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ORIGINAL RESEARCH

An Extended Regional Gender Gaps Index (eRGGI): Comparative Measurement of Gender Equality at Different Levels of Regionality

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Abstract
Gender equality has been widely explored, but there is limited research investigating its variability at regional level. This paper aims to fill this gap by developing and validating a new, regional gender gaps index, compatible with previous indices used to compare gender equality across nations but now fit for the purpose of measuring gender equality across regions, within nations. To this end, we (i) reviewed existing indicators of gender equality; (ii) assessed the contribution of the indicators most frequently used in previous research to measure gender equality; (iii) developed an extended, regional version of the gender gaps index (eRGGI), by extending it to include new indicators able to capture female empowerment in developed countries, like Italy; and, (iv) explored the variability of gender equality across Italian regions. In developing our eRGGI, some indicators traditionally used to measure gender equality were removed and others were introduced to capture new dimensions of gender equality to suit modern conditions regarding contexts where equality is considered important, in contemporary Europe. Results showed that gender equality varies dramatically across regions, also confirming the relevance of the new indicators we proposed to add. Such results call for more caution in interpreting results based on nationally aggregated data to inform policy and practice, arguing for regional comparisons to become more prominent.

Keywords Gender · Gaps · Equality · Region · Composite · Index

1 Introduction

Gender equality is a timely topic in the international agenda. For years it has been a priority, but no country in the world has reached complete gender equality in the key sectors of social life, i.e. economics, politics, health, and education (European Gender Equality Institute, 2019; World Economic Forum, 2020). Nonetheless, the national gaps between men and women differ across sectors (World Economic Forum, 2020,

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pp. 12–13). In particular, in all countries, gender inequality in favor of men is larger in politics and economics (even in Iceland—ranked 1st out of 153 countries in equality—the female-over-male ratio in economic participation and opportunities is 0.80): in 144 out of 153 countries, the female-over-male ratio in politics does not reach 0.50 and, in half of these countries, this ratio is largely lower than 0.20, and often close to zero—in a range from 0 (indicating complete inequality) to 1 (indicating complete equality) (World Economic Forum, 2020). In contrast, gender equality is higher in health and education. According to the World Economic Forum (WEF), this is more well-established in several north-western countries than in most of the southern or eastern countries: the gender gap in both Health and Education has dramatically narrowed in recent years and, in 2020, the female-over-male ratio was 0.97 in Health, and 0.96 in Educational Attainment. Female educational underachievement, in particular, has narrowed over time, especially throughout the industrialized world (Legewie & DiPrete, 2012), with girls achieving better than boys in both primary and secondary education, and with a higher percentage of women enrolling and completing Higher Education (HE) courses. Moreover, in contrast to the past, international comparisons show that 60% of the lowest achievers in mathematics, reading and science in grade 10 (on average, 15-years old students) are boys, and that girls outperform boys in reading in all countries participating in the OECD-PISA survey (Organisation for Economic Co-operation & Development, 2018).

Nonetheless, when we focus on scientific topics, e.g. Science, Technology, Engineering, and Mathematics (STEM), girls performance is lower than boys. The percentage of girls at the top of the STEM attainment distribution is relatively low compared to boys, in HE (Delaney & Devereux, 2019; Fisher et al., 2020) as well as in secondary education (Nollenberger & Rodríguez-planas, 2017; Nollenberger et al., 2016; Organisation for Economic Co-operation & Development, 2019; Rodríguez-Planas & Nollenberger, 2018). Similar patterns are observed for primary education, as TIMSS (Trends in Mathematics and Science Study) data from grade 4 (and 8) shows that "gender gaps that existed 20 years ago have persisted into the present" (Meinck & Brese, 2019, 20). Gender differences in education can be due to a number of factors but some sociological literature has shown that female underachievement is still strong especially in countries typically characterized by gender inequality in surrounding environments (Guiso et al., 2008; Penner, 2008; Penner & Paret, 2008) and by more traditional perceptions about female roles (Cascella, Williams, & Pampaka, 2021; Gonzalez de San Roman & De la Rica, 2016; Rodríguez-Planas & Nollenberger, 2018).

A number of gender equality measures have been developed over time. Most are based on nationally aggregated data, but research exploring gender equality at sub-national levels have revealed sometimes a huge variability across regions (Blancas Peral et al., 2008; Di Noia, 2002; Frias, 2008; Kjeldstad & Kristiansen, 2001; Straus, 1994; Thermaenius, 2000). Other studies (Cascella & Pampaka, 2020; Rice & Coates, 1995; Tuncer et al., 2005) have shown that measures of theoretically related concepts, such as attitudes towards gender equality, also vary across regions, within the same country, thus highlighting the need to explore gender equality at different levels of regionality. The importance of investigating gender equality at sub-national levels has also been recently argued by di Bella, Leporatti, Gandullia, and Maggino, (2020) who adapted the European Gender Equality Index (Bericat, 2012) at regional level to investigate the variability of gender attitudes across regions in Italy. Their results clearly showed that a regionalized approach to the study and the measurement of gender equality is necessary to set priorities and target regional policy actions.

The European Gender Equality index has been developed to measure gender equality in European countries, under the hypothesis that the meaning of deprivation and inequality in the so-called 'developed countries' is different from that in the so-called 'developing countries'.[1] The debate about the validity of the indicators used to measure gender equality in different contexts has received increasing attention over time. Permanyer (2010, 2013), for example, using data from the United Nations showed that the choice of indicators can have an important impact on the ranking of countries, especially for those that achieved high levels of gender equality. For this reason, our proposed extended Regional Gender Gaps Index (eRGGI) herein, is informed by a comprehensive review of existing indicators used so far to measure gender equality, focusing on those used in the so-called developed countries—where typically gender inequality is relatively lower than in the so-called developing ones. We also used data from Italy, to investigate the validity of the indicators used to construct global gender gap indices, such as the Global Gender Gap Index (Hausmann, Tyson, & Zahidi, 2006).

We focused on Italy, a 'developed' country, according to the WESP (United Nations, 2020), where gender gaps have already been studied, especially with reference to the job market and the gender pay gap (Addabbo & Favaro, 2011; Campa et al., 2011; Del Bono & Vuri, 2011; Mussida & Picchio, 2014) and less frequently, other dimensions such as the use of time spent by women at work compared to that spent looking after the house and children (Anxo et al., 2011). Those studies contributed to our review of the state of the art in the field and were also useful to interpret our empirical results.

The current paper thus purports to contribute to knowledge about the measurement of gender equality via three aims: (i) to select a new, updated and enriched set of indicators to capture female empowerment over time, informed by our systematic literature review of new measures of gender equality; (ii) from both a theoretical and an empirical perspective, to assess the contribution of old and new indicators to the measurement of gender equality for so-called 'developed' countries such as Italy and finally, (iii) to explore the variability of gender equality across sub-national geographical levels by using a combination of old and new indicators for Italy.

2 Systematic Literature Review

In this section, we present the approach and findings of the systematic review of published measures of gender equality.

[1] The World Economic Situation and Prospects (WESP) classifies all countries of the world into three broad categories (i.e., developed economies, economies in transition and developing economies) reflecting basic economic country conditions (United Nations, 2020). To distinguish between the so-called 'developed' and 'developing' countries, we used the definition provided by the United Nations Economic and Social Council (United Nations, 2020), in line with Altshuler, Holland, Hong, and Li (2016): a country is classified as 'developed' if it is characterized by economic wealth, social security, and efficient welfare state (as measured via per capita Gross National Income, a human assets index, and an economic vulnerability index, developed by the United Nations).

2.1 Systematic Review Approach

The keywords 'sex' OR 'gender' AND 'equality' (OR 'difference/s' OR 'inequality') AND 'index' (OR 'measure/s' OR 'composite' + 'indicator' OR 'scale')[2] were used into the main literature databases, i.e. Scopus, Web of Science, Eric, and Google.scholar to search for gender equality measures. Both scientific publications (peer-reviewed journal articles and books) and institutional reports were included, without any language or time restrictions in an attempt to find all relevant publications for gender equality measures. We should note, however, that our review may have missed indices not published in the above databases. Finally, starting from these records, a snowballing search was additionally carried out.

After removing duplicates retrieved from different databases, 124 publications were further considered based on the title, abstract, and methodological section: publications presenting new measures of gender equality were included, whereas the rest (i.e., those exploring genetic differences between sexes rather than gender gaps in society, or those using existing measures of gender equality in applied research contexts) were catalogued but excluded from the review.

The selected 65 publications were split into two groups: 1) those focused on the development of new measures of *global* gender equality (34 out of 65), i.e. capturing gender differences in various sub-dimensions such as economic participation and opportunity, health, education, and politics; and, 2) those focused on new measures quantifying just one specific sub-dimension of gender equality.

2.2 Overview of Systematic Literature Review Results

Table 1 provides an overview of the 34 new indices retrieved from this review. Most of the existing gender equality indices measure equality in terms of relative achievement of women compared to men in the key sectors of social life, i.e. work, leadership and political power, and education (Weber, 1947). In addition, some indices—developed to measure gender equality in developing countries (e.g., United Nations, 2011) or at global level (Hausmann et al., 2006)—have also captured access to health and welfare services.

More recent studies have suggested the importance of including further dimensions and indicators, like the gender pay gap or the use of time and in particular the proportion of time spent by women for work and for looking after home and children compared to men (Klasen, 2006). The pro-woman state index (Wernet, 2008), for example, grounded in the sociological theory of the welfare state with a human rights approach, includes information about structural, state-level policies that empower women to fully participate in society (such as fertility rates, maternity leave policies, abortion policies or the ratio of earned income by women). Other studies (Dilli et al., 2015, 2019) included information about: (i) long-lasting institutions of societies determining the style of governance, measured by considering the legal origins of the countries (Teorell et al., 2013); (ii) religion (Maoz & Henderson, 2013); (iii) legal and family systems classified according to their egalitarianism

[2] In searching the literature, we distinguished between indicator, index, and measure, in line with the definitions provided by (Jupp, 2011). Social indicators are indirect empirical representation used to define or refer to concepts when no direct measurement is possible. A composite index is used to measure unobservable constructs (like gender equality) by aggregating scores on observable variables (i.e., indicators) into an overall score. Similarly, a scale is a measure used to capture feeling, judgments, opinions, and perceptions of stimula, including attitudes, emotions, and perceptions.

Table 1 Gender (in)equality measures developed over time: a synopsis*

Name	Authors	Indicators									Calculation Method Individual/ Composite	Reliability analysis	Geographical Area
		A	B	C	D	E	F	G	H	Other			
Status of Women Index (SWI)	Yllö, 1984	x		x	x	x					Standardised/added	Cronbach a	American states
Gender Equality index (GEI_1)	Sugarman & Straus, 1988, Sugarman & Straus, 1988	x		x	x						%f/m/combined	Cronbach a	American states
Gender equality index (GEI_2)	Harvey et al., 1990	x	x	x		x					Ratios/arithmetic average	Factor Analysis	Ontario (Canada)
Gender Inequality	Young et al., 1994			x		x	x	x			Departure from parity	Theory driven (no statistics)	Global
Gender Development Index (GDI)	UNDP, 2015	x				x		x			Ratios—normalised/geometric mean	Not reported	Global
Gender Empowerment Measure (GEM)	UNDP, 2015	x	x	x							Geometric mean for m and f/ harmonic mean across genders[a]	Theory driven (no statistics)	Global
Relative Status of Women (RSW)	Dijkstra & Hanmer, 2000	x				x		x			Ratios—normalised/mean	Theory driven (no statistics)	Global
Swedish Gender Equality index for regional and local comparisons	Thermaenius, 2000	x	x	x		x	x				Not described	Theory driven (no statistics)	Norwegian locales
Norwegian Regional Gender Equality Index (NGEI)	(Kjeldstad & Kristiansen, 2001)	x	x	x		x	x				Ratios/additive index	Item-total correlations	Norwegian locales

Table 1 (continued)

Name	Authors	Indicators									Calculation Method Individual/ Composite	Reliability analysis	Geographical Area
		A	B	C	D	E	F	G	H	Other			
Standardized Index of Gender Equality (SIGE)	Dijkstra, 2002	x	x	x		x		x			Ratios—standardised/mean (no weights)	Cronbach alpha	Global
Gender Equality Index (GEI_3)	Di Noia, 2002	x	x	x	x		x	x			standardized/mean (no weights)	Cronbach alpha Correlations with other measures	American States and Regions
Regional Human Development Index (RHDI)	Martínez Peinado & Cairó Céspedes, 2004	x				x		x			Harmonic mean	Theory driven (no statistics)	Spanish regions
Gender *EQUITY* index (GEI_4)	Social Watch, 2005	x	x	x		x					Scale value (0 to 100)/mean (no weights)	Theory driven (no statistics)	Global
Global Gender Gap Index (GGGI)	Hausmann et al., 2006	x	x	x		x		x			Ratio/arithmetic mean	Theory driven (no statistics)	Global
Gender Equality Index	Blancas Peral et al., 2008		x	x		x	x	x		Gender violence	Criteria used to rank regions	Principal component analysis (PCA)	Spanish regions
Synthetic Index of Gender Inequality (SIGI_1)	Bericat & Sanchez Bermejo, 2008; Bericat & Sánchez Bermejo, 2016	x	x	x		x				Use of the internet	Indicators—mean (no weights)	Theory driven (no statistics)	Spanish regions
European Union Gender Equality Index (EUGEI)	Plantenga et al., 2009	x	x	x			x			Leisure	Indicators—standardized/arithmentic mean	Theory driven (no statistics)	European countries

Table 1 (continued)

Name	Authors	Indicators									Calculation Method Individual/ Composite	Reliability analysis	Geographical Area
		A	B	C	D	E	F	G	H	Other			
Social Institutions and gender index (SIGI_2)	Branisa, Klasen, & Ziegler, 2009,2013				x		x		x	Gender violence	Unweighted average of a non-linear function of subindices	Pearson Correlation	Non-OECD countries
Synthetic index of gender equality (SIGE)	Rioboo & Rioboo, 2009		x	x		x			x		(i) standardization; Ratio or percentage differences (ii) from the mean; (iii) over time (iv) Lineal rescaling	Theory driven (no statistics)	Spain
Gender and other inequalities	Walby & Armstrong, 2010	x	x	x	x	x	x		x		List of indicators	Theory driven (no statistics)	Great Britain
Gender Equality Index in Rural Area (GEIRA)	Rico Gonzalez & Gomez-Limon, 2011	x	x	x		x	x		x	Quality of life	Standardized/ additive or multiplicative weighted index	Theory driven (no statistics)	Castilla and Leon (Spain)
Gender equality in couples (GEC)	Sörlin et al., 2011	x	x			x	x			Parental leave	(1) a self-reported gender equality index, and (2) self-perceived gender equality question	PCA	Sweden
The European Gender Equality Index (EGEI)	Bericat, 2012	x	x	x		x					Ratio—mean (no weights)	Correlation	European countries

Table 1 (continued)

Name	Authors	Indicators									Calculation Method Individual/ Composite	Reliability analysis	Geographical Area
		A	B	C	D	E	F	G	H	Other			
Regional gender equality in UK (RGEUK)	Perrons & Dunford, 2013	x	x			x			x	Child poverty Infant mortality	Standardized/geometric mean	PCA Correlation	Regions in the UK
The Multidimensional Gender Inequalities Index (MGII)	Ferrant, 2014			x	x	x				Identity Autonomy of body	Indicators/ weighted scalar index	Face validity Multiple correspondence analysis (MCA)	Global
Pro-woman State Index	Wernet, 2008, 2016	x	x		x	x			x	Fertility rate Parental leave	List of indicators (used to rank countries)	Theory driven (no statistics)	Global
Facebook Gender Divide (FGD)	Otero-Hermida & García-Melón, 2018	x	x	x		x				Socialization Organizational culture	List of indicators	Experts' judgement	Global
Historical gender equality index (HGEI)	Dilli et al., , 2015, 2019		x	x			x		x		Ratios/ arithmetic mean	PCA	Global
African Gender Status Index (AGSI)	United Nations Economic Commission for Africa, 2004	x	x	x	x	x	x			Use of time Child health	Both indicators and ratios—index (no average) (+Women's Progress Scoreboard)	Theory driven (no statistics)	African countries
Survey-based Women's Empowerment index (SWPER)	Ewerling et al., 2017					x	x		x	Beating women and/or children	Indicators—composite index	PCA	African countries

Table 1 (continued)

Name	Authors	Indicators									Calculation Method Individual/ Composite	Reliability analysis	Geographical Area
		A	B	C	D	E	F	G	H	Other			
Gender Equality Index of Mexican States (GEIMS)	Frias, 2008	x	x	x	x	x					Indicators—standardized/ weighted mean	Factorial analysis Cronbach's alpha Correlations	Mexican States
Gender Equality Index	Swarna, 2007		x			x			x	Infant mortality	Indicators—composite index	Theory driven (no statistics)	India
Índice de Desigualdad de Género	Borrego Esquenazi & Rosales Vázquez, 2017		x	x		x				Maternity mortality Adolescents' fertility	List of indicators	Theory driven (no statistics)	Cuba

*Our literature search includes another paper aimed to develop a Gender equality measurements (GEM) in Lithuania (Streimikiene, D; Kiausiene, I., 2012). We requested the full paper to the author but we have never received it.

[a]GII values are computed using the association-sensitive inequality measure which implies that the index is based on the general mean of general means of different orders.s

A = Economic (Living standards/ Share of income); B = Employment; C = Political (Public power / Leadership); D = Legal; E = Education; F = Family formation / Home and children caring; G = Physical wellbeing/Health; H = Use of Time

Source: our elaboration

in inheritance practices, the freedom they allow children in terms of spousal selection, and co-residence practices (Rijpma & Carmichael, 2016).

From a methodological point of view, most of previous studies have defined a set of indicators and then transformed and or combined them in composite indices by computing alternatively: (i) ratio of achievement rates (and calculated as $[(x/p_x)/(y/p_y)]$, where x and y are the proportion of women who have reached a certain attainment or attained some resources and the proportion of men who have done the same, respectively); or, as we did in the current study, (ii) ratio of achievement share (calculated as [(x/y)] and thus expressing the proportion of women achieving something over the proportion of men achieving the same thing). Of course, when it can be assumed that there is an equal or approximately equal number of women and men, then there is no difference between the two approaches, and they can be used interchangeably (Bericat, 2012). According to the search criteria used to carry out our literature review, three more studies have just listed a set of indicators and just one study has developed a scale aimed to measure perceived gender equality (Table 2).

2.3 Developing an Extended Measure Informed by the Review

Among the measures of gender equality reviewed above, the Global Gender Gap index (GGGI), developed by Hausmann, Tyson, and Zahidi (2006) for the World Economic Forum, has been the most cited gender equality index, with more than 4,000 citations from 2006 to March 2021. We thus use herein the GGGI as both a reference and a starting point (see Table 3 where we discuss the extensions).

In Table 2, we list the outcome variables retrieved from previous studies, grouped in three main sub-dimensions, i.e. economics, power, and education. In addition, we include a fourth sub-dimension, i.e. 'Use of time', suggested for example by Klasen (2006), which has not been frequently used in constructing gender equality indices, with some exceptions (Table 1). In our study, we accounted for the proportion of time spent by women out of home (e.g., to study and/or to participate in economic, social, and political life), in their adult leisure activities, and for indoor activities/responsibilities—like caring for the house and the children—compared with men.

Table 2 Additional indicators included in our eRGGI

Indicators	Availability at sub-national levels		Year
	Regional	Macro-region	
Sub-dimension 1: Economic participation and opportunity			
Employment types (4 indicators: Full/Part time Permanent/Part time jobs)	No	Yes	2018
Self-employed versus employees			
Qualified versus not qualified jobs			
Occupational segregation (proportion of women over men employed in different job sectors)			
Sub-dimension 2: Use of time			
Time dedicated to job (including "travel as part of/during main/secondary job")	No	Yes	2018
Time dedicated to personal care	No	Yes	2018
Time dedicated to study	No	Yes	2018
Time dedicated to home (e.g. cooking, cleaning, ironing)			
Time dedicated to voluntary work and meetings	Yes	Yes	2013
Time dedicated to leisure and free time	Yes	Yes	2013
- social life and entertainment;	Yes	Yes	2013
- sports and outdoor activities;	Yes	Yes	2013
- hobbies and computing;	Yes	Yes	2013
- mass media	Yes	Yes	2013
Time dedicated to travel	Yes	Yes	2013
Time dedicated to household work when people live in couple with/without children and with one or both partners working			
Time dedicated to domestic work when people live in couple with/without children and with one or both partners working			
Time dedicated to family care when people live in couple and with one or both partners working			
Time dedicated to shopping and services when people live in couple with/without children (e.g., laundry, ironing and handicraft) and with one or both partners working			
Sub-dimension 3: Political power and leadership	No	Yes	2013
Percentage of judges and magistrates	No	Yes	2013

Table 2 (continued)

Indicators	Availability at sub-national levels		Year
	Regional	Macro-region	
Female over male senior officials or in leadership position in both private and public firms	No	Yes	2013
Time dedicated to shopping and services when people live in couple with/without children (e.g., laundry, ironing and handicraft) and with one or both partners working	No	Yes	2013
Female over male majors over males			
Female over male female president of region over males	No	Yes	2018
Female over male senior officials or in leadership position in both private and public firms	Yes	Yes	2017
Female over male assessors in each municipality			2018
Female over male majors over males	Yes	Yes	2017/2018
Female of male ratio of employees in prestigious occupations with decision power (e.g., executive managers)	Yes	Yes	2017/2018
Sub-dimension 4: Educational segregation and attainment			
Educational segregation (i.e., Tertiary students enrolled in Education, Humanities, Health, and Welfare studies or traditional male-dominated HE areas such Science, Technology, Engineering, Manufacturing, Construction, and Mathematics)	Yes	Yes	2017
Female to male literacy in Italian (i.e., Reading and Text Comprehension) in			2018
- primary school (grade 5)	No	Yes	2018
- lower intermediate school (grade 8)	Yes	Yes	2018
- secondary school (grade 10)	Yes	Yes	2017
Female to male literacy in Mathematics in			
- primary school (grade 5)	Yes	Yes	2017
- lower intermediate school (grade 8)			
- secondary school (grade 10)			

Source: our elaboration

Table 3 GGGI's structure (i.e., sub-indices and indicators)

GGGI	Regional GGGI
1. Economic participation and opportunity sub-index	
1.1. Female labor force participation over male value	1.1. Female labor force participation over male value
1.2. Wage equality between women and men for similar work	1.2. Wage equality between women and men for similar work
1.3. Female estimated earned income over male value	1.3. Female estimated earned income over male value
1.4. Female legislators, senior officials and managers over male value	1.4. Female senior officials or in leadership position in private firms
1.5. Female professional and technical workers over male value	1.5. Female professional and technical workers over male value
2. Educational Attainment sub-index	
2.1. Female literacy rate over male value	2.1. Female literacy rate over male value
2.2. Female net primary enrolment rate over male value (nationally)	2.2. Female net primary enrolment rate over male value (regionally)
2.3. Female net secondary enrolment rate over male value	2.3. Female net secondary enrolment rate over male value
2.4. Female gross tertiary enrolment ratio over male value	2.4. Female gross tertiary enrolment ratio over male value
3. Health and survival sub-index	
3.1. Sex ratio at birth (converted to female-over-male ratio)	3.1. Sex ratio at birth (converted to female-over-male ratio)
3.2. Female healthy life expectancy over male value	3.2. Female healthy life expectancy over male value
4. Political empowerment sub-index	
4.1. Females with seats in parliament over male value	4.1. Female mayor or president of region over males
4.2. Females at ministerial level over male value	4.2. Women in leadership position at public local administration
4.3. Number of years with a female head of State (last 50 years) over male value	4.3. Number of years with a female head of Municipality or Region (last 50 years) over male value

All indicators are available at Regional and Macro-area level

Source: Our adaptation from The Global Gender Gap Report 2017 (Full document is available at http://reports.weforum.org/global-gender-gap-report-2017)

We included more indicators to capture different aspects of gender gaps in the job market.[3] In particular, we included a combination of different employment types (fixed/full-time combined with permanent/temporary contract) to capture differences in the employment rate between men and women but also to mirror different degrees of financial security related to different types of employment. Moreover, we explored gender differences in self-employment under the hypothesis that women may prefer more secure jobs (that is rare in Italy—according to the 'Labor force' survey carried out by ISTAT (2006)—especially among women), even if less well paid, thus disregarding for example self-employment. Similarly to Bericat (2012), we included an indicator for occupational segregation given by the proportion of women over men employed in different job sectors,[4] and an indicator of the time dedicated to jobs by men and women.

Finally, we included indicators aimed to capture (i) female participation in politics at local levels; (ii) gender segregation in higher education that affects future employability and career; and (iii) female participation in economics, by region (Table 2).

[3] Similar to Bericat (2012) who uses the difference between male and female gross hourly earnings, we used data collected by the annual register on individual labor cost (*Tr. Registro Annuale sul Costo del Lavoro Individuale*—RACLI). RACLI is the national Italian register with information on employment, wages, labor costs, and hours for each employee job (i.e., a person might have one or more jobs, with the same or different employer, at the same time or not). In 2017, ISTAT provided information about the '*Gross hourly wage per hour paid of employee jobs in Euros* (*median*)' at macro-geographical level'. '*Gross hourly wage per hour paid of employee jobs in Euros* (*median*)' is provided by RACLI for men and women, with different education and different ages, and different economic sectors, comparatively. Less recent data (2015) is available also at regional level. Nonetheless, gender pay gap calculated at macro-geographical level in 2015 is very similar to that calculated at regional level, in each macro-geographical area, in 2017. For the purposes of this paper, we thus used the most recent data. In constructing our index to measure the gender pay gap, we employed the methodological strategy used by the International Labor Organization that considers the proportion of women and men in relation to four main factors (i.e., education, age, working-time status, and public-sector versus private-sector employment), "four indicators that together will pick up the major composition effects in most economic contexts" (ILO, 2020, 37). Following ILO's strategy, we calculate the gender wage gap as the difference between male and female median wages divided by male median wages. Wages are computed for full-time equivalent dependent employees and are expressed in Euros. For more information about data collected by ISTAT, see.
http://dati.istat.it/OECDStat_Metadata/ShowMetadata.ashx?Dataset=DCSC_RACLI&ShowOnWeb=true&Lang=en

[4] In Italy, jobs are classified by ISTAT according to the 'Classification of Jobs' (CP2001) that mirrors the international classification (ISTAT, 2013, 15). Jobs are classified depending on the nature of the job that characterizes the profession, the required education to do a job (as defined by following ISCED97), and the amount of training or experience required for that job (ISTAT, 2013). Jobs are therefore classified by ISTAT in nine main groups. ISTAT groups are: 1. Legislators, entrepreneurs, executive management; 2. Highly qualified, intellectual jobs; 3. Technical professions; 4. Clerical/Office jobs; 5. Qualified jobs in the commercial and service sectors; 6. Specialized artisans/works/farmer; 7. Plant and machine operators, and assemblers; 8. Not-qualified professions; 9. Army. Each of them includes other groups. For example, the first includes 1) Members of the legislative and government bodies, leaders and equals of public administration, in the judiciary, in the services of health, education and research, and in organizations of national and supranational interest; 2) Entrepreneurs, executive managers and directors in big firms or public administrations; as well as entrepreneurs and executive managers in medium and small firms. Unfortunately, data by region and gender is not provided by ISTAT for each region. For more information see http://professioni.istat.it/sistemainformativoprofessioni/cp2011/

3 Methodology

The section covers the strategy used to assess the contribution of each indicator measuring gender equality at both national and regional level in Italy, and then the procedure employed to construct our eRGGI and validate it.

3.1 Regional Context in Italy

According to the Italian National Institute of Statistics (ISTAT—*Tr. Instituto di STATistica*), Italy consists of four macro-geographical areas, relatively homogeneous in terms of social and economics characteristics. Within each area there are four or more non-federal regions as listed below:

(i) North-East (consisting of four regions, i.e. Emilia-Romagna, Friuli-Venezia Giulia, Trentino Alto Adige, and Veneto; and, two autonomous provinces, i.e. Bolzano; Trento);
(ii) North-West (consisting of four regions, i.e. Liguria, Lombardia, Piemonte, and Valle d'Aosta);
(iii) Centre (consisting of four regions, i.e. Lazio, Marche, Toscana, and Umbria); and,
(iv) South (with six regions, i.e. Abruzzo, Campania, Molise, Puglia, Basilicata, and Calabria—and the two big islands, i.e. Sardegna and Sicilia).

Even though the Italian Constitution gives regions a few legislative powers (Art. 117, Italian Constitution), such powers are exerted within the legal framework defined by the central Italian State and they mainly refer to the management of the local territories rather than to more substantive topics like legislation to guarantee gender equality or to regulate the job market. These characteristics make Italy an interesting case study. The availability of similar studies based on Italian data also allows framing our results within the appropriate literature.

3.2 eRGGI Development and Validation

As noted earlier the GGGI was used as a basis on which to add new dimensions and indicators—and as a benchmark—for comparison with the proposed eRGGI. We thus calculated the GGGI in Italy, at regional level, and used it to explore (i) how it and its sub-dimensions vary between regions, and (ii) whether and to what extent the indicators used to construct the GGGI captured relevant gender gaps or whether they are not so relevant in developed countries such as Italy.

3.2.1 eRGGI Construction

In line with previous studies (e.g., Bericat, 2012; Bericat & Sanchez Bermejo, 2008; Hardeman & Dijkstra, 2014; Hausmann et al., 2006; Sugarman & Straus, 1988; Yllö, 1984), most indicators identified in Table 3 were calculated as female-over-male ratios to ensure that the index captured gaps between male and female attainment levels rather than the levels themselves: 0 indicates perfect gender inequality and 1 perfect equality, whilst values between 0 and 1 indicate inequality in favor of men, and, values greater than 1 indicate

inequality in favor of women.[5] For example, if 20% of the population in permanent employment are women, and 80% are men, then the ratio of 20 women to 80 men is expressed as 20:80 (1 to 4), i.e. 0.25.

Moreover, since weighting indicators is a methodologically and theoretically sensitive procedure, prone to potential subjectivity bias (Schüler, 2006), in the absence of strong reasons to weight, it is recommended to apply the same weight to all indicators (Harvey et al., 1990). Therefore, similarly to the GGGI and in line with many other indices (see Table 1), our eRGGI was not weighted at any level of the structure. Such a weighing could have been counterproductive for the purposes of this study (i.e. to empirically quantify the contribution of each indicator and sub-dimension to the measurement of gender equality in developed countries).

For the combination of ratios and calculation of the eRGGI, we averaged natural logarithms of the female-over- male ratios (as shown in equation for eRGGI), instead of ratios themselves, to avoid analytical inconsistency: the arithmetic mean is an additive function, while ratio is a multiplicative function. Moreover, after having transformed the ratio in its natural logarithm, the overall value of the index can be decomposed to enhance the exploration of each sub-dimension's contribution to the measurement of gender equality (Benería & Permanyer, 2010).

The exponent of the arithmetic mean of the logarithms is then calculated for each sub-dimension or for the overall index.

$$eRGGI = \left(\exp\left(\frac{1}{n} \sum_{i=1}^{n} \ln R_i \right) \right)$$

n = number of components at one level of the index structure. R_i = gender equality ratios of these components. ln = natural logarithm. e^x = natural exponent.

3.2.2 eRGGI Validation

We first explored the internal consistency of the scales/index via the Cronbach's α (Hundleby & Nunnally, 1968) which provides "evidence of instrument quality" (Taber, 2018), as was also done for various indices reported in Table 1.

Finally, following the example of Di Noia (2002), we looked at the eRGGI's consequential validity by exploring the possible association between gender equality and attitudes towards and about gender and gendered roles in and outside family, as measured via a scale validated at regional level in Italy (Cascella & Pampaka, 2020) with data from the European Value Survey from 2008.[6] The association between eRGGI and gender attitudes has been explored in the hypothesis that gender equality is a culturally situated concept and that it relates to other socio-cultural dimensions that can vary also within the same country

[5] To construct the GGGI, all female-over-male ratios are truncated at the "equality benchmark", except the two health indicators (i.e., sex ratio at birth and healthy life expectancy because, for them, the equality benchmark is set at 0.9445 and at 1.06, respectively. The equality benchmark is considered to be 1, meaning equal numbers of women and men (WEF, 2018, 5). Nonetheless, truncating the data at the equality benchmarks for each assigns the same score to a country that has reached parity between women and men and one where women have surpassed men. Since the aim of our research is measuring gender gaps rather than just measuring relative female empowerment over men, we do not use any equality benchmark.

[6] see Appendix 1 for the list of items included in the scale.

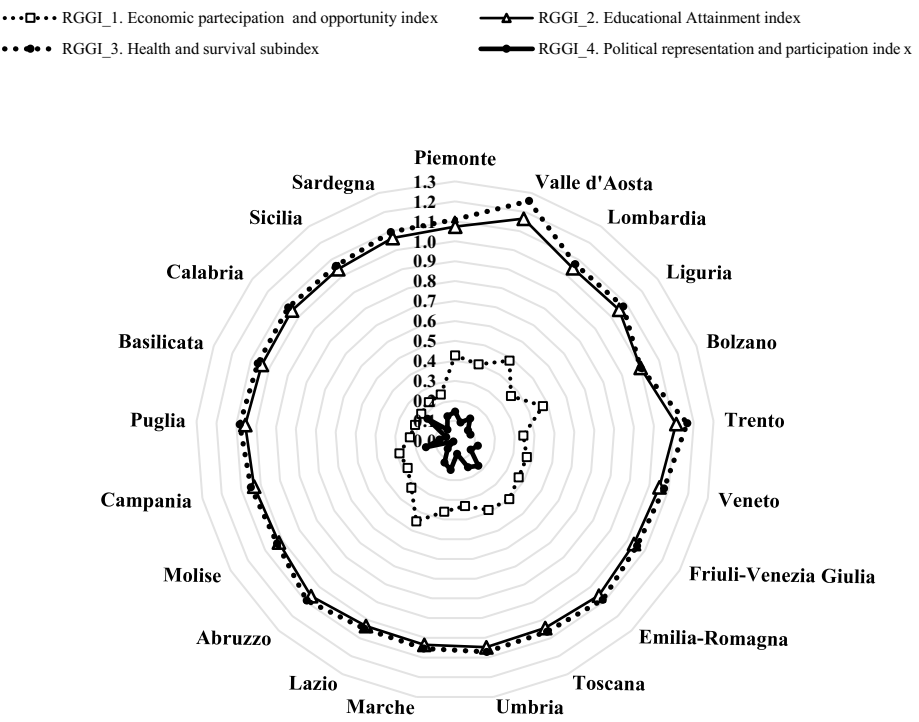

Fig. 1 Gender Global Index and its sub-indices calculated at different levels of regionality. Note. Data about female political empowerment were not available in Trento**.** In calculating our Regional Global Gender Gaps Index (RGGGI), we did not employ any equality benchmark to show gender differences also when they are in favor of women. *Source*: Our elaboration on ISTAT data, 2018. Data retrieved from www.dati.istat.it in February 2020

at different levels of regionality. Previous literature showed that the more traditional the gender attitudes, the larger the gender gaps (for studies carried out in Italy, see for example Campa et al., 2011; Casarico & Profeta, 2015). Therefore, investigating the association between gender attitudes and eRGGI is part of our validation process because a possible (positive) association between gender inequality and more traditional gender attitudes could be taken as a confirmation of the eRGGI's external validity (Di Noia, 2002).

4 Results

In this section, we investigate the contribution of old and new indicators to the measurement of gender equality in Italy which we then validate.

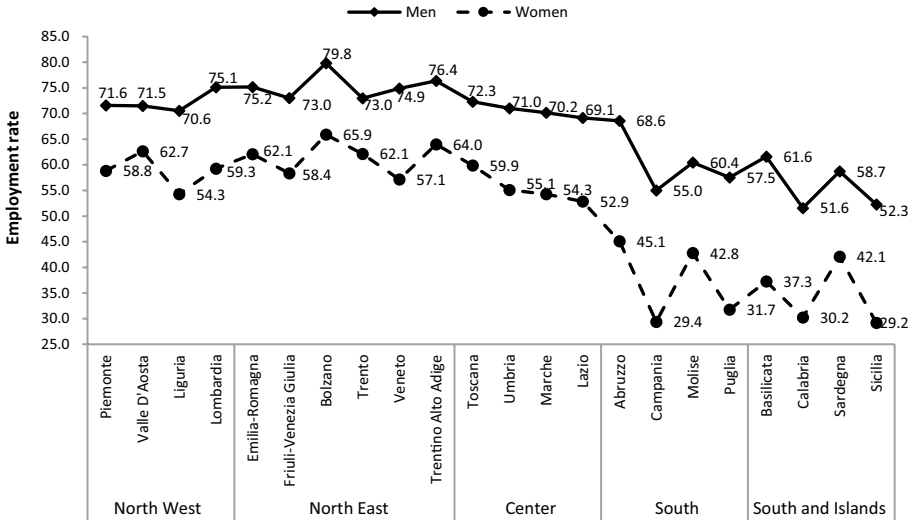

Fig. 2 Employment rate by gender, region, and macro-geographical area. *Source*: Labor force survey (ISTAT, 2018). Data retrieved from www.dati.istat.it in February 2020

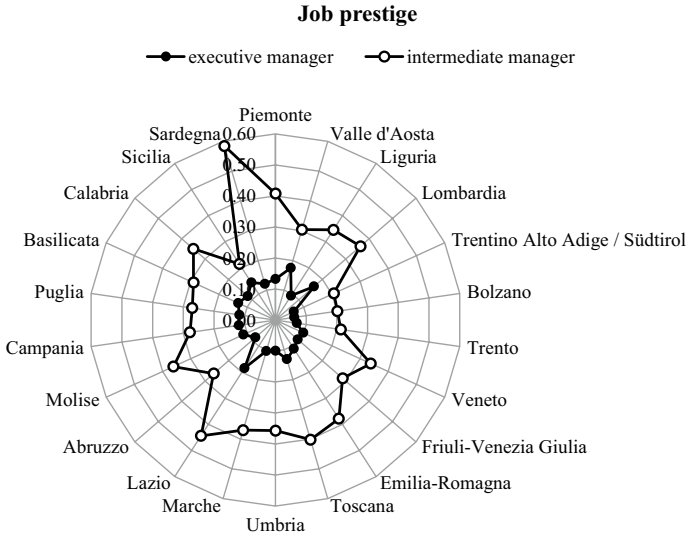

Fig. 3 Proportion of women over men in leading positions, by region. *Source*. Labor force survey (ISTAT, 2018). Data retrieved from www.dati.istat.it in February 2020

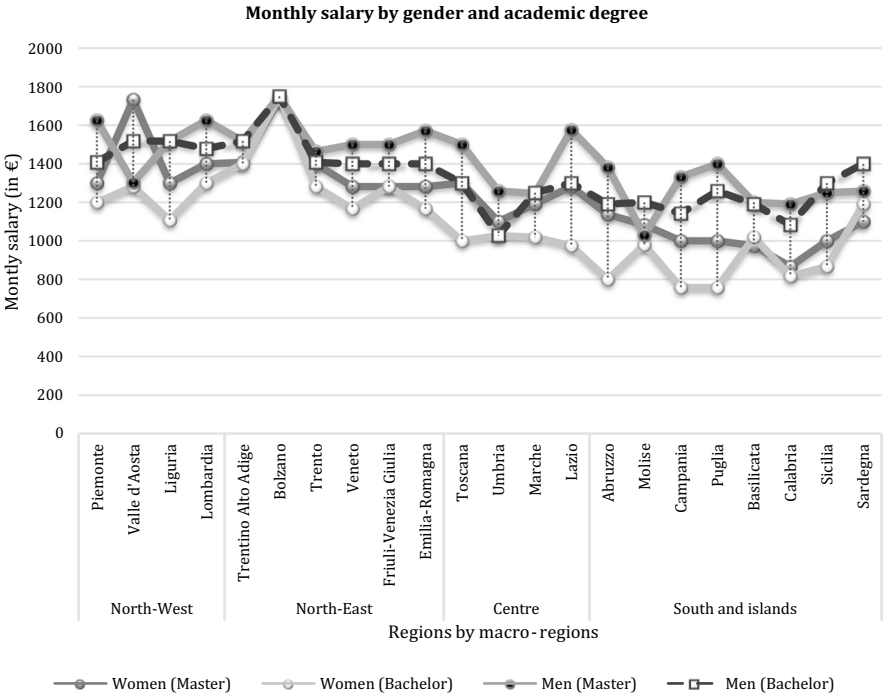

Fig. 4 Gender pay gap in the private sector by gender, education, region and macro-region. *Source*. Annual register on earnings, working hours and labor cost for persons and enterprises (RACLI), 2015 (Data retrieved from www.dati.istat.it in February 2020)

4.1 Old Indicators of Gender Equality

First, we focus on the indicators use to construct the Global Gender Gap Index, as they are the most frequently used to measure gender equality.[7] The radial graph in Fig. 1 reports on the GGGI calculated at regional level in Italy.

Figure 1 shows that, in most of the Italian regions, there are no gender differences in Health and Education where women outperform men, with two exceptions (i.e., Valle D'Aosta and Trento, in northern Italy). This is consistent with previous studies in Europe (Bericat, 2012; Branisa et al., 2009, 2013; Plantenga et al., 2009) claiming that both Education and Health cannot actually contribute much to the measurement of gender equality in more developed countries, where exclusion and deprivation do not indicate an actual material deprivation as in developing countries. In developed European countries—like Italy—it is less expected to find very significant gender differences in primary or lower intermediate school enrolments, or in access to healthcare treatment, life expectancy, or even in sex ratio at birth due to birth control policies, for example.

[7] For the list of indicators used in previous studies, see the Supplementary Material.

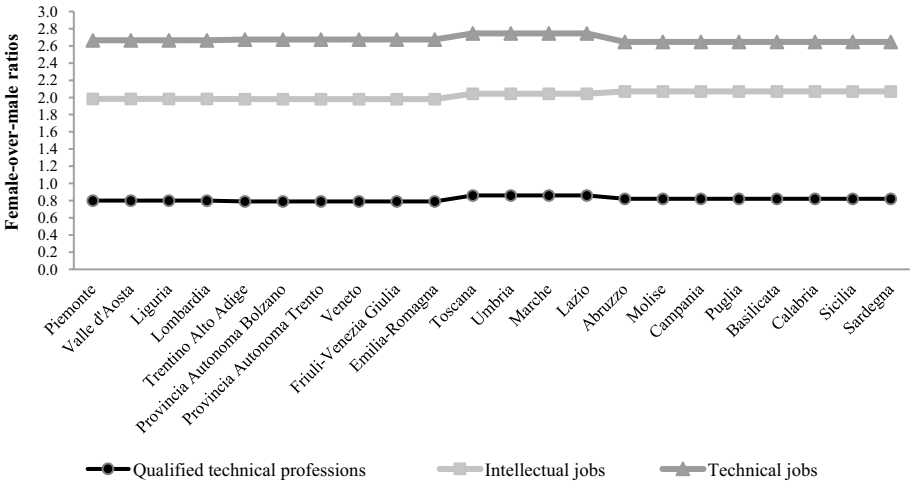

Fig. 5 Proportion of women over men in (i) qualified technical professions, (ii) intellectual jobs, and (iii) technical jobs, by region. *Source*. Labor force survey (ISTAT, 2018). Data retrieved from www.dati.istat.it on the 12th Februrary 2020

Figure 1 also shows that, consistently with the international trend, female-over-male participation in politics is close to zero in all regions. Most of the Italian regions have never been led by a woman as president, and the proportion of female members of the executive board significantly favors men in all regions, with a few exceptions at municipal level where the proportion of women-over-men is slightly bigger.[8]

In contrast, most of the other indicators of GGGI sharply vary by region. The sharpest difference is in the female-over-male employment rate (and the differences also shown with Fig. 2): albeit *all* Italian regions are far from gender parity, the gap between men and women is much sharper in the South than in the North. This is concerning, as the employment rate is much lower in southern than in northern Italy suggesting that women living in the South are more likely to experience poverty or deprivation compared to women living in the North. This demands further investigation which we address by including more information about the type of employment contract (fixed term/permanent, part-time/full-time, see next section).

Sharp gender differences are also disclosed when we account for leading, professional and technical positions. Figure 3 shows that the proportion of women in leading positions in private firms (executive manager) compared with men is close to zero, with a few exceptions in northern Italy (i.e., in Valle d'Aosta and in Lombardia, that is the heart of Italian economy) and in Lazio, the region hosting Roma, the capital city.

Even though female wages, on average, have increased over time (ISTAT, 2018, 2019), women are still largely disadvantaged compared to men in relation to wage as shown in Fig. 4 that shows how female disadvantage interplays with wage differences across regions.

[8] Data about the presence of women as political leader in the municipal assemblies are collected by the national Italian association for Italian municipalities (Tr. Associazione Nazionale Comuni Italiani, ANCI), and are available at http://www.anci.it/la-mappa-dei-comuni-amministrati-da-sindaci-donne-negli-ultimi-30-anni/

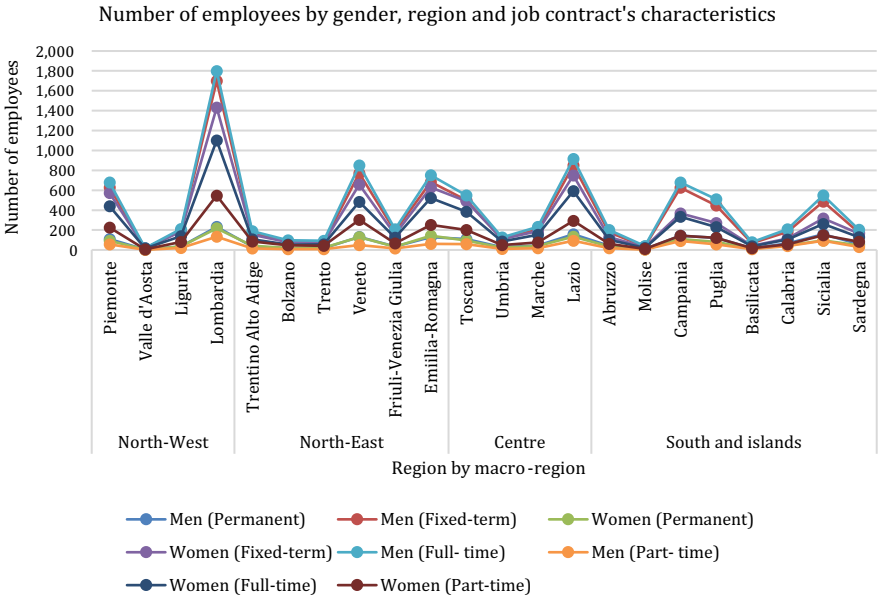

Fig. 6 Number of employees with part-time/full-time, fixed- term or permanent job, by gender and region of residence. Source: Data retrieved from www.dati.istat.it on the 16th April 2021

Table 4 Proportion of women over men employed with different contracts (female-over-male ratio)

	Permanent + Full-time job	Permanent + Part-time job	Fixed-term + full-time job	Fixed-term + part-time job
North West	0.618	5.613	0.694	2.193
North East	0.610	7.359	0.711	2.498
Centre	0.666	4.163	0.627	2.051
South and islands	0.496	2.093	0.51	1.617

Information provided by ISTAT about the combination of part-time/full-time and permanent/fixed-term job is not yet available for all regions. It is already available just at macro-regional level (i.e. North-West, North-East, Centre, South and islands). *Source*. Labor force survey (ISTAT, 2018). Data retrieved from www.dati.istat.it on the 12th February 2020

This information is important to understand the real gender pay gap because, in the South, even small differences between male and female wages can cause significant levels of vulnerability for women and often implies the exit of women from the job market.

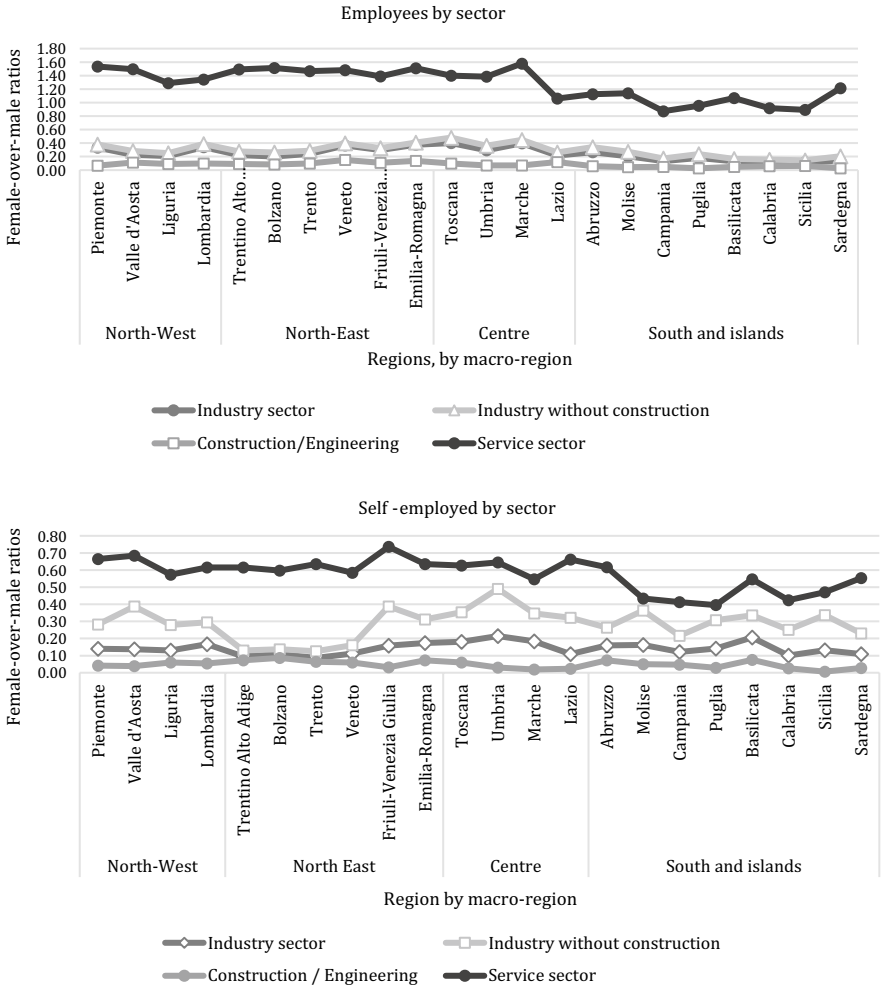

Fig. 7 Female and male employees and by self-employed sector, and by region. *Source*: Labor force survey (ISTAT, 2018). Data retrieved from www.dati.istat.it in February 2020

According to data from RACLI in 2015,[9] a gender pay gap exists in all sectors, even though in some, such as qualified technical professions, the gender gap has been almost closed, or in intellectual (e.g., teachers and white-collar) and technical jobs, in relation to which the number of women is relatively higher than the number of men (Fig. 5).

In summary, results presented so far showed that (i) the indicators used to measure Health and Survival do not actually contribute much to the measurement of gender equality as they are based on indicators like sex birth ratio and access to public health that do

[9] More information about the survey and the data collected by RACLI is available online at http://dati.istat.it/Index.aspx?lang=en&SubSessionId=1a692c53-9733-41fd-9c7e-0f2c4bc494b7.

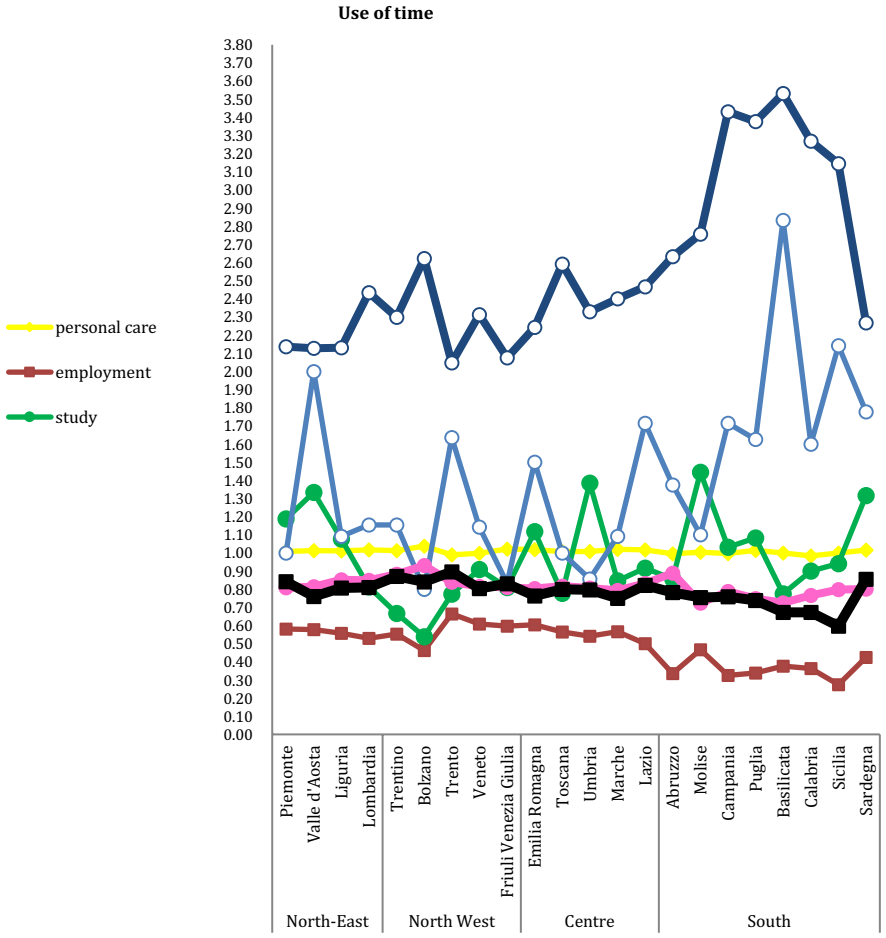

Fig. 8 Female-over-male ratios in the use of time, by region. *Source*. Data from 'Multipurpose survey on households: time use', ISTAT, 2013 (*Note*: More information about the survey is available online at http://dati.istat.it/?lang=en&SubSessionId=37e8372c-0ae5-4caf-8506-28d55b02770e)

not vary much regionally in a developed country like Italy; (ii) the gender gap in politics is huge but the indicators used to measure this sub-dimension do not show any significant differences between the national and the regional levels or any significant variability across regions; in contrast, (iii) female participation in economics significantly varies across regions thus suggesting caution in interpreting and using results based on nationally aggregated data; and finally, (iv) indicators used to measure gender gaps in education need to be revised in Italy where both males and females have (at least, formally) equal right to access all grades of education.

Table 5 Female and male literacy in 'Reading and Text Comprehension' and Mathematics, at different grades throughout compulsory education

	Grade 2			Grade 5	
	Italian	Mathematics		Italian	Mathematics
Males	199.00	203.00	Males	198.00	204.00
Females	201.00	198.00	Females	203.00	196.00
Difference	2	−5	*Difference*	5	−8
Relative difference	*0.010*	*−0.025*	*Relative difference*	*0.025*	*−0.041*
	Grade 8			Grade 10	
	Italian	Mathematics		Italian	Mathematics
Males	194.00	204.00	Males	194.00	204.00
Females	206.00	197.00	Females	207.00	195.00
Difference	12	−7	*Difference*	13	−9
Relative difference	*0.058*	*−0.036*	*Relative difference*	*0.063*	*−0.046*

Test scores have been estimated via the Rasch model and then linearly transformed into a scale with mean 200 and standard deviation 40. *Source*: our adaptation from INVALSI (2019, 62)

4.2 New Indicators and Their Contribution to the Measurement of Gender Equality

In this section, we present results with new indicators and dimensions that, in line with previous literature, we claim may be able to capture new, significant or even critical aspects of gender equality as shown in Table 2 and Table 3 for Italy.

4.2.1 Economic Participation and Opportunity

Since the characteristics of job contracts can significantly affect people's economic independence and stability, we included information about the job contract, i.e. part-time or full-time and permanent or fixed-term (Fig. 6).

Data from ISTAT showed that the proportion of women with both a permanent and part-time job is 6, 7, 4 and 2 times bigger than the proportion of men with the same contract in the North-West, the North-East, the Center, and the South respectively (Table 4). Moreover, the proportion of women with a part-time job is always bigger than the proportion of men, even among persons with fixed-term contracts. Results in Table 4 show that the number of women with a part-time job is much higher than that of men, especially when they have a permanent job. This is true in all macro-regions with slight differences across them. Such a result is not surprising as part-time work can be more easily combined with family life: according to ISTAT (2019), looking after home and children is still considered a female duty and the woman is expected to find a strategy to combine time for job and time for life outside work.

In order to really understand female participation and opportunity compared to men, we propose to include ratio of employed and self-employed men and women in different economic sectors, by region. Figure 7 shows the proportion of male and female employees in four economic sectors compared to the proportion of self-employed in the same sectors

Table 6 Female-over-male ratio in HE enrolment by subject and region

Region	Chemistry and Farmacy	Geo-biology	Engineering	Architecture	Agricultural science	Economics and Statistics	Medicine	Political and social sciences	Law	Languages	Teaching	Poetry and Literature	Physical education
Liguria	2.0	1.4	0.3	1.4	1.4	0.9	1.9	1.5	1.4	5.0	7.7	1.7	0.7
Bolzano	1.2	1.0	0.2	1.1	0.6	0.9	3.8	2.0	1.2	5.5	9.4	1.5	0.5
Valle d'Aosta	1.3	1.2	0.2	0.8	1.0	1.2	1.8	1.7	1.2	4.9	10.5	1.8	0.3
Lombardia	1.7	1.5	0.2	0.9	8.1	0.9	1.8	1.8	1.6	5.3	9.5	1.9	0.4
Piemonte	1.7	1.5	0.3	1.0	15.9	0.9	1.9	1.8	1.6	5.0	9.6	1.8	0.4
Emilia-Romagna	2.0	1.5	0.3	1.1	24.7	0.9	1.8	1.7	1.6	5.0	9.8	2.0	0.5
Trentino Alto Adige	1.6	1.2	0.2	0.9	0.6	1.0	2.7	2.0	1.5	5.5	11.3	2.1	0.6
Friuli-Venezia Giulia	1.9	1.1	0.2	1.1	1.5	1.0	1.9	1.7	1.6	4.5	14.3	1.8	0.7
Trento	1.8	1.2	0.2	0.9	0.5	1.0	2.3	2.0	1.6	5.5	14.8	2.3	0.6
Veneto	1.7	1.2	0.2	0.8	12.6	1.0	1.8	1.9	1.6	4.6	11.6	2.0	0.7
Lazio	1.9	1.8	0.3	1.2	1.1	0.8	1.7	1.3	1.5	4.3	11.2	2.2	0.4
Umbria	2.3	1.8	0.3	1.1	1.0	1.0	1.7	1.4	1.7	4.5	10.9	2.3	0.4
Marche	2.0	1.5	0.2	1.0	1.0	1.0	1.7	1.5	1.7	3.9	17.6	2.2	0.5
Toscana	1.8	1.4	0.2	1.0	16.5	0.9	1.7	1.6	1.6	5.0	12.1	1.9	0.5
Abruzzo	2.2	1.7	0.3	1.0	1.2	1.0	1.7	1.9	1.7	4.2	14.3	2.4	0.7
Molise	2.4	1.9	0.3	0.8	0.9	0.9	1.5	2.5	1.8	6.8	18.1	2.7	0.6
Puglia	2.2	2.4	0.3	1.0	7.3	0.9	1.5	1.6	1.5	4.8	15.6	2.8	0.6
Campania	2.2	2.7	0.3	1.0	9.0	0.9	1.2	1.8	1.5	5.6	19.0	3.0	0.5
Sardegna	2.4	1.8	0.4	0.9	1.0	1.2	2.0	1.9	1.9	4.3	12.0	2.3	0.7
Basilicata	2.5	2.4	0.4	1.3	1.0	1.0	1.5	1.8	1.8	5.3	11.7	2.8	0.4

Table 6 (continued)

Region	Chemistry and Farmacy	Geo-biology	Engineering	Architecture	Agricultural science	Economics and Statistics	Medicine	Political and social sciences	Law	Languages	Teaching	Poetry and Literature	Physical education
Sicilia	1.9	1.8	0.2	0.9	5.1	0.9	1.2	2.1	1.6	5.3	14.2	2.6	0.7
Calabria	2.5	2.0	0.4	1.0	0.7	1.0	1.4	1.8	1.9	5.9	11.5	2.4	0.4

Source: our elaboration on data provided by the Italian Ministry of Education. Data are available online at https://anagrafe.miur.it/index.php

(three of them, i.e. industry, construction, and engineering, traditionally male dominated, where the biggest female-over-male ratio – in central and northern Italy—is less than 0.5). In all male dominated sectors, the proportion of self-employed women is lower than the proportion of employed women compared to men in the same sectors, suggesting that starting a private enterprise is a typical male activity.

4.2.2 Use of Time

The use of time is somehow complementary to gender differences shown so far. The female-over-male ratio calculated in relation to time spent for leisure or travelling is close to zero in all macro-regions; whereas the percentage of time spent by women in looking after home and children is much bigger than that spent by men, especially in southern Italy where, for example, the female-over-male ratio calculated for domestic work equals 4.5 (Fig. 8). In contrast, women spend more time than men in studying, especially in southern Italy. Such a result is consistent with previous studies showing that women's enrolment in HE is higher—especially in scientific topics—where the job market is stagnant and the unemployment rate is high (Ma, 2009), as it is in southern Italy.

4.2.3 Education

As shown, enrolment rates are not helpful to measure gender inequality in Italy. Instead, we included female-over-male literacy in 'Reading and Text Comprehension' and in Mathematics in primary, lower intermediate, and secondary school. In this regard, gender differences were calculated as the difference between female and male performance divided by female attainment, as measured via the Rasch model (Rasch, 1960): positive ratio in Table 5 indicates a difference favoring girls whereas a negative difference indicates a difference favoring boys.

Gender differences are statistically significant but small (INVALSI, 2019), and with strong variations across regions, especially in mathematics and at the top of the attainment distribution (e.g., Nollenberger et al., 2016; OECD, 2018; Rodríguez-Planas & Nollenberger, 2018), and so stronger in Northern Italy where performance is above the national mean (Cascella, Pampaka, & Williams, 2018; Cascella et al., 2021). Such regional differences are interesting for the purposes of the present study. However, their interpretation is not straightforward. For instance, the gap between boys and girls appears smaller where overall attainment is low. Does this mean that female disadvantage in these areas (where the overall attainment is low) is a matter of lower concern compared with female disadvantage observed in geographical areas where attainment is higher? The absolute gender difference in mathematics attainment is lower in the regions where the overall attainment is low, but this may indicate that girls do not reach the levels of competence necessary to exert an active citizenship rather than indicating smaller gender differences in mathematics. In this regard, Italy, with its sharp differences in educational attainment across regions, makes a very interesting case study (INVALSI, 2019; Organisation for Economic Co-operation & Development, 2019) and, therefore, answering this question requires much more in-depth investigation than a simple difference between male and female performance (e.g., Cascella et al., 2021).

In addition to gender differences at school, as suggested by Bericat (2012), we calculated the relative participation of women in HE, in different academic sectors (Science, Technology, Engineering; and Mathematics; Medicine; Humanities, e.g. History, Philosophy,

Table 7 Reliability analysis based on all the items used to construct eRGGI

Cronbach's α = 0.319 Cronbach's α based on standardized items = 0.840	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Gender segregation in Social Sciences and Humanities	−0.792	0.481
Gender segregation in STEM	−0.250	0.331
Executive managers	0.091	0.318
Intermediate managers	0.148	0.313
Employment rate	0.852	0.273
Gender pay gap	0.811	0.313
Qualified technical jobs	−0.533	0.324
Intellectual jobs	−0.886	0.333
Technical jobs	0.893	0.293
Permanent full time	0.799	0.292
Permanent part time	0.708	0.346
Fixed term full time	0.958	0.274
Fixed term part time	0.962	0.134
Employees industry	0.755	0.282
Employees construction	0.862	0.303
Employees service sector	0.832	0.214
Employees service	0.832	0.214
Self employed industry	0.122	0.317
Self employed industry without construction	0.084	0.316
Self employed construction	0.226	0.317
Self employed service	0.727	0.281
Time personal care	0.518	0.316
Time employment	0.911	0.266
Time study	−0.074	0.328
Time housework	−0.819	0.508
Time voluntary	−0.532	0.449
Time leisure	0.334	0.312
Time social life	0.620	0.283
Time sport	0.505	0.300
Time hobbies	0.059	0.316
Time mass media	−0.282	0.325
Time travel	0.449	0.304
Senior officials leadership positions	0.080	0.318
Majors	0.724	0.245
President regions	0.527	0.307
Assessors city council	0.194	0.297

Teaching).[10] Data reported in Table 6 shows no strong gender differences in most of the academic sectors, with a few exceptions showing clear gender segregation, such as the proportion of women enrolling in engineering compared to men—that is very close to zero, in

[10] In this paper, we used the classification proposed by UNESCO. For further information, please see http://data.uis.unesco.org/index.aspx?queryid=165.

Table 8 Reliability analysis for sub-dimension 1 (i.e., economic participation and opportunity)

Cronbach's α = 0.517 Cronbach's α based on standarized items = 0.833	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Employment rate	0.883	0.487
Gender pay gap	0.836	0.517
Qualified technical jobs	− 0.614	0.526
Intellectual jobs	− 0.908	0.531
Technical jobs	0.929	0.502
Permanent full time	0.830	0.502
Permanent part time	0.935	0.809
Fixed term full time	0.984	0.488
Fixed term part time	0.994	0.380
Employees industry	0.654	0.500
Employees service sector	0.855	0.446
Self employed industry without construction	− 0.306	0.530
Self employed service	0.750	0.495

Table 9 Reliability analysis for 'Political Power and Leadership' sub-dimension

Cronbach's α = 0.510 Cronbach's α based on standarized items = 0.594	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Senior officials leadership positions	0.122	0.511
Majors	0.448	0.367
President regions	0.600	0.446
Assessors city council	0.233	0.571
Executive managers	0.123	0.511
Intermediate managers	0.476	0.423
Self employed industry	− 0.136	0.530
Self employed construction	0.013	0.518
Self employed service	0.466	0.407

Italy and globally (Organization for Economic Cooperation & Developement, 2019)—or the proportion of women in Teaching compared to men– that is at least 7 times bigger in southern compared to northern Italy.

4.3 Validity and Reliability of the New Measure

4.3.1 Reliability Analysis

Before presenting our eRGGI, we investigate its reliability and internal consistency with Cronbach's α (Cronbach & Meehl, 1955).

For the overall scale, the Cronbach's α is 0.319 (Table 7), and thus does not provide strong evidence of internal consistency. The Cronbach's Alpha, calculated if the item is

Table 10 Reliability analysis for "use of Time" sub-dimension

Cronbach's α = − 0.901 Cronbach's α based on standarized items = 0.271	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Time personal care	− 0.371	− 0.878[a]
Time employment	− 0.723	− 0.422[a]
Time study	− 0.222	− 0.698[a]
Time housework	− 0.246	− 0.933[a]
Time voluntary	0.091	− 5.110[a]
Time leisure	− 0.441	− 0.762[a]
Time social life	− 0.563	− 0.530[a]
Time sport	− 0.595	− 0.551[a]
Time hobbies	− 0.261	− 0.729[a]
Time mass media	− 0.145	− 0.872[a]
Time travel	− 0.611	− 0.630[a]

[a] the negative value is due to a negative averaged covariance between items

deleted, is lower than 0.319, with a few exceptions highlighted in grey, which helped us to identify possible items to delete to improve internal consistency. The corrected item-total correlation (in the penultimate column) is used to define the association of each item with the total score on the other items: this shows some moderate to strong correlations between most of the items and the total score on the other items that may be taken as evidence in support of overall internal consistency.

An iterative procedure—based on the results reported in Table 7—may be used to improve internal consistency. Nonetheless, we acknowledge that gender equality is a multi-dimensional concept (Constantin & Voicu, 2015), thus considering the items' content and their conceptual contribution to the measurement of gender equality—as discussed in previous sections—we decided to follow a confirmatory—rather than a merely statistically exploratory approach—by investigating the internal consistency of each sub-dimension identified in light of previous studies (see systematic review) presented in Tables 1 and 2.

For the first sub-dimension (i.e., economic participation and opportunity), Cronbach's α shows good internal consistency (0.517) and all selected indicators effectively contribute to such consistency with just a few exceptions (highlighted in grey) (Table 8). Internal consistency without these items is higher (i.e. 0.554). Moreover, previous studies have pointed out that low internal consistency is not unexpected with a wide range of items, but it could be "adequate for obtaining an approximation of the relative status of women in each state" (Yllo, 1984, 312).

In line with Bericat's methodological strategy (2012), we thus moved those items into the "Political Power and Leadership" sub-dimension (Table 8). Such a decision increased the internal consistency of both the 'Political power and leadership' and the 'Economic participation and opportunity' sub-dimensions (Table 9).

For the 'Political power and leadership' sub-dimension, Cronbach's alpha is 0.51. Such a value may depend on the number of indicators: all other things being equal, the higher the number, the higher the Cronbach's α. Therefore, since, for this sub-scale, we have less than 10 items, 0.50 can be considered sufficient according to Briggs and Cheek's (1986) recommendations of optimal ranges of 0.2 to 0.4 for the inter-item correlation (Pallant, 2011, 97). Moreover, these values increase if we exclude female over male ratio of assessors in

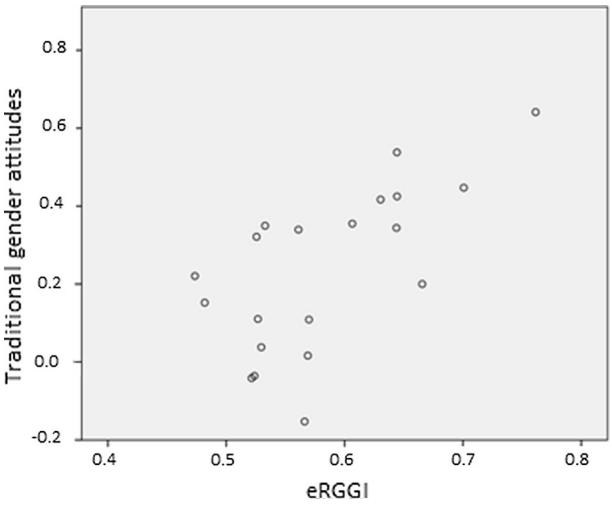

Fig. 9 The covariation of gender attitudes and eRGGI between the Italian regions. *Note*. Values equal 1 indicate complete gender equality; values lower than 1 indicate female disadvantage whereas values greater than 1 indicates female advantage compared with men

municipalities, and Cronbach's alpha then also equals 0.618. Such a result is not surprising because the proportion of women in leading positions in the Italian municipalities is close to zero whereas all the other ratios, even if always low, are higher than zero. Therefore, since Cronbach's alpha assumes that all variables are parallel, the female-over-male ratio lies out of the other ratios' pattern. Therefore, even if including this item worsens internal reliability, such result seems to be due to the mechanism behind the alpha construction. The information provided by this item mirrors a very important aspect of gender equality and thus we decided to keep it in the scale for further analysis.

As regards 'Use of Time', we used all the indicators provided by ISTAT (2013) that include time spent for personal reasons (Table 10), time for work, time for study and time to look after home and children that we considered as three independent aspects lying under the umbrella of "Use of time" along with time spent for personal reasons. The negative values in Table 10 indicated a violation of the assumption of the Cronbach's α that is not surprising as the items in this scale are to some extent complementary: the more time spent to study, the less the time spent for leisure, and so on. The relatively higher internal consistency is achieved by combining time for personal care, leisure, social life, employment and study, whose Cronbach's α is 0.014 (that is close to zero but nonnegative and) that becomes 0.494 when it is based on standardized items). We thus used these items to calculate the eRGGI, but we did not average them into a sub-index: we calculated the female-over-male ratio in relation to the use of time for personal care, leisure, social life, employment and study; then, added them into our eRGGI without combining them into a sub-index.

Similarly, as regards education, we added just three ratios that are of the female-over-male enrolment rate in Higher Education, by academic sector: (1) scientific (STEM/MED—Science, Technology, Engineering; and Mathematics; Medicine and biology; and, (2) Social Sciences and Humanities (SSH – Social Studies, History, Law, Philosophy, Literature, Psychology, and Teaching). We observed that female-over-male ratio sharply varies across those academic sectors: therefore, averaging these indicators might result in a false mean value thus hiding existing differences. Therefore, we did not calculate any sub-index for education and thus we do not perform any reliability analysis. Similarly to the 'Use of time', we calculated

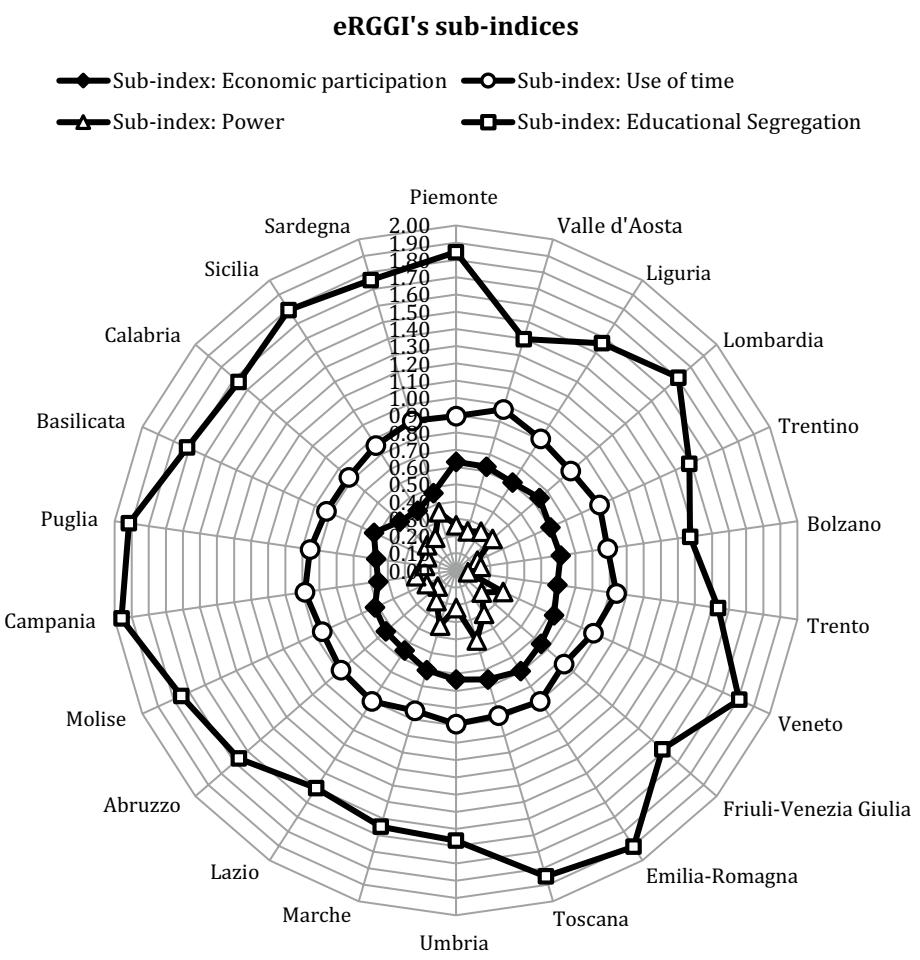

Fig. 10 Gender equality in 'Economic participation and opportunity', 'Use of time', 'Political power and leadership', and 'Educational segregation in Higher Education' by region, as calculated via our new, extended regional global gender gaps index

the female-over-male ratios in in STEM/MED and SSH; then, added them into our eRGGI without combining them into a sub-index (calculated as the average of the single ratios).

4.3.2 Gender Inequality and Gender Attitudes

Our final overall measure (eRGGI) ranges from 0 to 1 with 0 indicating full inequality against women and 1 complete gender equality; values lower than 1 indicate female disadvantage whereas values greater than 1 indicates female advantage compared with men We did not use any equality benchmark but our analysis did not disclose any region in which eRGGI was greater than 1.

We then explored the association between eRGGI and gender attitudes as measured at regional level—using the scale validated by Cascella and Pampaka (2020). Results in Fig. 9 show the distribution of gender attitudes and that of eRGGI and indicate a moderate (r = 0.421) association between the two: the higher the gender equality is, the higher the eRGGI (High scores of gender attitudes indicate people's more traditional perceptions about gender and gendered roles). Therefore, a positive association between gender attitudes and the eRGGI (and its sub-dimensions) is in line with previous studies claiming that the more traditional the gender attitudes, the larger the gender gaps are, and thus can be taken as a confirmation of the eRGGI's validity.

4.4 eRGGI: A Global Measure of Gender Equality

Figure 10 presents the eRGGI's sub-dimensions calculated by region. Results showed that women are highly underrepresented in politics and showed major room for improvement in terms of economic participation and opportunity, especially in some southern regions where women spend much more time (compared with men living in the South and both men and women living in the North) in looking after home and children. Such a result is probably due to a variety of factors, such as (i) the fragility of the welfare system in the South, especially in terms of childcare services (that are almost absent in most of the southern regions); (ii) the fragility of the job market that, in the South, is characterised by a higher unemployment rate, temporary employment rate and lower salaries that are even lower for women than for men. In contrast the time spent for study by women in the South is higher than that spent by women in the North, as also confirmed by the data reported above that show a gender gap in HE in favor of women, in southern more than in northern Italy. Finally, compared with the GGGI calculated at regional level (Fig. 1), the graph in Fig. 10 shows larger variability between regions of the eRGGI and of the indicators we proposed to develop it, also showing dimensions where gender gaps were in favor of women thus accounting for their empowerment.

5 Discussion

Gender equality is a priority of the international agenda, a goal listed by the United Nations along with another seven global 'Millennium Development Goals'. The number of indices and scales aimed to measure gender equality has increased over time to provide empirical evidence useful to inform policy and practice. Such measures have also been widely used in a number of different studies aiming to understand, for example, family structure and processes (Budig et al., 2012; M. Cunningham, 2008; Farré & Vella, 2013), the division of homework (Braun, 2008; Carlson & Lynch, 2013; Voicu et al., 2009), female disadvantage in the economic participation and, in particular, in the job market (Campa et al., 2011) or in politics (Dilli et al., 2015, 2019; Rijpma & Carmichael, 2016), or even gender equality in education (Gonzalez de San Roman & De la Rica, 2016; Guiso et al., 2008; Ireson, 2017; Lelleri et al., 2017; Nollenberger et al., 2016; Stoet & Geary, 2015, 2018).

In this paper, we systematically reviewed published measures of gender equality to understand and to discuss their differences. As the discussion on gender equality has received less attention in developed than in developing countries (Martínez Peinado & Cairó Céspedes, 2004), we focused on the indices (and the indicators) used to measure gender equality in developed countries. In line with previous literature (e.g., Bericat, 2012; Permanyer, 2013),

we claim that indicators used to measure gender equality in developing countries may not be appropriate for developed countries. This raises concerns about (i) the validity of indices constructed to measure gender equality in both developed and developing countries; and, (ii) their (frequent) use in subsequent studies. In order to demonstrate the consequential validity and/or application usefulness of our extended Regional Global Gender Gaps index (eRGGI), it was compared to the Global Gender Gap index (GGGI), developed by Haussman et al. (2006) for the World Economic Forum (Fig. 1) at regional level. As shown by our systematic review, GGGI includes most of the most frequently used indicators to measure other gender equality index. Therefore, contrasting our eRGGI with the GGGI calculated at regional level could imply similar differences with other existing measures of gender equality.

The results showed that Health and Surveillance and Educational Attainment in primary and secondary school cannot contribute much to measure gender equality in developed countries (as they deal with areas of basic exclusion and poverty). Such a result is consistent with previous studies claiming that "gender gaps in health and education variables have either vanished or even reversed, thus questioning their appropriateness to capture women's disadvantage in Europe and inviting to construct region-specific measures" (Permanyer, 2013, 946–947).

We thus added other indicators to reveal gender segregation in education and, in particular, in Higher Education. Results revealed sharp gender segregation in HE both in STEM (with a very low number of women enrolling for example engineering) and in Social Sciences and Humanities (with a significantly larger number of women choosing for example didactics, especially in southern Italy). Such a result is consistent with international evidence (OECD, 2019) and is not surprising in a country like Italy where, especially in southern Italy, the 'Men bread-winner and woman home-maker' model (Pfau-Effinger, 2004) is still dominant: teachers can prepare lectures and teaching materials from home, which fits better other domestic activities like taking care of home and children (Addabbo & Favaro, 2011; Addabbo et al., 2015; Anxo et al., 2011; Cascella & Pampaka, 2020; Del Bono & Vuri, 2011; ISTAT, 2013; Mussida & Picchio, 2014).

Our analysis showed a moderate association between those gaps and people's attitudes towards gender equality, by region, via EVS data, consistently with previous literature (Scarborough & Risman, 2018) claiming that gender inequality is not perpetuated exclusively through differential access to and control over material resources: gender norms and stereotypes reinforce gendered identities and constrain the behavior of women and men in ways that lead to inequality. The association between gender attitudes and gender equality indices implies that more culturally traditional environments are typically associated with sharper gender gaps in favor of males (e.g., Campa et al., 2011) and explains for example why, even within couples with both partners employed, the proportion of time spent by women in looking after home and children is significantly higher than that spent by men in the south compared with that observed in central and northern Italy.

The validation, in addition was explored through the substantive analysis of the relation between inequality (objectively measured with the eRGGI) and perceptions; the results showed a (moderate) association between gender attitudes and gender inequality, in line with previous studies (Arpino et al., 2015; Cunningham, 2008; Fortin, 2005). Such results are not only of substantive value and useful to effectively inform policy and practice, but also add credibility to the validity of measurement for such tasks.

Family is a cultural institution that affects gender outcomes and it also makes contributions to the intergenerational transmission of gender attitudes. In this regard, for example, Duranton et al. (2009), using the Emmanuel Todd's classification of medieval European family systems, found that family types influenced European regional disparities in household size, educational attainment, social capital, labor participation, sectorial structure,

wealth, and inequality and concluded that "these links remain, despite the influence of the modern state and population migration, suggests that such structures are either extremely resilient or in the past were internalized within other social and economic institutions as they developed" (ibid, 23). Similarly, Bertocchi and Bozzano (2015) – using data on school enrolment by gender across 69 Italian provinces over twenty-years covering the 1861–1901 period – showed that family structure can explain gender gaps in educational attainment, even in compulsory primary school.

6 Conclusion

In this paper, a new gender equality index for use in comparisons and investigations at regional level has been developed, consistent with those previously used in international comparisons, but which has been validated here at regional level using empirical data for Italy.

Our results showed a granularity in the distribution of both gender attitudes and gender equality across regions (with some very traditional and less gender-equal regions in the North and some more modern and more gender-equal regions in the South) that cannot be ignored to deeply understand gender differences and properly inform both policy and future research.

Nonetheless, in interpreting the results reported in this paper, the reader can consider Italy not (only) as a *special* case. In this study, our results confirmed that gender attitudes are associated with gender inequality which is in accordance with existing evidence Recent studies (Authors, under review) have shown that gender attitudes significantly vary across regions in *all* European countries, and that the variability across regions is larger than that between countries. Therefore, if gender gaps are associated with gender attitudes (as our results suggest), then more caution in interpreting and using results only based on nationally aggregated data (both in Italy and in other countries) is necessary not only to properly inform policy and practice but also to better interpret and understand (e.g., social, economic, politic and/or educational) phenomena for which gender inequality is used as an explanation variable.

We have shown why it is necessary to, and how to develop and validate such a new gender equality index in the case of Italy and what its effect is in comparison with the GGGI. The Italian data used of course cannot be used in other countries but in many developed countries similar national data sets exist that researchers might use to construct relevant and regionally sensitive indices, such as the eRGGI.

Appendix 1

See Table 11.

The table below reports on the list of indicators used by Authors (2020) to develop a gender attitude scale at different levels of regionality, in Italy. Moreover, it reports on the original EVS coding and the scoring used to analyse EVS data.

Table 11 EVS items, their original response option and the current coding

Item in full	Item number and code	EVS original response options	Current scoring
When jobs are scarce, men have more right to a job than women	v103 (Q21B)	1 = *agree*	1
		2 = *disagree*	3
		3 = *neither agree nor disagree*	2
		− 1 = *I do not know*	Missing
		− 2 = *missing*	Missing
A man has to have children in order to be fulfilled	v152 (Q47A)	1 = *agree strongly*	5
		2 = *agree*	4
		3 = *neither agree nor disagree*	3
		4 = *disagree*	2
		5 = *disagree strongly*	1
		− 1 = *I do not know*	Missing
		− 2 = *missing*	Missing
A pre-school child is likely to suffer if his or her mother works (in 2008)	v160 (Q48B)	1 = *agree strongly*	1
		2 = *agree*	2
		3 = *disagree*	3
		4 = *disagree strongly*	4
		− 1 = *I do not know*	Missing
		− 2 = *missing*	Missing
A job is alright but what most women really want is a home and children	v161 (Q48C)	1 = *agree strongly*	1
		2 = *agree*	2
		3 = *disagree*	3
		4 = *disagree strongly*	4
		− 1 = *I do not know*	Missing
		− 2 = *missing*	Missing

Table 11 (continued)

Item in full	Item number and code	EVS original response options	Current scoring
Being a housewife is just as fulfilling as working for pay	v162 (Q48D)	1 = *agree strongly*	1
		2 = *agree*	2
		3 = *disagree*	3
		4 = *disagree strongly*	4
		− 1 = *I do not know*	Missing
		− 2 = *missing*	Missing
If a woman wants to have a child as a single parent, but she does not want to have a stable relationship with a man, do you approve or disapprove?	v151 (Q46)	1 = *approve*	3
		2 = *disapprove*	1
		3 = *depends*	2
		− 1 = *I do not know*	Missing
		− 2 = *missing*	Missing
Homosexual couples should be able to adopt children	v154 (Q47B)	1 = *agree strongly*	5
		2 = *agree*	4
		3 = *neither agree nor disagree*	3
		4 = *disagree*	2
		5 = *disagree strongly*	1
		− 1 = *I do not know*	Missing
		− 2 = *missing*	Missing

Table 11 (continued)

Item in full	Item number and code	EVS original response options	Current scoring
It is alright for two people to live together without getting married	v155 (Q47D)	1 = *agree strongly*	5
		2 = *agree*	4
		3 = *neither agree nor disagree*	3
		4 = *disagree*	2
		5 = *disagree strongly*	1
		− 1 = *I do not know*	Missing
		− 2 = *missing*	Missing
A working mother can establish just as warm and secure a relationship with her children as a mother who does not work	V159 (Q48A)	1 = *agree strongly*	4
		2 = *agree*	3
		3 = *disagree*	2
		4 = *disagree strongly*	1
		− 1 = *I do not know*	Missing
		− 2 = *missing*	Missing
Both husband and wife should contribution to household income	v164 (Q48F)	1 = *agree strongly*	4
		2 = *agree*	3
		3 = *disagree*	2
		4 = *disagree strongly*	1
		− 1 = *I do not know*	Missing
		− 2 = *missing*	Missing

Table 11 (continued)

Item in full	Item number and code	EVS original response options	Current scoring
In general, fathers are as well suited to looking after their children as mothers	v165 (Q48G)	1 = *agree strongly*	4
		2 = *agree*	3
		3 = *disagree*	2
		4 = *disagree strongly*	1
		− 1 = *I do not know*	Missing
		− 2 = *missing*	Missing
Men should take as much responsibility as women for the home and children	v166 (Q48H)	1 = *agree strongly*	4
		2 = *agree*	3
		3 = *disagree*	2
		4 = *disagree strongly*	1
		− 1 = *I do not know*	Missing
		− 2 = *missing*	Missing

Source: our adaptation from EVS questionnaire (2008)

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