Innovation and sustainability: the Italian scenario

Rosanna Cataldo, Maria Gabriella Grassia, Paolo Mazzocchi, Claudio Quintano, Antonella Rocca

1. Introduction

Recent public and governmental concerns regarding sustainability have increased attention on the possibility of improving firms' efficiency in terms of the emerging topic of sustainable innovation. The perspective of what represents innovation has changed significantly in the pioneering and the wide usage of patent statistics. In fact, a large number of research papers have suggested significant advancements in the usage of indicators connected to measuring innovation (see, among others, Rothwel, 1992; Hagedoorn and Cloodt, 2003; Smith, 2005; Gössling and Rutten, 2007; Makkonen and Van der Have, 2013). One of the most frequently used set of indicators to assess the innovation level of European countries is the European Innovation Scoreboard (EIS; European Commission, 2020), while the Regional Innovation Scoreboard (RIS; European Commission, 2019) represents a regional extension of the EIS. Compared to EIS, the RIS assesses the innovation performance using a limited number of indicators. The fourth edition of the Oslo manual (OECD, 2018) proposed a detailed updated guideline focused on measuring innovation in the business sector, and Dziallas and Blind (2019) contributed to the literature review of innovation measurements by carrying out an extensive analysis. Nevertheless, there still remains a broad discussion on these issues.

Sustainable innovation combines the innovation topic and the characteristics connected to sustainable development, which in turn involve three dimensions of sustainability: economic, social and environmental (or ecological) features (Sood and Tellis, 2005). These subjects can also be investigated considering several goals of sustainable development. Among others, Carrillo-Hermosilla et al. (2009; 2010) presented an overview of connections among innovation, ecological sustainability, eco-innovation and sustainable innovation.

Since the research question connected to the impact of the innovation on sustainability is still open, the present work attempts to shed light upon this relationship, considering the Italian Regions. As for the theoretical model, the present article considers a higher order construct (Wetzels et al., 2009), also known as a hierarchical (component) model (HCM), which is based on the Structural Equation Model (SEM) Partial Least Squares (PLS) Path Modelling (PM). In the authors' opinion, from a policy maker's and managerial point of view, the possibility of improving firms' efficiency in terms of several dimensions of sustainable innovation represents a relevant topic that must be investigated.

2. Sustainable innovation in the business sector

As mentioned above, the OECD (2018) manual focuses on measuring innovation in the business sector following the SNA 2008 recommendations. It suggests a framework for measuring innovation using a common definition, and it recommends—for international comparisons—several specifications to avoid weaknesses in empirical analysis. According to a similar perspective, to provide homogenous and comparable indicators—and to avoid the exclusion of relevant dimensions— specific economic activity boundaries and spatial perimeters of the firms investigated

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can be fixed, considering small-sized and medium-sized enterprises (SMEs). Durst and Edvardsson (2012) highlighted that SMEs are the drivers of most nations all over the world; the present research dedicates special prominence to them, also considering potentially innovative SMEs that could become innovative but cannot because they do not yet have all the requirements. In addition, since some economic sectors are more interested in innovation than others, and since international comparisons of innovation features require the specification of a homogeneous structure to perform the analysis, consequently specific NACE codes can be considered for each Italian Region.

As stated earlier, this empirical work is performed to address the research question aimed at verifying the impact on the sustainable innovation via HCM, and the authors postulate that the sustainable innovation is the only higher-order latent variable in their model. To investigate the statistical significance of the relationship, one endogenous variable (*Sustainable Innovation*) is estimated using four (exogenous) latent constructs: *Business Standard Innovation (BSI), SMEs Innovation (SmI), Economic Sustainability (EcS)* and *Social Sustainability (SoS).* Given this definition, the authors express the following general form of the *Sustainable Innovation* equation:

$$Sustainable\ innovation = f(BSI, SmI, EcS, SoS) \quad (1)$$

The model proposed is based on a well-defined path diagram shown in Figure 1 to describe the relationships between the different dimensions. More details about codes and variable definitions are provided in Table 1.

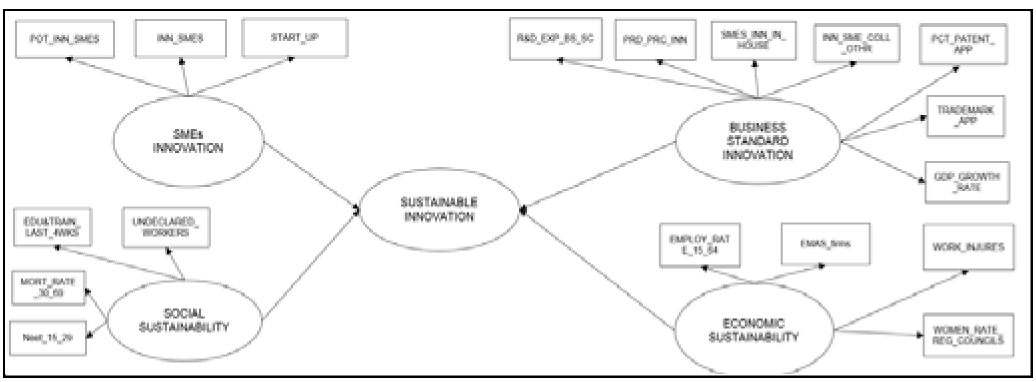

Figure 1: Path diagram.

3. Preliminary results

Since the higher order construct has no manifest variables connected to it, among the methods proposed in the literature, this contribution considers the Two-Stage (step) Approach (TSA) (Ringle et al. 2012; Wetzels et al. 2009) to state this limitation. TSA refers to the scores obtained through a principal component analysis (PCA) applied to the lower order components. All the manifest variables of the lower order construct have been treated in a reflective way (each manifest variable reflects-and it is an effect of- the corresponding latent variable), while the higher order construct involves a formative mode (see Hair et al., 2017 for an extensive evaluation of these issues). Concerning the outer model assessment, since the model is supposed to be reflective, all the blocks of manifest variables must be one-dimensional and homogeneous, and Table 2 checks the homogeneity and the one-dimensionality of the constructs. This table shows three main indices for checking the block homogeneity and one-dimensionality - Cronbach's α, Dillon-Goldstein's ρ (or Jöreskog's ρ) and the PCA eigenvalues – which confirm that the model assumptions seem to be appropriate. To prevent these indices from appearing inadequate in the estimations, several variables required a transformation since these indicators had their original scale inverted.

Table 1: Latent dependent variables, manifest variables, codes and sources.

Latent variable names	Manifest variable names	Codes	Sources
SMEs innovation	Potential innovative SMEs	POT_INN_SMES	I
	Innovative SMEs	INN_SMES	I
	Innovative start-up	START_UP	I
Business Standard Innovation	R&D expenditure business sector	R&D_EXP_BS_SC	II
	Product or process innovators	PRD_PRC_INN	II
	SMEs innovating in-house	SMES_INN_IN_HOUSE	II
	Innovative SMEs collaborating with others	INN_SME_COLL_OTHR	II
	PCT patent applications	PCT_PATENT_APP	II
	Trademark applications	TRADEMARK_APP	II
	Annual GDP growth rate	GDP_GROWTH_RATE	III
Social Sustainability	Neet (15-29)	NEET_15_29	III
	Mortality rate (leading causes of death) [30-69]	MORT_RATE_30_69	III
	Education and training activities during the last 4 weeks [percentage participation rate]	EDU&TRAIN_LAST_4WKS	III
	Undeclared workers	UNDECLARED_WORKERS	III
	Employment rate (15-64)	EMPLOY_RATE_15_64	III
Economic Sustainability	EMAS firms for 1,000 employees of local units	EMAS_FIRMS	III
	Work injuries	WORK_INJURES	III
	Women rate nominated to regional councils	WOMEN_RATE_REG_COUNCILS	III

Sources: I—Bureau van Dijk (Amadeus) database (https://amadeus.bvdinfo.com); II—Regional Innovation Index 2019 (https://interactivetool.eu/RIS/RIS_2.html); III—ASviS (https://asvis.it/database-sugli-sdgs/). Full description of each variable and more details about the sources are available on request.

Table 2: Main indices for checking the block homogeneity and one-dimensionality.

Latent variable names	Dimensions	Cronbach's α	Dillon-Goldstein's ρ	PCA eigenvalues
SMEs innovation	3	0.800	0.883	2.144; 0.510
Business Standard Innovation	7	0.874	0.909	4.243; 1.078
Social Sustainability	5	0.962	0.971	4.354; 0.423
Economic Sustainability	3	0.658	0.815	1.788; 0.738
Sustainable innovation	4			2.641; 0.664

Different variables, originally involved in the model, have been removed from the analysis due to the fact that they presented several weaknesses which require further investigation (for instance: the percentage of renewable energy consumption expressed as a percentage of final energy consumption; the energy produced by using renewable sources; the number of the spin off for regions; the usage of public transport by employees and students; etc.).

Since the SEM–PLS literature indicates several measurements to assess the quality of the outer, the inner and the global models, Figure 2 and Table 3 present the corresponding results. In more detail, Figure 2 shows the loading between (1) the manifest variables and their own latent variables and (2) the manifest variables and the remaining latent variables. This figure visually verifies that the shared variance between a construct and its indicators is larger than the variance with other constructs. Table 3 summarises the weights, the loadings, the communalities, the R^2 and the GOF.

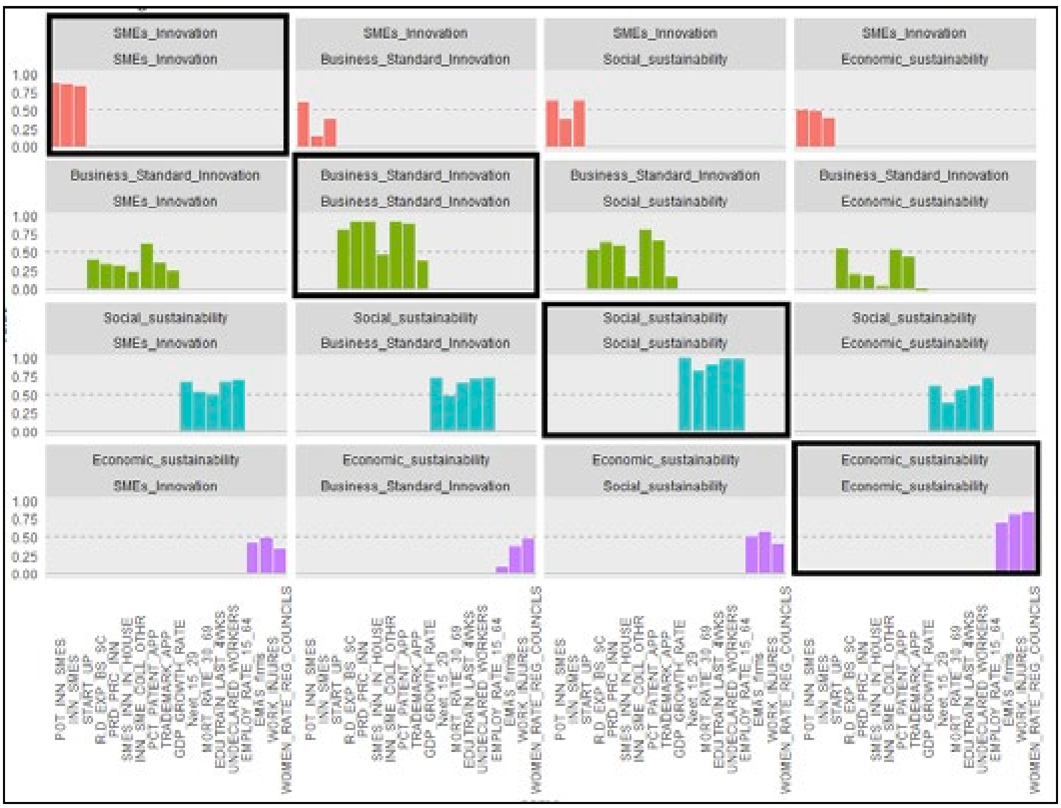

Figure 2: Cross-loadings.

When the TSA SEM-PLS approach is performed, analysing the path coefficients, it appears that $Sustainable\ innovation$ depends on its latent variables expressing the equation in the following form:

$$Sustainable\ innovation = 0.302BSI + 0.303SmI + 0.304EcS + 0.306\ SoS$$

The equation above indicates that all the latent constructs appear to be positively (and significantly) correlated with sustainable innovation. The coefficients are significant at the 0.05 level, and the non-parametric bootstrap procedure has been used to statistically validate the model. Supplementary findings that can derive from the latent variable scores, and more details concerning the analysis, are available on request.

Table 3: SEM-PLS assessment: indices.

Latent variables	Manifest indicators	Weighs	Loadings	Communalities	R^2	GOF
SMEs Innovation	POT_INN_SMES	0.457	0.856	0.734		
	INN_SMES	0.331	0.854	0.729		
	START_UP	0.397	0.821	0.674		
Business standard innovation	R.D_EXP_BS_SC	0.207	0.787	0.619		
	PRD_PRC_INN	0.195	0.913	0.833		
	SMES_INN_IN_HOUSE	0.185	0.914	0.835		
	INN_SME_COLL_OTHR	0.084	0.466	0.217		
	PCT_PATENT_APP	0.263	0.906	0.820		
	TRADEMARK_APP	0.215	0.876	0.767		
Social sustainability	GDP_GROWTH_RATE	0.068	0.370	0.137		
	Neet_15_29	0.231	0.985	0.971		0.829
	MORT_RATE_30_69	0.171	0.813	0.662		
	EDU.TRAIN_LAST_4WKS	0.199	0.907	0.823		
	UNDECLARED_WORKERS	0.227	0.973	0.947		
Economic sustainability	EMPLOY_RATE_15_64	0.238	0.975	0.951		
	EMAS_firms	0.371	0.677	0.458		
	WORK_INJURES	0.477	0.800	0.641		
	WOMEN_RATE_REG_COUNCILS	0.443	0.829	0.687		
Sustainable innovation					0.999	

4. Future work

The preliminary significant and positive relationships presented in this work require a certain caution in analysing the interaction among the *Sustainable Innovation* and its latent constructs. Potential awareness might be relevant from a policy point of view considering that the topic of the study is the analysis of the effects that may affect *Sustainable Innovation*. Prospective research endeavours could consider several model modifications to strengthen sustainable strategies and, in future investigations, the number of indicators and the contextual factors may also be extended. Supplementary considerations can originate from the possible causal relationships between the manifest variables and/or different constructs, which can also have an impact on *Sustainable Innovation.* Since the path coefficients represent the direct effects, it is important to evaluate the indirect effects. In addition, the interaction effects – which refer to the influence that an additional variable might have on the relationship between an independent and a dependent variable – can be investigated as well. According to a similar perspective, the analysis of moderating effects - which imply the involvement of a variable as a moderator indicator and which could change the strength and the direction of a relationship between the constructs in the model - cannot be omitted.

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