Chapter 7
A Robust Approach to Composite Indicators Exploiting Interval Data: The Interval-Valued Global Gender Gap Index (IGGGI)

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Abstract Gender equality is a pillar of the sustainable development agenda. Women empowerment and gender mainstreaming are the bases of sound gender policies, especially in countries where greater gender gaps are observed, e.g. rural areas. This issue becomes particularly relevant in least developed countries, where an effective regulation is compelling. It is convened that gender equality is a powerful driver of economic development and social change, especially for its capacity of facilitating entrepreneurship. The appropriate gauging of the legal, economic, social and cultural factors determining or underlying a potential gender gap is crucial to shape and define such gender policies. Thus, it turns fundamental to attribute more robust bases to measure such phenomenon. *With the scientific purpose of measuring gender gap in a more reliable way, this work aims to furnish a robust framework to compute composite indicators in the field of gender economics*. We consider the weights of the different components. Thus, we apply an interval data analysis to the World Economic Forum's Global Gender Gap Index. The results show consistent differences among the rankings of the two indexes, translatable in diverse policy implications.

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7.1 Introduction

Gender empowerment, together with poverty reduction, is today considered a core development policy strategy, to be coupled with market boosting (WB 2009; Agovino et al. 2018). Gender equality is strictly connected with rural development, since rural areas are often the places where the greater divides are observed. Two stylized facts to be spotted are that poverty affects 70% of the rural worldwide population—roughly the 55% of the global population (IFAD 2011; Agovino et al. 2018)—and that the substantial representation of gender inequality determines the relegation of women to marginal roles (Donovan et al. 2015; Agovino et al. 2018). Rural people are often the most exposed to risks, where their vulnerability is hampered from the higher dependency on agriculture trends and seasonality and are often captured in poverty traps (Gatto et al. 2016). These populations usually lack savings, basic earnings, and face food insecurity (Briganti and Gatto 2015; FAO 2017). In this framework, women are the most exposed, together with other vulnerable categories, i.e. the minorities, the poorest, and people with special needs. Poverty alleviation programs, structured through resilience policies designed with the scope to tackle vulnerability, have become necessary for the economic and social development of local communities.

Microfinancial tools can tangibly improve rural life by ensuring business and social-economic possibilities. This is often facilitated by microloans and saving programs, especially for women's entrepreneurship (Gatto 2018). Other useful tools are microinsurances, that smooth the risks of shocks through, and remittances, that provide incomes from expatriate's revenues (Gatto et al. 2016). Empirical evidences show that women are the best candidate recipient for microfinancial tools. This fact is corroborated by women's greater propensity to thrift and care of household long-term priorities (Yunus 1999). Though, the access to financial programs in rural areas is often inhibited by economic, legal and cultural barriers that create gender constraints (WEF 2013). Considering the gender constraints, gender mainstreaming in rural finance is necessary to design an inclusive rural financial sector.

The strategy to improve rural livelihoods deals on one hand with agriculture and harvesting, and on the other hand with rural non-farming economy boosting; the latter includes grassroots manufacturing, tourism, microbusinesses and local cooperatives, and organizations facilitating the local and international trade. Gender policies are paramount in agriculture: it is esteemed that equal access to productive resources would increase cropping of 30% and diminish starving people of 17% (Briganti and Gatto 2015; Gatto et al. 2016). In all the cases, women entrepreneurship emerges as a prior development strategy. Despite a strong role in the household decision making, production fields, tasks and earnings of the whole value chain, women are often inhibited in their access to many markets and phases of production.

Gender equality deserves a whole Goal within the Agenda 2030—i.e., the Sustainable Development Goal (SDG) 5. Its targets include the end of women discrimination in every country (i), the promotion and the guarantee of equal opportunities and participation to the economic activities for women (vi). At the same time, it is targeted to consider reforms that result fundamental to guarantee equality of rights to the resources, and more specifically economic resources (viii). More importantly, it is reputed necessary to consider some policies designed to promote gender equality and women empowerment (UN 2015).

The use of composite indicators to define and describe the diverse dimensions of gender gap is particularly useful for gender empowerment and policy-making sakes. The relevant question we consider is: "*Is it possible to measure robustly worldwide gender gaps, in order to promote adequate policies toward gender equality targets*"? In particular, we wonder whether it is possible to furnish a scientific contribute towards an improvement of a pivotal index dealing with gender gaps, and more specifically the Global Gender Gap Index developed by the World Economic Forum. The second section (ii) reviews robust approaches to the composite indicators. In the third section (iii), it is described the methodology adopted for analyzing the gender gap worldwide through interval data—the Interval-valued Gender Gap Index-. In the fourth section (iv), we present and discuss the results and the policy relevance. The fifth part (v) concludes.

7.2 Background Literature

Methodological choices for the construction of an indicator are not univocal. Composite indicators are defined as a way to measure complex phenomena, based on the weighted combination or aggregation of different identified indicators (Nardo et al. 2005; OECD 2008). They can be a useful instrument to perform analyses requiring complex evaluations that are based on more than a single indicator. In many cases, it is necessary to measure multidimensional phenomena which cannot be explicitly captured by a single indicator. Many different choices can be related to the construction of the composite indicators. One choice is connected with the definition of the different weights applied to the composite indicator. In this sense, the result obtained can be dependent on the ratio of the weights of the composite indicator. Usually, the techniques that are adopted to assess the analysis of the different results, based on different assumptions on the components of the composite indicator, are assessed on uncertainty and sensitivity analyses (see Saisana et al. 2005). With these regards, the impact of different assumptions on the rankings of the composite indicator is analysed to assess the robustness of the results obtained. This is particularly relevant, considering the importance to yield the robustness of the different results. Robustness is a focal point for sound policy-making that can empower the accountability of the policy choices; this is due to the fact that policy choices based on a robust indicator are better justifiable. For this reason, the rationale on which this approach to composite indicators can be detected as the best candidate for policy analysis. This fact is particularly

important to establish a specific linkage between the use of the composite indicators and the design or the evaluation of the policies (Saltelli 2007).

A vast set of more objective methods has been proposed into the composite indicators literature, with the scope of increasing the robustness, as compared to linear methods. Sensitivity analyses reveal to be necessary to augment the reliability of the results within a scientific analysis. Some of these works attempt to improve most renowned indexes. Floridi et al. (2011) and Luzzati and Gucciardi (2015), propose a wider, '*non-simplistic*' approach to gauge composite indicators by computing a range of possible indicators and rankings. Maggino and Ruviglioni (2009), match subjective and objective weights, in light of a more participative calculation of the indicator. Agovino et al. (2018), compute an adjusted index to ameliorate the best renowned Economist Intelligence Unit-Barilla Center for Food Nutrition's Food Sustainability Index. In this case, it is used the combination of the *Data Envelopment Analysis* and the '*Method of Penalties by Coefficient of Variation*'—i.e. the *Mazziotta-Pareto method*-(Mazziotta and Pareto 2011)-to measure food, agriculture and nutrition sustainability and to differentiate the policy variables from the real variables. Busato and Gatto (2017), offer a set of methodologies valuable to improve the robustness of the methodological choice. Exploiting the World Bank's World Development Indicators, the robustness analysis used by the *Global Energy Vulnerability Index* adopts the Borda rule, equal weights and subjective weights to corroborate the outputs of the chosen method—the *Principal Component Analysis*—. It is showed a high correlation among the methods, that confirms the validity of the choice. Doni et al. (2018) consider the interval-based gender diversity composite indicators in the area of gender studies. Drago and Gatto (2017), propose the use of interval data to compute an energy resilience index, on the basis of the International Bank for Reconstruction and Development's Regulatory Indicators for Sustainable Energy, reputed to furnish a less objective glance on energy policy. Our paper is in line with this last set of works explored. Furthermore, it exploits a pivotal index—the World Economic Forum's Global Gender Gap Index—attempting to furnish a more scientific baseline to the index.

7.3 Methodology

The Global Gender Gap Index is elaborated from the World Economic Forum (WEF) since 2006. It analyzes the men/women gap by considering four dimensions: (i) Economic Participation and Opportunity; (ii) Educational Attainment; (iii) Health and Survival; and (iv) Political Empowerment (World Economic Forum 2017). It is important to consider that 14 different indicators are the components of the four sub-indexes. The final result is based on the mean of the four sub-indexes (an unweighted mean). The advantage of the index is that it identifies immediately the gender equality/inequality on each sub-index. The disadvantage is the equal weight assigned to the index. In this sense, we propose an approach that improves the robustness of the indicator, computing a new index that is based on different weights and different sub-indexes.

The diverse choices on the construction of the composite indicators are particularly relevant, above all when it comes to weighting choices. An approach that allows to internalize the diverse impacts of the different weighting rationale is the method based on interval data proposed by Drago (2017). Interval data can be based on symbolic data (Billard and Diday 2003). In this framework, we can consider the existence of many different measurements, thus the need to represent adequately the information of the data. In the case of the interval data, the challenge is to represent adequately the variation of the different indicators based on different assumptions (e.g. different weights). This approach found application on gender studies by Doni et al. (2018). In this context, interval data are used to measure adequately the different impact of the diverse choices and assumptions on the composite indicators. More importantly, the first relevant decision could be based on the different choices in weighting. The result is based on the construction of different intervals which can be usefully compared and interpreted.

For this work, we consider the different single indicators to construct our composite indicator, the Interval-valued Global Gender Gap Index (IGGGI). The different weightings which are requested to obtain the indicator are analysed. We examine 10000 simulations, where in each simulation we obtain four weights. Thus, we generate the multiple values of the weights by a uniform distribution with a minimum of 0 and a maximum of 10. Hence, one get the single value dividing the value obtained for each weight on the total. The number of run simulations is useful to represent different weighting scenarios which can guarantee to cover different parameterizations. At the end of the procedure, after running 10000 simulations for each different country, we are able to compute the minimum and the maximum. At the same time, one can measure the different lower bounds (minima), upper bounds (maxima), as well the centre of the interval computed. At the end of the procedure, we construct the different ranking by the centre of the interval gauged. Finally, we compute the non-parametric regression lowess (Cleveland 1979), related the relationship between the index and the centre calculated on the different intervals (Fig. 7.1). The results confirm the consistency of the interval

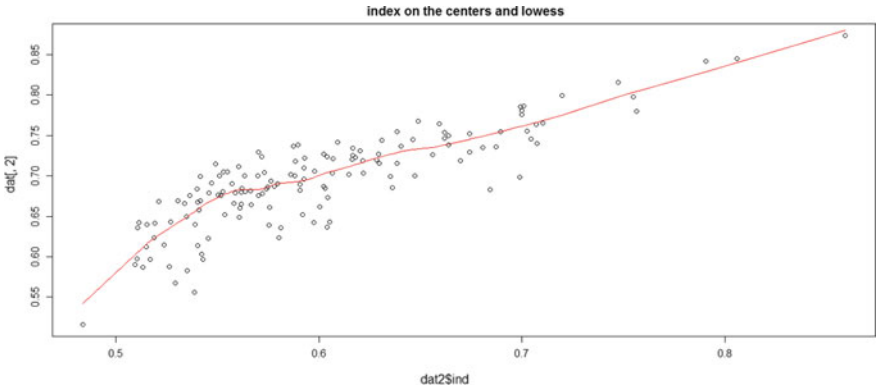

Fig. 7.1 Non parametric regression lowess of the center of the IGGGI on the results of the IGGGI

composite indicator: in general, the result for the centre of the interval of the IGGGI tends to be confirmed by the WEF's Global Gender Gap Index.

7.4 Results

The interval data methodologies present the advantage of offering an increased robustness. The methodology adopted has also the novelty to offer new results in the ranking. Analysing the centres and the first positions, we can observe equal results. For these nations, the output confirms the results obtained. For the other countries, they are displayed relevant discrepancies. It is important to note that the centre is one of the relevant elements to examine. Another focal point is represented by the range of the interval. Hence, it is important to consider the best and the worst index computed on the different simulations. This could be important, being aware of consistent differences between the indicators.

Analysing specific cases, some of the countries present equal or similar results, both within the best and in the worst performers clusters. Some other countries vary dramatically. These are the cases of Bangladesh—72nd to 17th-, India—87th to 20th-, Angola—117th to 54th-, Timor-Leste—125th to 56th-, Algeria—120th to 63rd-, Tunisia—126th to 75th-, Mauritania—129th to 76th-, Bahamas—37th to 87th-, and Botswana—54th 110th-, that present variations of 50 or more positions. The variation displayed by Italy is also significative: passing from the 50th to 24th, the variation in the methodology determines 26 positions of difference. The interval shows the variations between the results considering the sensitivity to the different weightings. The highest the interval, the highest the sensitivity of the weightings on the different indexes. This result need to be considered when the composite indicators are employed to design and promote policies, showing the cruciality of the sensitivity analysis (see Nardo et al. 2005; see Saisana et al. 2005).

For these reasons, we need to consider more cautiously the different countries which tend to have different positions. In fact, in these cases we can have situations of higher equality regarding some components of the original index than the other. In these cases, some specific policies show to be more useful in improving the single component score (Table 7.1).

Table 7.1 WEF's Global gender gap index and interval-valued GGGI rankings

Ranking WEF's GGGI	Ranking interval-valued GGGI	Country	Minima	Maxima	Center
1	1	Iceland	0.729	0.989	0.859
2	2	Finland	0.623	0.989	0.806
3	3	Norway	0.594	0.987	0.791
10	4	Nicaragua	0.524	0.988	0.756
6	5	Ireland	0.522	0.988	0.755
4	6	Sweden	0.509	0.986	0.747
5	7	Rwanda	0.476	0.963	0.720
13	8	Germany	0.450	0.970	0.710
27	9	Cuba	0.429	0.986	0.707
15	10	South Africa	0.428	0.986	0.707
23	11	Bolivia	0.436	0.973	0.705
16	12	Netherlands	0.425	0.980	0.702
7	13	Philippines	0.413	0.988	0.701
9	14	New Zealand	0.416	0.984	0.700
11	15	Switzerland	0.418	0.982	0.700
8	16	Slovenia	0.413	0.986	0.699
72	*17*	*Bangladesh*	*0.440*	*0.958*	*0.699*
17	18	France	0.391	0.988	0.690
32	19	Costa Rica	0.389	0.986	0.687
87	*20*	*India*	*0.424*	*0.944*	*0.684*
33	21	Argentina	0.376	0.986	0.681
20	22	United Kingdom	0.363	0.985	0.674
36	23	Cape Verde	0.369	0.980	0.674
50	*24*	*Italy*	*0.357*	*0.983*	*0.670*
29	25	Spain	0.345	0.983	0.664
21	26	Mozambique	0.388	0.940	0.664
22	27	Estonia	0.338	0.986	0.662
19	28	Denmark	0.340	0.984	0.662
14	29	Namibia	0.331	0.988	0.659
40	30	Ecuador	0.326	0.986	0.656
12	31	Burundi	0.345	0.953	0.649
66	32	Mexico	0.309	0.986	0.647
24	33	Belgium	0.307	0.986	0.646
31	34	Portugal	0.300	0.981	0.641
53	35	Tanzania	0.324	0.953	0.639
18	36	Latvia	0.289	0.988	0.639
82	37	Senegal	0.340	0.932	0.636
70	38	Chile	0.284	0.987	0.635
25	39	Lithuania	0.274	0.988	0.631

(continued)

Table 7.1 (continued)

Ranking WEF's GGGI	Ranking interval-valued GGGI	Country	Minima	Maxima	Center
52	40	Austria	0.278	0.981	0.630
38	41	Poland	0.271	0.987	0.629
48	42	Serbia	0.274	0.983	0.628
61	43	Uganda	0.290	0.954	0.622
49	44	Israel	0.258	0.985	0.622
35	45	Canada	0.257	0.983	0.620
44	46	Trinidad and Tobago	0.252	0.984	0.618
34	47	Luxembourg	0.248	0.985	0.617
41	48	Bulgaria	0.250	0.984	0.617
47	49	Panama	0.248	0.984	0.616
64	50	El Salvador	0.247	0.983	0.615
26	51	Moldova	0.233	0.985	0.609
46	52	Australia	0.229	0.985	0.607
62	53	Albania	0.247	0.966	0.607
117	*54*	*Angola*	*0.276*	*0.934*	*0.605*
100	55	Sri Lanka	0.227	0.981	0.604
125	*56*	*Timor-Leste*	*0.255*	*0.953*	*0.604*
42	57	Jamaica	0.220	0.988	0.604
83	58	Bosnia and Herzegovina	0.224	0.982	0.603
80	59	Peru	0.227	0.977	0.602
39	60	Colombia	0.217	0.987	0.602
109	61	Ethiopia	0.260	0.941	0.600
57	62	Lesotho	0.208	0.988	0.598
120	*63*	*Algeria*	*0.233*	*0.962*	*0.598*
45	64	United States	0.200	0.986	0.593
56	65	Zimbabwe	0.211	0.974	0.593
73	66	Macedonia, FYR	0.213	0.972	0.593
114	67	Liberia	0.258	0.926	0.592
88	68	Indonesia	0.203	0.979	0.591
78	69	Honduras	0.195	0.986	0.591
28	70	Barbados	0.191	0.988	0.590
51	71	Kazakhstan	0.192	0.985	0.588
68	72	Croatia	0.191	0.985	0.588
30	73	Belarus	0.187	0.988	0.587
63	74	Kenya	0.217	0.955	0.586
126	*75*	*Tunisia*	*0.201*	*0.962*	*0.581*
129	*76*	*Mauritania*	*0.223*	*0.937*	*0.580*
77	77	Czech Republic	0.172	0.987	0.580

(continued)

Table 7.1 (continued)

Ranking WEF's GGGI	Ranking interval-valued GGGI	Country	Minima	Maxima	Center
79	78	Brazil	0.170	0.986	0.578
74	79	Venezuela	0.166	0.987	0.576
110	80	Nepal	0.208	0.944	0.576
124	81	United Arab Emirates	0.172	0.978	0.575
81	82	Kyrgyz Republic	0.170	0.980	0.575
85	83	Cameroon	0.214	0.934	0.574
60	84	Madagascar	0.180	0.966	0.573
95	85	Suriname	0.158	0.986	0.572
43	86	Lao PDR	0.186	0.958	0.572
37	*87*	*Bahamas*	*0.153*	*0.988*	*0.570*
99	88	China	0.197	0.943	0.570
65	89	Vietnam	0.177	0.963	0.570
108	90	Malta	0.175	0.958	0.567
89	91	Montenegro	0.153	0.980	0.566
91	92	Uruguay	0.140	0.987	0.564
69	93	Ukraine	0.139	0.987	0.563
84	94	Cyprus	0.140	0.984	0.562
107	95	Swaziland	0.146	0.977	0.562
92	96	Greece	0.143	0.980	0.562
111	97	Japan	0.141	0.982	0.561
116	98	Korea, Rep.	0.156	0.966	0.561
55	99	Singapore	0.153	0.969	0.561
94	100	Slovak Republic	0.133	0.984	0.559
105	101	Guatemala	0.149	0.967	0.558
76	102	Romania	0.132	0.983	0.557
58	103	Mongolia	0.126	0.984	0.555
113	104	Mauritius	0.125	0.983	0.554
59	105	Ghana	0.153	0.953	0.553
90	106	Georgia	0.129	0.976	0.553
97	107	Dominican Republic	0.126	0.978	0.552
67	108	Malawi	0.153	0.949	0.551
96	109	Paraguay	0.116	0.985	0.550
54	*110*	*Botswana*	*0.113*	*0.986*	*0.549*
75	111	Russian Federation	0.109	0.986	0.547
93	112	Tajikistan	0.143	0.948	0.546
130	113	Turkey	0.125	0.966	0.545
137	114	Morocco	0.141	0.945	0.543

(continued)

Table 7.1 (continued)

Ranking WEF's GGGI	Ranking interval-valued GGGI	Country	Minima	Maxima	Center
134	115	Jordan	0.108	0.977	0.542
71	116	Thailand	0.101	0.982	0.542
102	117	Armenia	0.109	0.974	0.542
112	118	Cambodia	0.135	0.946	0.541
104	119	Gambia, The	0.137	0.944	0.540
132	120	Egypt	0.122	0.959	0.540
86	121	Azerbaijan	0.112	0.968	0.540
122	122	Guinea	0.164	0.914	0.539
143	123	Pakistan	0.154	0.924	0.539
98	124	Belize	0.091	0.982	0.537
141	125	Saudi Arabia	0.110	0.960	0.535
115	126	Maldives	0.095	0.974	0.535
106	127	Malaysia	0.093	0.975	0.534
101	128	Hungary	0.078	0.983	0.531
142	129	Syria	0.095	0.964	0.529
118	130	Nigeria	0.134	0.920	0.527
139	131	Iran, Islamic Rep.	0.082	0.970	0.526
131	132	Bahrain	0.076	0.972	0.524
103	133	Brunei Darussalam	0.066	0.976	0.521
121	134	Bhutan	0.096	0.943	0.519
128	135	Kuwait	0.063	0.975	0.519
136	136	Côte d'Ivoire	0.115	0.919	0.517
123	137	Burkina Faso	0.106	0.924	0.515
133	138	Oman	0.061	0.969	0.515
140	139	Chad	0.126	0.901	0.513
119	140	Qatar	0.056	0.967	0.511
127	141	Benin	0.106	0.915	0.511
135	142	Lebanon	0.059	0.961	0.510
138	143	Mali	0.120	0.899	0.509
144	144	Yemen	0.058	0.910	0.484

Left: IGGGI ranking obtained comparing the different centres of the interval with the ranking for the Global Gender Gap Index. Last three columns (respectively): lower, upper bound and centre of the interval

7.5 Conclusions

This work explores the composite indicators framework within gender economics and development policy, proposing a robust index to compute the gender gap worldwide, the Interval-valued Global Gender Gap Index.

Gender inequality disables long-run development and intergenerational, multidimensional sustainability, having been detected as a major limit for investments, occupation and economic growth. Gender equality is compelling in rural areas, where greater gaps are often observed. On the policy-making side, a wide consensus established among both academia and the international community, detects gender gap as a major plague to development and structural change. Empowering gender equality is a core issue of the development agenda, deserving a whole goal and more targets within the Sustainable Development Goals.

The current fashion of composite indicators implies the need of increasing preciseness and reliability in the phases of elaboration, measurement and use, especially for policy-making effectiveness. For this sake, an interval data analysis has been shown to be preferable to linear methods. The results display some similarities in the position of the countries, but also widely different rankings for some other countries. This mismatch can be due to the different values for the index components, which are not taken into account by an unweighted index.

Poor indicators can lead to poor policies. This fact allows to consider the potential differences between the components of an indicator as an important policy target. This indicates the relevance of relying on solid definitions and robust calculation when building composite indictors.

The importance of composite indicator lies in the analysis and design of public policies. Policy-makers and practitioners can benefit from the use of the interval-based composite indicators for multiple reasons. The approach can be useful to assess policy efficiency, as well as to gauge and track the gap that separate the factual achievements from a specific policy target. Furthermore, the use of interval data within the composite indicators framework, can be exploited to evaluate overall and thematic national performances.

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