insurance	-0,27 (2)	1,28 (0)	-1,08 (2)	0,86
Real Estate and Consulting	-0,30 (1)	1,02 (0)	-0,79 (1)	0,62
R&D	0,08 (4)	0,47 (0)	-0,20 (0)	0,76
Education		0,14 (0)		0,59
Health, Culture, etc.		0,08 (0)		0,41
Utilities	0,06 (4)	0,30 (0)	-0,33 (0)	0,78

Empty fields imply the absence of statistically significant estimates (level of significance is 10% or more).
Sources: Author's estimations based on official statistics for the Russian economy in 2003-2010

To obtain estimates of the model parameters we have estimated a technology matrix $\{a_{i,j}\}_{i,j=1,\dots,n}$ for the year 2010 and an elasticity matrix $\{e_{i,k}\}_{i=1,\dots,n;k\in\{0;ExR\$R;WR;IRR\}}$ by constructing multiple regressions using quarterly statistics of Russia from 2003-2010 (see Table 1). The period 2003-2010 was chosen for estimation for two reasons. First the Russian economy's experienced demand constraints during 2003-2010 which are handled well with a demand-side type of model. In the second place, the Russian national accounts had transitioned to a new classification of economic sectors from 2003, as a result sectoral data before 2003 are not comparable with data after 2003.

Estimations given in Table 1 can be interpreted as estimates of the competitiveness of sectors in the face of the deterioration of conditions in the corresponding aggregate market. It allows us to use the theory of intersectoral competition to interpret the results of calculations in the model and to explain changes in the structure of the Russian economy.

To construct a model for the aggregate money market we use the well-known Baumol-Tobin model to simulate money demand and a new-Keynesian concept of inflation based on adaptive learning. For the inflation model we assume that inflation expectation include non-monetary factors. Based on quarterly statistics for 2003-2010 we have estimated the following two regressions:

$$\mathrm{Ln}((1+IRN_t)/(1+IRN_{t-4})) = -0{,}02+0{,}16^*\mathrm{Ln}(P_{t-4}/P_{t-8}) - 0{,}08^*\mathrm{Ln}(\,(M_t/P_t)\,/\,(M_{t-4}/P_{t-4})\,) + 0{,}16^*\mathrm{Ln}(X_{t-5}/X_{t-9})\ (R^2 = 80{,}2\%) \quad (4)$$

$$\mathrm{Ln}(P_t/P_{t-4}) = 0{,}146^*\mathrm{Ln}(M_t/M_{t-4}) + 0{,}979^*\mathrm{Ln}(P_{t-1}/P_{t-5}) - 0{,}321^*\mathrm{Ln}(P_{t-2}/P_{t-6}) \quad (R^2 = 67{,}1\%) \quad (5)$$

Where

IRN_t: the average annual interest rate for 1year or less credits for non-financial sector in quarter t

P_t: GO deflator index in quarter t

M_t: money supply (M2) in quarter t

X_t: real GO in quarter t

The model for the money market allows us to endogenize the interest rate and the inflation rate, and as a result endogenize the links between the aggregate money market and the product market. The money supply is the only exogenous variable in this case.

A model of currency market is based on estimation of currency inflows and outflows in the Russian Balance of payments and allows to simulate dynamic of exchange rate of the Russian ruble to USD. Based on quarterly statistics for 2003-2010 we have estimated following regression:

$$\mathrm{Ln}(ExR\$N_t/ExR\$N_{t-4}) = -0{,}04+1{,}20^*\mathrm{Ln}(1+dPrivateReserves_t/CurrenceInflows_t) - 0{,}49^*\mathrm{Ln}(1+dCurrenceInflows_t/CurrenceInflows_t)\ (R^2 = 79{,}5\%) \quad (6)$$

Where

$ExR\$N_t$: the average exchange rate of the Russian ruble to USD in quarter *t*

$dPrivateReserves_t/CurrenceInflows_t$: ratio of change in net foreign currency reserves of private sector to total foreign currency inflows in the Russian economy in quarter *t*

$dCurrenceInflows_t/CurrenceInflows_t$: ratio of net foreign currency inflows in the Russian economy to total foreign currency inflows in the Russian economy in quarter *t*

To make the exchange rate for the endogenous regression for import of goods and services (7) and normative model for exports of goods and services (8) are constructed:

$$\text{Ln}(1+Im_t/P_t{*}X_t) = 0{,}125 + 0{,}025{*}\text{Ln}(ExRR_t/ExRR_{t-4}) \text{ (PV = 99,7\%)} \tag{7}$$

$$Ex_t = ExNonO\&G_t + OilPrice_t{*}ExpOilVol_t/dOil_t \tag{8}$$

Where

$ExRR_t$: real exchange rate of the Russian ruble to the USD

Im_t: imports of goods and services in rubles in quarter *t*

Ex_t: exports of goods and services in rubles in quarter *t*

$ExNonO\&G_t$: non oil&gas exports of goods and services in rubles in quarter *t*

$OilPrice_t$: average actual export price of the Russian oil in USD per barrel in quarter *t*

$ExpOilVol_t$: oil exports in barrels in quarter *t*

$dOil_t$: average share of oil export in total oil&gas export in quarter *t*

Flows of capital and financial instruments accounts of the Balance of payments and non oil&gas exports of goods and services are exogenous. For the purpose of macroeconomic forecasting these flows are defined exogenously according to considered scenarios of economic development and macroeconomic policy, historical data and expert estimations.

The regressions above have a good correspondence with the theoretical framework and should show statistical significance for main hypotheses.

3. Scenarios of the forecast of the Russian economy in 2013-2015 with different scenarios of monetary policy

The macroeconometric GE-IO model of the Russian economy with aggregate money and currency markets presented above allows us to estimate the influence of a change in monetary policy on the dynamics and structure of the Russian economy. The transition of the Russian Central Bank to inflation targeting, in order to suppress the inflation rate to 4%

in due to the economic growth slowdown, makes this issue very relevant. For example, according to our estimates, an increase of 1 percent in real interest rates results in a 0.39% decrease of GDP growth and a 1.05% decrease of Investments in fixed capital growth.

2010 is the base year for our calculations. The calculation for the period 2011-2012 is the simulation of the Russian economy with actual values of all parameters of the model except total output growth rates. 2013–2015 is the forecast period. To ensure comparability of the results of the calculations for the different scenarios of monetary policy we construct a base variant of forecast for 2013-2015. The key assumptions for base variant of the forecast for 2013-2015 are as follows.

1. Annual growth rate of actual export prices of the Russian oil is 2%.
2. Annual growth rate of real wages in 2013 is 5.5%, in 2014-2015 – 5.0%.
3. Annual growth rate of GDP deflator of USA is 1.5%.
4. Annual growth rate of non-oil and gas exports is 5.1% in USD.
5. Share of crude oil in total oil and gas exports is 52.2%.
6. Annual growth rate of oil and gas extraction is 1.0%.
7. Net outflows of capital from Russia will increase from 72.4 bln USD in 2013 up to 79.8 bln USD in 2015.
8. Simulation of inflation rates is based only on assumptions about monetary factors and adaptive learning. The role of non-monetary measures of suppressing inflation is not considered.

The base variant of the forecast does not take into a consideration of the impact of the sanctions after the Ukraine crisis and its effects on the Russian Economy.

Three scenarios of the Russian Economy for 2013-2015 are considered to estimate the impact of the restriction of the money supply. In the first scenario ‘Inflation targeting’ it is suggested that annual inflation rates will be suppressed to 4.0% in 2015. The second scenario ‘Neutral policy’ assumes that Central bank of Russia would not intrude in the money market to reduce inflation. The third scenario ‘Monetary easing’ implies high growth rates of the money supply to stimulate the Russian economy. All three scenarios share similar dynamics of oil prices and real wages to carry ‘ceteris paribus’ comparative analysis. The first two scenarios incorporate endogeneity of the money supply, which depends on the Russian Central bank’s inflation targets. Inflation rates are exogenous. The third scenario incorporates endogeneity of inflation rates and exogeneity of the money supply.

4. Results of the calculation: the influence of monetary shocks on the Russian economy in 2013-2015

The results of the calculation are presented in the Table 2. The data given in the Table 2 show that a gradual transition to inflation targeting in Russia in 2011-2012 had led to significant growth in real interest rates from -4.4% in 2011 to 2.5% in 2012 and 4.5% in 2013.

To achieve a 4.0% inflation rate in 2015, the Central bank of Russia should decrease the growth rate of the money supply from 11.9% in 2012 to only 0.9% in 2015. As a result there would be a sharp decrease in real GDP growth rates from 3.4% in 2012 to 1.0% in 2015. Fixed capital producers and capital investments suffer the most negative impact from the inflation targeting. The average annual growth rate of capital investments would be –3.1% in this scenario. The main reason for this is the significant rise in real interest rates from 2.5% in 2012 to 5.6% in 2015. According to the results of these calculations the inflation targeting policy leads to significant fall in the growth of Russian GDP in 2013-2015 approximately 1.3% in comparison to 'Neutral policy' scenario. This causes higher real GDP losses from 0.9% in 2013 to 4.0% in 2015 in relation to the 'Neutral policy' scenario (see Figure 1). Total real GDP losses in 2013-2015 are equal to 7.2% of GDP in 2012.

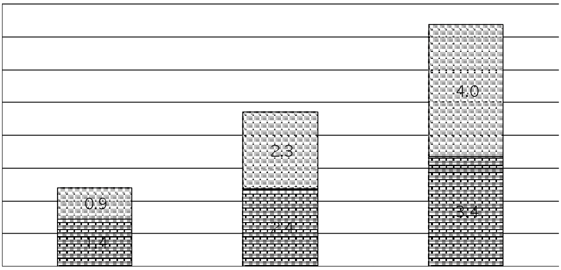


Figure 1 – Estimation of GDP losses from inflation targeting in Russia in 2013-2015. *Sources: results of calculations.*

The results of the simulations lead us to conclude that the inflation targeting policy would be suitable for the Russian economy only in the case of of a high level of investment. But in the current Russian economy characterized by an extremely low level of investment and technological backwardness it would cause excessive GDP losses and further decline in capital investment.

Thus, our results substantiate the inconsistency of the existing model of macroeconomic policy in Russia which is characterized on the one side by monetary-oriented suppression of inflation which lead to high real interest rates and as a result to the squeezing of investment and on the other side by structural policy aimed at modernizing and stimulating innovation which requires significant growth in investment activity.

According to our results macroeconomic policy shocks have significant impact on the development and structure of the Russian economy under current conditions. The most significant impact is related to monetary shocks. For example, the easing of monetary policy through increasing annual growth rates of the money supply from 20% to 30% lead to increased annual growth rates of the Russian economy in the short-term period from 2.3-2.5% to 3.2-4.4%.

Table 2 – Dynamics of some key macroeconomic indicators of the Russian economy in 2010-2015.

	Actual data			Forecast: 1st scenario "Inflation targeting"			Forecast: 2nd scenario "Neutral policy"			Forecast: 3rd scenario "Monetary easing"		
	2010	2011	2012	2013	2014	2015	2013	2014	2015	2013	2014	2015
Average export price of the Russian oil, USD per barrel	74,1	101,7	103,1	99,6	101,6	103,7	99,6	101,6	103,7	99,6	101,6	103,7
Money supply change rate, %	31,1	22,3	11,9	14,6	10,0	6,8	20,7	20,1	20,0	30,0	30,0	30,0
GDP change rate, %	4,5	4,3	3,4	1,4	0,9	1,0	2,4	2,3	2,5	3,2	3,8	4,4
Capital investments change rate, %	6,3	10,8	6,6	-2,2	-3,7	-3,6	0,4	-0,2	0,5	2,6	3,8	5,1
Average nominal exchange rate, Russian rubles per USD	30,4	29,4	31,1	31,8	32,5	33,3	32,0	33,2	34,8	32,4	34,4	37,4
GDP deflator change rate, %	14,2	15,9	7,5	6,4	5,6	4,0	7,2	9,1	9,0	8,3	13,6	13,8
Average annual nominal interest rate, %	13,4	10,4	11,2	11,4	11,3	9,8	9,6	11,3	10,9	8,4	11,6	10,4
Average annual real interest rate, %	-0,4	-4,4	2,5	4,5	5,4	5,6	2,2	2,0	1,7	0,1	-1,8	-2,8

Sources: 2010-2012 – Rosstat, Central bank of Russia; 2013-2015 – results of calculation in GE-IO model of the Russian economy with aggregated money and currency markets

The estimates of the impact of fiscal policy shown by simulation in the present version of GE-IO model show a restricted influence of indiscriminate measures. At the same time specific measures of fiscal policy targeted to certain sectors can have a significant influence on certain processing industries and on construction. However the present version of the model has some restriction of application to detailed consideration of dynamic aspects of the influence of macroeconomic policy on sectoral outputs. We plan to solve this in our further studies.

5. Some estimates of the influence of fiscal shocks on the Russian economy

The current version of the model used for estimation of the influence of monetary shocks in this study has not developed enough to obtain insight on the consequences of fiscal shocks on the Russian economy. For this purpose it requires further development and incorporation of a multisectoral model of the state budget, reproduction of fixed capital, etc into the general model according to scheme 1, that has been planned for the next stages of the study. Nevertheless we can use this model to get some preliminary estimates of direct short-term effects of changing Russian fiscal policy. More updates will be presented in our following papers.

The two following fiscal instruments will be considered: subsidizing interest rates of bank loans and growth of government purchases of goods and services.

Subsidizing interest rates of bank loans

To obtain estimates of the effects of subsidizing interest rates of bank loans we simulate the scenario 'Inflation targeting' for 2013 with reducing the calculated annual nominal interest rate by 1 percentage point. A result of the simulation is that the growth rate of GDP in constant prices in 2013 rises from 1.45% to 1.85% in this scenario, that is equal to additional growth of GDP of 260.8 bln rubles in current prices. We also can estimate about 67.8 bln rubles of additional budget income in 2013 due to growth of the fiscal base and the acceleration of the economy as a result of the subsidies[2]. To estimate the additional expenditures of the state budget for this policy we use statistics of the Central Bank of Russia. According to official data the total volume of loans to organizations and householders by the Russian bank system is 45'003 bln rubles in 2013. It allows us to get a crude estimate of state expenditures for subsidies at the level of 450 bln rubles. So even if we take into account only bank loans to organizations and households approved by the Russian bank system the pressure on the state budget in this policy would grow at least at 193.0 bln rubles, but it appears to be much more. Considering loans from abroad and issued bonds in 2013 we have to conclude that the policy of subsidies of should be applied very selective and aimed only at investment activity. Additional investigations are required to get appropriate estimates.

Growth of government purchases of goods and services

To estimate the impact of the growth of government spending of goods and services to the growth of Russian real GDP we use official data for the components of GDP by expenditure category in 2000-2012. Correcting the

[2] Additional budget income is calculated by multiplying a ratio budget income to gross output (GO) in 2013 (20.8%) and additional growth of gross output (GO) due to subsidizing (+325.2 bln rubles).

estimates of Russian GDP on changes in inventories and statistical errors we obtain the following results as shown in Figures 2 and 3.

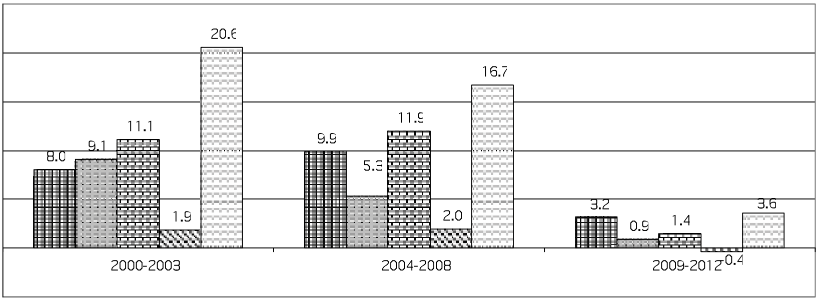


Figure 2 – Average annual growth rates of Russian GDP (corrected) and its components, in percent.

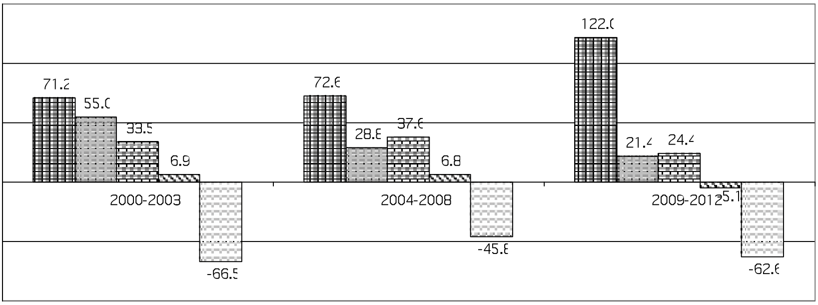


Figure 3 – Contribution of the components of GDP to average annual growth rates of Russian real GDP (corrected), as a share, in percent.

As we can see from figures 2 and 3, the main contribution to GDP growth in Russia in 2000-2012 was private consumption while the effects of government spending were considerably restricted. Moreover in 2009-2012 the contribution of government spending to real GDP growth was negative. Another important issue is the faster growth of the imports of goods and services in comparison to all other components of GDP. This occurred despite strengthening of real exchange rate of the ruble (approximately by 4 times by the end of 2012 from the beginning of 2000) and an extremely low share of capital investment in GDP in Russia (18.3% in average in 2000-2012).

The assessment of the effect of the growth of government purchases of goods and services is based on the concept of full costs in the Leontief model (see Table 3).

Table 3 – Estimations of full cost coefficients for the main sectors of the Russian economy in constant prices of 2010.

	Full costs	Approximate direct budget income effect to 1 ruble of expenditures*
Agriculture	2,041	0,425
Coal	2,165	0,451
Oil	1,387	0,289
Natural Gas	1,554	0,324
Other minerals	2,033	0,424
Food, beverages, etc.	2,605	0,543
Clothes	2,778	0,579
Pulp industry	2,426	0,505
Oil refinery	1,859	0,387
Chemistry industry	2,752	0,573
Construction materials	2,331	0,486
Ferrous metallurgy	2,511	0,523
Non-ferrous metallurgy	2,304	0,480
Metal products	2,820	0,588
Machinery	2,597	0,541
Other industrial products	2,636	0,549
Energy	1,899	0,396
Water supply	1,939	0,404
Construction	2,290	0,477
Trade	1,731	0,361
Transport	1,911	0,398
Communication	2,623	0,546
Finance and Insurance	1,612	0,336
Real Estate and Consulting	2,303	0,480
R&D	2,061	0,429
Education	1,544	0,322
Health, Culture, etc.	1,592	0,332
Utilities	1,810	0,377

* Estimations are based on the ratio of budget income to GO of Russia in 2013 and need to be refined with detailed multisectoral model of state budget.

6. Aggregate macroeconometric GE model

To assess the macroeconomic effects caused by monetary and fiscal policy in 2003-2013 we refine our estimates for the growth rate of the GDP deflator in quarter t to the same quarter of the previous year (π_t, in percent), annual nominal interest rates (R_t, in percent), and construct an equation for the real GDP growth rates (y_t, in quarter t to the same quarter of the previous year, in percent):

$$\hat{\pi}_t = -0{,}016 + 0{,}765 \cdot \pi_{t-1} + 0{,}118 \cdot m_t + 0{,}608 \cdot (y_t - y_{t-1}), R^2 = 0{,}79 \qquad (9)$$

$$\hat{R}_t = -0{,}576 + 0{,}773 \cdot R_{t-1} + 0{,}077 \cdot \pi_{t-1} - 0{,}038 \cdot m_t + 0{,}139 \cdot y_{t-3}, R^2 = 0{,}94 \qquad (10)$$

$$\hat{y}_t = -0{,}344 - 0{,}064 \cdot rER_{t-4} + 0{,}499 \cdot rW_t - 0{,}384 \cdot (R_t - \pi_t) + 0{,}516 \cdot e_{t-1}, R^2 = 0{,}94 \qquad (11)$$

Where

m_t: growth rate of money supply M2 in quarter t to the same quarter of the previous year, in percent rER_t: growth rate of real exchange rate of the Russian ruble to USD in quarter t to the same quarter of the previous year, in percent

rW_t: growth rate of real wages in quarter t to the same quarter of the previous year, in percent

e_t: deviation of actual growth rate of real GDP in quarter t to the same quarter of the previous year from calculated.

These three equations form the aggregate macroeconometric GE model of the Russian economy, which is based on the same assumptions as the GE-IO model described above. The aggregate model allows us to estimate the contribution of fiscal and monetary shocks to the growth of real GDP of the Russian Federation in 2003-2013 (see Figures 4 and 5, respectively, and Figure 6 for combined effects).

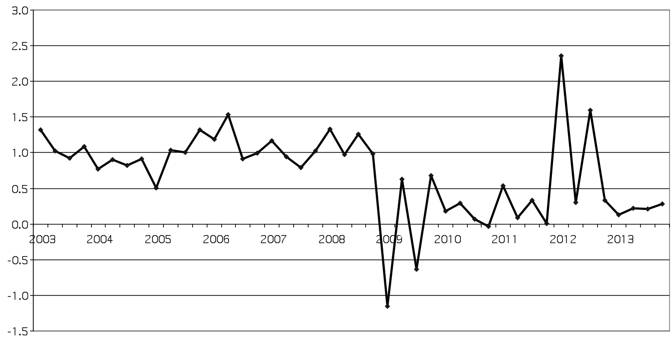


Figure 4 – Contribution of fiscal shocks* to growth rates of real GDP of the Russian Federation in 2003-2013, compared with the same quarter of the previous year.
* related only with changes in real wages in state sector and government spending

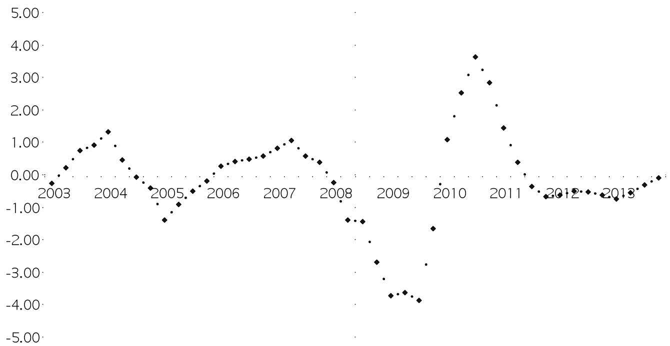


Figure 5 – Contribution of monetary shocks* to growth rates of real GDP of the Russian Federation in 2003-2013, compared with the same quarter of the previous year.
* as changes in money supply M2 annual growth rates

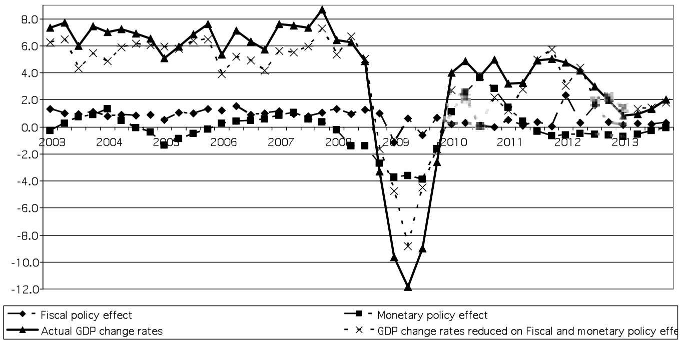


Figure 6 – Contribution of fiscal and monetary shocks to GDP growth rates in the Russian Federation in 2003-2013, compared with the same quarter of the previous year, in constant prices.

7. Conclusion

The main result of these calculations is that macroeconomic policy in Russia has an accelerating influence on GDP growth in 2000-2011, in contradiction to its traditional stabilizing role. It allows us to suggest that one of the main sources of economic growth in Russia in 2000-2008 and after the crisis of 2009 in 2010-2011 was the redistribution of oil and gas export incomes through the state budget system with appropriate monetary policy. But monetary policy had been changed considerably in 2012. The transition to inflation targeting with extremely ambitious targets and a high contribution of non-monetary factors to inflation in Russia made credit conditions very tight and led to suppressing of the growth of the Russian economy.

The above applications of the macroeconometric general equilibrium input-output model of the Russian economy with aggregate money and currency markets and its aggregate version for estimation of effects of macroeconomic policy show high relevance and usefulness. Considering aggregate markets and macroeconomic shocks the model allows us to simulate different scenarios of macroeconomic policy and obtain estimates for policy making. At the same time the presented version of the model is very simple and requires more extension, especially in the incorporation of the multisectoral model of state budget and the model of reproduction of fixed capital into the general model according to scheme 1.

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THE IMPACT OF MACROECONOMIC FACTORS ON THE SECTORAL STRUCTURE OF THE RUSSIAN ECONOMY*

Natalia Bozo[a]

While the Russian economy has recovered enough to reach the pre-crisis levels of GDP and industrial production, the growth rates of key macroeconomic indicators began to decline steadily from mid-2012. In 2013, the growth of industrial production virtually ceased, surpassing the level of 2012 by only 0.3%, which is statistically insignificant (Gaidar Institute 2014). At the same time in 2013, the Russian economy saw a slowdown of investment activity; investment in fixed capital was lower than in 2012 by 0.3 % (Gaidar Institute 2014).

The main objective of economic policy is the coordination of measures to overcome the recession by implementing a strategy for socioeconomic development. According to Glazyev S.Y. (Glazyev 2010), the reason is a reduction of state resources, which entails a reduction in investment activity, and a reduced rate of capital accumulation in favor of the measures for maintaining consumption. However, this approach is futile because it does not address the structural impediments of economic growth.

Governmental measures have limited impact on the economy. Because the Central Bank fights inflation, taking active monetary measures to stimulate demand is not fully possible. According to many authors, an increase in the money supply will stimulate only inflation. Under such conditions, it is necessary to stimulate the production base and pursue an active policy for investment and production.

The purpose of research is to develop a methodological approach to assess the joint impact of short-term and medium-term factors on the dynamics of key industries and on the economy as a whole. Basic components affecting the dynamics of the Russian economy have been summarized in three groups; short, medium and long term factors. In this study, a methodical approach produces an estimate of the influence of factors from both the macro and micro level.

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An assessment of the impact of short-term factors on the dynamics of the Russian economy has been previously considered by Gil'mundinov V.M. (Gil'mundinov 2011). He concluded that the main contributions to changes in the sectoral structure of the Russian economy were changes in real interest rates, wages, and the exchange rate of the ruble. Namely, there were significant differences in the degree of reaction of production by sector to these factors. His study focuses on the effect of short-term factors at the macro level. Quantitative estimates of industry competitiveness on financial resources were obtained, which enable a discussion about the significant vulnerability of fixed capital producers in domestic industries to high real interest rates. In addition, the estimates help to determine the usefulness of the state's policy of low interest rates while the Russian economy is still recovering from the global financial crisis, as well as allowing discussion of a full-scale modernization effort.

This study considers the effect of short term and medium-term factors at the micro and macro level. To estimate the influence of factors for structural changes in the Russian economy we constructed an approach which includes the following 6 steps.

1. Development of a classification of factors affecting the dynamics of industries under consideration.
2. Identification of indicators corresponding with the factors determined by the previous step.
3. Analysis of the dynamics of production for industries under consideration.
4. Evaluation of the sensitivity of production to the selected factors for each industry under consideration.
5. Ranking industries according to this degree of sensitivity.
6. Suggesting the most effective measures of government policy based on the estimates obtained to stimulate production in the industries under consideration.

Based on this approach we can conclude that the dynamics of the Russian economy are strongly influenced by factors such as production capacity, labor force, and relative prices. However, we also must consider such factors as profitability, availability of funds, and wage dynamics.

The classification of factors was done first. All the known factors with influence on the basic industries development and the economy as a whole were divided into three primary groups.

1. Factors having an impact on demand.
2. Factors having an impact on supply.
3. Institutional factors.

Factors of each these groups were classified by target audience:

1. an impact on macro level;
2. a sectoral impact;
3. an impact on the enterprise level.

Table 1 – Classification factors influencing basic industries development and the whole economy (fragment).

		Factor name	Short-term period	Medium-term period	Long-term period
Factors having an impact on supply	An impact on the enterprise level	Flow of costs	+	+ -	
		Production capacity		+	+
		Degree of utilization of production capacity	+	+	
		Rent, electricity	+		
		Bringing the product to the end consumer	+		
		Investments		+	(+)
		Goods and services quality		+	+
		Scale of production		+ -	+
		Production internalization level	+	+	+
		Capital internalization level		+	+
		Mobility of labor	+	+	+
		Recreation services		+	
		Labor costs	+	+ -	
		Creative potential	+	+	+
	A sectoral impact	Technology opportunities			
		- innovative activity	+ -	+	
		- science and technology development level		+	+
		Character of techniques in operation		+	
		Flow of costs	+	+ -	
		Taxification	+	+	+ -
		Government support level (targeted)	+	+ -	- +
		Expectations of manufacturers	+	+	
		Inventory level	+		
		Production capacity			
		Production capacity (загруженность)		+	+
		Degree of utilization of production capacity (backlogs)	+	+	
		Labor accessibility		+	+
		Bringing the product to the end consumer	+		
		Investments		+	(+)
		Competiveness	+	+	+
		Level of competition	+	+ -	
		Customs policy	+	+	+
		Regional integration		+	+
		Foreign economic policy		+	+

	Factor name	Short-term period	Medium-term period	Long-term period
An impact on macro level	Accessibility of financing (liquidity of banking system)	+	+	
	Exchange rate		+	
	Customs policy	+	+	
	Regional integration		+	+
	Quota, excise taxes, import duties	+	+	
	Labor accessibility		+	+
	Relative prices (inflation)	+	+	
	Economic freedom level		+	
	Antitrust regulation	+	+	+

In each subgroup there was a detailed analysis, which highlights in which time-frame there is the largest impact of one or another factors on basic industries development and the economy as a whole. There were three time-frames determined – short-term, medium term and long-term. Table 1 shows a sample of these factors, classified by their impact.

Although there are a variety of factors, 10 were selected which have an effect in the near-term and 10 factors which have effects in the medium-term.

Each selected factor was matched with a statistical factor, which will more precisely reflect its impact.

The most interesting indicators were those in 2003-2013.

An assessment of the impact of short-term factors on the dynamics of the Russian economy has been previously considered by Gil'mundinov V.M. Therefore, the most interesting were the medium-term factors, whether they have an impact on the dynamics of production in the current period or in the medium-term. Two models were built on this basis.

Model 1. Impact of short and medium term factors on current economic capacity (in comparable prices adjusting for the effect of seasonality)

The purpose of the research is to understand how the factors from the supply side operate in the short-term, whether they have an impact on manufacturing now or not.

$$Y = f(L, K, W, V, N), \qquad (1.1)$$

Where
L: labour force
K: fixed assets
W: relative wages
V:value added (VA)
N: profitability

In Table 2 there are evaluation results by 15 primary types of economic activity (manufacturing and mining industries were considered as a whole). The table contains: R^2 – coefficient of determination, value and standard errors. Factors which are not listed in this table are non-significant.

Table 2 – Assessment results of the impact of the medium-term factors on the gross output in the short-term of Russian economy (Model 1).

Type of economic activity	Constant	Salaries	Value added	Employment	Fixed assets	Profitability	R^2
Agriculture and Forestry	0,018	0,989 (0,260)		0,694 (0,138)			0,49
Fishing	-0,004			0,691 (0,089)			0,64
Electricity, gas and water supply	0,008			0,933 (0,125)			0,62
Construction	-0,720	1,096 (0,175)	2,206 (0,491)	1,030 (0,134)			0,85
Tradeand Services	-2,133	0,465 (0,154)	4,403 (1,246)	1,181 (0,194)			0,75
Transport and Communications	-0,613		1,590 (0,735)	1,492 (0,274)			0,58
Finances	0,055	-0,138 (0,220)		1,270 (0,181)			0,60
Investments	0,043	1,829 (0,518)		1,040 (0,438)			0,29
Science and Information Technology	0,003			0,512 (0,177)			0,20
Public Health Services, arts, culture and other social services	-1,263		2,689 (1,407)	0,464 (0,127)			0,33
Other community, social and personal services	-0,005			1,612 (0,310)			0,44
Mining and quarrying	0,150			0,863 (0,204)	-2,713 (0,844)		0,43
Manufacturing	-1,467	1,797 (0,243)		1,114 (0,099)	-5,283 (0,722)		0,92
Hotels and restaurants	0,046			1,465 (0,140)			0,79
Public administration and defense; social insurance							

Part of the estimates confirmed expected results.

For example, it is quite obvious that the impact of fixed assets will not appear in the short term. As further calculations show (refer to Table 3), this factor appears in the medium-term aspect by primary industries of economic activities. As we could see in Table 2 qualified labor force (corresponded to the indicator 'Employment' in Table) influences on the volume of output for all types of economic activity in the short-term, except 'Public administration and defense; social insurance'. Public administration is based on the annual budget, which also considers the costs of social insurance and national defense. None of the considered factors show a statistically significant result in this industry.

A negative influence of real wage growth on output is revealed only in 'Financial intermediation and insurance'. In other words, this sector is characterized by large sensitivity to wage level, growth of which has a significant negative influence on profitability and output growth rates. This effect is much less apparent in other industries.

Model 2. Impact of medium-term factors on the dynamics of production in the short-term

This is a quarterly model where two primary factors are used all types of economic activity, and additional factor are included for manufacturing sectors. The primary factors are – labor force and productive assets. The lack of a qualified labor force is a big problem for Russia and it becomes more and more important. Also, in Russia, there has been observed underinvestment in technological development, so the analysis of fixed assets is still important. The existence of expenditure statistics on technological innovations for manufacturing industries makes it possible to add a cofactor to the model. This cofactor was considered accumulated technological knowledge, because it is necessary to include not only technological innovations, but also licensee dynamics.

$$Y_t = L_{t-1}^{\alpha} K_{t-1}^{\beta} I_{t-1}^{\gamma} \quad (2.1)$$

where I is technological innovations,

$$lnY_t = \alpha lnL_{t-1} + \beta lnK_{t-1} + \gamma lnI_{t-1} \quad (2.2)$$

The results are shown on Table 3. This model fell short of expectations, because of a problem that appeared in industries such as 'Public Health Services'. Strong correlations among factors did not allow us to get a significant statistical estimation and for others it distorted the results.

Table 4 shows the growth rate of labor productivity and capital productivity, while table 5 shows the ratios of labor productivity by types of economic activity.

Table 3 – Assessment results of the impact of the medium-term factors on the gross output in the medium-term of Russian economy (Model 2).

Type of economic activity	Constant	Fixed assets	Accumulated technological knowledge	Em-ployment	R2
Agriculture and Forestry	0,054	3,454 -0,669			0,51
Fishing					
Electricity, gas and water supply	-0,215		0,811 -0,298	-11,446 -3,21	0,34
Construction	0,31			4,637 -1,538	0,26
Trade and Services	0,047			3,476 -0,495	0,66
Transport and Communications	0,03	0,978 -0,132		4,037 -0,656	0,76
Finances	0,116			2,141 -0,166	0,86
Investments	Multicollinearity is close to 1				
Science and Information Technology	0,004			0,751 -0,134	0,546
Public Health Services, arts, culture and other social services	-0,008	0,273 -0,05		1,867 -0,347	0,68
Other community, social and personal services	0,059	-0,427 -0,141		3,271 -0,764	0,566
Mining and quarrying	0,052		0,287 -0,053		0,533
Manufacturing	0,201		0,813 -0,167	2,613 -0,548	0,501
Hotels and restaurants	0,144	1,052 -0,207		1,759 -0,331	0,694
Public administration and defense; social insurance	0,06	0,325 -0,024		-0,58 -0,084	0,893

Table 4 – Growth rates of labor productivity and capital productivity for types of economic activity of the Russian economy, in 2013 to 2003.

Type of economic activity	Growth rate	
	Labor productivity	Capital productivity
Agriculture and Forestry	1,628	1,318
Fishing	0,935	1,133
Electricity, gas and water supply	1,050	0,803
Construction	1,496	1,521
Trade and Services	1,635	1,027
Transport and Communications	1,585	1,176
Finances	2,093	1,624
Investments	1,598	1,614
Science and Information Technology	1,057	0,76
Public Health Services, arts, culture and other social services	1,113	0,777
Other community, social and personal services	1,021	0,757
Mining and quarrying	1,207	0,698
Manufacturing	1,650	0,858
Hotels and restaurants	1,627	1,324
Public administration and defense; social insurance	1,031	0,668

Over the last 10 years the highest labor productivity growth was in the mining industry and the lowest was in the education sector. It is not a secret that the mining industry is one of the most important for the Russian economy. For example, in 2004, 21 oil fields were brought into production with a cumulative oil production of more than 150 thousand tons with headway in exploratory drilling of about 145 thousand meters. And in 2013 in the Astrakhan Region the largest hydrocarbon reservoir of the last 20 years was opened with a capacity of about 300 million tons of oil and 90 billion cubic meters of gas.

There was not a significant increase of labor productivity as well as strong correlation between labor productivity and output in the Russian education sector in the considered period. It may be explained by two main reasons. The first one is a deep demographic decline in Russia in 1993-1998. This decline had caused a sharp reduction of the number of children, teenagers and youth. As a result it has negatively affected on demand for education. The second reason is a weak intensity of labor force dismissal for expenditure optimization in the Russian education sector because of prevalence of state organizations.

Table 5 – Labor productivity dynamics of the major sectors of Russian economy in 2003-2013.

Type of economic activity	Labor productivity by gross output, $/employed		Labor productivity by VA, $/employed	
	2003 year	2013 year	2003 year	2013 year
Agriculture and Forestry	5365	21181	2790	10498
Fishing	30205	50880	16691	23892
Electricity, gas and water supply	20459	91647	7140	31444
Construction	10454	51078	5030	23148
Trade and Services	11222	44687	8013	26749
Transport and Communications	13911	59985	7790	28250
Finances	23199	102136	16401	72380
Investments	12793	58311	8362	38074
Science and Information Technology	2451	12642	1701	9552
Public Health Services, arts, culture and other social services	4591	24162	2741	14801
Other community, social and personal services	5772	20962	3099	11644
Mining and quarrying	47176	273403	22561	180775
Manufacturing	17207	92800	5183	26303
Hotels and restaurants	4940	30032	2660	14640
Public administration and defense; social insurance	13730	60958	6499	32336

The multiplicative effect of medium-term factors and the impact of integrated medium-term factors made it possible to get following analysis.

$$Y_t = (L_{t-1}K_{t-1}I_{t-1})^{\delta} \quad (2.2a)$$

$$lnY_t = \delta ln\,(L_{t-1}K_{t-1}I_{t-1}) \quad (2.3a)$$

$$lnY_t = \delta e^{(l+k+i)(t-1)} \quad (2.4a)$$

If we suppose in model 2 that $\alpha + \beta + \gamma = 1$ (refer to formula 2.1), it is true that:

$$\frac{Y_t}{L_{t-1}I_{t-1}} = \frac{L_{t-1}^{\alpha}K_{t-1}^{\beta}I_{t-1}^{\gamma}}{L_{t-1}I_{t-1}} = \left(\frac{K_{t-1}}{L_{t-1}I_{t-1}}\right)^{\beta} \quad (2.2b)$$

$$ln\left(\frac{Y_t}{L_{t-1}I_{t-1}}\right) = \beta \cdot ln\left(\frac{K_{t-1}}{L_{t-1}I_{t-1}}\right) \quad (2.3b)$$

Evaluation results of the impact of the multiplicative effect on medium-term factors (δ) and integrated factors (β) on the physical volume of gross output are shown in Table 6.

Table 6 – Assessment of the multiplicative effect impact of the medium-term and integrated factors on the physical volume of gross output for the Russian economy.

Type of economic activity	Multiplicative effect of medium-term factors (δ)	Integrated factor (β)
Agriculture and Forestry	-1,442	2,014
Fishing	0,503	-0,071
Electricity, gas and water supply	-0,119	0,350
Construction	1,590	-1,268
Trade and Services	0,513	0,472
Transport and Communications	0,987	0,699
Finances	0,717	0,830
Investments	1,475	-3,388
Science and Information Technology	-0,209	0,062
Public Health Services, arts, culture and other social services	0,284	0,235
Other community, social and personal services	-0,412	-0,536
Mining and quarrying	0,342	0,275
Manufacturing	0,749	0,382
Hotels and restaurants	1,256	0,560
Public administration and defense; social insurance	0,170	0,091

Figure 1 shows the correlation between changes in labor force and fixed assets for the major sectors of the Russian economy. From this figure, the most significant growth of labor force and fixed capital is in Finance. Nevertheless, this figure is not informative enough.

Figure 2 allows us to divide sectors. The dependence of Finance, Investments, Manufacturing, Construction etc. on the labor force seems to be too low. Another group of sectors, Mining and quarrying, Public Health Services, Fishing, etc., has a strong dependence on the labor force as well as fixed capital.

The results of the analysis shows that high labor and capital productivity levels not always lead to a significant growth of gross output. It is often connected with extra administrative barriers.

Ranking of main factors (short term or medium term) in the degree of impact on a particular sector determines the policy. The short-term

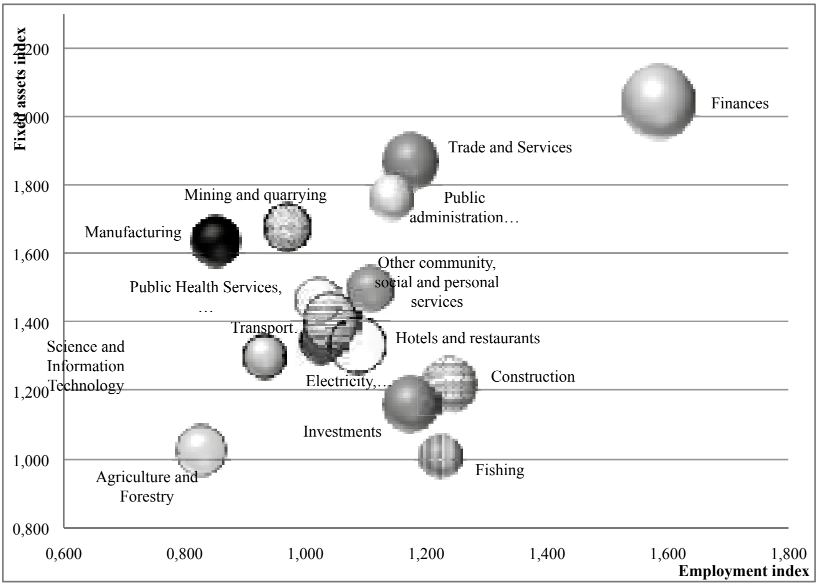

Figure 1 – Dependence of the Russian economy sectors output on employment and fixed assets indexes (2013 to 2003)

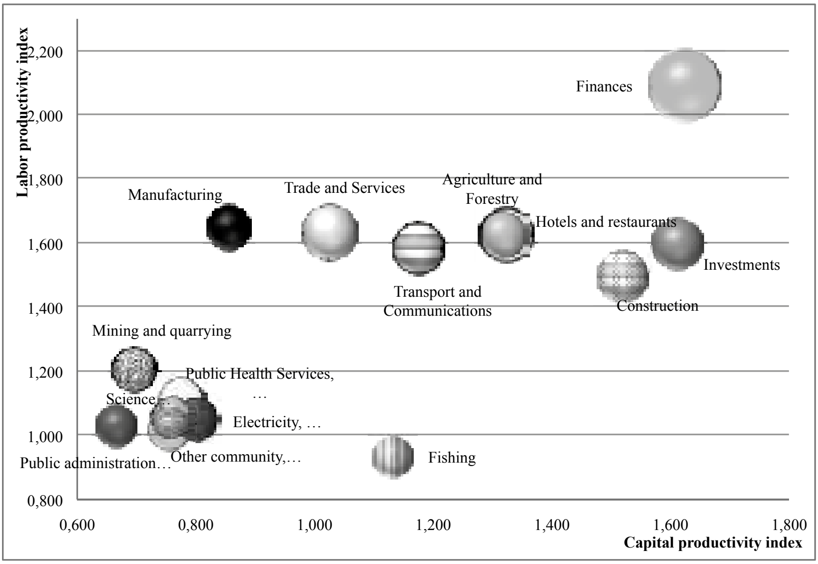

Figure 2 – The dependence of the Russian sectors' output on labor productivity and capital productivity indexes (2013 to 2003).

policy would be to stimulate demand, and for the medium-term a policy of supply is required.

The dynamics of labor productivity measured in US dollars for manufacturing industries is presented in Table 7. The largest growth of labor productivity is in Electrical, Electronic and optical equipment.

Table 7 – The dynamic of labor productivity for sub-sectors of manufacturing of the Russian economy.

Manufacturing Details	Labor productivity by gross output, $/employed	
	2003 year	2013 year
manufacture of food products, including beverages, and tobacco	26578,0	80751,7
manufacture of textiles and textile products	7463,7	14488,1
manufacture of leather, leather products and footwear	8437,8	26025,7
manufacture of wood and wood products	12079,1	27851,0
manufacture of pulp, paper and paper products; publishing and printing	25013,1	59068,0
manufacture of chemical products	24775,1	141935,2
manufacture of rubber and plastics products	20497,6	78048,4
manufacture of other non-metallic mineral products	13265,6	63241,1
manufacture of basic metals and fabricated metal products	32786,7	119548,7
manufacture of electrical, electronic and optical equipment	9186,9	59663,9
manufacture of transport equipment	15555,6	82490,4
other manufacturing	46003,9	83054,0

Figure 3 shows the relationship between labor productivity and capital productivity indexes and a share of the costs of technological innovation in the subsectors of the processing industry. The size of the ball reflects the ratio of costs of technological innovation to sales.

The most innovative industry in Russian manufacturing is electrical, electronic and optical equipment. As a result, this industry has the largest capital productivity index and the second highest value of the labor productivity index of all manufacturing industries, but there is no correlation between innovation activity and changes in factor productivity.

Table 8 shows tthe industries ranked according to the influence of the primary factors (short and medium term). Comparison of the results of the influence of the demand of economic sectors with the results of the impact of the supply-side factors is also shown in table 8. It allows us to determine the policy impact.

A comparison of the results with Gil'mundinov V.M. (Table 8) whose analysis was previously published in the article *Analysis of Structural*

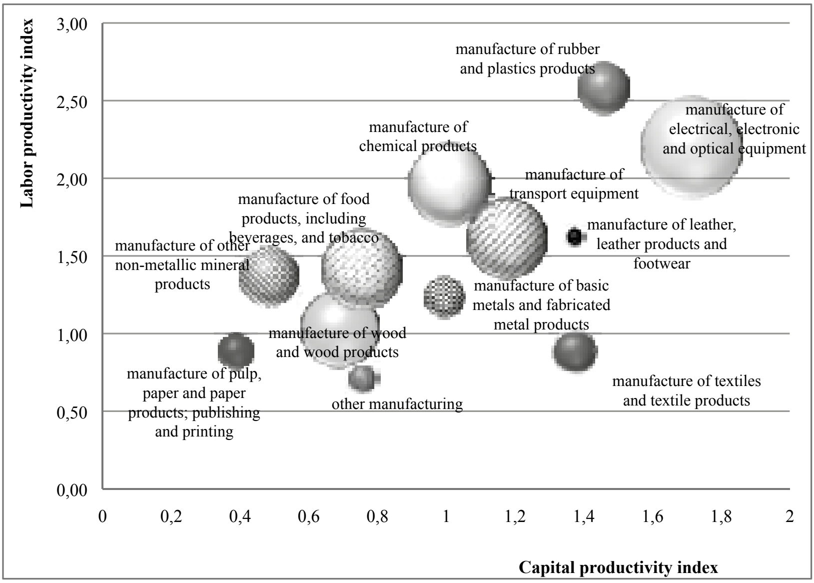

Figure 3 – The correlation of share expenses on the technological innovation in volume of sales and the labor productivity and capital productivity indexes (detailed by manufacturing sector).

Table 8 – The Comparison of the results of the demand and supply factors on economic industries.

Type of economic activity	R^2 of the results which were obtained by demand factors	R^2 of the results which were obtained by supply factors
Agriculture and Forestry	0,20	**0,493**
Fishing	0,20	**0,639**
Mining and quarrying	0,17	**0,428**
Manufacturing	0,61	**0,915**
Electricity, gas and water supply	0,49	**0,620**
Construction	0,61	**0,845**
Trade and Services	**0,92**	0,749
Transport and Communications	**0,53**	**0,575**
Finances	**0,86**	0,601
Investments	**0,62**	0,286
Science and Information Technology	**0,76**	0,197
Public Health Services, arts, culture and other social services	**0,41**	**0,332**
Other community, social and personal services	**0,78**	0,443

Changes in the Russian Economy in Conditions of Intersectoral Competition (Gil'mundinov 2011) allows us to summarize that *the medium-term factors have a greater impact on* the following sectors:

- Agriculture and Forestry;
- Fishing;
- Mining and quarrying;
- Manufacturing;
- Electricity, gas and water supply;
- Construction.

This means that in order to stimulate demand for these industries, policy must stimulate manufacturing. This has a significant impact on the dynamics of these industries, which have short-term factors determining the demand for their products. These circumstances mean that to stimulate the development of these industries along with government policies focused on expanding demand, there should first be policy instruments largely focused on the increase of skilled labour. Extractive industries, in their development, are limited to a greater extent by factors of production and transport of capacities, and the production of agricultural products faces increasing pressures from the availability of labour force.

The short-term factors (demand side) have a significant impact on:

- Trade and Services;
- Finances;
- Investments;
- Science and Information Technology;
- Other community, social and personal services.

For these industries, it is not desirable to stimulate demand, because this only leads to higher prices. It is necessary to remove the factors curbing growth, such as administrative barriers, limited access to long-term lending, lack of skilled labor, lack of access to new technologies and incentives for research and development, etc.

Sectors which are affected both by demand supply factors are:

- Transport and Communications;
- Public Health Services, arts, culture and other social services.

Demand and supply factors have a significant impact on the dynamics of these industries, which have short-term factors determining the dynamics of demand for their products. These circumstances mean that to stimulate the development of these industries, along with government policies focused on expanding demand, there should first be policy instruments largely focused on increasing qualified labor force.

For such industries as electricity, gas and hot water, including distribution services as well as mining and quarrying, investments in innovation and financial government support would have a positive effect.

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NEW MODEL DEVELOPMENTS

WED MODEL: WORLD ECONOMY AND ENERGY FORECASTING

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Daria Kiritsa[a]*, Nina Ryabtseva*

Abstract

Since the future level of energy consumption determines energy companies' appropriate level of investment in primary energy resources production and government energy policy, it is necessary to develop methods and tools to forecast global energy consumption. The energy use level depends on the economic growth of each country. On the one hand, energy consumption increases with GDP growth, on the other hand, it promotes energy efficiency and thus restrains energy consumption. Taking these and other energy consumption features into account, the team of authors proposes to use WED model for the purpose of energy consumption forecasting (including total primary energy consumption, oil, gas, coal, electricity).

1. Introduction

Rosneft's Expert-Analytical group[1] has developed a World Economic Dynamics model (WED) and used it to generate the global economy and energy projections through the year 2045.

The analysis takes into account historical data from 1971 to 2013. The main sources of information are: World Bank, International Monetary Fund, and the International Energy Agency. The WED model and projections consider 28 countries (including European Union-28), and other countries as an aggregate region. The 27 countries covered and European Union accounted for 89% of GDP and primary energy consumption in 2013.

WED is a large-scale simulation model designed to replicate how country economies, the world economy, and energy demand function. It consists of two main modules: economy and primary energy consumption (Figure 1).

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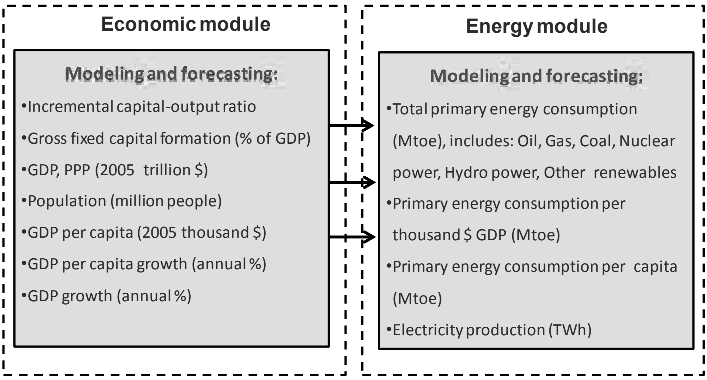

Figure 1 – Modeling and forecasting global economy and primary energy consumption: WED model.

The economic module generates projections of:

- incremental capital-output ratio;
- gross fixed capital formation (% of GDP);
- GDP, PPP (2011 trillion $);
- population (million people);
- GDP per capita (2011 thousand $);
- GDP per capita growth (annual %);
- GDP growth (annual %).

The energy module generates projections of:

- Total primary energy consumption (Mtoe), including the following forms of primary energy:
  1. Oil consumption;
  2. Natural Gas consumption;
  3. Coal consumption;
  4. Nuclear power consumption;
  5. Hydro power consumption;
  6. Other renewables consumption;
- Primary energy consumption per thousand $ GDP (Mtoe);
- Primary energy consumption per capita (Mtoe);
- Electricity consumption (TWh).

The algorithm for generating forecasts of a given country's economic dynamics and energy consumption is illustrated in Figure 2.

1. First, we generate the projections for economic dynamics in the economy module.
2. These estimates are used to calculate the forecasts for both total primary energy consumption and electricity production.

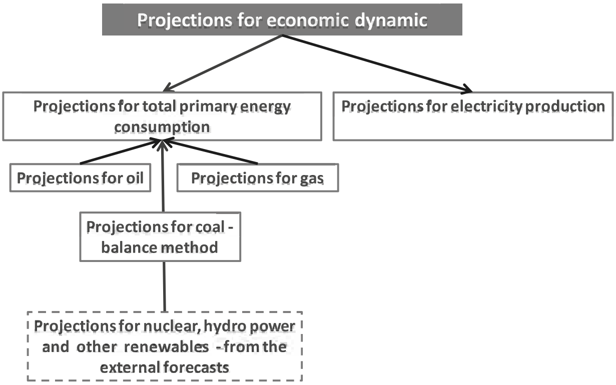

Figure 2 – Modeling and forecasting global economy and primary energy consumption: general logic.

3. Separately, we generate the projections for oil and natural gas consumption.
4. Nuclear, hydro power, and other renewables consumption are taken from external forecasts.
5. Coal consumption is estimated by using the balance method.

2. Economic modeling and forecasting in the WED model

The main factors determining economic growth are: gross fixed capital formation, incremental capital-output ratio, and population. The basic equation of economic growth is:

GDP per capita growth $_{t}$ *=Gross fixed capital formation* $_{t-1}$ */(Incremental capital-output ratio* $_{t-1}$*+1) (1)*

Taking into account analysis of historical trends, we made the following key assumptions.

- The United States remains the leader in terms of their economy and technology. In the long run, however, the gap between other countries and the United States will be reduced.
- Developing countries are attempting to close the gap with developed countries by increasing their gross fixed capital formation.
- Productivity of capital will decline in all countries (in the absence of breakthroughs in science and technology).
- Working-age population in the major developed countries is reduced. Population growth rates in emerging economies are also gradually declining.

3. Modeling of primary energy consumption

The WED model's main factors determining primary energy consumption are energy intensity with respect to GDP elasticity and GDP growth. This calculation algorithm is presented in Figure 3.

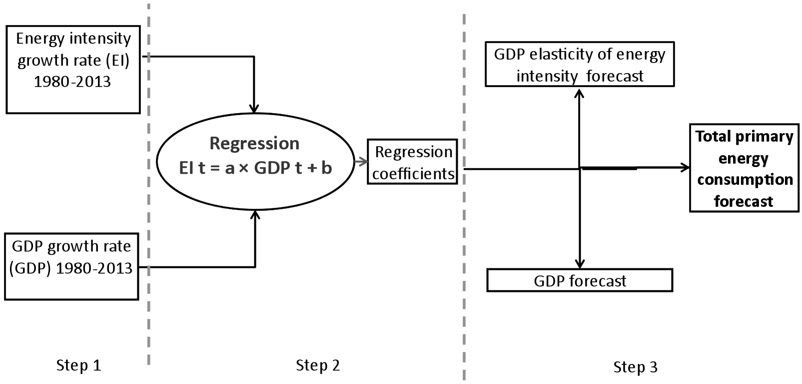

Figure 3 – Modeling of total primary energy consumption.

The forecast of energy intensity with respect to GDP elasticity is constructed using regression equations. It is assumed that in the forecast period, certain countries' elasticities move closer to the level of the United States.

4. Electricity consumption modeling and forecasting in the WED model

The WED model is used to forecast world electricity consumption. Calculations are based on International Energy Agency (IEA) data. The elasticities approach is implemented to estimate future rates of electricity consumption, which are subsequently used to calculate absolute values of electricity consumption.

Historical IEA data is used to develop the electricity consumption forecast. The time series of total electricity consumption for 1971 through 2013 are examined for every country in consideration.

According to the historical data, global electricity consumption increased by 442% between 1971 and 2013. In the same period, electricity consumption grew by 273% in developed countries and 875% in developing countries. Approximately 21,370 TWh of electricity was consumed in the world in 2013. Figure 4 shows that 9,470 TWh was consumed by developed countries, while 11,900 TWh was consumed by developing countries. Figure 5 illustrates that the five largest electricity consumers of 2013 are: China (5,046 TWh), USA (4,077 TWh), European Union (3,066

TWh), Japan (1,013 TWh), and India (983 TWh). The quickest increases in electricity consumption between 1971 and 2013 were in the United Arab Emirates (electricity consumption increased by 51,920%, reaching 98 TWh in 2013), Saudi Arabia (13,410% to 265 TWh), and Indonesia (by 11,550% to 195 TWh).

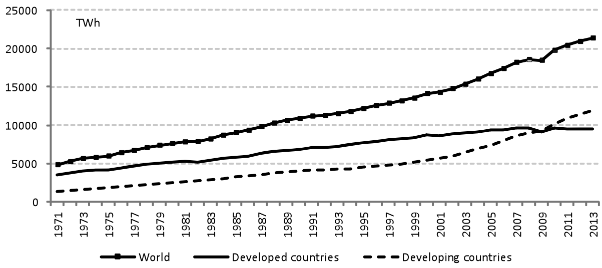

Figure 4 – Electicity consumption in 1971-2013, TWh. *Source: IEA*

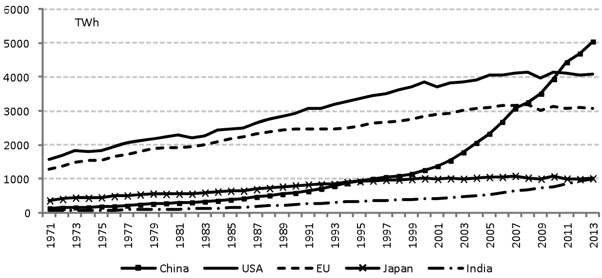

Figure 5 – Electricity consumption in 5 largest consumers in 1971-2013, TWh. *Source: IEA*

Figure 6 shows that the percentage of electricity consumed by developed countries has been falling for almost 20 years. Until 1996, it stood at nearly 65% of global electricity consumption. By 2013, however, the share of electricity consumed by developed countries decreased to 44%. Figure 7 illustrates that the share of the five largest electricity consumers has not changed significantly since 1980, and in 2013 was approximately 66%. China demonstrated the most impressive change, increasing from 4% of global electricity consumption in 1980 to 24% in 2013. On the other hand, the share of USA declined from 29% in 1980 to 19% in 2013. The same pattern was demonstrated by the European Union, with its global electricity consumption falling from 25% in 1980 to 14% in 2013. Japan and India's share of electricity consumption did not experience any substantial changes between 1980 and 2013. Each country amounted to 5% of global electricity consumption in 2013.

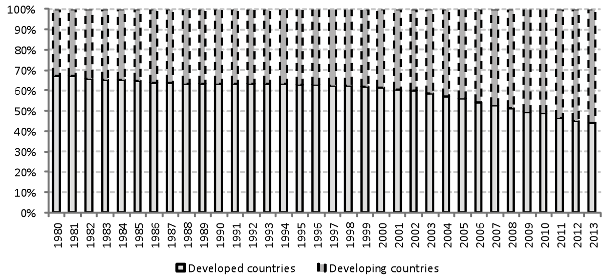

Figure 6 – Shares of developed and developing countries in global electricity consumption in 1980-2013, %. *Source: IEA*

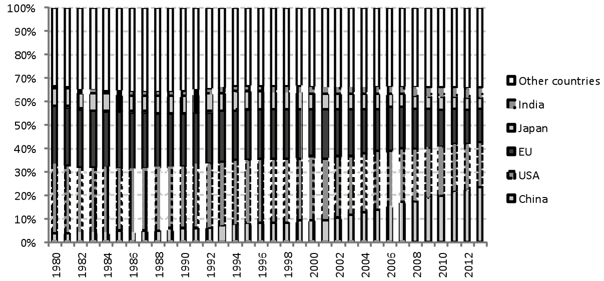

Figure 7 – Shares of 5 largest consumers in global electricity consumption in 1980-2013, %. *Source: IEA*

Worldwide cumulative average growth rate (CAGR) of electricity consumption was 3.6% for the period of 1972 to 2013. Developed countries grew at a CAGR of 2.4%, while developing countries grew at a CAGR of 5.3%. Figure 8 shows that from 1980 to 2013, the CAGR of electricity consumption in the five largest consumers were: China –9.2%, USA –2.3%, European Union –2.1%, Japan – 2.5%, and India –7.1%.

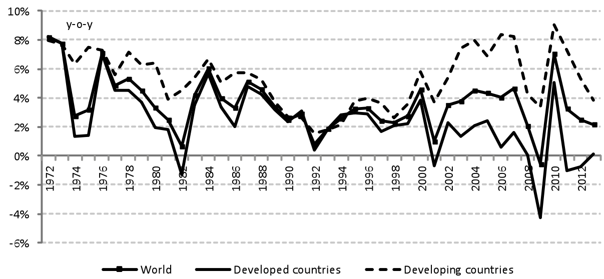

Figure 8 – Electricity consumption growth rates in 1972-2013, %. *Source: IEA*

GDP plays an important role in the dynamics of electricity consumption. To better understand how these indicators are connected, it is useful to look at electricity intensity. An economy's electricity intensity is defined as electricity consumption divided by country's GDP. Figure 9 illustrates that electricity intensities of developed and developing countries are converging. This fact indicates that developed countries are closer to their saturation in electricity consumption, meaning growth rates of electricity consumption will be lower than growth rates of GDP. On the other hand, developing counties are still approaching electricity consumption saturation. Future growth rates of electricity consumption will be at least slightly higher than GDP growth rates in these countries.

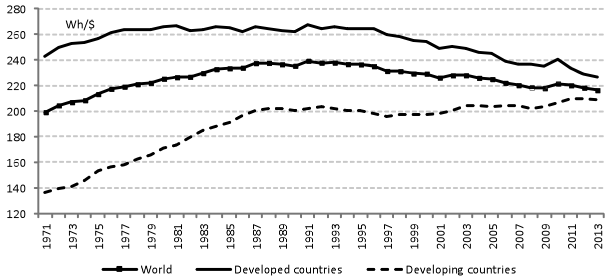

Figure 9 – Electricity intensity in 1971-2013, Wh/$. *Source: IEA, World Bank*

Two assumptions are made to forecast electricity consumption. According to the first assumption, the amount of electricity consumed can be used as a measure of wealth. Typically, as an individual's income rises, they are more likely to use electronic devices and machines such as air conditioners. Since GDP is a measure of wealth too, GDP should trend with total electricity consumed. Figure 10 shows that this correlation has been observed for more than 40 years. It is assumed that this fundamental relationship between growth rates of GDP and electricity consumption will continue to exist in future.

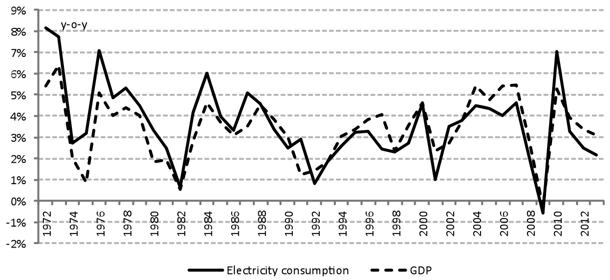

Figure 10 – Growth rates of global electricity consumption and world's GDP. *Source: IEA, World Bank*

The second assumption states that electricity consumption should remain stable or grow in the future. This assumption should be correct mainly due to urbanization patterns seen in developing economies around the globe. Many different estimates and forecasts show that individuals in developing countries such as China, India, and some African countries are likely to continue migrating from rural regions to more densely populated areas where electricity is more heavily consumed.

After these assumptions are made, average electricity consumption elasticity for GDP can be calculated in accordance with equation 2:

$$Growth\_rate\_elast = {}^{CAGR\_Electr}/_{CAGR\_GDP} \quad (2)$$

where *CAGR_Electr* denotes compound annual growth rates of electricity consumption and *CAGR_GDP* denotes compound annual growth rates of GDP. Former Soviet Union countries use data that cover 1998 through 2013. For other countries, equation 2 is estimated for 1990 to 2013. These periods were chosen since they are characterized by better stability in GDP and electricity consumption trends.

According to estimates, average elasticities for the biggest developed economies (European Union, USA, and Australia) are all less than 1. This fact demonstrates that developed countries are very close to their saturation in electricity consumption. In contrast, almost all of the developing countries have average electricity consumption elasticity for GDP near or above 1, which indicates that electricity consumption in these countries is still volatile and depends on GDP.

After growth rate elasticities are estimated, the forecasted GDP growth rates are used to calculate future growth rates of electricity consumption. This is done by fixing the elasticities on the constant level and multiplying them by future growth rates of GDP in accordance with equation 3:

$$Elec\_GR_t = Growth\_rate\_elast * GDP\_GR_t \quad (3)$$

where $Elec\_GR_t$ denotes electricity consumption growth rates in period *t*, and GDP_GR_t denotes GDP growth rates in period *t*.

5. Oil consumption modeling and forecasting in the WED model

Oil has been used by mankind for thousands of years, but drilling and oil production began only in the second half of the 19th century after a successful attempt to extract kerosene from oil. Gradually, coal as the main source of energy was replaced by more energy-intensive oil. The share of oil in global primary energy consumption had increased steadily until the first oil crisis, which served as the impetus for the development of alternative sources of energy.

The retrospective analysis of oil[2] consumption is based on IEA statistics from 1971 to 2013. Oil still holds the largest share of the world's consumed energy sources[3], increasing every year since the mid-1980s with the exception of recent economic crises. For the period under review, world oil consumption increased by 1.7 times. The patterns of world oil consumption generally followed the trajectory of world GDP. However, the global economy continued to grow slowly during the first two energy crises, even while oil consumption declined.

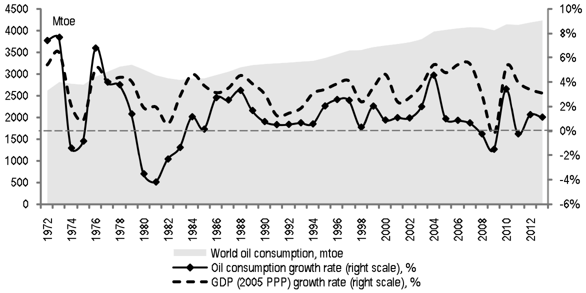

Figure 11 – World oil consumption and economic growth rate. *Source: IEA, World Bank.*

In many aspects, the world demand for oil from 1971 to 2013 was influenced both by the energy saving processes in the developed countries and industrialization in developing countries. The saturation of needs resulted in lower oil consumption in developed countries. However, significant growth of population and a higher demand for oil in developing countries ultimately led to rising oil consumption worldwide. Despite the significant growth of oil consumption in developing countries (by 3.3 times) for the period under review, there is a huge gap in oil consumption per capita between the developed and developing countries (4 times).

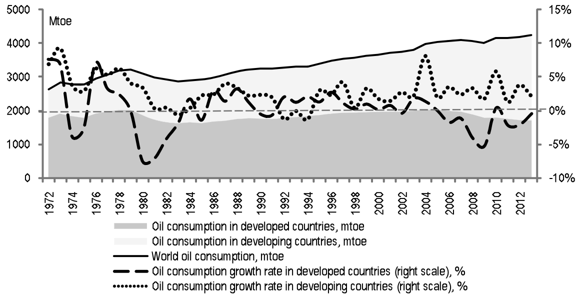

Figure 12 – Oil consumption growth rate in developed and developing countries. *Source: IEA, World Bank.*

2 Crude oil plus natural gas liquids (NGL).

3 The share of oil in world primary energy consumption falls from 44% in 1971 to 31% in 2013.

According to the IEA, the transport sector is the most significant consumer of global oil (over 55%). During the years analyzed, oil consumption steadily increased in transport (from 38% in 1971 to 55% in 2011) and petrochemicals (from 9% in 1971 to 15% in 2011). Together, they account for 70% of oil consumption. At the same time, the share of oil consumed in electricity production has declined from 11% in 1971 to just 7% in 2011.

As previously mentioned, the transport sector is the largest consumer of oil. As it is a significant part of a nation's economy, the growth and development of transport is considered an indicator of economic and social development. Consequently, we analyze the relationship between oil consumption in the transport sector and economic growth.

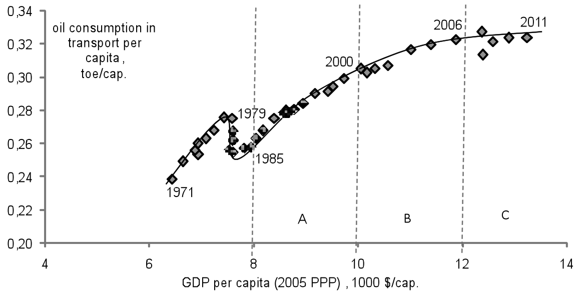

Figure 13 – Oil consumption in the transport sector per capita vs world GDP per capita, 1971-2011. *Source: IEA, World Bank.*

There is a strong correlation (more than 94%) between oil consumption in the transport sector per capita and world GDP per capita. As the standard of living increases, the number of automobiles per capita also rises. As we can see in figure 13, there was a steady increase in oil consumption per capita in the transport sector from 1971 to 1979. After the energy crisis of 1979-1980, however, a significant change in the trajectory was observed. The dependence of oil consumption per capita in the transport sector on GDP per capita began to fall to a lower growth curve. The growth of both GDP per capita and the consumption growth of motor vehicles are slowing. This is likely connected with the global economy approaching its saturation level. The relationship between per capita oil consumption in the transport sector and world GDP per capita is well approximated by the Gompertz function:

$$\frac{Consumption}{capita} = \gamma e^{\alpha e^{\beta (GDP/capita)}}, \qquad (4)$$

where γ is a saturation level, α and β are parameters to be estimated.

Oil balances, developed by IEA for every country are used to forecast a country's oil consumption. Thus, 28 countries consuming nearly 75% of world oil by 2013 have been chosen for our model. It is assumed that future growth in oil demand will be mainly driven by developing countries with a growing population and that world oil reserves are large enough to meet future world oil demand.

Given that the transport sector is the major oil consumer and its share of total oil consumption is growing steadily, our methodology of modeling future oil demand is based on forecasting the amount of oil consumed by transport. Figure 14 illustrates this modeling methodology. First, we investigate the relationship between the oil consumption in transport per capita and GDP per capita. By analyzing the graphical representation of this relationship, we get the curve that describes, rather accurately, how oil consumption in transport per capita depends on GDP per capita. The choice of the curve also takes into account the t-statistic of estimation regression. In this way, we get the equation that describes the relationship between the oil consumption in transport per capita and GDP per capita. After that, we can apply the GDP per capita forecast described earlier. Therefore, the future oil consumption in the transport sector can be estimated for all countries.

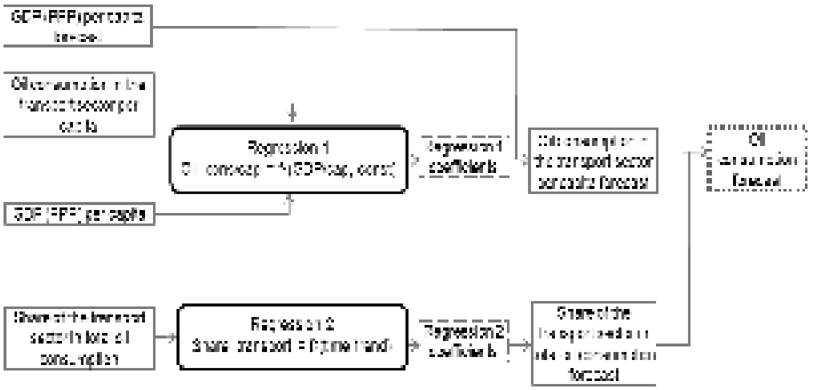

Figure 14 – Modeling of oil consumption: methodology.

Next, we analyze the historical share of oil consumed by transport compared to total oil consumption for each individual country. We typically use a linear trend based on the graphical representation of the share to get the forecast one. However, in some instances we also implement the same procedure that we apply to get the equation describing the relationship between the oil consumption in transport per capita and GDP per capita. Then, by multiplying the a country's future oil consumption in the transport sector by the forecasted share of transport in total oil consumption, we can estimate that country's future total oil consumption.

6. Natural gas consumption modeling and forecasting in the WED model

Over the past 40+ years, worldwide demand for natural gas has risen substantially. This has led to a 320% increase in gas consumption between 1971 and 2013. The dynamics of demand growth is sufficiently smooth. Only 2009 demonstrated a decline in natural gas consumption, associated with the slowdown in global economic growth.

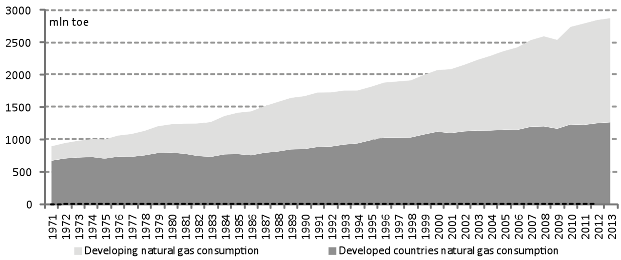

Figure 15 – Natural gas consumption in developed and developing countries. *Source: IEA.*

Analysis of historical trends shows that the growth rate of natural gas consumption is closely related to the GDP growth. Additionally, it is correlated with the growth of electricity production. This is largely due to the fact that electric utilities are one of the largest consumers of natural gas.

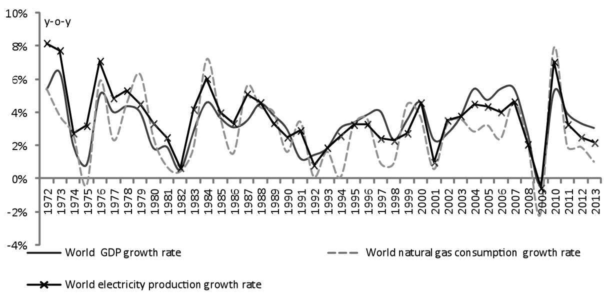

Figure 16 – Growth rates of global natural gas consumption world's GDP and electricity production. *Source: IEA, World Bank.*

Active development of liquefied natural gas (LNG) helped to increase natural gas consumption. Establishment of the LNG market began in the 1970s. Despite the fact that the increase in LNG supply for the period from 1972 to 2013 was unstable, LNG contributed to the emergence of new markets for natural gas. Remote consumers, such as Japan, South Korea, Spain, and other countries have an opportunity to organize LNG shipping. In addition, tanker deliveries made it possible to increase production and exports from distant suppliers such as Qatar, Trinidad and Tobago, and Nigeria.

In the early 1970s, developed countries consumed 75% of available natural gas, with 71% being consumed by the US and the EU. However, increasing consumption in developing countries led to an equal share of natural gas being consumed by developed and developing nations in 2003-2004. By 2013, the share of natural gas consumed by developed countries fell to 44%, of which 34% came from the US and the EU. Reasons for lower consumption in developed countries include increased energy efficiency and the development of renewable energy.

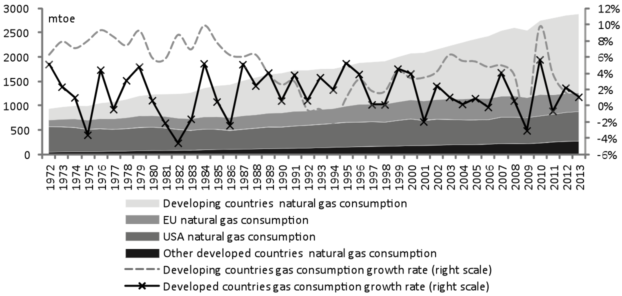

Figure 17 – Natural gas consumption growth and growth rates in developed and developing countries. *Source: IEA.*

The following factors influenced the rise in natural gas consumption: increase in oil prices, use as an alternative fuel, the oil crises (1974-1975, 1979-1983), cold winters (1976-1977, 2002-2003, 2009-2010), commitment to reduce emissions, environmental programs, and the organization of new LNG supply routes. Natural gas is relatively environmentally friendly when compared to other primary energy sources. New technology helps natural gas producers to spend less on machinery maintenance. Transport options for LNG has improved, allowing consumers to increase their consumption level.

The main factors that contributed to the slowdown of natural gas consumption in recent years were: the collapse of the USSR (1991), the global crisis (2008-2009), warm winter (2011-2012), and the transition to renewable energy sources.

During the 1970s, developed countries produced more than 59% of GDP and the gas intensity of GDP was more than double that of developing countries. In connection with the previously described factors (energy efficiency, switching to renewable energy sources, and so forth) gas intensity of GDP in developed economies declined and became almost equal to gas intensity of GDP in developing countries.

Today's supply weak constraints (established traditional sources, other alternative, sources such as shale gas, new extraction techniques, variety of transport methods) will be accounted for, allowing supply to be equal to demand. That allows us to concentrate on consumption level forecasting.

To forecast a country's natural gas consumption we use natural gas balances created by IEA. In our model we have chosen 28 countries, which make up almost 90% of natural gas consumption in 2013.

Our methodology of modeling natural gas consumption uses the structure of consumption. Total gas consumption can be divided among three main sectors: electricity production sector, residential or households consumption, and other sector's consumption. Additionally, knowing outputs (or in case of household – the population) allows us to count coefficients of unit consumption. By making some hypotheses or using models, we can estimate how the sector's consumption will change over time.

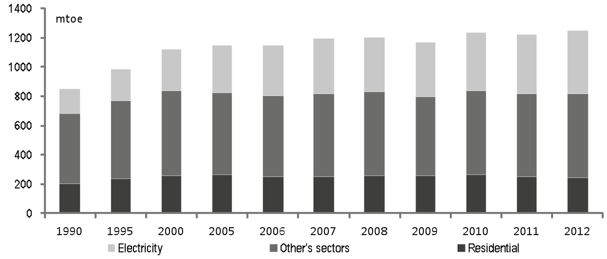

Figure 18 – Developed countries natural gas consumption structure. *Source: IEA*

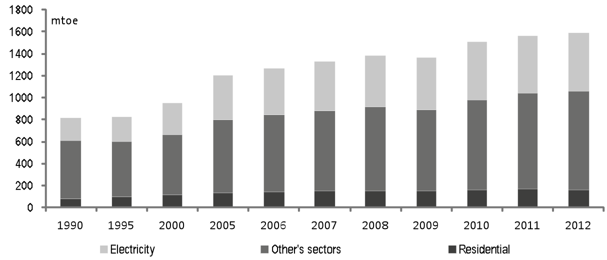

Figure 19 – Developing countries natural gas consumption structure. *Source: IEA*

$$\begin{aligned}&\textit{Total Natural gas consumption}\\&= \textit{Natural gas consumption in electricity} + \textit{Natural gas consumption in households}\\&+ \textit{Natural gas consumption in other sectors}\end{aligned} \quad (5)$$

Electricity

$$\begin{aligned}&\textit{Natural gas consumption in electricity}\\&= \text{UGCEG} * \textit{share of gas in electricity} * \textit{generation electricity production}\end{aligned} \quad (6)$$

where, UGCEG – unit gas consumption for electricity generation coefficient, which shows us how much gas we should use to produce 1 GWh of electricity in today's technological situation.

The electricity sector's natural gas consumption forecasting fall into two parts: UGCEG assumptions and the share of natural gas in power assumption.

1. UGCEG

Even if the efficiency level rises (or UGCEG will decrease), we will eventually achieve the maximum efficiency level for today's technological level. At this point, the unit production cost will stop declining or will decline extremely slowly, until new technology will be invented. In order to limit the possibility of reducing the consumption with an increase in energy efficiency, we use technological coefficients of electricity produced with natural gas in case of 100% efficiency.

Usually the speed of declining of UGCEG rates depends on a country's energy efficiency policy. To forecast the unit gas consumption coefficient, we review growth rates in the previous 20 years and built a linear trend. Using this, we counted consumption growth rates until 2024. Starting from 2025, we assume that the speed of efficiency growth will shift into low gear. To simulate the development of growth rates after 2025 we use a Gompertz function, assuming that the previous year's growth rates target will be less than 1%. With this methodology, growth rates in the first forecasting years, which were initially increasing rather quickly, become slower and slower. As a result, the unit gas consumption coefficient still declines, but the lowest level that might be achieved is the technological coefficient of efficiency.

2. Share of gas in electricity generation

To forecast the amount of gas which will be used in electricity, it is not enough to know the UGCEG level. It is necessary to understand what the natural gas share in power generation will be. The share of gas in power is forecasted the same way as the level of UGCEG in electricity: using growth rates with the assumption that historical trends will still dominate. Knowing the amount of electricity produced (with electricity forecasting in WED), we can calculate natural gas consumption in electricity.

Households

$$Natural\ gas\ consumption\ in\ households = RPCC * population \qquad (7)$$

where, RPCC is residential per capita natural gas consumption.

For households, the level of consumption depends primarily on access to the pipeline, but also on residential income level. However, if there is access to gas consumption in the household, there will be very low consumption elasticity for income. To estimate natural gas consumption in households, we check if residential per capita gas consumption growth correlates with GDP per capita growth. If the correlation exists, we assume that consumption of natural gas in the residential sector will grow alongside the GDP per capita growth rate. GDP per capita was chosen because it reflects household's income level. If natural gas consumption grows faster than GDP, we assume the country starts a policy of providing gas to residential sectors and builds new pipelines. In this case, we use linear trends calculated with previous year's statistics. The same methodology is used in the opposite case when access to pipelines already exists across the country and natural gas consumption growth is slower than GDP growth because of increasing efficiency of new technologies for household heating. Using a forecast of population growth, we can forecast natural gas consumption.

Other sectors

$$Natural\ gas\ consumption\ in\ other\ sectors = TICOSC\text{gas} * GDP \quad (8)$$

where, TICOSCgas, total input coefficient on other sectors consumption, is equal to natural gas consumed by other sectors divided by GDP.

Other sectors consists mostly of businesses, so its main purpose is to maximize profit and minimize costs. Therefore, we need to simulate the reduction of natural gas consumption as part of their costs. We calculate TICOSC dividing other sectors' gas consumption by GDP. Next, we estimate the growth rate of this parameter. Assuming that future consumption will continue on its historical trajectory, we calculate an equation of linear trend for growth rates of total input coefficient on others sectors, thereby forecasting natural gas consumption. Knowing GDP from the economics part of our model, we get natural gas consumption in other sectors.

7. Coal consumption modeling and forecasting in the WED model

Coal consumption review

Since 1971, the world coal consumption increased by 280%, reaching an equivalent of about 4 billion toe. The main coal consumers are developing countries (75% of world coal consumption in 2013) (Figure 20). China is the single largest coal consumer in the world. In 2013, coal consumption in China (2,04 bln toe) exceeded the consumption of all other countries combined. China's stable economic growth enabled it to secure high growth rates of coal consumption for the whole period. Other major consumers of coal are the United States, India, the EU, Russia, and Republic of South Africa. These six countries, which will be analyzed in our research, account for 85% of the global demand for coal (Figure 21).

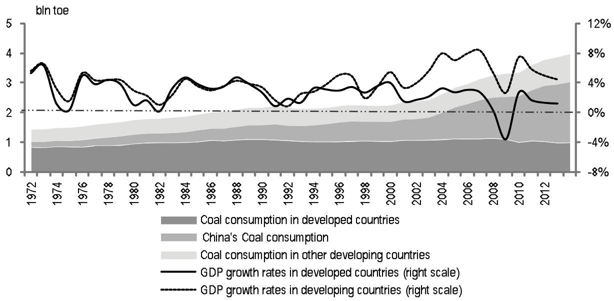

Figure 20 – Coal consumption in developed and developing countries. Источник: IEA

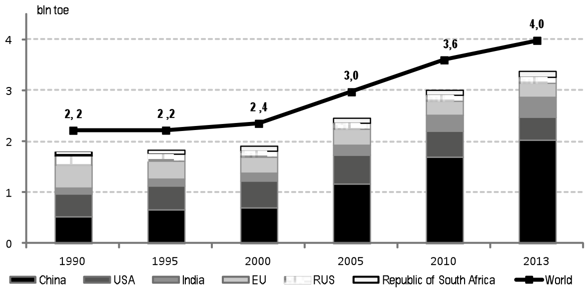

Figure 21 – Coal consumption structure by countries. Источник: IEA

Coal consumption modeling and forecasting

The WED model used energy balances from the International Energy Agency (IEA) for the period 1971-2013 for modeling and forecasting coal consumption in different countries and in the world in general through 2045. The amount of consumed coal from this data is equal to the sum of the following types of coal: anthracite, coking coal, other bituminous coal, sub-bituminous coal, and lignite.

In the WED model, coal consumption through the year 2045 is calculated using the balancing method, derived from indicators such as total energy consumption and consumption of oil, gas, nuclear energy, hydropower, and other renewable energy resources.

To establish a control of the derived coal consumption in countries using the balancing method, the WED model also used two additional methods to forecast coal consumption:

- coal consumption model by the key sectors;
- coal intensity calculation.

The result of using these two additional methods will be a more qualitative coal consumption forecast in the WED model.

Coal consumption model by the key sectors – 1st method

The first method is based on forecasting coal demand by key sectors. When analyzing the coal consumption structure across countries, the key consumer is the electricity sector. Among observed countries, the electricity sector's demand for coal was at least 52% of total coal consumption (Figure 22). Therefore, there are only 2 groups of consumers in this model: the electricity sector and all other consumers (Figure 23).

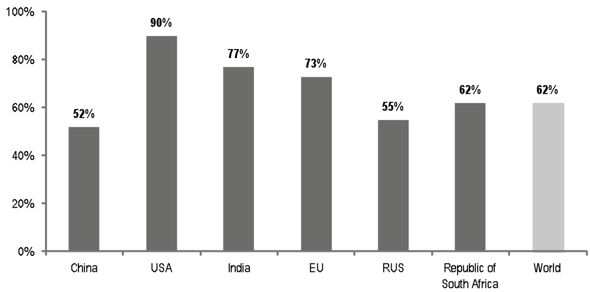

Figure 22 – Share of coal consumption by electricity sector, 2012. Источник: IEA

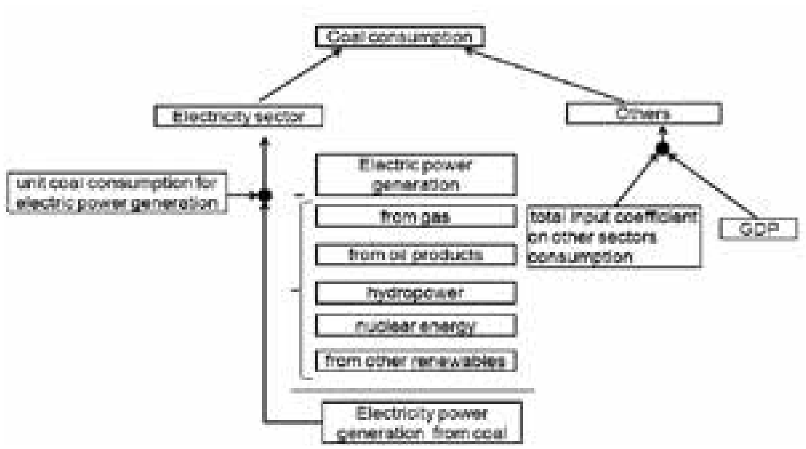

Figure 23 – Coal consumption model by key sectors.

Total coal consumption
= coal consumption in electricity sector (8)
+ coal consumption in other sectors

Forecasting coal consumption in the electricity sector:

Coal consumption in electricity sector
= unit coal consumption for electric power generation (9)
** share of electricity generation from coal*
** electricity production*

The unit coal consumption for electric power generation is the technological coefficient, which shows the amount of coal needed to produce 1 Gwh of electricity, will decline in the future. This coefficient is forecasted identically to the gas model, by using trends observed in the previous 40 years and a Gompertz function, which will limit the decline.

The share of electricity production generated from coal is calculated as the difference between total electricity production and electricity production generated by means of other resources (gas, oil products, hydropower, other renewables, and nuclear energy). Forecasted values of total electricity production and the share of electricity generated by gas are set in the WED model. The share of hydropower and nuclear energy are set exogenously. The growth of electricity production from other renewables is proportional to the growth of other renewables consumption, which are also exogenous. The share of electricity produced from petroleum is relatively small, not exceeding 1-2%. For this reason, it is assumed that the share of electricity produced using oil products will be stable throughout the entire forecast period.

Forecasting coal consumption in other sectors:

$$\textit{Coal consumption in other sectors} = \text{TICOSCcoal} \, {*}\textit{GDP} \qquad (10)$$

Where TICOSCcoal: total input coefficient on other sectors consumption, which is equal to coal consumed by other sectors divided by GDP.

The total input coefficient on other sectors consumption relative to the GDP is forecasted by using linear trends observed in the previous 40 years. GDP is taken from the economic part of WED model.

In summary, coal consumption model by key sectors used the following assumptions for the calculation of all indicators:

- unit coal consumption for electric power generation should decline in every country;
- due to the fact that the share of electricity produced from oil products is minor, we consider it to be constant throughout the whole forecasting period;
- the growth of electricity production from other renewables is proportional to the growth of other renewables consumption.

As a result, this method allows us to forecast not only the structure of coal consumption by sectors, but also the structure of electricity generation by type of resources.

Coal intensity calculation – 2nd method

The second method used to forecast coal consumption in different countries through 2045 is the coal intensity calculation. We use a four-step methodology, presented in Figure 24. Using historical data from IEA and the World Bank, a regressive equation was estimated showing the coal intensity with respect to GDP elasticity. This indicator is considered to be constant throughout the whole forecasting period. So, the coal demand of individual countries through 2045 is derived by multiplying this elasticity and GDP from the WED model.

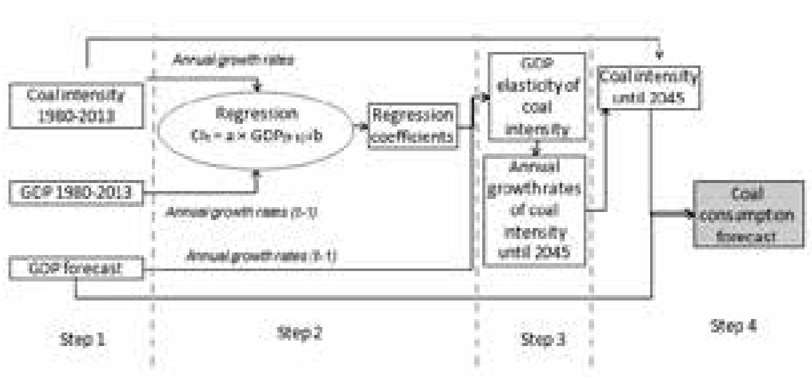

Figure 24 – The coal intensity calculation: methodology.

Coal Forecasting Conclusion

Coal consumption forecasting by two additional methods in the WED model allows to choose a more appropriate and more useful tool. This helps to control results of coal consumption through 2045 obtained by a balancing method. However, coal consumption until 2045, calculated by means of coal intensity, will be higher than results of coal demand calculated by the coal consumption model. This is likely due to the second method not accounting for scientific and technical progress factors and varying political and ecological factors.

8. Conclusion

In our research we have analyzed the historical data of energy consumption and economic growth for the largest countries separately and for the global economy as a whole. We have defined the main trends and determinants of economic growth and energy balances structural changes. In this way we have developed the tool describing the world economy and energy – the WED model.

Using the WED model, we forecast global economic growth and the growth of the largest countries. Understanding the growth rates of countries, and taking into account their energy policy features, we forecast the primary energy consumption level. Future energy resources use depends on current energy balances, different current and prospective energy policies and innovation in technology of energy consumption. To forecast energy demand it is essential to pay attention to the changes taking place in technology, such as energy efficiency, switching to renewable energy and others.

Further development of the model will be associated with the improvement of energy forecasting, elaboration of oil consumption estimation methods related to automobile use, adding the tool for forecasting renewables. Authors also plan to estimate future sectors'primary energy use.

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INFORTW: AN INTERINDUSTRY FORECASTING MODEL OF THE TAIWANESE ECONOMY

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Chih-Hsun Lin[a], *Yi-Lin Chang*[a]

1. Introduction

The Inter-industry Forecasting Model of Taiwan (INFORTW) illustrates the interaction between 47 industries and the macroeconomic environment in Taiwan. In today's society, production has become more efficient as specialization and connections between industries have been strengthened. Inter-industry models enable economic activities to be forecasted and simulated, and allow the relationships between industries to be elucidated. Using ample time series data ensures that highly accurate, reliable estimation results are yielded. In addition, accurate simulation results can assist policy formulation. Because of the need for a policy analysis tool, INFORTW was developed based on a considerable foundation of data with the assistance of the Taiwanese government.

INFORUM-type models have been widely used in numerous countries over the past 30 years (Almon 1991, 2014; Bardazzi *et al.* 1991; Bardazzi, Barnabani 2001; McCarthy 1991; Monaco 1991; Nyhys 1991; Orlowski, Tomaszewicz 1991; Werling 1992; Yu 1997). Historical data are analyzed in these models, and most parameters are obtained by estimation. Although using a large dataset ensures comprehensive, reliable estimated results, the use of a large dataset complicates the estimation process because amassing and maintaining a large dataset is difficult. However, this problem has been resolved by computational progress.

In 2013, the Taiwanese government began developing an inter-industry model to portray the economic interaction between industries in Taiwan, particularly energy-consuming industries, such as the iron, steel, and chemical industries. INFORTW is a local extension of the INFORUM model. This model efficiently estimates and forecasts annual output and price indices for 47 industries in Taiwan, as well as consumption

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demands, investment demands, government expenditures, net exports, wages, depreciation expenses, operating profits, and indirect taxes for each industry. Additionally, aggregated economic variables, such as the gross domestic production (GDP) and the employed population, can be obtained using this model. The RAS method is used to resolve inconsistent data. Generally, this model is dedicated to inter-industry planning, government policy analysis, and contributes to a general understanding of the economic environment.

2. The interindustry forecasting model of Taiwan

2.1 Real side

The real side of INFORTW estimates the final demand and output for 47 industries in Taiwan. The first central equation of INFORTW is

$$y = A\,y + f \qquad (1)$$

where y is the output vector (1×47), f is the final demand vector (1×47), and A is the input coefficient matrix (47×47). This equation represents the equivalence of the supply and demand for each industry. In other words, the output equals the intermediate demand ($A\,y$) plus the final demand. Throughout this paper, the boldface type represents matrices (denoted in upper case) and vectors (denoted in lowercase), while italics represent variables.

The final demand is composed of five sectors: consumption demand (c), investment demand (i), government expenditures (g), exports (x), and imports (m). These five sectors are all vectors (1×47). For each industry, the final demand is the summation of its consumption, investment, government expenditure, and net export, expressed as:

$$f = c + i + g + x - m \qquad (2)$$

The behavioral equation of sector demand for each industry is obtained using estimation. The five sectors are introduced as follows.

The consumption demand of an industry i at time t ($c_{i,t}$) could be explained by itself using the previous year ($c_{i,t-1}$), because consumption patterns are fairly regular and do not change dramatically in the short-term. Based on demand theory, the consumption demand for industry i is also a function of the price index for industry i ($p_{i,t}$) and total income (y_t). A time variable (t) was also incorporated to represent long-term trends. The consumption demand of industry i at time t is expressed in the following behavioral equation:

$$c_{i,t} = C(c_{i,t-1}, p_{i,t}, y_t, t),\ i = 1, \ldots 13. \qquad (3)$$

The investment demand of an industry i at time t ($i_{i,t}$) is determined by investment demand in the previous year ($i_{i,t-1}$) and the output of industry i ($y_{i,t}$). In macroeconomics, investment demand is typically affected by interest rates (r_t), and the time trend (t) must also be considered. The investment demand for industry i at time t is expressed by the following behavioral equation:

$$i_{i,t} = I(i_{i,t-1}, y_{i,t}, r_t, t)\ , i = 1, \ldots 19. \quad (4)$$

In practice, data categories are not matched to industries. For example, consumption demand is calculated based on a dataset comprising 13 categories which are not matched to the 47 industries considered in INFORTW. Moreover, the investment demand is calculated using a dataset containing 19 categories, which are also not matched to the 47 industries. The consumption and investment demands by category are converted to the final consumption and investment demands by industry by using a bridge matrix. These conversions are expressed as:

$$\mathrm{c} = B_{\mathrm{c}} \cdot \tilde{\mathrm{c}} \quad (5)$$

where $\tilde{\mathrm{c}}$ is the consumption demand vector by category, B_C is the consumption bridge matrix, and:

$$i = B_I \cdot \tilde{i} \quad (6)$$

where $\tilde{i}$ is the investment demand vector by category and B_I is the investment bridge matrix. Thus, the final demand by industry is obtained by multiplying the final demand by category by the bridge matrix.

The government expenditure of an industry i at time t ($g_{i,t}$) is expressed as an exogenous variable. To calculate the government expenditures of the 46th industry, public administration services, annual government expenditure data collected before 2012 were directly analyzed. Government expenditures for public administration services after 2012 were calculated based on the average growth rate of the preceding 10 years. Government expenditures of the other industries were all set to zero. Moreover, based on trade theory, exports were considered influenced by the export price ($p^e_{i,t}$) of industry i, the foreign price (p^f_t), and foreign income (y^f_t). The exports of industry i ($e_{i,t}$) were also derived from the historical patterns of the previous year ($e_{i,t-1}$). The same logic was applied to imports. Imports ($m_{i,t}$) are affected by the import price ($p^m_{i,t}$), the local price ($p_{i,t}$), the local income (y_t), and its lagged term ($m_{i,t-1}$). Thus, the exports and imports of industry i at time t are expressed in the following behavioral equations:

$$e_{i,t} = E(e_{i,t-1}, p^e_{i,t}, p^f_t, y^f_t)\ , i = 1, \ldots 47. \quad (7)$$
$$m_{i,t} = M(m_{i,t-1}, p^m_{i,t}, p_{i,t}, y_t)\ , i = 1, \ldots 47. \quad (8)$$

After the final demand was estimated using Equations 2 to 8, the output ($y_{i,t}$) for each industry on the real side is obtained by solving Equation 1, which can be rewritten as:

$$y = (I_0 - A)^{-1} f \qquad (9)$$

where I_0 is an identity matrix (47×47) and $(I_0 - A)^{-1}$ is a Leontief inverse matrix. The solution for the output is interactive. Because current output, consumption, investment, government expenditures, and net exports are mutually dependent, these six sets of equations are solved simultaneously in the model.

2.2 Price-Income side

The price-income side of INFORTW estimates the value added and unit prices for 47 industries in Taiwan. The second central equation of INFORTW is:

$$p = A' p + v \qquad (10)$$

where p is the unit price vector (1×47), v is the unit value-added vector (1×47), and A' is the transposition of the input coefficient matrix (47×47). As this equation shows, the unit price is equal to the sum of the unit material cost ($A' p$) and the unit value-added cost. The unit value-added cost ($v_{i,t}$) is derived from the total value-added cost ($va_{i,t}$) divided by the output, expressed as:

$$v_{i,t} = \frac{va_{i,t}}{y_{i,t}}, \; i = 1, \ldots 47. \qquad (11)$$

According to the national accounts, the total value added (va) is composed of four components: wages (w), depreciation expenses (d), operating profit (pr), and indirect taxes (t). Thus, the total value added is calculated by:

$$va = w + d + pr + tax \qquad (12)$$

Each component of the value added is estimated for each industry. The wages of industry i at time t ($w_{i,t}$), which constitutes the principal component of value added in Taiwan, are a function of that industry's lagged term ($w_{i,t-1}$), average wages (w_t), and labor productivity ($prl_{i,t}$). Generally, wages in a specific industry gradually change over time; thus, the lagged term represents the pattern of its autocorrelation. In addition to industry-specific factors, the economic environment influences wages. Thus, the average wage of all industries is considered. The wages of industry i at time t are expressed in the behavioral equation:

$$w_{i,t} = W(w_{i,t-1}, w_t, prl_{i,t}), \; i = 1, \ldots 47. \qquad (13)$$

In addition, wage levels depend on industry-specific labor productivity, which is estimated as a function of changes in output ($\Delta y_{i,t}$), investment in the previous year ($i_{i,t-1}$), and the time trend (t). Changes in output and lagged investment are derived from the estimated results of the real side of INFORTW. The function of the labor productivity of industry i at time t is expressed as:

$$prl_{i,t} = PRL(\Delta y_{i,t}, i_{i,t-1}, t)\ , i = 1, \ldots 47. \tag{14}$$

After the fitted labor productivity is obtained using Equation 14, the wage behavioral equation is estimated by regarding labor productivity as an explanatory variable. Furthermore, the labor demand of industry i at time t ($l_{i,t}$) is obtained from the output divided by the labor productivity, expressed as:

$$l_{i,t} = \frac{y_{i,t}}{prl_{i,t}}\ , i = 1, \ldots 47. \tag{15}$$

The depreciation expenses of industry i at time t ($d_{i,t}$) are estimated according to the industry's lagged term ($d_{i,t-1}$), the proxy variable of the capital stock for industry i at time t ($k_{i,t}$), and the time trend (t). Because actual capital stock data for each industry are unavailable, a proxy variable is employed. The proxy variable used for the capital stock is the cumulative investment, which is also obtained from the real side of INFORTW. The depreciation expenses of industry i at time t are expressed in the following behavioral equation:

$$d_{i,t} = D(d_{i,t-1}, k_{i,t}, t)\ , i = 1, \ldots 47. \tag{16}$$

The operating profits of industry i at time t ($pr_{i,t}$) are a function of the industry's lagged term ($pr_{i,t-1}$), changes in output ($\Delta y_{i,t}$), and the price index for industry i in the previous year ($p_{i,t-1}$). Based on production theory, prices affect revenue directly, which in turn affects profits. The operating profits of industry i at time t are expressed in the following behavioral equation:

$$pr_{i,t} = PR(pr_{i,t-1}, \Delta y_{i,t}, p_{i,t-1})\ , i = 1, \ldots 47. \tag{17}$$

Finally, a behavioral equation is used to estimate the indirect taxes of industry i at time t ($tax_{i,t}$), which are simply a function of the value added of industry i ($va_{i,t}$) and the time trend (t). As the linear function indicates, taxes are a proportion of the total value added, excluding the time trend, and expressed as:

$$tax_{i,t} = TAX(va_{i,t}, t)\ , i = 1, \ldots 47. \tag{18}$$

After estimating the value added using Equations 11 to 18, the price index ($p_{i,t}$) for each industry in the price-income side is obtained by solving Equation 10, which can be rewritten as

$$p = (I_0 - A^{'})^{-1}\, v. \qquad (19)$$

Similarly, the solution for the price is interactive. Because the current price, value added, and its four components are all mutually dependent, these sets of equations on the price-income side of INFORTW are solved simultaneously.

2.3 Connection between the real and price-income side

Figure 1 shows a detailed flow chart of the real and price-income sides of INFORTW. INFORTW was programmed using Stata statistical software (version 12).

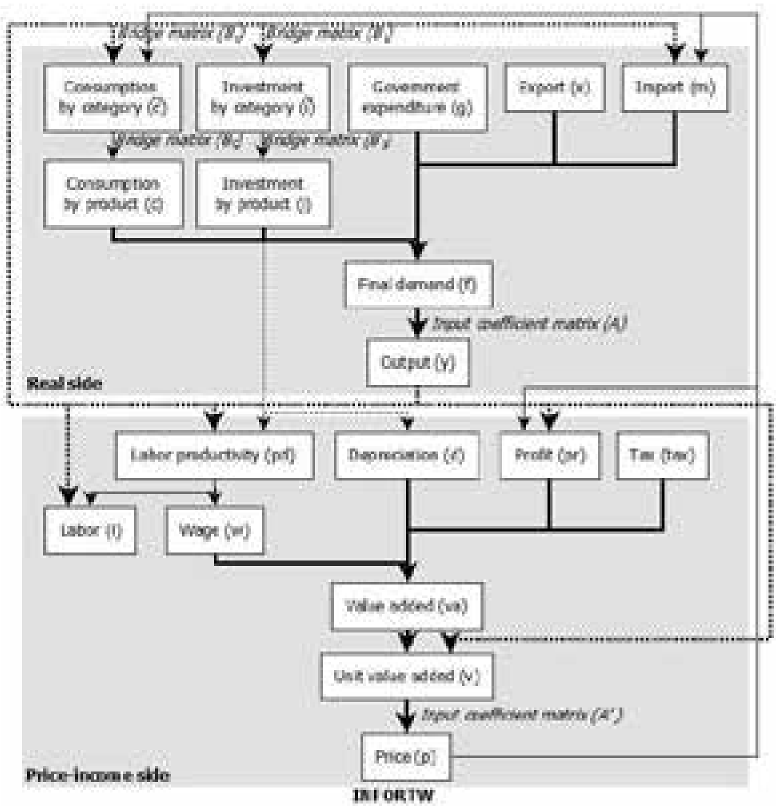

Figure 1 – Connection of real and price-income sides of INFORTW.

2.4 RAS method

In this study, a data mismatch occurred because the data were acquired from various sources. In particular, the output for each industry differed between I-O tables and national accounts, causing unstable estimated results when simultaneously using the industrial structure from the I-O tables and the time series data from national accounts. Thus, one of the datasets had to be reasonably adjusted to synchronize the I-O table with the national account. In addition, I-O tables are updated every five years, but industrial structures can change substantially within five years, rendering the industrial structure outdated. However, national accounts are revised annually. Integrating the I-O table into the national account can allow the latest annual I-O coefficient and data to be obtained. Thus, to solve these problems, the RAS method (Bacharach, 1970) was employed before the INFORTW was used for estimation.

Beginning with an I-O table (matrix A, 47×47), which represents the interindustry structure, two constrained conditions from the national account were set, including the output minus final demand (vector u, 1×47) and the output minus value added (vector v, 1×47) for each industry. Using recursive estimation, the RAS method was used to adjust each element of the I-O table, and making the row-sum and column-sum equal to the vector u and v, respectively, by industry. After the revised I-O coefficients (matrix B, 47×47) were obtained, the INFORTW could be estimated.

2.5 Data

INFORTW is not the only econometric model involving I-O techniques, but it is distinguished from numerous models used to model the Taiwanese economy by its data foundation. This data foundation is composed of I-O tables updated every five years, and time series data regarding outputs, prices, five sectors of final demand, and four components of value added. All data are collected for the 47 industries of INFORTW. The substantial foundation of data used in this model contributes to both the estimation of behavioral equations and its forecasting ability.

Time series data were obtained from various sources. Taiwanese economic data, such as the national account or the I-O table, were primarily acquired from the Directorate General of Budget, Accounting and Statistics (DGBAS) of Taiwan. The I-O table has been updated every 5 years since 1981, and the latest I-O table was updated in 2006. Other economic data are updated annually and range between 1981 and 2011. Data regarding Taiwan's annual government expenditures, exports, and imports were acquired from the Ministry of Finance of Taiwan. To consider the international economic situation when estimating net exports, the global production and price data from the World Development Indicators of the World Bank were used. Historical data between 1981 and 2012 were utilized to estimate the model. To avoid over-extrapolation, the forecasting interval of the INFORTW was set to 2013-2025. When future data is available, the forecasting period can be lengthened accordingly.

In addition, the original data was not exactly sorted according to 47 industries. Thus, data were merged or divided as necessary. The 47 industries described by INFORTW were classified as presented in Appendix 1.

3. Scenarios

According to the IEA (2010), energy efficiency has been emphasized by governments worldwide in recent years. Since 2008, the Ministry of Economic Affairs of Taiwan implemented a policy target for improving energy efficiency by 2% per year. Moreover, technical feasibility was considered based on the Forecasting Energy Consumption Analysis and Simulation Tool (FORECAST), a German model with a Taiwanese extension under development. FORECAST is a bottom-up technical model for measuring energy use (Fleiter *et al.* 2011, 2012). The bottom-up model is used because of its engineering base, which is neglected in economic models, including INFORTW. The FORECAST model involves using outputs in the base scenario of INFORTW as exogenous variables and is used to estimate the technically feasible amount of energy saving in the future. This energy saving is then set as exogenous variables into INFORTW to simulate economic impacts in different scenarios of energy efficiency improvement. Using the results of a technical model would increase the reliability of the exogenous energy saving rate set by INFORTW.

To model energy efficiency improvements in the iron and steel industries, technical feasibility, investment amount, and energy saving targets were considered in modeling 'weak' and 'strong' energy efficiency scenarios. In the weak scenario, the electricity and gas inputs were decreased by 3% and 0.5%, respectively, and this energy efficiency improvement was considered financially supported by USD$50.7 million (TWD$1.5 billion) of investment after 2015. The strong scenario was modeled in two stages. At the first stage, the electricity and gas inputs were decreased by 4% and 0.7%, respectively, and annual investment was set at USD$67.6 million (TWD$2 billion) after 2015. The production process was expected to have progressed by 2020, implying greater improvements in energy efficiency. Thus, at the second stage of the strong scenario, the electricity and gas inputs decreased further, by 8% and 2%, respectively, and annual investment was increased by an additional USD$67.6 million (TWD$2 billion). These two scenarios were considered technically feasible after referring to the FORECAST model and consulting specialists' opinions. Thus, three scenarios modeled for the iron and steel industries in Taiwan were specified as follows:

Scenario 1: Base scenario.
Scenario 2: Weak scenario:
Electricity input decreases by 3% and gas input decreases by 0.5% after 2015.
Annual investment increases by USD$50.7 million after 2015.
Scenario 3: Strong scenario:
Stage 1: Electricity input decreases by 4% and gas input decreases by 0.7% after 2015.
Annual investment increases by USD$67.6 million after 2015.
Stage 2: Electricity input decreases by 8% and gas input decreases by 2% after 2020.
Annual investment further increases by USD$67.6 million after 2020.

4. Estimated results

4.1 Base scenarios

Figure 2 shows the estimated results of the economic environment in Taiwan from 1981 to 2025 obtained using INFORTW; the values after 2012 were forecasted. As shown in Figure 2 (A), the fitted value of Taiwan's GDP was remarkably similar to the actual value, particularly in the last 15 years. An upward trend was also observed. Moreover, some of Taiwan's recent economic shocks, such as the global financial crisis in 2009, the SARS epidemic in 2003, and the Asian financial crisis in 1998, were indicated by drops in GDP. These results indicated that the estimation ability of the INFORTW was satisfactory, which implied that the forecast values were reliable. GDP was predicted to be USD$479.7 billion at an economic growth rate of 2.05% in 2013, and USD$577.8 billion at a 1.98% growth rate in 2020.

The fitted value was markedly accurate around 2006, because the I-O table of the 2006 version was used. Further from 2006, the estimated error was more substantial because the industry structure had changed. For forecasting purposes, the latest industrial structure should be used to ensure that the most accurate forecasting values were obtained. The 2011 version of the I-O table is expected to be released in late 2014, at which time the input coefficients can be updated.

The iron and steel industries were modeled to demonstrate the industrial explanatory ability of INFORTW. Figure 3 shows the estimated results of the base scenario between 1981 and 2025, in which values after 2011 were predicted. A slow upward trend was observed. The output (or value added) of the iron and steel industry in Taiwan was predicted to be USD$6.75 billion and USD$7.04 billion in 2015 and 2020, respectively, at an average annual growth rate of approximately 1%.

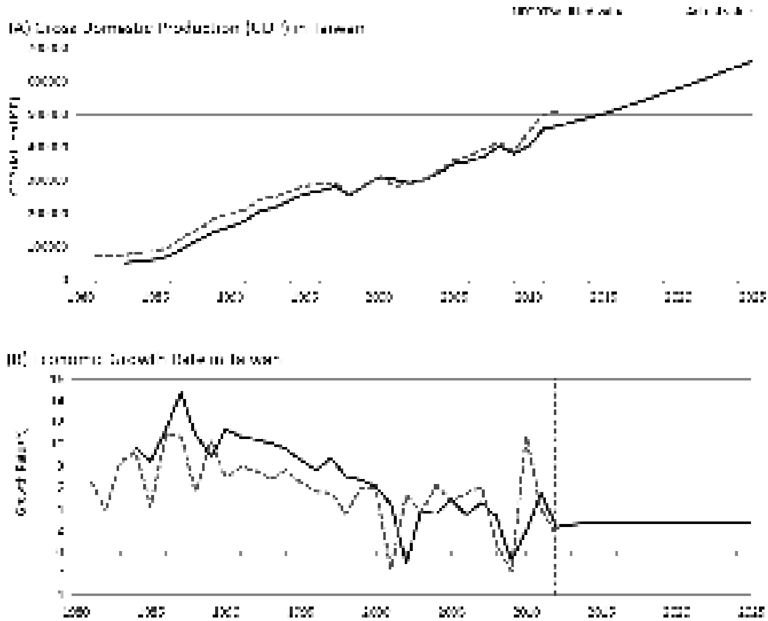

Figure 2 – INFORTW estimated results of macroeconomic variables (1981-2025).

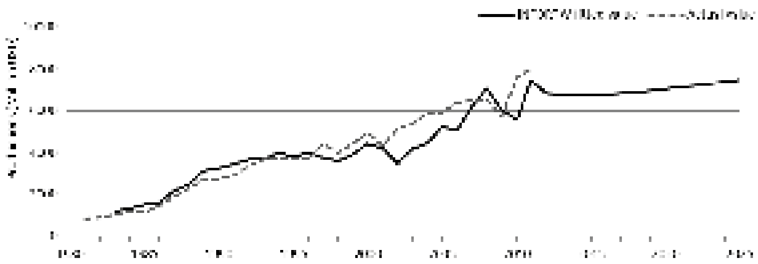

Figure 3 – INFORTW estimated results for productions of the iron and steel industry (1981-2025).

4.2 Economic Impact simulation

Three scenarios were simulated: the base scenario, the weak scenario, and the strong scenario. Table 1 lists the estimated results for the iron and steel industries, while Table 2 lists the overall estimated results for the general Taiwanese economy. The values for the weak and strong scenarios listed in Tables 1 and 2 represent the difference from the base scenario.

Policy influences caused by improving energy efficiency would thus be captured by changes in output and job opportunities.

Table 1 – INFORTW estimated results for iron and steel industry in Taiwan.

Year	*Scenario 2-1: Base scenario*		*Scenario 2-2: Weak scenario*		*Scenario 2-3: Strong scenario*			
	Production	Employee	Production changes	Employee changes	Production changes		Employee changes	
	(Million USD)	(People)	(1000 USD)	(People)	(1000 USD)		(People)	
					Stage1	*Stage2*	*Stage1*	*Stage2*
2013	6770.1	96047	-	-	-	-	-	-
2014	6742.8	94776	-	-	-	-	-	-
2015	6749.3	93674	-524.7	18	-699.4	-699.4	24	24
2016	6780.3	92627	-400.1	13	-533.2	-533.2	17	17
2017	6829.4	91635	-279.2	12	-373.2	-373.2	17	17
2018	6891.8	90691	-184.2	12	-244.9	-244.9	16	16
2019	6964.3	89790	-110.3	12	-147.3	-147.3	16	16
2020	7044.3	88927	-54.4	12	-72.8	-1361.9	15	41
2021	7129.8	88099	-11.1	11	-14.3	-1106.4	15	30
2022	7219.2	87309	23.2	11	30.6	-828.8	14	29
2023	7310.6	86564	49.1	10	65.5	-595.4	14	29
2024	7405.1	85805	70.2	10	92.9	-407.0	13	28
2025	7501.2	85043	85.0	10	113.5	-256.5	13	27

Note: The currency exchange rate (TWD/USD) is fixed at 29.6 of the 2013 value.

As shown in Table 1, the output of the iron and steel industry exhibited a slow growth in the base scenario. Based on this slight upward trend, production immediately decreased when the investments in energy efficiency were applied. Because of increasing investment, the value added of the iron and steel industry was immediately crowded out. In the weak scenario, production decreased by USD$524.7 thousand in 2015. In the strong scenario, output dropped by USD$699 million in 2015 and decreased by USD$1362 million in 2020. However, this negative effect was compensated by progressive improvements in energy efficiency. This improvement rendered the production process more efficient, causing a subsequent increase in output after investing. According to the INFORTW results, the recovery period was approximately six years. Output changes caused by the investment and recovery processes are shown in Figure 4(A). After the immediate drop in the first years of investment (in 2015 and 2020), the negative output change gradually decreased and then became positive approximately six years later. This pattern was similar in both the weak and strong scenarios, but the degree of influence on production was higher for the strong scenario.

Table 2 – INFORTW estimated results for Taiwan.

Year	*Scenario 2-1: Base scenario*		*Scenario 2-2: Weak scenario*		*Scenario 2-3: Strong scenario*			
	GDP	Growth rate	GDP changes	Employee changes	GDP changes		Employee changes	
	(Million USD)	(%)	(Million USD)	(People)	(Million USD)		(People)	
					Stage1	*Stage2*	*Stage1*	*Stage2*
2013	482303.7	2.05	-	-	-	-	-	-
2014	492473.0	2.11	-	-	-	-	-	-
2015	502732.4	2.08	182.83	1387	243.83	243.83	1849	1849
2016	513113.3	2.06	207.01	1613	275.93	275.93	2150	2150
2017	523604.5	2.04	218.05	1667	290.70	290.70	2222	2222
2018	534195.1	2.02	223.96	1700	298.54	298.54	2266	2266
2019	544886.1	2.00	227.00	1719	302.65	302.65	2292	2292
2020	555693.1	1.98	227.80	1723	303.75	482.73	2298	3704
2021	566650.8	1.97	227.72	1719	303.54	541.78	2292	3939
2022	577798.1	1.97	225.71	1696	300.95	564.84	2263	4039
2023	589213.0	1.98	221.61	1641	295.49	571.13	2190	4005
2024	600898.1	1.98	206.18	1556	275.02	548.22	2074	3872
2025	612940.7	2.00	198.13	1514	264.24	535.65	2024	3816

Note: The currency exchange rate (TWD/USD) is fixed at 29.6 of the 2013 value.

In addition, this energy efficiency improvement produced a strong linkage effect throughout the Taiwanese economy. The changes in Taiwan's GDP caused by energy efficiency improvements in the iron and steel industries are shown in Figure 4(B). The improvements undertaken in the weak scenario, which involved annual investment amounts of $50.7 million, were estimated to increase Taiwan's GDP by USD$198.1 million until 2025. The strong scenario, which involved annual investment amounts of USD$67.6 million and USD$135.2 million in Stage 1 and Stage 2, respectively, was estimated to increase GDP by USD$303.8 million at Stage 1 until 2020 and by USD535.7 million at Stage 2 until 2025. Thus, the multiplier was approximately four times, suggesting that the iron and steel industries exert a strong linkage effect on Taiwan's current economic situation. This positive effect was almost permanent except for a small glide in later years, which could be ignored within a decade.

The output results indicated that the iron and steel industries are an appropriate target industry for improving energy efficiency and promoting the economy. Because of the industry's strong linkage effect on the general economy, the positive influence of such improvements would be substantial. However, because of the long recovery period (approximately six years), enterprises in the iron and steel industries, particularly small and medium-sized enterprises that hold limited assets, have little incentive to invest in energy efficiency. Thus, the authorities must intervene in increasing energy efficiency investment incentives, which spur more efficient use of energy and boost the economy. Soft incentives, such as subsidies and tax deductions, or hard incentives, such as regulations, could be employed.

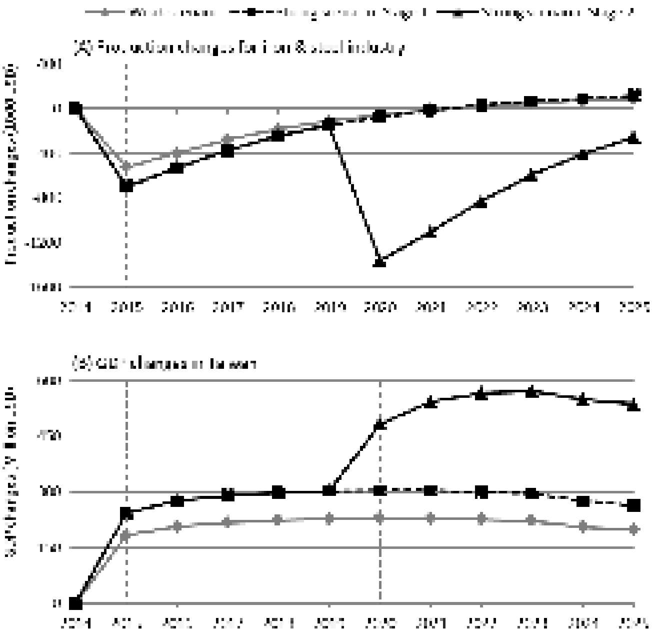

Figure 4 – Production changes due to energy efficiency improvement in iron and steel industry.

5. Conclusion

In this paper, a multi-sectoral economic model of Taiwan, INFORTW, is presented. INFORTW contains two sides – the real side and the price-income side – and each side incorporates different sectors to describe 47 industries in Taiwan. The real side estimates consumption demands, investment demands, government expenditures, net exports, final demands, and total outputs. The price-income side estimates wages, labor productivity, labor demands, depreciation expenses, operating profits, indirect taxes, value added, and price indices. In addition, the RAS method is used to resolve inconsistencies in the data related to discrepancies between the I-O table and the national account. In addition to the 47 industries, the overall economic environment can also be analyzed using INFORTW. Similar to other models in the INFORUM family, INFORTW can be employed to simulate various economic impacts when formulating policies. In other words, INFORTW can be used to answer the 'what if' economic questions.

To evaluate INFORTW, fitted values were compared with actual values for each industry and for the general Taiwanese economy. The estimated results for the fitted values were extremely similar to the actual values. Thus, the estimation ability of the INFORTW was satisfactory, which suggests that its forecasting values are reliable.

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Appendix

Appendix 1 – The classification for INFORTW 47 industries.

No.	Industry	No.	Industry
The primary sector		24	Lighting equipment
1	Agriculture, livestock, forestry & fishing	25	Domestic appliances
The secondary sector		26	Other electrical materials
2	Minerals	27	Mechanical equipment
3	Process foods, beverages & tobacco	28	Motor vehicles & Transport equipment
4	Textiles & wearing apparel	29	Other manufactures
5	Leather, fur & related products	30	Electricity supply
6	Wood & related products	31	Gas supply
7	Pulp, paper & paper products	32	Water supply & remediation Services
8	Printing	33	Construction
9	Petroleum products	**The tertiary sector**	
10	Coal products	34	Wholesale & retail trade
11	Chemical materials	35	Land transportation
12	Chemical products & medicines	36	Water transportation
13	Rubber & plastic products	37	Air transportation
14	Non-metallic mineral products	38	Supporting services of transportation
15	Iron & steel products	39	Warehousing & storage
16	Other metals	40	Postal & courier services
17	Semi-conductors	41	Accommodation & food services
18	Optoelectronic materials & components	42	Communication, telecommunication & information services
19	Printed circuit assembly	43	Finance, insurance & real estate services
20	Other electronic components & parts	44	Professional, scientific & technical services
21	Computers, electronic & optical products	45	Education, health, social work & entertainment services
22	Power generation, transmission & distribution machinery	46	Public administration services
23	Wires, cables & wiring devices	47	Other services

THE LONG-TERM FORECAST OF THE RUSSIAN ECONOMY USING RIM, THE RUSSIAN INTERINDUSTRY MODEL

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The paper is one of a series of articles dedicated to the Russian Interindustry Model. Some of the articles have been published in Inforum books, for example, a paper *The current progress in the Russian Interindustry Model* by Sofia Kaminova in the collection of works presented at the XXI Inforum World Conference.

The Russian Interindustry Model (RIM) is a model of the Inforum type. At its core is an annual time series of 44-sector input-output tables from 1980-2010. The model calculations are made in constant and current prices. G7 and Interdyme are main tools for the model building. Additionally, PortableDyme is used for model construction since the INFORUM XX World Conference in Florence.

The model database consists of two main parts. The first part consists of the I-O tables developed by Marat Uzyakov. The necessity of the tables' creation is stipulated by the fact that the last official I-O tables are published by Russian Statistics Service only for 2003. Furthermore, trade and transport matrices as well as tax and import ones have also been prepared. Besides, the data sets for production capacity balances and sector investment were produced by research by the Institute of Economic Forecasting.

The second part of the model database is consists of officially published national accounts. The consolidated budget data, demography and employment statistics, indicators of the Balance of payments, the energy resources production data, prices data and the money statistics (including exchange rates indicators) are also used.

The current version of RIM has been permanently updated and expanded. Nevertheless, there is still much work to be done. At the present stage the calculations of households and public consumption, investment in fixed capital, exports and imports as well as equations for capital stock and employment by sector have been developed. We have started working on the regressions for the indicators of the value-added by sectors (profits, net taxes, salaries etc.). During the last year the equations for the net taxes on production and on products have been estimated and built in the model. Also the creation of the energy block was accomplished in 2014. Work on the demographic

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equations is on-going. In the very near future we intend to build a financial block and equations for the Balance of payments indicators.

The sequence of calculations in each iteration is shown schematically in Figure 1 below. In the first stage we estimate final demand in constant prices. Then gross output by sector is calculated by solving the Leontief model. After the calculation of value-added variables the Leontief price model is solved and we get estimates of sector prices. Finally, the incomes of households, business and government are calculated to obtain their expenses and consumption.

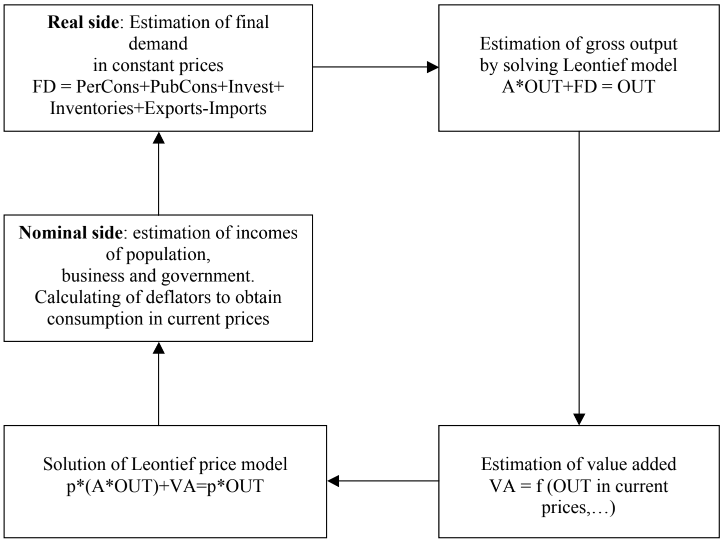

Figure 1 – Sequence of Calculations in RIM.

1. Taxes and government budget

In the previous papers about RIM the main equations and identities from the fiscal and budget model block were discussed. Now we describe a new part of the block that calculates net taxes on products and taxes on production as part of sectoral value-added.

Net taxes on products are equal to taxes paid by sector, less budget subsidies:

$$\textit{net taxes on products used} = \textit{taxes paid} - \textit{subsidies} \qquad (1)$$

In the model this linkage is realized by the following regressions:

$$\textit{net taxes}_i = a * (A7_i + A11_i + A24_i) + b * \textit{export}_i + c * (\textit{import used}_i) + + d * VAT_i + e * \textit{BudgetExpenses} \qquad (2)$$

Where
i: sector number

$(A7_i + A11_i + A24_i)$: intermediate consumption of excise goods by sector i

import used$_i$: Σ_k ImportMatrix$_k$

$VAT_i = VAT\ received_i - VAT\ paid_i = VAT\ rate_i * OUT_i - (\Sigma_k\ VAT\ rate_k * OUT_{ki}) - VAT\ rate_i * Export_i$

In the regression (2) the first term is equal to sum of intermediate consumption of excise goods by sector i, and is associated with excises paid by industry. In the RIM classification excise goods are sold by sectors 7 'Food, beverage and tobacco production', 11 'Petroleum refining' and 24 'Production of automobiles and highway transport equipment'.

The next term in the regression (2) corresponds to export duties and is determined by the sector's exports. The third term is used for import duties and equal to the sum along the column number i of the import matrix. The *VAT* term is equal to the value-added tax of the sector by selling its production less the tax paid to other sectors when enterprises buy some intermediate goods. Additionally, we subtract the VAT on export as it returns to producers when goods are sold abroad.

Finally, the last regression term is associated with the subsidies from the government budget and the regression parameter e should be negative as subsidies decrease the value of net taxes.

The results of the regression the net taxes on products are shown below, for Agriculture:

```
1 Agriculture - Net taxes on products used
 SEE   =  1059.17 RSQ  = 0.9846 RHO =  0.32 Obser =  19 from 1992.000
 SEE+1 =  1009.62 RBSQ = 0.9802 DW =  1.35 DoFree =  14 to  2010.000
 MAPE =   24.54
  Variable name      Reg-Coef Mexval Elas  NorRes   Mean  Beta
 0 tax1          - - - - - - - - - - - - - - - - -  9128.57 - - -
 1 A7,1+ A11,1+ A24,1    0.02656   2.3  0.29  2.18 100341.76
 2 export1         0.02816  18.3  0.27  1.99 87846.87 0.349
 3 VAT1          0.02543  12.9  0.26  1.03 93461.33 0.202
 4 GovExpenses       -0.01348   1.5 -0.12  1.02 84048.67 -0.133
 5 import used1       0.04425   1.0  0.28  1.00 57565.08 0.289
```

As can be seen, the budget expenses variable correlated with subsidies has a negative regression coefficient. The most significant Mexvals are observed for the VAT and export duties.

Net taxes on production are also calculated as taxes paid less subsidies:

$$net\ taxes\ on\ production = taxes\ paid - subsidies \qquad (3)$$

For these taxes the regressions are of the following form:

$$net\ taxes_i = a * OUT_i + b * capstock_i * GDP\ deflator + c * BudgetExpenses \quad (4)$$

Where
i: sector number (except i = 2, 3)

For $i = 2$ (Petroleum extraction sector):

$$taxes_2 = a * tax\ rate_2 * oil\ extraction$$

$tax\ rate_2$ = 493*(Urals Crude Oil price -15)*rateusd/261

For $i = 3$ (Natural gas extraction sector):

$$taxes_3 = a * tax\ rate_3 * gas\ extraction$$
$tax\ rate_3$ = 700 rubles/1 billion m3

The first term in the regression (4) is associated with all taxes on production except tax on the company property. The company property tax is accounted by the second term in the regression (4). The last regression term corresponds to the subsidies from the government budget and should have a negative regression coefficient.

These calculations apply to all sectors except sector 2 'Petroleum extraction' and sector 3 'Natural gas extraction' as for these industries the resources usage tax is the main part of the taxes on production and has special formulas for the tax rates. In these calculations we use official tax rate definitions with the crude oil prices in dollars and the dollar to ruble exchange rates.

The results of the regression for net taxes on production paid by sector 'Production of Machinery' are shown below:

```
19 Machinery - Net taxes on production
 SEE   =   109.43 RSQ   = 0.9682 RHO = -0.57 Obser =  6 from 2003.000
 SEE+1 =    88.83 RBSQ = 0.9470 DW =  3.13 DoFree =  3 to  2010.000
 MAPE =     2.95
  Variable name       Reg-Coef Mexval Elas  NorRes   Mean  Beta
 0 b.taxop19       - - - - - - - - - - - - - - - - -  2746.53 - - -
 1 intercept       242.29373  12.1  0.09  31.42   1.00
 2 out19          0.00235  176.0  0.74  1.35 861058.38 0.821
 3 capstock19*def      0.52040  16.3  0.17  1.00  922.50 0.190
```

2. Investments and capital stock

The next elaboration of RIM has been done in respect of the investment and capital stock estimations. First of all, we add the cumulative volume of credits borrowed by companies in the regressions for capital investment. This additional parameter lets us take into consideration the financing constraints for the investment process if enterprises have too much debt. The coefficient of this parameter should be negative. Besides, we use other parameters such as sectoral profit, the value of investment in the previous year, the ratio of usage of capital stock and difference between current and the maximum sector output. The regression is as follows:

$$capinv_i = a * (output_i / capstock_i) + b * profit_i + c * credits_i + d * capinv_i [t\text{-}1] + e * @pos (OUT_i - peakOUT_i) \quad (5)$$

Where
capinv: capital investments by sectors
output/capstock: ratio of usage of capital stock
credits: cumulative credits received divided by GDP deflator (level of debt load)
peakOUT: maximum sector output for years 1,…,*t*-1

An example of the regression results for sector 1 'Agriculture' is presented below:

```
1 Agriculture - Investments in capital stock
 SEE   =    23.96 RSQ   = 0.9330 RHO =   0.15 Obser =   9 from 2002.000
 SEE+1 =    24.22 RBSQ = 0.8928 DW =   1.70 DoFree =   5 to   2010.000
 MAPE =    7.15
  Variable name       Reg-Coef Mexval Elas  NorRes   Mean  Beta
 0 capinv1          - - - - - - - - - - - - - - - - -  307.42 - - -
 1 OUT1 - peakOUT1      0.00038  59.0  0.12  58.50 97090.67
 2 profit          1.78771  109.2  0.77  3.56  133.18 1.071
 3 OUT1 / capstock1      0.01457  38.0  0.20  1.15  4160.60 0.103
 4 (credits)/def     -42.88828   7.4 -0.09  1.00   0.65 -0.248
```

All regression parameters should have positive coefficients except the parameter called Credits which has a negative sign.

The next estimations were done by Clopper Almon. Dr. Almon suggested using the 'cascading two-bucket' system similar to a system of two buckets, one above the other (see Figure 2). Water that flows into the top bucket corresponds to investments. Water that leaks through a hole in the bottom of top bucket into the second bucket symbolizes the depreciation of the capital stock. Equipment may remain in use after it is depreciated and such equipment corresponds to the water in the second bucket. Both buckets have holes and the outflow of water is proportional to how much water is in the buckets.

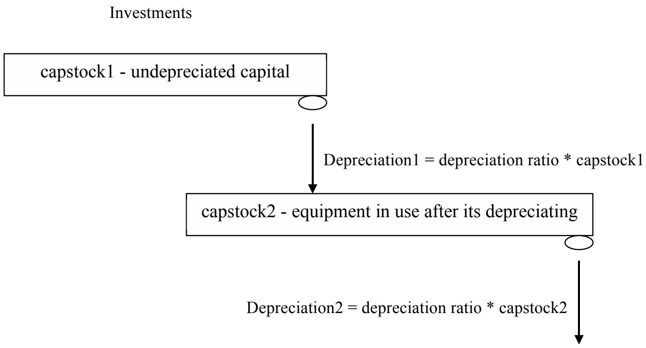

Figure 2 – Sequence of Calculations in RIM.

Such a system can be presented in G7 by the following equations[1]:

$$
\begin{aligned}
&ub1 = @cum(ub1,1,Ri)\\
&a = @exp(embTech_i*(t))\\
&capstock1_i = @cum(cuminv1_i, a*capinv_i, R_i) / ub1 \qquad (6)\\
&capstock2_i = @cum(cuminv2_i, capstock1_i, R_i)/ub1\\
&capstock_i = capstock1_i + capstock2_i
\end{aligned}
$$

Where
capinv: capital investments by sectors
cuminv: cumulative capital investments for $t = 1, ..., t\text{-}1$
R_i: depreciation ratio
$embTech_i$: rate of growth productivity embodied in capital

While calculating the capital stock we should remember that the main purpose is to get production functions for estimation of employment. And these estimations should reflect the fact that the investment process not only increases the quantity of fixed capital but also improves its quality as a new model of machine may be more productive than the previous one but sell for the same price. This sort of technical progress is 'embodied' in capital and industry gets the benefit of it only if it invests.

We were not in a position to estimate rates of growth of productivity embodied in capital (marked as embTech in equations (6)) as there are not necessary data for Russian establishments. Dr. Almon suggested using the results of the PhD thesis at the University of Maryland by Daniel

[1] For more details about system of 'unit buckets' and its version in G7 see Almon 2012.

J. Wilson (Wilson 2001). He found that typical values of rates of embodied technical progress range from 3 to 10 percent per year. Initially, the rate of 5 percent per year was used and then was changed to get appropriate regression coefficients in the production functions that will be discussed in the chapter 'Employment'. The final values for the industry embodied rates are found in table 1.

Table 1 – Depreciation rates and rates of growth productivity embodied in capital by sectors.

№	Rate of growth productivity embodied in capital	Depreciation rate	Industry
1	0.05	0.15	Agriculture
2	0.05	0.15	Petroleum extraction
3	0.00	0.15	Natural gas extraction
4	0.05	0.15	Coal mining
5	0.05	0.15	Other fuels, including nuclear
6	0.00	0.15	Ores and other mining
7	0.05	0.15	Food, beverages, tobacco
8	0.05	0.15	Textiles, apparel, leather
9	0.05	0.15	Wood and wood products
10	0.00	0.15	Paper and printing
11	0.00	0.15	Petroleum refining
12	0.05	0.15	Chemicals
13	0.00	0.15	Pharmaceuticals
14	0.00	0.15	Plastic products
15	0.05	0.15	Stone, clay, and glass products
16	0.05	0.15	Ferrous metals
17	0.07	0.15	Non-ferrous metals
18	0.00	0.15	Fabricated metal products
19	0.07	0.15	Machinery
20	0.00	0.15	Computers, office machinery
21	0.00	0.15	Electrical apparatus
22	0.05	0.15	Radio, television, communication equipment
23	0.00	0.15	Medical, optical, and precision instruments
24	0.10	0.15	Automobiles, highway transport equipment
25	0.05	0.15	Sea transport equipment and its repair
26	0.05	0.15	Airplanes, rockets, and repair
27	0.00	0.15	Railroad equipment and its repair

№	Rate of growth productivity embodied in capital	Depreciation rate	Industry
28	0.00	0.15	Recycling and other manufacturing not included in the previous sectors
29	0.00	0.15	Electric, gas, and water utilities
30	0.05	0.15	Construction
31	0.05	0.15	Wholesale and retail trade
32	0.07	0.15	Hotels and restaurants
33	0.00	0.15	Transport and storage
34	0.07	0.15	Communication
35	0.07	0.15	Finance and insurance
36	0.07	0.15	Real estate
37	0.08	0.15	Equipment rental
38	0.00	0.15	Computing service
39	0.00	0.15	Research and development
40	0.07	0.15	Other business services
41	0.05	0.15	Government, defense, social insurance
42	0.00	0.15	Education
43	0.00	0.15	Health services
44	0.05	0.15	Other social and personal services

3. *Employment*

The next part of Dr. Almon's work was a construction of the productivity functions for taking into account the benefit to the economy from more investment as it increases labor productivity. The well-known Cobb-Douglas form of production function was used:

$$Q_t = Ae^{rt} L_t^{\alpha} K_t^{1-\alpha} \tag{7}$$

After some transformations we get the final function form that was used in the regression:

$$\log(L/K) = -\frac{\log A}{\alpha} - \frac{r}{\alpha}t + \frac{1}{\alpha}\log(Q/K). \tag{8}$$

In these regressions we use capital stock variables obtained by the 'two-bucket' system (see the section 'Investments and capital stock'). Note that we expect the coefficient of t to be negative while that of the last term should be something in the neighborhood of 1.5, corresponding to a value of $a = 2/3$. For getting the right coefficients the embodied technical progress rates (marked as 'embTech' in equations 6) should be changed as described in the previous section.

The regression results for the industry 1 'Agriculture' are shown below. All regression coefficients are of reasonable signs and magnitudes:

```
1 Agriculture - LOG (L/K)
 SEE   =     0.08 RSQ   = 0.9509 RHO =   0.48 Obser =   11 from 2000.000
 SEE+1 =     0.08 RBSQ = 0.9386 DW =   1.04 DoFree =   8 to   2010.000
 MAPE =    2.82
  Variable name       Reg-Coef Mexval Elas  NorRes   Mean  Beta
 0 LOG(L/K)        - - - - - - - - - - - - - - - - -   2.35 - - -
 1 intercept         66.54471   49.1 28.35  52.15   1.00
 2 time           -0.03798   63.0 -32.45  33.14  2005.00 -0.328
 3 LOG (Q/K)         1.44628  475.6  5.09  1.00    8.27 0.726
```

4. Forecast

A long-term forecast has been developed for the business-as-usual scenario that assumes consistency of tax rates, coefficients of intermediate consumption, rates of embodied technical progress, depreciation rates and other exogenous parameters. Forecast results are obtained for rather wide set of economic indicators so only the most important results will be shown in the paper. The most attention will focus on the variables defined by regressions from the previous sections of the paper: capital stock and employment by sector, as well as net taxes on production and products used.

The results of the business-as-usual simulation for each sector's employment and capital stock are shown in Figures 3-6 below. Please remember that these results are very preliminary.

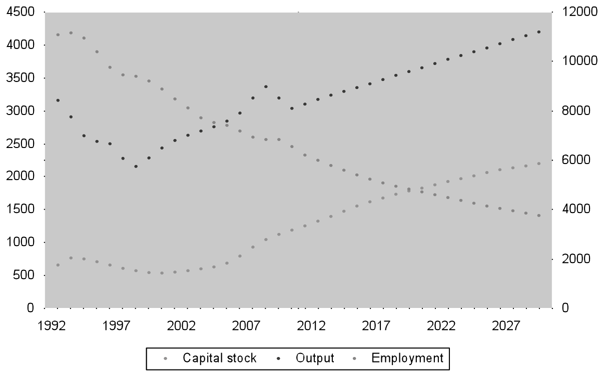

Figure 3 – Capital stock (green line, left scale), output in constant prices (blue line, left scale) and employment (red line, right scale, thousands people) in Agriculture sector.

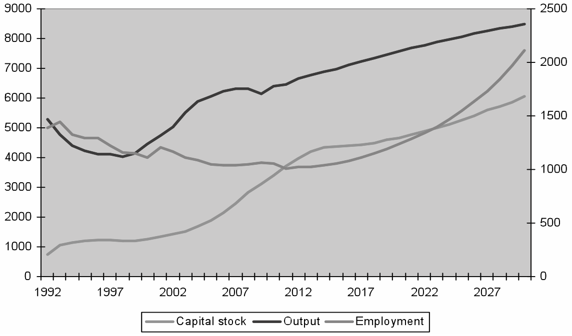

Figure 4 – Capital stock (green line, left scale), output in constant prices (blue line, left scale) and employment (red line, right scale, thousands people) in Mining sector.

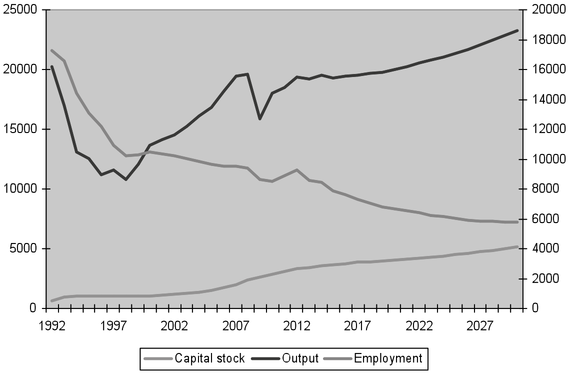

Figure 5 – Capital stock (green line, left scale), output in constant prices (blue line, left scale) and employment (red line, right scale, thousands people) in Manufacturing sector.

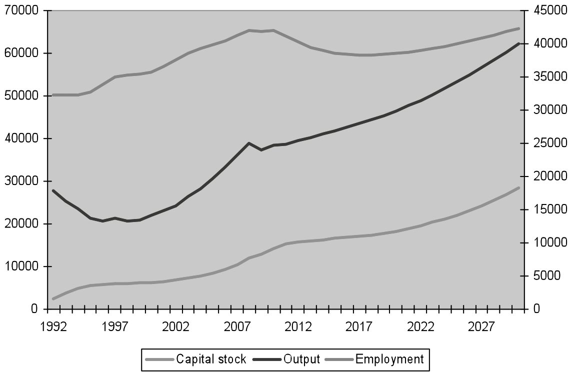

Figure 6 – Capital stock (green line, left scale), output in constant prices (blue line, left scale) and employment (red line, right scale, thousands people) in Services sector.

As we can see (Figures 3 and 5), the number of employees in the Agriculture and Manufacturing sectors will decrease as these sectors productivity and capital stock will grow. However, an increase in employment will be observed for certain manufacturing industries: Food and Beverages production, Paper and printing, Petroleum refining, Plastic products, Electrical apparatus and Railroad equipment. The main reason for such growth will be an increase of capital stock lagging the industry's output.

The number of employees in the Mining sector will double from 1.04 million people in 2014 to 2.1 million people by 2030 (see Figure 4). This will be related to the worsening of the climate and geographical conditions of resources extraction, especially in natural gas production. Rapid capital stock expansion will not be adequate enough to eliminate these changes. More and more people will be required for setting up and maintaining the extraction infrastructure: railway and automobile roads, new types of natural gas and crude oil production equipment proper for working in the permafrost conditions and so on.

As for the Services sector, multidirectional changes will be observed for this sector's employment. The number of employees in Health services, Computing services, Trade and Transport will grow due to the fastest (among whole economy) increases of output in the respective industries. On the other hand, employment in other service industries will decline or stagnate as labor productivity will increase more rapidly than other sectors. The Services sector will be the most sensitive to new technologies (especially, computing and information ones) that will enable the use of the highest embodied technical rates of labor productivity change.

Figure 7 – Population (blue line, left scale, thousands people) and employment (red line, right scale, thousands people) in Russia.

Total employment is expected to decline until 2020 as overall capital stock in the economy will rise due the high levels of investment in the 2000s. In the second part of the simulation period (2020-2030) growth in the economy will require an increase in employment. After 2020 the Russian economy may suffer from the problem of labor shortage, as the population and number of the economically active people will decline (from 143 million people in 2015 to 139 million people in 2030).

The next set of simulation results are obtained for net taxes on production and products used. The variables are estimated in current prices that makes the analysis of the absolute values meaningless. Therefore we suggest that we should explore the structure by sectors of taxes paid by the economy as a whole (see Tables 2 and 3).

Table 2 – Structure of net taxes on products paid by sectors, % to total.

	2013	2015	2020	2025	2030
Agriculture	1.4	1.3	1.1	0.8	0.6
Mining	16.2	16.1	15.8	15.4	14.9
High-technology manufacturing	1.9	2.0	2.2	2.4	2.6
Medium-technology manufacturing	8.5	8.3	7.9	7.5	7.1
Low-technology manufacturing	14.1	15.1	17.2	18.6	19.8
Electric, gas, and water utilities	5.4	5.5	5.9	6.4	6.8
Construction	5.1	4.9	4.6	4.6	4.5
Wholesale and retail trade	7.5	7.2	6.4	6.1	5.9
Hotels and restaurants	0.6	0.6	0.7	0.7	0.8
Transport and storage	7.9	7.9	8.0	8.1	8.1
Communication	1.4	1.4	1.5	1.5	1.6
Finance and insurance	1.3	1.3	1.2	1.2	1.2
Real estate	15.1	15.3	15.3	15.1	14.9
Research and development	1.3	1.4	1.7	1.8	1.8
Government, defense, social insurance	6.5	6.7	7.5	8.1	8.7
Education	1.3	1.2	1.1	1.1	1.1
Health services	1.9	1.6	0.7	0.1	-0.2
Other social and personal services	1.8	1.4	0.4	-0.5	-1.2

First of all, one should pay attention to the fact that the Mining sector's contribution to total net taxes is rather significant: 14-16% for taxes on products used and 16-17% for taxes on production. Even if this contribution declines to 2030 its decrease will not be more than 3 percentage points.

The next feature is the decline of contribution to the net taxes paid by personal and public services sectors as Health services, Education and Government, defense, social insurance. This situation will be based on growing subsidies from the government budget that will reduce net taxes.

Under the conditions of constant tax rates, the net taxes paid by business are completely determined by the economic growth and structure of output and profit by sector. Thus, in the long-run perspective the contributions to taxes paid will rise for such industries as High-technology manufacturing, Electric, gas and water utilities, Transport and storage, Communication and Research and development.

Table 3 – Structure of net taxes on production paid by sectors, % to total.

	2013	2015	2020	2025	2030
Agriculture	-5.8	-5.8	-5.8	-5.6	-5.4
Mining	17.2	17.4	17.6	16.8	15.8
High-technology manufacturing	0.4	0.4	0.3	0.3	0.2
Medium-technology manufacturing	37.4	37.0	36.1	35.6	35.1
Low-technology manufacturing	2.7	2.8	3.0	3.2	3.4
Electric, gas, and water utilities	5.9	6.0	6.1	6.3	6.4
Construction	1.1	1.1	0.9	0.9	0.9
Wholesale and retail trade	7.9	8.1	8.6	9.2	9.8
Hotels and restaurants	0.3	0.4	0.4	0.5	0.5
Transport and storage	7.8	7.9	8.3	8.7	9.1
Communication	1.9	1.9	2.0	2.1	2.3
Finance and insurance	9.4	9.4	9.3	9.3	9.3
Real estate	3.1	3.2	3.5	3.8	4.1
Research and development	0.5	0.5	0.4	0.3	0.3
Other business services	1.8	1.8	1.8	1.8	1.9
Government, defense, social insurance	2.3	2.2	2.0	1.8	1.7
Education	2.3	2.2	2.0	1.8	1.6
Health services	1.3	1.2	1.2	1.2	1.1
Other social and personal services	1.2	1.2	1.1	1.0	1.0

5. Conclusions

The main goal of this paper is to demonstrate the recent progress in the development of RIM. Currently, the model consists a set of regressions and identities that enable the estimation of the main economic variables by sector such as the GDP, production and usage, value-added, production resources (employment and capital stock) as well as the wide range of financial indicators (for example, the government budget revenues and expenditures). Moreover, the successful experience of the long-term simulations using RIM prove the usefulness of this model.

This paper's results show that the use of production functions with rates of embodied technological change calculated for the US data is useful for the Russian economy model. Dr. Almon's idea is that since these rates relate to machinery which is internationally traded, it's reasonable to suppose that similar rates would be found for post-Soviet Russia appears to be correct. The production functions incorporated in RIM let us estimate the effects of investments on labor productivity.

Additionally, an example of work with the third quadrant of the input-output balance is shown in the article. Particularly, we managed to build regressions for the net taxes on production and products used as part of the sector's value-added that can be used for solving of the Leontief price model.

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STEPS TO A RUSSIAN NATIONAL ACCOUNTS MODEL (RUNA)

Georgy Serebryakov

The elaboration of the Russian National Accounts Model was inspired by two starting points. The first is derived from two papers by Clopper Almon, namely the paper on Identity centered modeling (Almon 1997) and the paper on Working with the SNA Institutional Accounts [1]. The second was my teaching experience. Many students interested in macroeconomic modeling do not distinguish between assumptions and proven statements, between identities and equations, and finally, they are hardly aware of the SNA. Meanwhile the SNA is a good starting point for macroeconomic. So the elaboration of Russian National Accounts Model has both tutorial and practical usage aims.

Data: the data base for the model is the set of the Integrated tables of national accounts for 2002-2012 published by Federal State Statistics Service (Rosstat). The Integrated table (Table) is very large and it is not convenient to work with on the computer screen. However the table combines data from all national accounts and it allows us to observe all accounts interconnections to understand them. This is the advantage of studying and working with the SNA.

Table review: the Table consists (Table 1) of two large parts: the right side is resources, the left side is uses. The six columns of each side are for the six institutional sectors. These are: Non-financial enterprises, Financial enterprises, Governments, Households, Non-commercial, Rest of the World. Last left and last right columns tell account names. The central column shows the list of measures for each account and the corresponding codes. There are two columns with totals in each side: Total Domestic and Total, which contain the row sums.

Modeling: the Modeling process was divided into four steps: 1) identities, 2) simple behavioral ratio mequations, 3) regressions, 4) real dynamics.

The Table is published in MS Excel format. For most students it is comfortable to work with Excel. I decided to stay with Excel while the model is static but not yet dynamic. It is convenient to observe the modeling process in Excel for a clear understanding the SNA's basic features.

As Clopper Almon wrote «A "tautology" is a statement true by the definitions of its words, and our model will be hold exactly for the historical data by the definition of its variables and equations».

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1. Step 1 – Identities

The first step is to form and to write identities. They are known as the main macroeconomic identities. All balancing rows in the table notated by the code *B.<number>* are actually the result of calculated identities. So we should put identities instead of these balancing rows.

Again as Clopper Almon wrote «The identities are either right or wrong». If we make a mistake building an identity, the result of identity calculation will be different from the historic table meaning.

The Table starts with *Production account* with measures notated by *P.<number>*. Output and import sources are used for intermediate and final consumption, gross capital formation and exports. In the Table there are Output and Intermediate consumption. The first balancing row is Gross value added/GDP (GVA) row which is the result of subtraction of Intermediate consumption from Output for each domestic institutional sector. The notation in codes is: *B*.1*g* = *P*.1-*P*.2. So we put the formulas into the left Use side of the Table. The row sum of GVA sector meanings gives us the GDP value to put into the Total column. It becomes immediately clear in Excel that we are right since we compare calculation results with historic values from the Table. Next one row is Net value added/NDP (NVA) which is the result of subtraction of Capital Consumption from GVA/GDP row (*B*.1*n* = *B*.1*g*-*K*.1). Both GVA and NVA were obtained as results from the Use side of Production account. These GVA and NVA at the same time are the sources for further income distribution in *Generation of income account*, this is why their definitions are to be put into Source right side of this last account. We do it by formulas. So the left side and right side total values in the Table are identical.

The balance of Goods and services row is the balance for Imports and Exports (*B*.11 = *P*.7 – *P*.6) in the Use side for Rest of the World. National Exports are considered in the Table as the Use of funds of Rest of the World sector, national Imports are the Source of income for Rest of the World sector in order to buy Russian Exports. To finish the work on identities for the certain account we are to put sums of row meanings into Total columns.

Then we go to the Use side of *Generation of income account*. The Use side of the Compensation of employees row consists of values paid by institutional sectors. The Source side shows Compensation of employees values received by Households and Rest of the World sector. So we may put the identity that Compensation of employees values received by Households is equal to the corresponding Total of Compensation of employees paid by all sectors minus Compensation of employees values received by Rest of the World sector.

Taxes on Production & Imports Net paid by sectors are the sum of Taxes on Products and Other Taxes on Production Net (Use side). The only institution to receive taxes is Governments. Taxes on Production & Imports Net received by Governments are the sum of received Taxes on

Products and Other Taxes on Production Net (Source side of Allocation of primary income account).

The balancing row here is Gross operating surplus. In order to calculate it one needs to subtract Compensation of employees and Taxes on Production & Imports Net (both paid by institutional sectors) from GVA taken from the Source side of the account for each domestic sector besides Households ($B.2g = B.1g\text{-}D.1u\text{-}(D.2\text{-}D.3)$). Households get Gross mixed income calculated the same way as Gross operating surplus was done ($B.3g = B.1g\text{-}D.1\text{-}(D.2\text{-}D.3)$). Net operating surplus results by subtraction of Capital Consumption from Gross operating surplus ($B.2n = B.2g\text{-}K.1$). The same is for Net mixed income ($B.3n = B.3g\text{-}K.1$). The balanced results for the Use side of Generation of income account should be put into the Source side of *Allocation of primary income account*.

Now it is necessary to calculate the balance of Income from Properties received by sectors (Source side) and Income from Properties paid by sectors (Use side). Summing this last balance meaning with Gross operating surplus from Source side we obtain Balance of primary income ($B.5g = B.2g + (D.4s\text{-}D.4u)$). Governments add received Taxes on Production & Imports Net to the sum of net Income from Properties and Gross operating surplus. Households add Compensation of employees and Gross mixed income from Source side instead of Gross operating surplus to the balance of Income from Properties ($B.5g = D.1s + B.3g + (D.4s\text{-}D.4u)$). The row sum of Balance of primary income sector meanings gives the Gross National income value to put it into Total column.

Secondary distribution of income account is the next one. Current Taxes on Income are paid by all sectors excluding Governments (Use), but they are received only by Governments (Source). So this will be the identity for Current Taxes on Income for Governments.

Gross Disposable Income is the result of the sum of Gross National income and the balance of transfers paid and transfers received. Enterprises pay Current Taxes on Income, Social transfers, Other transfers, but receive some of Payment to Social Security and Other transfers. Governments pay Social Security and Other transfers and receive Current Taxes on Income, Payment to Social Security, Other transfers. Households pay Current Taxes on Income, Payment to Social Security, Other transfers and receive Social transfers, Other transfers. The notation in general will be $B.6g = B.5g\text{-}D.5u\text{-}D.61u\text{-}D.62u\text{-}D.7u + D.5s + D.61s + D.62s + D.7s$. Net Disposable Income is the result of subtraction of Capital Consumption from Gross Disposable Income ($B.6n = B.6g\text{-}K.1$). To finish the account it is necessary to form Total and Source side.

The whole sum of Total Social transfers in Natural form paid by sectors (Use) is received by Households (Source) in *Natural form of income account*. Finally Disposable Income is to be adjusted to incomes in natural form: Social transfers in Natural form should be added to Disposable Income.

These values of Disposable Income are the sources in Use of disposable income account. Final consumption expenditures and Net pension fund changes adjustment are uses here. Households receive whole sum of pension fund changes adjustment. Clearly, Sector Gross Savings are the rest of Disposable Income after these uses and sources ($B.8g = B.6g\text{-}P.3u\text{-}D.8u + D.8s$). At the end of the account Balance of current transactions is calculated. It is the balance of all Rest of the World's receiving from Source side (column sum) and spending taken from Use side (column sum).

The last account is the *Capital account*. Gross Savings from the Use of disposable income account are the Source for capital expenditures. Net Financial Investment including Statistical Discrepancy is the balance between Gross Savings and Gross Fixed Capital Formation, Changes in Inventories, Acquisitions and Net Capital Transfers.

Thus all balancing identities have been formed.

2. Step 2 – Simple behavioral ratio equations

In this formulation of the model we have too many exogenous variables and we can do nothing but balancing. However we have not yet concerned ourselves with all the other data from the table observed and collected by Rosstat. It is clear that many economic measures have certain relationships that should be modeled. It is possible to substitute many figures from the Table by simple equations with coefficients, mostly behavioral (we denote them with *cf* suffix). If we put these coefficients to a separate sheet in Excel workbook this sheet will present a certain economic scenario which we could run to test it.

Suffix *u* stands for Use, Suffix *s* stands for Source.

The model output for each institutional sector may be formed from the base output value and exogenous growth rates:

$$out = out0*gr.$$

Exports are the result of the share of exports to output: $ex = ex\_cf*out$. It is natural to take the historic value for the base value of the coefficient:

$$ex\_cf = ex/out.$$

The same is for imports: $im\_cf = im/out$, hence $im = im\_cf*out$.

Sector material intensity will be expressed through the Intermediate consumption share in output:

$$incon\_cf = incon/out$$

Compensation of employees paid is proportional to sector Gross value added:

$$comempu\_cf = comempu/gva$$

Compensation of employees paid by Rest of the World takes a certain share in total domestic compensation of employees sum: *comemprwu_cf = comemprwu/comemptotdu*.

Compensation of employees received by Rest of the World takes a share in total domestic compensation of employees sum: *comemprws_cf = comemprws/comemptotds*.

Taxes on Products paid take a share in GDP: *taxp_cf = taxp/ GDP*.

Other Taxes on Production Net paid by sectors are formed as a share of sectoral GVA: *taxop_cf = taxop/GVA*.

Income from Properties requires additional work since it is a complicated aggregate value. It is enough to mention that it includes rental and interest flows together.

At the present time Income from Properties paid (Use) by:

- Non-financial enterprises takes a share in Gross operating surplus;
- Governments and Non-commercial takes a share in GVA;
- Households takes a share in Gross operating surplus and Compensation of employees received;
- Financial enterprises take a share in Income from Properties received by the sector;
- Rest of the World takes a share in Total Domestic Income from Properties paid.

Income from Properties received (Source) by:

- Financial enterprises takes a share in sum of Income from Properties paid by all domestic non-financial sectors;
- All other domestic non-financial sectors takes a share in sum of Income from Properties paid by all domestic sectors;
- Rest of the World is the rest of Income from Properties paid and received.

Current Taxes on Income paid by sector take a share in sector Balance of primary income.

Payment to Social Security paid by sector takes a share in sector Balance of primary income.

Social transfers paid by sector take a share in sector Compensation of employees paid.

Other transfers paid by sector take a share in sector Balance of primary income.

Other transfers received by sector take a share in total sum of Other transfers paid.

Social transfers in Natural form paid by sector take a share in sector Disposable Income, Gross.

Sector Final consumption expenditures take a share in sector Disposable Income, Gross.

Net pension fund changes adjustment paid (Use) take a share in Total Compensation of employees.

Capital account sector uses take shares in sector GVA.

Table 1 – Russian Integrated economic accounts, 2011.

2.2.7. Integrated economic accounts, 2011

(mln rub., current prices)

Use											Source								
		S.2	S.1	S.15	S.14	S.13	S.12	S.11			S.11	S.12	S.13	S.14	S.15	S.1	S.2		
Account name	Total	Rest of the Wolld	Total Domestic	Non-commercial	Households	Governments	Financial enterprises	Non-financial enterprises	Code		Non-financial enterprises	Financial enterprises	Governments	Households	None-commer	Total Domestic	Rest of the Wolld	Total	Account name
Production	12 164 389								P.7	Imports							12 164 389	12 164 389	Production
account	16 940 916	16 940 916							P.6	Exports								16 940 916	account
Goods and services	97 365 448								P.1	Output	76 536 608	2 796 816	10 322 343	7 464 383	245 299	97 365 448		97 365 448	Goods and service
account	49 859 946		49 859 946	115 628	2 796 804	4 396 995	860 286	41 690 234	P.2	Intermediate consumption								49 859 946	account
	8 294 070								D.21-D.31	Taxes less subsidies						8 294 070		8 294 070	
	55 799 573		55 799 573	129 670	4 667 580	5 925 348	1 936 530	34 846 374	B.1g/B.1*g	Gross value added /GDP	34 846 374	1 936 530	5 925 348	4 667 580	129 670	55 799 573		55 799 573	Generation of
	2 614 919		2 614 919	10 971	196 667	171 581	43 147	2 192 552	K.1	Capital Consumption									income
	53 184 654		53 184 654	118 699	4 470 913	5 753 767	1 893 383	32 653 822	B.1n/B.1*n	Net value added / NDP	32 653 822	1 893 383	5 753 767	4 470 913	118 699	53 184 654		53 184 654	account
		-4 776 528							B.11	Balance of Goods and services							-4 776 528		
Generation of	27 761 875	115 352	27 646 522	115 316	459 197	5 597 407	890 940	20 583 662	D.1	Compensation of employees				27 368 684		27 368 684	393 191	27 761 875	Allocation of
income	10 879 984		10 879 984	875	42 160	80 501	98 996	2 363 383	D.2-D.3	Taxes on Production & Imports, Net			10 879 984			10 879 984		10 879 984	primary income
account	8 294 070		8 294 070						D.21-D.31	Taxes on Products			8 294 070			8 294 070		8 294 070	account
	2 585 914		2 585 914	875	42 160	80 501	98 996	2 363 383	D.29-D.39	Other Taxes on Production , Net			2 585 914			2 585 914		2 585 914	
	13 106 843		13 106 843	13 479		247 441	946 593	11 899 330	B.2g	Gross operating surplus	11 899 330	946 593	247 441		13 479	13 106 843		13 106 843	
	4 166 223		4 166 223		4 166 223				B.3g	gross mixed income				4 166 223		4 166 223		4 166 223	
	10 688 591		10 688 591	2 508		75 860	903 446	9 706 777	B.2n	Net operating surplus	9 706 777	903 446	75 860		2 508	10 688 591		10 688 591	
	3 969 556		3 969 556		3 969 556				B.3n	Net mixed income				3 969 556		3 969 556		3 969 556	
Allocation of	8 654 617	1 128 068	7 526 549	102	265 884	319 663	1 614 259	5 326 641	D.4	Income from Properties	1 703 404	1 747 432	668 655	1 897 110	25 565	6 042 166	2 612 451	8 654 617	
primary income	54 037 351		54 037 351	38 943	33 166 133	11 476 417	1 079 767	8 276 092	B.5g/B.5*g	Gross National income	8 276 092	1 079 767	11 476 417	33 166 133	38 943	54 037 351		54 037 351	Secondary
account	51 422 432		51 422 432	27 971	32 969 466	11 304 836	1 036 619	6 083 540	B.5n/B.5*n	Net National income	6 083 540	1 036 619	11 304 836	32 969 466	27 971	51 422 432		51 422 432	distribution of
Secondary	4 610 514		4 610 514	721	2 167 770		392 482	2 049 540	D.5	Current Taxes on Income, etc			4 610 514			4 610 514		4 610 514	income
distribution of	4 418 019		4 418 019		4 418 019				D.61	Payment to Soc ial Security	189 390	96 314	4 131 873		443	4 418 019		4 418 019	account
income	5 419 305		5 419 305	41 575		5 224 039	39 206	114 485	D.62	Social transfers				5 413 515		5 413 515	5 790	5 419 305	
account	4 064 677	480 250	3 584 427	23 604	594 720	1 181 854	927 055	857 194	D.7	Other transfers	586 485	994 192	1 322 992	252 496	339 222	3 495 387	569 291	4 064 677	
	53 942 521		53 942 521	312 708	31 651 635	15 135 902	811 529	6 030 748	B.6g	Disposable Income, Gross	6 030 748	811 529	15 135 902	31 651 635	312 708	53 942 521		53 942 521	Natural form of
	51 327 602		51 327 602	301 736	31 454 968	14 964 321	768 381	3 838 196	B.6n	Disposable Income, Net									income
Natural form of	5 022 407		5 022 407	234 114		4 788 293			D.63	Social transfers in Natural form				5 022 407		5 022 407		5 022 407	account
income	53 942 521		53 942 521	78 593	36 674 042	10 347 609	811 529	6 030 748	B.7g	Disposable Income, Gross, adj.	6 030 748	811 529	10 347 609	36 674 042	78 593	53 942 521		53 942 521	Use of disposable
account	51 327 602		51 327 602	67 622	36 477 375	10 176 028	768 381	3 838 196	B.7n	Disposable Income, Net, adj.	3 838 196	768 381	10 176 028	36 477 375	67 622	51 327 602		51 327 602	income account
									B.6g	Disposable Income, Gross	6 030 748	811 529	15 135 902	31 651 635	312 708	53 942 521		53 942 521	
Use of disposable									B.6n	Disposable Income, Net	3 838 196	768 381	14 964 321	31 454 968	301 736	51 327 602		51 327 602	
income account	37 439 339		37 439 339	0	32 186 871	5 252 469			P.4	Actual Final consumption								37 439 339	
	37 439 339		37 439 339	234 114	27 164 464	10 040 762			P.3	Final consumption expenditure								37 439 339	
	57 107		57 107				57 107		D.8	Net pension fund changes adjustment				57 107		57 107		57 107	
	16 503 182		16 503 182	78 593	4 544 279	5 095 140	754 421	6 030 748	B.8g	Savings, Gross	6 030 748	754 421	5 095 140	4 544 279	78 593	16 503 182		16 503 182	Capital
	13 888 263		13 888 263	67 622	4 347 612	4 923 560	711 274	3 838 196	B.8n	Savings, Net	3 838 196	711 274	4 923 560	4 347 612	67 622	13 888 263		13 888 263	account
	-2 919 476	-2 919 476								Balance of current transactions							-2 919 476	-2 919 476	
Capital	11 595 155		11 595 155	14 062	2 498 549	1 215 937	193 850	7 672 757	P.51	Gross Fixed Capital Formation							0	11 595 155	
account	2 614 919		2 614 919	10 971	196 667	171 581	43 147	2 192 552	K.1	Capital Consumption (-)									
	2 131 986		2 131 986		73 978		497	2 057 511	P.52	Changes in Inventories								2 131 986	
	480 610		480 610		142 214	-4 275	…	342 671	P.53	Acquisitions, Net								480 610	
	0	0	0			-43 260	…	43 260	K.2	Acquisition oth.									
									D.9	Capital Transfer received	519 179	0	2 234	1 104 872	0	1 626 285	24 418	1 650 702	
									D.9	Capital Transfer given	9 726	88	1 601 864	22 161	0	1 633 840	16 863	1 650 702	
	-624 046	-2 911 921	2 287 875	64 531	2 912 248	2 327 108	559 987	-3 575 999	B.9	Net Financial Investment inc.Statistical Discrepancy									

3. Conclusion

The positive features of the model are mostly derived from Excel's abilities. They are as follows:

- there is no need of a new tool to learn since Excel is familiar to many people;
- it is very common especially for newcomers to have both mistakes and bugs during the modeling process. Excel in this sense is immediately transparent environment. There is a permanent online debugging capability in Excel;
- the model reproduces the historic table exactly;
- the methodical comments are available for any cell.

The main advantage is simultaneous modeling and learning of the SNA.

The negative features of the model are as follows:

- the technical ones. The easy and common Excel tool turned to result to very rigid model structure which is hard to develop. After one comes up to Step 3 further modelling needs a programming tool;
- the model still has many exogenous variables. It is open to a large extent;
- at the present stage the model does not account for real dynamics;
- there is no prices in the model.

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ESTIMATING BEHAVIORAL EQUATIONS IN *TURINA*

Meral Ozhan[a]

1. *Introduction*

The current state of the Turkish economy can be portrayed with some basic figures. Using 2013 statistics, Turkey is an upper-middle income country with a population of 77.4 million, $US 813 billion nominal GDP (Gross domestic product), and per capita nominal income of US $10,953. Turkey is a member of the G20 and ranks as the 15th largest economy out of 19. However, in terms of per capita nominal income it ranks only 58 out of 189 countries, slightly above the world average (US$10,472). In the third quarter of 2014 the overall unemployment rate is 9.8%, and out of 29.3 million labour force, 2.9 million are unemployed. Youth unemployment rate is 18.2%. The inflation rate, CPI (consumer price index), is 5%, the government budget deficit rate to GDP is 1% and the current account deficit is 7.1% of GDP.

Although Turkey is not a centrally planned economy it boosts and coordinates the economic growth and development affords with medium term development plans. The Tenth-Five-Year Development Plan covering the period 2014-2018 targets about 5.5% annual average GDP growth rate. The long term perspective of the 'Tenth Plan' is the 'Vision 2023', the year Turkey will celebrate the Centenary of the establishment of modern Turkish Republic. Thus the 11th Plan will be framed for the next five-year period from 2019 to 2023. By 2023 GDP is expected to exceed US$2 trillion, and per capita income could reach the EU average (about US$25,000).

Our team aims basically to provide answers to the following questions. How do we calculate or forecast that per capita income in Turkey will reach $25,000 in 2023? Which path will the economy follow, and what will be the structure of GDP broken down into sectoral detail? What will be the exchange rate, unemployment rate, inflation rate, and so on…? Turkey`s Interindustry Analysis Model (hereinafter Turina) is designed to provide answers to these types of questions. Furthermore, it can also be used as an instrument for policy formulation and evaluation at the macro level.

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An interindustry macroeconomic model consists of three pillars:

i. a set of IO related balancing equations;
ii. a consistency check between macroeconomic data coming from standard national accounts sources (SNA) and IO tables; and
iii. a large number of behavioral equations.

The first pillar directly comes from the relevant IO theory (Almon 2011). However the achievement of the second pillar requires skilled labor intensive work and extensive balancing efforts. For the Turina model this step was completed earlier and the results are presented in a separate paper by its team members (Ozhan, Wang, Ozhan 2013). The present paper is a progress report which describes the development of regression estimates of the parameters of the behavioral equations. After this introductory section the theoretical framework and current structure of Turina is described in Section 2. Section 3 is devoted to an exposition of the regression analysis. Section 4 is a general discussion of the results. The final section concludes and suggests ways to improve the model further.

2. The Interdyme Method of Modeling and Turina

Turina is a version of the Inforum model based on Turkish Input-output (IO) tables. Inforum (Interindustry Forecasting Project at University of Maryland) was established by Clopper Almon in 1967, and who is now Professor Emeritus. Clopper Almon was a student of Leontief at Harvard. At present this not-for-profit research organization has about 30 partner teams in 28 countries around the world. The Turkish team is one of them.

Turina uses the Interdyme (Interindustry dynamic macroeconomic modeling) package developed at Inforum. In a broad sense it is a general equilibrium model based on the input-output framework (IO). The basic structure of the IO framework is shown below in Figure 1.

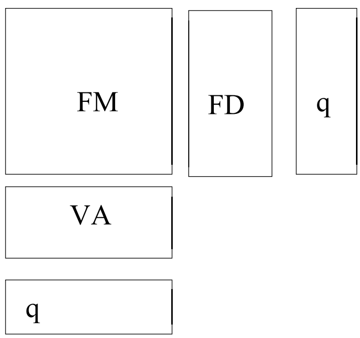

Figure 1 – Schematic Input-Output Table.

In Figure 1, FM is the flow matrix in value terms expressed in national currency. The names of the sectors (industries) in the table are placed both across the rows and at the top of columns. Any row of FM shows the value of sales by a producing sector to other sectors and final demand categories. The FD matrix shows the sale of output by producing sectors to the various final demand categories. The columns of FM measure the payment for intermediate goods and services used to produce output and payments to primary inputs or factors of production. The VA matrix is the value added block. Each column of VA measures the value added generated and paid to factors of production by producing sectors. The total output vector is denoted by *q*. It should be noticed that the FM matrix is square, and FD and VA are rectangular matrices.

In Turina, there are 35 production sectors so that FM is a square matrix of 35x35 measuring total (domestic plus import) intermediary inputs among sectors[1]. There are five final demand categories in the FD block:

1. Private household final consumption expenditures;
2. Government current expenditures on goods and services
3. Investment (gross fixed capital formation, excluding change in inventories);
4. Exports; and
5. Imports (with minus sign).

The total value of output measured in rows is shown in the form of a column vector, q. Therefore, q is a 35-element column vector. In the value added block (VA matrix) there are five income categories:

1. Depreciation;
2. Labour compensation (wages);
3. Capital share (gross profit);and
4. Net indirect taxes (taxes minus subsidies).

In the IO framework, for every sector, the sum of the receipts in the rows must equal the sum of the expenditures in columns. Therefore the column totals of the IO system in Table 1 equal the row vector of total output, *q*.

There are three blocks or three sets of equations in an interindustry model (IM). They together form the basic structure of the Interdyme. The first set of equations which represent the real side or the production part of the multisectoral model is:

$$q = Aq + f \qquad (1)$$

Where

q: the total output vector consisting of n elements each of which represents gross output (production) of one sector

[1] To save space the names of all 35 sectors are not listed here.

A: input–output coefficient matrix of n by n
f: final demand vector representing demand by consumers, government, investors, and foreigners (export minus imports in each industry)

A typical element of A, a_{ij}, shows the share of input from sector i which goes into one unit of output produced by sector j.

The second set of equations is defined for the price-income side:

$$p' = p'A + v' \qquad (2)$$

Where
p': price vector in row form, all elements of which are unity for the initial year
v': the vector of the unit value added (value added shares) in output, in row form

Another name for Equation 2 is the input-output costing model. A useful property of Inforum`s models is that with the use of Equation 2 it is possible to predict the changes in prices in each and every sector of the economy over the forecasting horizon. For example, in a macroeconomic multisectoral model for Viet Nam both real and nominal GDP are forecasted from 2008 to 2020 (Meade 2010). As a result the GDP deflator is also predicted for the same period. In addition the exchange rate, employment, unemployment, and aggregate productivity are calculated.

Premultiplying Equation 1 by p' and postmultiplying Equation 2 by q one can obtain the following two equations respectively:

$$p'q = p'Aq + p'f \qquad (3)$$
$$p'q = p'Aq + v'q \qquad (4)$$

Equation 3 and 4 imply that

$$v'q = p'f \qquad (5)$$

Equation (5) shows that as price changes in various sectors the value of final demand in nominal terms ($p'f$) should be equal to nominal value added ($v'q$).

The third part of the Interdyme model is known as the 'Accountant', The Accountant does the work of the national income accountant. This concept has been evolved over the long period of interindustry modeling practice at Inforum. Within the framework of macroeconomic modeling, the approach is theorized by Clopper Almon as «identity centered modeling» in *the Craft of Economic Modeling* (Almon 2014). The accountant checks the consistency between IO tables and national income aggregates (standard national accounts, SNA figures). For example GDP by expenditure or output approach in a macroeconomic model is given by

$$Y = C + G + I + (X\text{-}M) \qquad (6)$$

Where
Y: GDP (gross domestic product)
C: private consumption expenditure
I: investment (gross fixed capital formation, also includes change in inventories)
X: exports of goods and services
M: imports of goods and services

All variables in Equation (6) are scalar variables or macro variables – in other words, they are not vector variables. Therefore trouble can arise, when, for any given year, the sum of elements in the private consumption vector in the final demand block of the IO table (FD in Figure 1) is not equal to C which comes from the SNA sources. Similarly, the sum of the elements in the labour compensation row in the value added block (VA in Figure 1) may not be equal to wage figures recorded in other tables of the SNA sources. It is likely that, for various reasons, these totals could never match. Therefore the role of the accountant is to equalize the totals in IO tables to the SNA figures for the same variables. Without these balances between the IO column and row totals and relevant macro variables, the model will never converge.

Inforum-type dynamic models are generally characterized as IO econometric models. The typical model solves annually, and a typical forecast interval is from 10 to 50 years (Meade 2014). A long term projection by the Inforum group was tried for a period of 75 years from 2010 to 2085 in which they analyzed the health care policy implications (Meade *et al.* 2011). Their work provides a brief description of the LIFT model and represents an important example of long-term implications of the 86-sector IO-based model of the US economy. The LIFT is the acronym for the Long-term Interindustry Forecasting Tool developed at Inforum specifically designed for the US economy. A second example is the Jidea model (Japanese Interindustry Dynamic Econometric Analysis) which is also adopted from LIFT. And finally, the current version of the Turkish model Turina is adapted from the Jidea model.

The first version of Turina was constructed in 2008 with the contribution of Paul Salmon from the University of Rennes. The name of the model was then TinyTurk using not Interdyme but only G7. G7 is a regression and macroeconomic model building program developed by the Inforum group. In TinyTurk the 58-sector 2002 IO table of TurkStat (Statistical Institute of Turkey) was employed. The 2002 IO table is still the latest one available. The second version of Turina was developed during 2010 and 2011 with the contribution of Yinchu Wang from the China Economic Information Network of the State Information Center. In this second version more regression equations were added, in particular to estimate the private consumption functions for 10 broad categories. For this purpose a bridge matrix converting the 10-element vector of private final consumption into the 58-sector IO vector was constructed (Ozhan, Wang, Ozhan 2010).

In 2012 the Turina team started to construct a new Interdyme model for the Turkish economy using not only the 2002 IO table but also the time series of 35-sector annual IO tables from 1995 to 2009. These IO tables were published by the WIOD (World Input-Output Database) of the EU (European Union). They provide both domestic and import matrices for the 27 EU countries, and plus 13 big non-EU countries, including China, Japan, Russia, United States, Turkey, and some others (WIOD 2014). A new set of regression equations for various endogenous variables were estimated and put into the master file of the model[2].

In 2013 the Turina team started to cooperate with the Japanese team of ITI (Institute for International Trade and Investment at Tokyo). In 2013 and 2014 the Turina and Jidea teams organized two workshops at ITI in Tokyo. Jidea runs on the 85-sector annual IO tables of the Japanese economy. One of the main differences between the Jidea and Turina is the number of sectors, the former has 85 sectors but the latter has only 35. With the voluntary support of the Jidea team, the Turina team is now able to estimate hundreds of regression equations for final demand categories and value added parts of the IO structure. Frequently, the Turina team also receives online help from Inforum staff.

3. Regression Analysis

This section presents the estimation process and the results of the regression equations in Turina. At the present stage there are five types of regression equations, three of which are designed for the final demand components: Personal consumption, investment, and exports. The remaining two are for the components of value added block: depreciation and profits. Import equations are still under construction.

Before moving to the regression analysis, two data banks are introduced, namely the macro bank and the vam bank. The macro bank contains the macro variables. For Turina this file is labelled *macro.stb* as shown in Table 1. Presently, it has only 19 time series of basic macroeconomic variables.

The Vam bank for Turina contains vectors and matrices as shown in Table 2. The name of this bank in Interdyme models is Vam.cfg file. It shows the names and dimensions of each vector or matrix along with the names of the files giving the titles of the rows or the columns of the matrix or vector[3].

[2] The Ministry of Development (MoD) supported the project for one month. The Turina team acknowledges this support with sincere thanks.

[3] For a full description of Vam.cfg file, see Almon 2011.

Table 1 – Turina macro.stb File.

```
#\head Table of Turina data bank.
#\dates 98 99 00 01 02 03 04 05 06 07 08 09
#\under =
#\9 1 65 2 2 11
\decs 1
&
;
;Population and other variables
Pop      ; Population (1000)
GDPnt; Target GDP nominal by Ministry of Development
GDPrt; Target gdp real by Ministry of Development
def      ; GDP Deflator (1998 = 100)
cpi      ; Consumer price index (1998 = 100)
exrat    ; Exchange rate (TL per US Dollar)
;

;Variables from Turina vam bank
;
totfcehh   ; Final consumption expenditure of domhh
totfcenp   ; Final cons expend of not for profit organizations
totgfcf ; Gross fixed capital formation
totcivv    ; change in inventories
totexp     ; Total exports
totimp     ; Total imports
totfd      ; Final demand
totout     ; Total output of all sectors (1-35)
;
totwag     ; Total wage
totpro     ; Total profit
totdep     ; Total depreciation
tottms     ; Total tax minus subsidies
totva      ; Total value added
;
```

Table 2 – Vambank for Turina Vam.cfgFile.

```
#
#-----------------------------------------------------------------------------------
#
#    Vam.cfg file for the InterDyme Model of TURKEY TURINA
#
#-----------------------------------------------------------------------------------
##
1995 2028
#
#    Matrices
#
am$      35  35 p sectors.ttlsectors.ttl #    Input-output coefficient matrix in nominal,
domestic+import
am       35  35 p sectors.ttlsectors.ttl #    Input-output coefficient matrix in nominal,
domestic+import
amr      35  35 p sectors.ttlsectors.ttl #    Input-output coefficient matrix in real,
domestic+import
#
```

```
#    Vectors
#
#    Final Demand side in Dollar terms
#
intout$   35   1 0 sectors.ttl   # Total Intermediate output, current price
fcehh$    35   1 0 sectors.ttl   # Final consumption expenditure by households, current price
fcenp$    35   1 0 sectors.ttl   # Final consumption expenditure by non-profit, current price
fcegov$   35   1 0 sectors.ttl   # Final consumption expenditure by government, current price
gfcf$     35   1 0 sectors.ttl   # Gross fixed capital formation, current price
civv$     35   1 0 sectors.ttl   # Changes in inventory and valuables, current price
exp$      35   1 1 sectors.ttl   # Exports, current price
imp$      35   1 1 sectors.ttl   # Imports, current price
fd$       35   1 0 sectors.ttl   # Final demand, current price
ddtot$    35   1 0 sectors.ttl   # Domestic demand = fd+imp-exp, current price
out$      35   1 2 sectors.ttl   # Gross output, current price
#
#    Final Demand side in Million TL
#
intout    35   1 0 sectors.ttl   # Total Intermediate output, current price
fcehh     35   1 0 sectors.ttl   # Final consumption expenditure by households, current price
fcenp     35   1 0 sectors.ttl   # Final consumption expenditure by non-profit, current price
fcegov    35   1 0 sectors.ttl   # Final consumption expenditure by government, current price
gfcf      35   1 0 sectors.ttl   # Gross fixed capital formation, current price
civv      35   1 0 sectors.ttl   # Changes in inventory and valuables, current price
exp       35   1 1 sectors.ttl   # Exports, current price
imp       35   1 1 sectors.ttl   # Imports, current price
fd        35   1 0 sectors.ttl   # Final demand, current price
ddtot     35   1 0 sectors.ttl   # Domestic demand = fd+imp-exp, current price
out       35   1 2 sectors.ttl   # Gross output, current price
#
intoutR   35   1 0 sectors.ttl   # Total Intermediate output, constant price
fcehhR    35   1 0 sectors.ttl   # Final consumption expenditure by households, constant price
fcenpR    35   1 0 sectors.ttl   # Final consumption expenditure by non-profit, constant price
fcegovR   35   1 0 sectors.ttl   # Final consumption expenditure by government, constant price
gfcfR     35   1 0 sectors.ttl   # Gross fixed capital formation, constant price
civvR     35   1 0 sectors.ttl   # Changes in inventory and valuables, constant price
expR      35   1 0 sectors.ttl   # Exports, constant price
impR      35   1 0 sectors.ttl   # Imports, constant price
fdR       35   1 0 sectors.ttl   # Final demand, constant price
outR      35   1 0 sectors.ttl   # Gross output, constant price
ddtotR    35   1 0 sectors.ttl   # Domestic demand, constant price
intinptR  35   1 0 sectors.ttl  # Total intermediate input, constant price
#
pdo       35   1 1 sectors.ttl    #price index of domestic output prices in TL
pim       35   1 1 sectors.ttl    #price index of import prices in TL
pex       35   1 1 sectors.ttl    #price index of export prices in TL
pdd       35   1 1 sectors.ttl    #mixed price index of domestic and import prices in TL
unitwag   35   1 1 sectors.ttl    #wage in current price of per unit output in constant price
unitpro   35   1 1 sectors.ttl    #profit in current price of per unit output in constant price
unitdep   35   1 1 sectors.ttl    #depreciation in current price of per unit output in constant price
unittms   35   1 1 sectors.ttl    #tax minus in current price of per unit output in constant price
unitva    35   1 1 sectors.ttl    #value added in current price of per unit output in constant price
#
#   Value added side in Dollar terms
#
intinpt$  35   1 0sectors.ttl   # Total intermediate input, current price
wag$      35   1 0 sectors.ttl   # Wages, current prices
pro$      35   1 0 sectors.ttl   # Profit, current prices
dep$      35   1 0 sectors.ttl   # Depreciation, current prices
tms$      35   1 0 sectors.ttl   # Taxes less subsidies, current prices
```

```
va$       35  1 0 sectors.ttl  # Value added
tranmarg$  35  1 0 sectors.ttl  # International transportation Margin
#
#   Value added side in TL
#
intinpt   35  1 0 sectors.ttl  # Total intermediate input, current price
wag       35  1 0 sectors.ttl  # Wages, current prices
pro       35  1 1 sectors.ttl  # Profit, current prices
dep       35  1 0 sectors.ttl  # Depreciation, current prices
tms       35  1 0 sectors.ttl  # Taxes less subsidies, current prices
va        35  1 0 sectors.ttl  # Value added
tranmarg   35  1 0 sectors.ttl  # International transportation Margin
#
#
emp       35  1 0 sectors.ttl   #employment
prd35  1 0 sectors.ttl   #productivity (emp/outr)
capstkR  35  1 0 sectors.ttl   #capital stock,1995 price
#
#   SEIDEL
#
impshare   35  1 0 sectors.ttl  # import share of domestic demand
demtot   35  1 0 sectors.ttl  # Domestic demand ( = totint + fd)
imptim   35  1 2 sectors.ttl        # Nyhust time trend
disc      35  1 0 sectors.ttl  # for Seidel discrepancy
#
#    Workspace
#
x         35  1 0 sectors.ttl   #working space
y         35  1 0 sectors.ttl   #working space
z         35  1 0 sectors.ttl   #working space
w         35  1 0 sectors.ttl   #working space
bmcolumn    3  1 0 sectors.ttl   #working space
fix      2000  1 0 fix.ttl      #   for fixer
```

Given the set of variables in these two files it was possible to form regression equations for five of the basic endogenous vector variables.

i. *Consumption functions*

The first set of regression equations are for final consumption expenditures of private households, *fcehh*. This variable is a vector with 35 elements. For each element of this final demand vector a simple generic linear regression function is estimated over the sample period. Here, only six sectors from those showing satisfactory regression results are presented. The first one is for sector 2, Mining and quarrying.

For any sector a simple linear consumption function in per capita terms is defined as follows:

$$fcepc = \beta_0 + \beta_2 pci + \beta_2 relpri \qquad (7)$$

Where
fcepc: final consumption expenditure per capita in any sector i, $i = 1, 2, \ldots, 35$

pci: total per capita income (= *GDPreal/pop*)
relpri: relative price (price index in sector *i* divided by consumer price index, pdd_i/cpi)

The price index for a sector *i* is defined for the total final demand for this sector excluding export and called the price for domestic demand, pdd_i. The results of this regression function for sector 2 are shown in Table 3 below. Although this sector mainly produces intermediate goods it also produces coal and lignite which are consumed by households.

Table 3 – Consumption in Mining and Quarrying (2).

```
ti 2 Mining and Quarrying
f fcepc =  fcehhR2/pop
f pci = b.GDPrt/pop
f relpri = pdd2/cpi
r fcepc = pci,relpri

:                                2 Mining and Quarrying
  SEE   =       0.00 RSQ   = 0.8573 RHO =   0.57 Obser  =   15 from 1995.000
  SEE+1 =       0.00 RBSQ  = 0.8335 DW  =   0.86 DoFree =   12 to   2009.000
  MAPE  =     193.44
    Variable name           Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
  0 fcepc                - - - - - - - - - - - - - - - - -       0.01 - - -
  1 intercept              -0.05903    61.2  -4.17    7.01       1.00
  2 pci                     0.06296    97.1   5.27    1.13       1.19  0.809

       3 relpri                  -0.11415     6.5  -0.10    1.00       0.01 -0.174
```

An inspection of Table 3 reveals a close fit for the historical period indicated in a relatively high RSQ (coefficient of determination) and RBSQ (adjusted RSQ). Regression coefficients of two explanatory variables carry expected signs as *pci* has positive sign and relative price variable *relpri* has negative sign[4]. The fitted values of this function along with the actual values are shown in Figure 2.

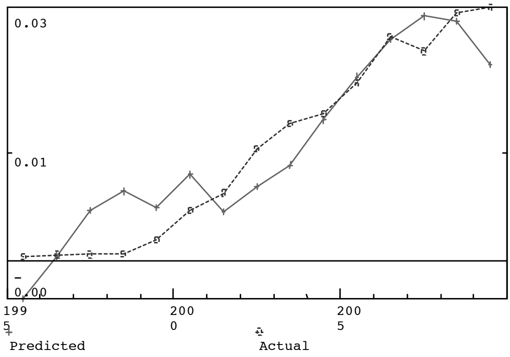

Figure 2 – Consumption in Mining and Quarrying (2).

[4] For a full explanation of a table presenting regression results, see Almon 2014.

While reading Table 3 three points should be emphasized. The first is about the regression coefficient for the first explanatory variable *pci*. The estimated coefficient for his variable in the standard Keynesian consumption function should be less than one. This parameter (β_1 in Equation 7) is called marginal propensity to consume out of (personal) disposable income. If, however, disposable income is not available, total income is used instead of disposable income as it is the case in the present model. It can be checked from Table 1 that, at present, personal disposable income is not available in Turina`s macro bank. Therefore per capita real GDP is used instead of per capita personal disposable income. Thus marginal propensity to consume out of income in per capita terms is 0.06296 or about 6.3 percent.

The second point is about β_2, the regression coefficient of the second variable, *relpri*. It measures the relative price sensitivity of the demand for this sector. A negative value for this coefficient (-0.11416) means that household the demand for Coal is inversely related with its relative price. The relative price in this model is defined as the ratio of price index in one sector to the general price index (consumer price index, cpi, in this case).

The third point is related to the elasticity values. From the 'Elas' column it is seen that income elasticity of demand at midpoint is measured as 5.27. It means that as per capita income increases by one percent per capita consumption increases by 5.27 percent. This high value of income elasticity puts Coal in the consumer basket of goods in luxury (superior) status which is hard to accept. One would expect that the coal should be a normal good, even for some families it can be an inferior good. Therefore this result necessitates the need for further checking of data and the form of the function.

In the same column relative price elasticity of demand is less than unity (-0.10) in absolute terms. However this elasticity differs from the usual meaning of the concept of price elasticity. In the present model it is defined as fallows

$$\eta_2 = \frac{d(fcepc_2)/fcepc_2}{d(p_2/cpi)/(p_2/cpi)} \qquad (8)$$

In Equation 8, η_2 is a measure of relative price elasticity of demand in sector 2, i.e., the percentage change in quantity demanded with respect to percentage change in the relative price of sector 2. The value of $\eta_2 = -0.10$ implies that the demand for coal is relatively price inelastic.

One further point in relation to Table 1 is that the money unit in Turina is 1 million Tl at 1998 prices. Thus the mean per capita consumption in Sector 2 over the period 1995 to 2009 is 0.01 million (= 10 000) Tl while per capita income is 1,19 million TL. These values are listed in the 'Mean' column of the table. In the same column, the mean relative price is 0.01, which shows that the price index in the Mining and quarrying sector is much smaller than the consumer price index on the average.

The second consumption function is for sector 7, Pulp, paper, printing and publishing. The definition of the variables and regression results for this function are shown in Table 4.

Table 4 – Consumption in Pulp, Paper, Printing and Publishing (7).

```
ti 7 Pulp, Paper, Printing And Publishing
f fcepc =  fcehhR7/pop
f pci = b.GDPrt/pop
f relpri = pdd7/cpi
r fcepc = pci,relpri

:                     7 Pulp, Paper, Printing and Publishing
  SEE   =       0.00 RSQ   = 0.7904 RHO =   0.58 Obser  =   15 from 1995.000
  SEE+1 =       0.00 RBSQ  = 0.7555 DW  =   0.85 DoFree =   12 to   2009.000
  MAPE  =      20.98
    Variable name          Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
  0 fcepc                - - - - - - - - - - - - - - - - -      0.01 - - -
  1 intercept              0.00188     1.4   0.37    4.77       1.00
  2 pci                    0.00426    11.7   1.00    2.27       1.19  0.296
  3 relpri                -0.09185    50.6  -0.37    1.00       0.02 -0.670
```

The plot of regression results along with the actual values for the consumption function for sector 7 is given in Figure 3.

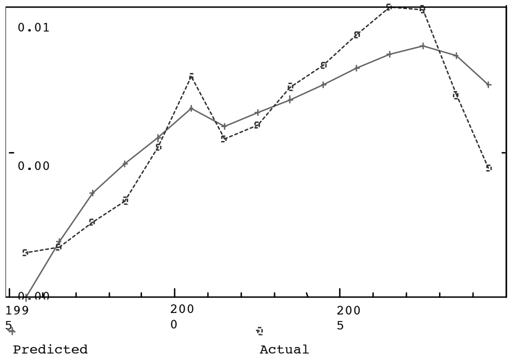

Figure 3 – Consumption in Pulp, Paper, Printing and Publishing (7).

Both Table 4 and Figure 3 show that the regression results in this sector, as in the first example, reveal a close fit between estimated and actual values. This is reflected in a relatively high RBSQ. Also a very low SEE (virtually zero) supports this interpretation. However, the value of SEE is dependent on the unit of measurement chosen. In the present model the unit is 1 million TL and the mean per capita income is close to zero (0.01 million TL). Therefore the main reason for the low SEE is the low value of income itself. To overcome this difficulty MAPE value can play a better role. Its value is 20.98 for the present case which is one on the smallest of all regression results.

Finally, the signs of β_1 and β_2 also satisfy prior expectations. The income elasticity if demand in this sector is unity which implies that the good in question is a necessity. A low level of relative price elasticity again as in the first case implies that the consumer demand for this sector is relative-price inelastic.

The third consumption function is for sector 8, Coke, refined petroleum and nuclear fuel. The definitions of the variables and regression results for this function are shown in Table 5.

Table 5 – Consumption in Coke, Refined Petroleum and Nuclear Fuel (8).

```
ti 8 Coke, Refined Petroleum and Nuclear Fuel
f fcepc =  fcehhR8/pop
f pci = b.GDPrt/pop
f relpri = pdd8/cpi
r fcepc = pci,relpri

:                       8 Coke, Refined Petroleum and Nuclear Fuel
  SEE   =       0.00 RSQ   = 0.8200 RHO =   0.56 Obser  =   15 from 1995.000
  SEE+1 =       0.00 RBSQ  = 0.7900 DW  =   0.88 DoFree =   12 to   2009.000
  MAPE  =      42.87
    Variable name           Reg-Coef  Mexval  Elas   NorRes     Mean   Beta
  0 fcepc                 - - - - - - - - - - - - - - - - -     0.01 - - -
  1 intercept               -0.02487    13.1  -2.11    5.56     1.00
  2 pci                      0.03367    37.3   3.39    1.31     1.19  0.605
  3 relpri                  -0.13789    14.5  -0.28    1.00     0.02 -0.359
```

The plot of regression results along with actual values for the consumption function for sector 20 is given in Figure 4.

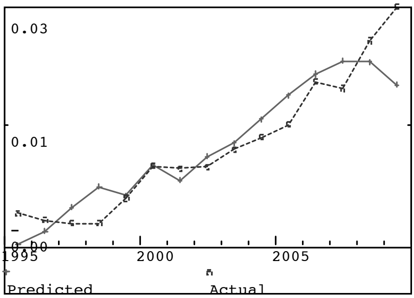

Figure 4 – Consumption in Coke and Refined Petroleum (8).

The third consumption model also shows a close fit between actual and estimated values. A relatively high RBSQ and very low (virtually zero) SEE lead to this conclusion. Again this low value of SEE should be mainly attributed to the low per capita consumption, the dependent variable of the model. The elasticity for the first independent variable is again unexpectedly higher than unity (3.39). But the relative price elasticity (-0.28) is lower than unity in absolute value which implies that the demand for Coke and refined petroleum is relatively price inelastic.

A final consumption function is for sector 22, Hotels and restaurants. The regression results for this function are shown in Table 6.

Table 6 – Consumption in Hotels and Restaurants (22).

```
ti 22 Hotels and Restaurants
f fcepc =  fcehhR22/pop
f pci = b.GDPrt/pop
f relpri = pdd22/cpi
r fcepc = pci,relpri

:                               22 Hotels and Restaurants
  SEE   =       0.00 RSQ   = 0.8546 RHO =   0.37 Obser  =   15 from 1995.000
  SEE+1 =       0.00 RBSQ  = 0.8304 DW  =   1.26 DoFree =   12 to   2009.000
  MAPE  =       7.35
    Variable name           Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
  0 fcepc                 - - - - - - - - - - - - - - - - -      0.01 - - -
  1 intercept               0.01123    64.5   1.48    6.88       1.00
  2 pci                     0.00717    99.6   1.12    3.95       1.19  0.659
  3 relpri                 -0.22445    98.8  -1.60    1.00       0.05 -0.655
```

As in all previous regression functions the consumption function for Hotels and restaurants show a good fit. It appears with the highest RBSQ and the lowest MAPE value among four consumption functions presented in this section. Still a better result is that it has an income elasticity of demand slightly greater than one (1.12) which indicates that consumption in hotels and restaurants is a luxurious good. This is a plausible result as suits common prior expectations.

The plot of regression results along with actual values for the consumption function for Sector 22 is depicted in Figure 5.

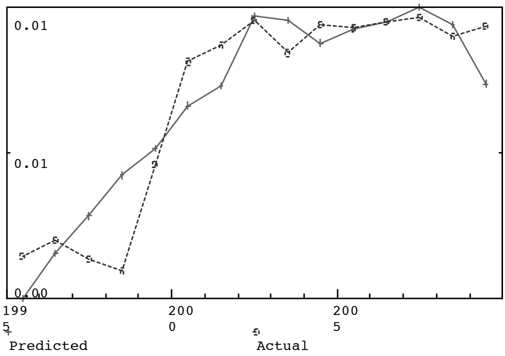

Figure 5 – Consumption in Hotels and Restaurants (22).

ii. *Investment Functions*

With the current data stored in the macro bank it is possible to estimate only one aggregate investment function. A simple functional form for aggregate investment is defined as follows

$$gfcfr = \beta_0 + \beta_1 replace + d[1] + \beta_2 d[2] \qquad (9)$$

Where
gfcfr: total real gross fixed capital formation (or, investment in short) in the final demand block
replace: replacement investment for wear and tear of fixed capital stock
d: first difference in the real GDP series (*d* = *GDP* – *GDP*[1])

There are two versions of regression function for investment estimated successfully in this paper, one without a constraint and one with a constraint. Both the form and results of the first version is shown in Table 7.

Table 7 – Investment (Gross Fixed Capital Formation) (Unconstrained).

```
# gfcfr.reg - Regression to explain fixed investment
fdates 1995 2009
lim 1998 2009
ti Gross Private Domestic Fixed Investment
subti Fitted vs. Actual
f gfcfr = b.totgfcf/b.def
f d = b.GDPrt - b.GDPrt[1]
f replace = .05*@cum(stockf, gfcfr[2], .05)
r gfcfr = replace, d[1], d[2]

:                         Gross Private Domestic Fixed Investment
  SEE   =      12.89 RSQ   = 0.8556 RHO =  -0.51 Obser  =   12 from 1998.000
  SEE+1 =      10.60 RBSQ  = 0.8014 DW  =   3.03 DoFree =    8 to   2009.000
  MAPE  =       7.38
    Variable name           Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
  0 gfcfr                 - - - - - - - - - - - - - - - - -    155.99 - - -
  1 intercept               95.74855   197.8   0.61     6.92       1.00
  2 replace                  0.58125    24.7   0.16     4.34      43.39  0.309
  3 d[1]                     0.00463    55.8   0.10     2.91    3216.00  0.465
  4 d[2]                     0.00574    70.6   0.13     1.00    3505.92  0.562
```

The variables that appear in this estimated form of the investment function are defined as follows.

gfcfr: real total gross fixed capital formation. It is defined as the sum of elements in the fixed investment column of the IO tables and deflated by the GDP deflator. This variable comes from the Vam bank (named *a*) and stored in the macro bank (named *b*).

GDPrt: Real gross domestic product, target values. It comes from the MoD (Ministry of Development). It is a series of actual or realized values for the historical period, 1995-2009.

Replace: The replacement part of gross investment, and defined as a function of cumulated values of gross investment series with 5 percent annual depletion rate[5].

[5] For further note on this function see Almon 2014.

The same regression results for the first form of investment function are depicted in Figure 6.

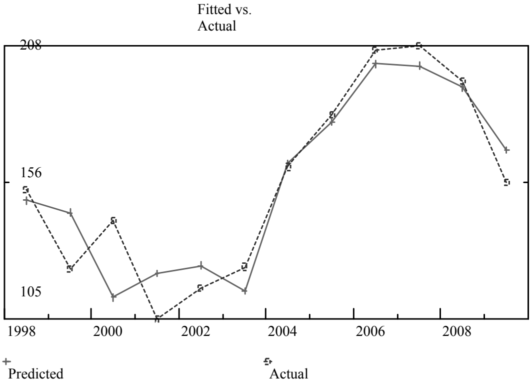

Figure 6 – Gross Fixed Investment (Unconstrained).

A prior expectation from the estimated form of the regression function for investment is that the coefficient of the `replace' term, the second parameter after the intercept term, should be close to 1. This requirement reflects the fact that to keep the capital stock intact gross investment should be equal at least to the replacement investment (depreciation). An inspection of Table 7 reveals that this requirement is not met in the first version of the investment model. Thus a new model with the addition of a constraint on the second variable should be estimated. This is done in the second version of the model and named constrained investment model. The results of the second regression model of investment are given in Table 8.

Table 8 – Investment (Gross Fixed Capital Formation) (Constrained).

```
# gfcfr.reg - Regression to explain fixed investment
fdates 1995 2009
lim 1998 2009
ti Gross Private Domestic Fixed Investment
subti Fitted vs. Actual
f gfcfr = b.totgfcf/b.def
f d = b.GDPrt - b.GDPrt[1]
f replace = .05*@cum(stockf, gfcfr[2], .05)
con 10000 1.0 = a2
r gfcfr = replace, d[1], d[2]
:                         Gross Private Domestic Fixed Investment
  SEE   =      14.55 RSQ   = 0.8162 RHO =  -0.16 Obser  =   12 from 1998.000
  SEE+1 =      13.87 RBSQ  = 0.7472 DW  =   2.32 DoFree =    8 to   2009.000
  MAPE  =       7.90
    Variable name           Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
  0 gfcfr                 - - - - - - - - - - - - - - - - -    155.99 - - -
  1 intercept               82.03044   241.3   0.53   52.39      1.00
  2 replace                  0.98888   594.2   0.28    3.42     43.39  0.526
  3 d[1]                     0.00422    40.1   0.09    2.28   3216.00  0.424
  4 d[2]                     0.00498    50.8   0.11    1.00   3505.92  0.488
```

The only difference between the first and the second model is the addition of a new line just before the regression command

Con 10000 1.0 = *a*2

This is a command to the computer to add a block of 10000 artificial observations with 1s in the `replace` column and zeros in the columns for the remaining variables. The results of the second version of the investment function shows that this trick works and regression coefficient for the `replace` turns to be exactly 1 (= 0.98888). A major cost for this improvement is a slight reduction in the RBSQ from 0.8014 to 0.7472.

The graphical display of the regression results for the second form of investment function is shown in Figure 7.

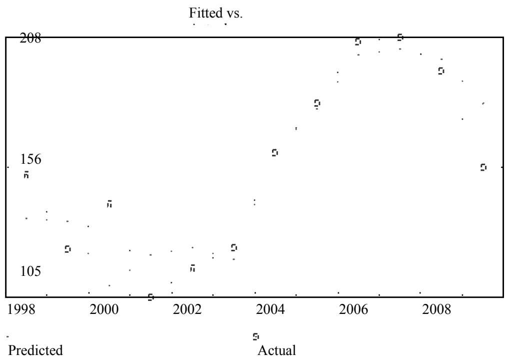

Figure 7 – Gross Domestic Fixed Investment (Constrained).

iii. *Profit functions*

The last group of regressions is for profits. A simple two-variable linear regression model is applied in this case.

$$pro = \beta_0 + \beta_2 out \quad (11)$$

Where
pro: profit in sector *i*, *i* = 1, 2, …, 35
out: output in sector *i*

Since profit is part of value added in the VA block on figure 1 it is quite normal to suggest a linear relation between profit in one sector and output in the same sector. To test this relation two results are presented below.

The first one is for sector 3, Food, beverages and tobacco. The results are given in Table 13.

Table 9 – Profit in Food, Beverages, and Tobacco (3).

```
ti 3 Food , Beverages and Tobacco
r pro3 = out3

:                              3 Food , Beverages and Tobacco
  SEE   =      73.98 RSQ   = 0.9996 RHO =   0.68 Obser  =   15 from 1995.000
  SEE+1 =      61.38 RBSQ  = 0.9995 DW  =   0.64 DoFree =   13 to   2009.000
  MAPE  =       8.32
    Variable name           Reg-Coef  Mexval  Elas   NorRes     Mean   Beta
  0 pro3                  - - - - - - - - - - - - - - - - -   4668.59 - - -
  1 intercept              203.18463    99.6   0.04 2387.68      1.00
  2 out3                     0.08444  4786.4   0.96    1.00  52880.25  1.000
```

Table 13 shows that there is almost one-to-one close relationship between profit and output in this sector. This is apparent from the high RSBQ which is virtually one. The same relation is also shown in Figure 12. In this figure it is clear that the actual values of profit and its estimated values the regression are almost identical as two curves are coincides.

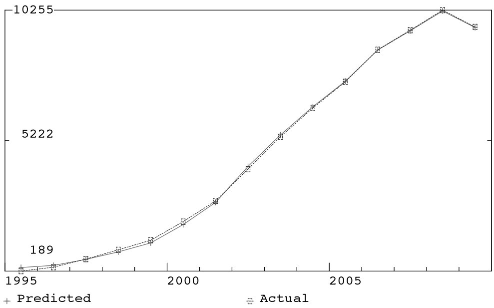

Figure 8 – Profits in Food, Beverages and Tabaco (3).

The final regression equation presented here is for profit in sector 8, Coke, refined petroleum and nuclear fuel. Table 14 shows the results for this regression.

Table 10 – Profit in Coke, Refined Petroleum and Nuclear Fuel (8).

```
ti 8 Coke, Refined Petroleum and Nuclear Fuel
r pro8 = out8

:                      8 Coke, refined petroleum and nuclear fuel
  SEE   =      77.51 RSQ   = 0.7192 RHO =   0.63 Obser  =   10 from 2000.000
  SEE+1 =      78.01 RBSQ  = 0.6841 DW  =   0.74 DoFree =    8 to   2009.000
  MAPE  =      10.52
    Variable name           Reg-Coef  Mexval  Elas   NorRes     Mean   Beta
  0 pro8                  - - - - - - - - - - - - - - - - -    604.30 - - -
  1 intercept              167.03780    16.0   0.28    3.56      1.00
  2 out8                     0.02584    88.7   0.72    1.00  16924.64  0.848
```

Again a relatively high RBSQ (= 0.6841) and a positive regression coefficient both reflect a close positive association between profit and output in this sector 8, Coke, refined petroleum and nuclear fuel. Figure 13 depicts the same relation.

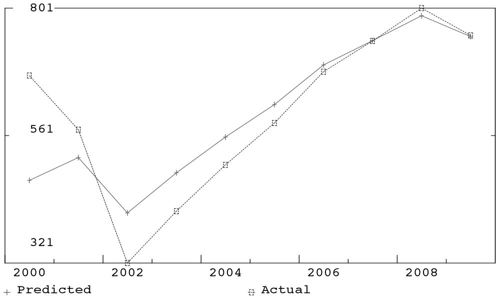

Figure 9 – Profits in Coke, Refined Petroleum and Nuclear Fuel (8).

Other regression functions (under development)

In the present model investment is treated as the sum output by some limited number of industries producing mainly investment goods, such as construction and machinery and equipment industries. This approach is called investment by origin. However investment by purchasing sectors is another information which is vital for a dynamic for a multisectoral modeling practice. This approach is called investment by destination. Therefore investment by destination requires a new method to estimate the demand for fixed investment by all 35 sectors of the economy. This method is still under development.

Three other important final demand (FD block) variables of the IM model are government expenditures, change in stocks, exports, imports. Usually government expenditures are treated as exogenous. Therefore there is no need for a behavioral regression analysis for this variable. The remaining three variables (exports, imports, change in stocks) will be designated as endogenous variables. Therefore three new regression blocks for the final demand categories will be completed in the near future.

As for the value added block (VA), currently only profit variable is estimated with a set of simple two-variable linear regression model. Other components of VA block include taxes minus subsidies, wages, and depreciation. Still these three variables are under investigation for the construction of appropriate regression models.

4. Discussion

Inforum models are generally characterized as IO-Econometric models. They adapt a bottom-up approach to economic modeling in a sense that all calculations are carried out at sectoral level and then aggregates are calculated in a consistent way. The definitions and equations applied in this process are fully consistent with the rules of national income accounting. A possible alternative approach would be to build a CGE (Computable General Equilibrium) model. However it can be checked that there are plenty of models built for the Turkish economy applying various forms of CGE models. But the present model (Turina) is a different approach to multisectoral macroeconomic modeling in Turkey. Inforum models have a superior property for long term projections at sectoral level both in real and nominal values of major macroeconomic variables. And the Turina team is comparatively better equipped to follow the path that our partners at Inforum have been following for almost half a century. Furthermore, all of the software and related documents at Inforum website are free of charge and relatively easy to apply.

At present in Turina databanks a series of annual IO tables from 1995 to 2009 have been balanced and a set of sufficient macroeconomic data collated from the websites of both national and international institutions. Regression equations for some basic endogenous variables, like consumption, investment, exports, imports, profit, wages, taxes minus subsidies have been estimated. Some of them, however, require further thought for improvement. Therefore a bulk of regression functions are still under development. In particular, the investment and exports equations should be expanded to include additional explanatory variables and new functional forms.

5. Conclusions

The interindustry macroeconomic modelling process has four basic stages: data collection, estimating regression equations for endogenous variables, testing the model for the historical period, and forecasting. The Turkish team of the Turina model has roughly completed the first two stages. However, some regression equations still require further checking and running as they cannot satisfy the basic predictions of macroeconomic theory.

Concerning the last two phases, the model is still under construction. Without producing a set of satisfactory results in historical simulations the model cannot be run for forecasting or policy evaluation. This should be possible by expanding the databank with new variables, such as employment, capital stock, monetary variables, and income in trading partners in international markets.

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