Gender INequality Indicator for Academia (GINIA)

Margherita Silan, Giovanna Boccuzzo

1. Introduction

Gender equality is a fundamental right, a common value of Europe, and a necessary condition for the achievement of the EU objectives of growth, employment and social cohesion (European Commission, 2019). Over the last few decades, women in all countries in Europe have caught up with or even surpassed men in terms of their level of education, but they are still facing segregation in different forms. Indeed, the career of women remains markedly characterized by strong vertical segregation throughout the Europe. The term vertical segregation refers to the under-representation of a clearly identifiable group of workers (in this case women) in top levels of occupations or sectors.

Another problem is that Science and Technology have historically been and still are male dominated areas. In this case, there is a problem of horizontal segregation, which shows that there is an unequal distribution of women and men in different scientific fields.

To strengthen the role of women in scientific research, the European Commission funded the Gender Time Project (Gender Time, 2012), from which this work originated.

The main aim of this work consists of a methodological proposal for a composite indicator that, together with a system of indicators, represents and measures gender inequality in academia. In this paper, the indicator is shaped in order to represent gender inequality in the staff of University of Padova (Unipd), however, the proposal is extremely flexible with the purpose to fit also different academic environments. We called the composite indicator GINIA (Gender INequality Indicator for Academia) and, for the sake of brevity, the acronym will be used in the following.

2. Measuring Gender Equality

In recent decades, several indices have been proposed in the literature in order to measure gender equality in different contexts and areas. In order to properly define the aspects and dimensions to be considered in the theoretical definition of GINIA we carefully considered them and converted their specification into an academic environment.

Among others, the proposal made by the European Institute for Gender Equality (EIGE), the Gender Equality Index (EIGE-GEI), represents a solid methodology for measuring gender disparity among European countries. Its value has been continuously updated since 2005, both for Europe and for the Member States (Barbieri et al., 2021). The entire system of the EIGE's Gender Equality Index is based on an interesting framework of collecting data divided into six core domains and two satellite domains (violence and intersecting inequalities).

In the existing literature on the systems for measuring gender equality in Academic and Research Institutions, a good solution may come from the GenisLab project (Genis Lab, 2010), funded by the European Commission in 2010. Three elements were highlighted as fundamental dimensions in gender budgeting: the allocation of funds and the management of time and space.

Margherita Silan, University of Padua, Italy, silan@stat.unipd.it, 0000-0001-5541-0603
Giovanna Boccuzzo, University of Padua, Italy, giovanna.boccuzzo@unipd.it, 0000-0003-2143-7730

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3. Theoretical framework

The first step to define the structure of GINIA consists in the definition of the theoretical framework that supports it. Starting from existing indexes described in Section 2, in our approach the gender gap is detected in seven domains (Figure 1): work, money, knowledge, time, power, health and space (Boccuzzo et al., 2016). These seven domains are better specified and declined through twelve sub-domains that are measured by seventeen variables. The composite indicator is the result of a three-step aggregation of variables, sub-domains and domains and provides a synthetic measure of gender inequality in the University of Padova.

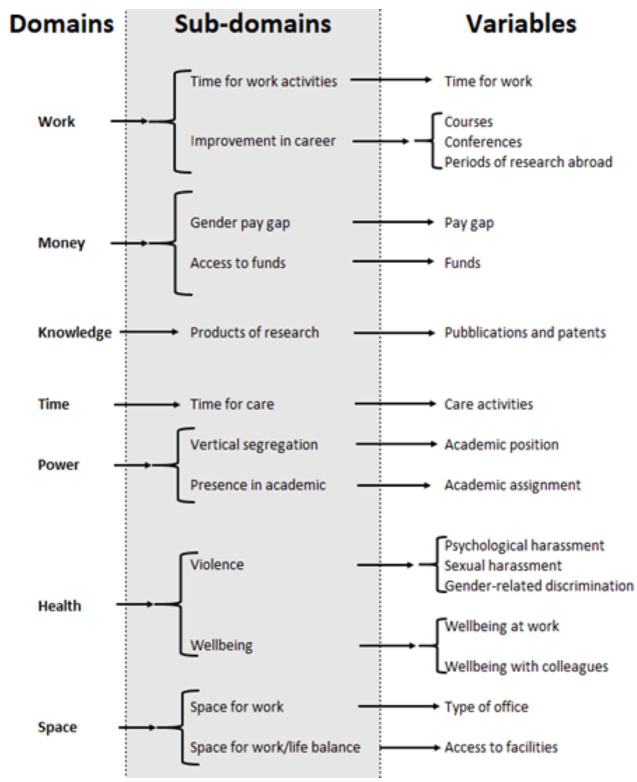

Figure 1: The theoretical framework to measure gender equality in the University of Padova.

4. Data and Population

Data used to build and compute the gender equality index in the University of Padova come both from administrative official datasets (numbers of people per role, action plans, code of conducts, expertise, etc.) and from an ad-hoc survey that was carried out in September/October 2015 by Unipd research group as part of the GenderTime Project. The questionnaire was distributed to all academic staff of the University of Padova. The target population of the questionnaire is Unipd academic staff members at 31^{st} December 2014, including Full and Associated Professors, Assistant Researchers, Research Fellows (fixed-term) and Post-Doc Fellows. All members of the target population were asked to be part of the survey; however, only the 31% replied to the questionnaire. This response rate is in line with the expected response rate for a web survey, especially with respect to such a delicate topic. There are some differences between the target population and the respondents. It is really important to evaluate those differences in order to evaluate the representativeness of the respondents' population. For instance, there is an over representation of women and young academics at the beginning of their carrier. This result is probably due to a stronger involvement in the survey contents.

The following analysis are based on respondents of the survey; but, since they do not reflect the distribution (for gender, age, academic position and school) of the whole population, it will be necessary to weight answers. Thus, we compute post-stratification weights for each intersection of gender, academic position and school.

5. Methods

5.1 Normalization and age standardization

All indicators need to have the same direction defined in the theoretical framework. In GINIA's system, the direction is given by "higher is better", which means that all indicators have higher values for better situations. When this is not the case, the indicator has to be reversed.

Having different data sources and several measurement scales, the need to make all the variables of the system of indicators vary between in a common interval has to be addressed in order to compare them. We chose the Min-Max method for normalization, which makes the variables vary in a range between 0 and 1. So, the normalised variable I_{ji} related to the person i, who has gender j, is:

$$I_{ji} = \frac{\text{Observed Value}_{ji} - \text{Theoretical Minimum}}{\text{Theoretical Maximum} - \text{Theoretical Minimum}} \tag{1}$$

Since there are differences in the age distribution among the male and female population employed in the University of Padova at 31^{st} December 2014, the comparison between male and female could be biased by the different age structure of the two populations. Indeed, even the academic position could depend on the age structure. To take into account the different age structures in the calculation of the indicator, we calculated crude and also standardized indicators considering three main age classes, applying direct standardization and using as a reference the whole academic staff of the University of Padova.

5.2 Weighting

After the definition of the theoretical framework, the data selection and normalization and imputation of missing data, weighting and aggregation techniques should be taken into account. Their choice should be done along the lines of the underlying theoretical framework.

The assigning weights to single indicators is necessary when not all of them contribute to the formation of the composite indicator in the same measure.

In this work, we will consider two weighting methods: equal weights and preference matrix weights (based on the importance respondents have given to each dimension in the final question of the web survey). Indeed, most composite indicators rely on equal weighting (EW), i.e. all variables are given the same weight. This essentially implies that all variables have the same relevance in the composite (or there is insufficient knowledge of causal relationships or a lack of consensus on the alternative).

Respondents are asked to order items that represent domains according to their importance. The answers are used to compute a weighting system based on preference analysis which is used to aggregate the domains into the final composite indicator. The main advantage of this weighting method is that it takes into account the ranking made by the respondents. In addition,

Table 1: Alternative weighting and aggregation methods used for the computation of the composite indicator. The combination of weighting and aggregation techniques chosen for GINIA is underlined.

	Variables	Sub-domains	Domains
Aggregation	**Arithmetic Mean**	**Arithmetic Mean**	Arithmetic Mean
		Geometric Mean	**Geometric Mean**
Weighting	**Equal Weighting**	**Equal Weighting**	Equal Weighting
			Preference Matrix Weights

it can be used both for qualitative and quantitative data, and it increases the transparency of the composite. The main disadvantages are that it requires a high number of pairwise comparisons, and thus it can be computationally costly; furthermore, the results depend on the set of respondents.

5.3 Aggregation

The literature on composite indicators offers several examples of aggregation techniques. In this work we use two common aggregation methods: arithmetic and geometric mean aggregation.

The arithmetic mean is a complete compensatory method, which means that poor performance in some indicators can be compensated for by sufficiently high values for others. Although widely used, this aggregation entails restrictions on the nature of indicators and the interpretation of weights. Furthermore, it requires that the indicators have to be preferentially independent, which is a very strong condition, especially in this application.

If we want some degree of non-compensability, geometric aggregation is better suited. It is a less compensatory approach, indeed, while in a linear aggregation, the compensability degree is constant, in a geometric aggregation, the compensability is lower for composite indicators with low values (a low score on one indicator will need a much higher score on the others to improve the situation). It is very sensitive to data far from the central value, and it will be nullified if there is an indicator equal to zero.

5.4 GINIA composition

Every indicator of the GINIA system of indicators for the University of Padova is the result of the comparison between the elementary indicators corresponding for men and women. The comparison is carried out by the following formula (Boccuzzo et al., 2016):

$$\text{Inequality Indicator} = \frac{\text{Indicator for women}}{\text{Indicator for men}} \tag{2}$$

Thus, the indicator is close to 1 in the most equalitarian scenario, when indicators for men and women are more similar. Moreover, when the value of the indicator is below one, there is a situation in which women are penalized compared to men; whereas, when it is above 1, women are privileged with respect to men.

In order to compute GINIA, we are dealing with three levels of aggregation: one for variables (arithmetic mean), one for sub-domains (arithmetic mean) and the final step that puts together domains in order to obtain the final composite indicator with geometric mean (Table 1). Indeed, according to our theoretical framework, variables related to the same domain can compensate each other, while this consideration is not plausible for the domains.

The computation of confidence intervals of the GINIA is not trivial, especially due to the correlation between indicators. Thus, we computed confidence intervals using bootstrap (10000 iterations). Bootstrap samples are extracted with replacement assigning to each unit a probability to be selected proportional to post-stratification weights, then in each sample the GINIA is computed.

The choice of weighting and aggregation methods is a fundamental step because the indicator may substantially change modifying the weighting and aggregation methods. This is why we performed a sensitivity analysis considering different combinations of weighting and aggregation techniques (shown in Table 1) to assess the robustness of the composite indicator as a final step in the analysis.

6. Results

Looking at the indicators computed for the seven domains disaggregated, it is possible to detect which are the aspects where women are more disadvantaged with respect to men. Since in Table 2 only standardized indicators are reported, the observed differences do not depend on a different age structure.

Table 2: The standardized indicators for each domain by gender and their rate.

	Work	Time	Power	Knowledge	Space	Health	Money
Women	0.447	0.815	0.254	0.142	0.643	0.642	0.404
Men	0.461	0.815	0.304	0.195	0.687	0.752	0.530
W/M	0.970	1.000	0.836	0.728	0.936	0.853	0.761
CI 95% lower	0.943	0.981	0.771	0.643	0.908	0.825	0.682
CI 95% upper	0.997	1.019	0.903	0.826	0.964	0.882	0.844

In domain *time*, we find perfect equality between men and women with respect to satisfaction in work-life balance. This does not mean that men and women working at the University of Padova have the same time allocation in terms of family care and work, but it means that they are equally satisfied with respect to their desired time allocation. On the other hand, in all the other domains we find a significant disadvantage for women, with a more serious situation for domains *knowledge* and *money*. The domain *knowledge* is based on the number of publications in the last two years, and the fact that women have more difficulties to get published is an important limitation that needs to be acknowledged. Indeed, having a low number of publications also affects other aspects of academic life, such as career possibilities and access to funds. This second aspect is a part of the *money* domain (the other with a mostly low value). Since in Italy academic salaries are fixed and linked to the covered position, this domain is composed by access to research funds and additional activities that yield an extra return.

In Table 3, the values of GINIA are reported both crude and standardized. Both show a marked disadvantage for women. The crude indicator is lower than the standardized one; this is probably because a part of the disadvantage detected by the crude indicator is actually due to the different age structure between man and women in academia.

Table 3: The crude and standardized composite indicators (arithmetic mean and then weighted geometric mean) by gender, with bootstrap confidence intervals.

	Crude indicators	Standardized indicators
Women	0.395 (0.382-0.408)	0.405 (0.392-0.418)
Men	0.477 (0.466-0.488)	0.473 (0.463-0.483)
W/M (GINIA)	0.829 (0.796-0.862)	0.856 (0.824-0.888)

From the sensitivity analysis, whose results are shown in Figure 2, the use of geometric mean as aggregation methods results in indicators with lower values due to the lack of compensability, especially when it is used at the domains' level. The use of weights computed by preferences analysis results in values slightly lower than the equal weights solution, probably because the domains stated as more important are also those in which women are more disadvantaged.

	Domains Aggregation	Domains' weights	Sub-domains Aggregation	Value
Crude	Geometric	Pref. Matrix	Geometric	0.816
	Geometric	Equal	Geometric	0.820
	Geometric	Pref. Matrix	Arithmetic	0.829
	Geometric	Equal	Arithmetic	0.832
	Arithmetic	Pref. Matrix	Geometric	0.862
	Arithmetic	Equal	Geometric	0.864
	Arithmetic	Pref. Matrix	Arithmetic	0.873
	Arithmetic	Equal	Arithmetic	0.874
Standardized	Geometric	Pref. Matrix	Geometric	0.845
	Geometric	Equal	Geometric	0.854
	Geometric	Pref. Matrix	Arithmetic	0.856
	Geometric	Equal	Arithmetic	0.864
	Arithmetic	Pref. Matrix	Geometric	0.879
	Arithmetic	Equal	Geometric	0.885
	Arithmetic	Pref. Matrix	Arithmetic	0.889
	Arithmetic	Equal	Arithmetic	0.894

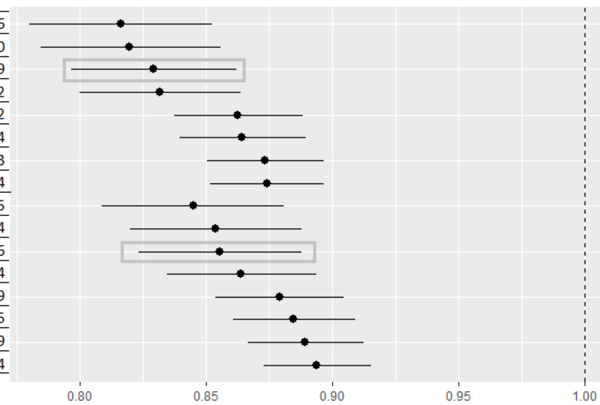

Figure 2: GINIA values and respective bootstrap confidence intervals in all cases considered by the sensitivity analysis.

7. Conclusions

As concluding remarks, we may say that the GINIA indicator seems useful for measuring and monitoring gender equality in academia. The situation at the date of the questionnaire seems improvable; therefore, it would be interesting and useful to repeat the experience in order to evaluate changes. The observation of the disaggregated domains' indicators shows a critical aspect referred to publications that could be a good starting point to meditate on effective policies to reduce the gap.

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