

The Interrelation Between Responsible Research and Innovation Dimensions and Macro Indicators

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Abstract. Responsible Research and Innovation (RRI) concept has become an important topic in the academic community and in policy circles (van de Poel et al., 2017) and encompasses six main policy agendas (or dimensions): ethics; gender equality; governance; open access; public engagement; science education (RRI Tools, 2023). RRI concept, including gender (equality) as one of the dimensions, still lacks empirical explorations-based understanding. This paper aims to explore the peculiarities of interrelations between gender (equality) as one dimension of the Responsible Research and Innovation and societal progression in gender equality and innovativeness on macro level. Starting with generating original data-base of [n – 214] indicators quantitative secondary data analysis of descriptive characteristics of the selected variables and (Spearman) correlation (RS) analysis between the variables was accomplished. Descriptive and correlation analysis of interrelations between women's involvement in four R&I (i.e. Business, Higher education, Governmental and Private Non-profit) sectors and Gender Equality Index and Global Innovation Index in 2013–2020 shows rather small changes of the indicators and fragmental interrelations between them during the period.

Keywords: *responsible research and innovation (RRI), gender equality, global innovation index, gender equality index.*

Introduction

Relevance of the article

As a concept, Responsible Research and Innovation (RRI) emerged within EU policy discourse in the beginning of the 2010s (Jakobsen et al., 2019). Until now, the concept has become an important topic in the academic community and in policy circles (van de Poel et al., 2017) as it has been incorporated into European Framework Programmes such as Horizon 2020 and has become one of the key concepts of this programme (Ministry of Science, 2012).

By definition, RRI refers to research and innovation (R&I) that is ethically acceptable and socially desirable (Gurzawska et al., 2017) and encompasses six main policy agendas (or dimensions): ethics; gender equality; governance; open access; public engagement; science education (RRI Tools, 2023). Gender equality, as one of the RRI dimensions, is about “promoting gender-balanced teams, ensuring gender balance in decision-making bodies, and considering always the gender dimension in R&I to improve the quality and social relevance of the results” (RRI Tools, 2023). Moreover, gender equality is a long-lasting EU policy priority integrated among the European Research Area (ERA) priorities (i.e. “encouraging gender diversity to foster science excellence and relevance” (EC, 2019)) and in the EC guiding objectives for Horizon 2020 program projects (e.g., “integrating gender/sex analysis in research and innovation (R&I) content” (EC, 2021)).

However, as “the relationship between knowledge economies and ‘responsible’ research and innovation is not self-evident” (Deblonde, 2015), empirical substantiation is still needed. This article contributes to the elaboration of empirically based evidence by exploring such macro indicators as women's involvement in the RRI realm, gender equality level and innovation level in society.

Level of problem investigation

Jakobsen et al. (2019) claim that “RRI remains an immature and relatively narrow area of inquiry, with a top-down approach and guided by standardised principles”. Most of the recent studies on RRI focus on development of the definition and explanation of the conception of the RRI (Burget et al., 2017; Jakobsen et al., 2019; Rip, 2014), exploration of the RRI practices (Schuijff & Dijkstra, 2020) or development and adaptation of the RRI tools for enterprises (Gurzawska et al., 2017; Nazarko & Melnikas, 2019). Meanwhile analysis of separate RRI dimensions are rather rare

still (e.g. Otero-Hermida & García-Melón, 2018). Besides, exploration of interrelations between the RRI dimensions and their relation to other macro level processes are on initial phases still (EC, 2018; Wroblewski et al., 2015).

Scientific problem

How does the RRI interrelates with other societal processes on macro level? More specifically, how does gender (equality) status in RRI framework interrelates with more general gender equality achievements and general innovativeness level?

Object of the article – interrelations between gender (equality) as one of the RRI dimensions and societal progression in gender equality and innovativeness.

Aim of the article – to shed some light on peculiarities of interrelations between gender (equality) as one of the RRI dimensions and societal progression in gender equality and innovativeness on macro level.

Objectives of the article:

1. To discuss RRI concept including gender (equality) as one of the RRI dimensions;
2. To describe empirical explorations of RRI and gender (equality) as one of the RRI dimensions;
3. To reveal peculiarities of interrelations between gender (equality) as one of the RRI dimensions and Gender Equality Index (GEI) and Global Innovation Index (GII) as macro level indicators.

Methods of the article

Analysis and synthesis of scientific literature; quantitative statistical analysis of secondary data.

1. Theoretical aspects of responsible research and innovations and gender equality

The RRI concept was mentioned for the first time in the 7th Framework Programme in 2013 (EU, 2013). Then, the main emphasis was placed on cooperation between science and society and on building public trust in science. Later, the RRI concept has been given a prominent place in the policy context by the ongoing debate in the EU on the European R&I Policy (Jakobsen et al., 2019) and on how to link R&I for finding the impact of research on innovation (EC, 2014; Stilgoe & Guston, 2017; von Schomberg, 2013).

The concept of RRI is commonly based on research, most of which refers to “policy and socio-ethical perspective and focusing on academic R&D environments” (Blok & Lemmens, 2015, p. 20). Jakobsen et al. (2019) described the concept of RRI as a framework with three main features. First, RRI fosters debate about research goals and innovation and how to achieve them ethically, inclusively and democratically. In doing so, it initiates discussions about desirable societal benefits and public engagement (Genus & Stirling, 2018; Stilgoe et al., 2013). Second is “the need for developing mechanisms for reflection and inclusion in the R&I process” (Jakobsen et al., 2019, p. 2331). This would ensure equitable R&I outcomes in an open reflection process, where stakeholders are involved beyond those directly participating in the innovation activity. Third, “RRI is not a topic for researchers alone, but rather one that should engage entrepreneurs, businesspeople, policymakers, public institutions and research funding agencies” (Jakobsen et al., 2019, p. 2331). Although the concept of the RRI is frequently used in research publications and various institutional documents, its definition and aspects are still not clear and specific (Owen et al., 2012). Therefore researchers suggest that the main goal of the RRI is to move towards a broader innovation policy (Levidow & Neubauer, 2014; Stahl, 2013) as the RRI is “supposed to help research to move from bench to market, in order to create jobs, wealth and well-being” (Zwart et al., 2014, p. 16).

Thus, conceptualisation of the RRI leads to understanding of particular policy agendas (or dimensions – i.e. ethics, gender equality, governance, open access, public engagement, and science education) (see e.g. RRI Tools, 2023), to identification of numerous stakeholders and untangle of complex interrelations among them, and consideration of specific processual characteristic of the RRI (i.e. transparency, accessibility, reflexivity, inclusiveness) (see e.g. D’Haese et al., 2015).

Gender equality refers to “the equal rights, responsibilities and opportunities of women and men and girls and boys” and denotes that “women’s and men’s rights, responsibilities and opportunities

will not depend on whether they are born male or female” (UN Women, 2023). Inglehart et al. (2003, p. 92) claim that “growing emphasis on gender equality is an important factor in the process of democratisation”, as gender equality is “seen both as a human rights issue and as a precondition for, and indicator of, sustainable people-centred development” (UN Women, 2023). Thus, series of new concepts such as ‘gendered innovations’ (EC, 2013; Schiebinger & Schraudner, 2011), ‘women’s talents’, ‘women’s economic power’, other (Catalyst, 2004; McKinsey and Company, 2007) has been introduced in academic world.

Since middle of 1990s, call for gender equality in research has been taken up by many influential politicians (EC, 2010, p. 18–19) and the concept has been embedded in both political and academic discourses. Currently, the concept ‘gender equality’ is used for naming political issues without particular theoretical elaboration (see e.g. Lombardo et al., 2012; Squires, 2007).

2. Empirical explorations of the responsible research and innovations and gender equality

Results of inceptive and relatively still narrow analysis of the RRI (Jakobsen et al., 2019) suggest that at least 2 additional RRI dimensions – i.e. sustainability and care – should also be included in the future in the context of the RRI concept (Burget et al., 2017). Further, it is already known that the practice of RRI is most prevalent in North-Western Europe; that women are first authors of the RRI focused papers less frequently than men; that the RRI focused studies mostly cover nanotechnology, ICT and synthetic biology (Schuijff & Dijkstra, 2020). As it is known, RRI is described as a social innovation and as a part of broader institutionalisation process (some solidification of divisions of moral labour, discursively, culturally, and institutionally) (Rip, 2014). Other authors (Nazarko & Melnikas, 2019) suggest weighted responsibility criteria; RRI maturity models and RRI scorecards as RRI tools for enterprises and highlighted at company size matters (Gurzawska et al., 2017).

Other authors (Otero-Hermida & García-Melón, 2018) suggest a list of 23 indicators measuring gender equality in the context of RRI in Spain. The indicators consist of prioritised areas as different and asymmetric socialisation and education; organisational culture; substantive representation, informal and formal networks, intersectionality and science; vertical segregation; work relations; visibility of women researchers as references; research contents; gender expertise enhancement and resources.

3. Interrelation between women’s participation in research and innovation sectors, Gender Equality Index and Global Innovation Index

Research methodics

Aim of the research: To reveal peculiarities of interrelations between gender (equality) as one of the RRI dimensions and GEI and GII as macro level indicators.

Objectives of the research:

1. To describe distributions of women’s involvement in different R&I sectors in 2013–2020;
2. To describe tendencies of GEI and GII in 2013–2020;
3. To explore interrelations between women’s involvement in the sectors and the macro level indicators.

Research methods

Starting with generating original data-base of [n – 214] indicators defining three selected variables, quantitative secondary data analysis of descriptive characteristics (total number of cases (N), minimum (min) and maximum (max) indicators, mean, standard deviation) of the selected variables and (Spearman) correlation (R_s) analysis between the variables was accomplished using SPSS 18.0 software for Windows. The variables:

- The concept ‘gender equality’ in RRI context is defined by ‘women’s involvement in R&I sectors’. As a variable, it was measured by statistical data on women’s involvement in 4 R&I

sectors: business sector (BES), government sector (GS), higher education sector (HES) and private non-profit sector (PNPS).

- The concept ‘gender equality’ as the general societal achievement is defined by GEI, which is “a tool to measure the progress of gender equality in the EU” (EIGE, 2023). The GEI encompasses six general variables, which are based on several sub-variables: work, money, knowledge, time, power and health (EIGE, 2023).
- Societal innovativeness level is measured by GII, which is a striving to “provide a more complete picture of innovation ecosystems across the globe” (Dutta et al., 2022, p. 226). The overall GII score is the average of five innovation input sub-indexes (institutions; human capital and research; infrastructure; market sophistication; business sophistication) and two innovation output sub-indexes (knowledge and technology outputs; creative outputs), on which the GII economy rankings are produced (Ibid.).

The secondary data for all European Union countries were collected from Eurostat (<https://ec.europa.eu/eurostat>), EIGE (<https://eige.europa.eu/gender-equality-index/2022>) and GII (https://www.wipo.int/global_innovation_index/en/) databases between November 2022 and January 2023. The period 2013–2020 was chosen for the statistical analysis of the data. The year 2021 is not included in the data analysis as the data is not available yet.

The research data analysis and the discussion of the results

Descriptive analysis of the data (Table 1) shows, over the period analysed, the average indicators of women’s involvement in R&I activities ranged from 26% to 28% in the BES, from 47% to 49% in HES, from 48% to 52% in GS, and from 49% to 51% in PNPS. Thus, increase of women’s involvement in R&I activities was just 2% in the BES, HES and PNPS, but 4% in GS during the period. In the BES, women’s involvement is lower than in other sectors. This is not surprising given the stereotype of the male entrepreneur that still persists in Europe. The terminology is that of ‘hero’, and the constructed identities of entrepreneurs are ideological, based on the lifestyles of men (Allen & Truman, 1991; Cohen & Musson, 2000). Ogbor (2000) strongly critiques the language associated with the term ‘entrepreneur’ as essentially masculine; infused with supernormal qualities and myths that reflect the archetype of the male ‘white hero’, whereas women are purportedly the ‘antithesis of entrepreneurial norms’ (Ogbor, 2000, p. 21). Despite gender stereotypes are attempted to be removed, it still remains an open question for future research whether the business sector creates negative conditions for women to engage in R&I activities in the sector in terms of reconciling work and family, and in terms of raising and caring for young children.

Table 1

Descriptive findings											
	N	Min	Max	Mean	SD		N	Min	Max	Mean	SD
BES 2013	29	12,0	43,0	26,50	7,536	GS 2013	29	19,2	63,5	47,70	8,530
BES 2014	19	18,3	39,6	27,35	7,317	GS 2014	26	18,9	63,6	48,51	9,216
BES 2015	28	12,8	40,5	26,25	7,237	GS 2015	28	23,6	65,5	49,08	8,187
BES 2016	20	17,9	39,9	27,45	6,795	GS 2016	24	20,3	67,4	50,43	10,001
BES 2017	29	15,0	41,6	26,43	6,750	GS 2017	29	39,1	63,8	50,30	7,084
BES 2018	19	17,2	36,7	27,11	6,023	GS 2018	23	37,2	67,0	51,24	7,821
BES 2019	27	15,4	37,4	26,49	6,105	GS 2019	27	18,2	66,7	50,40	9,330
BES 2020	19	17,6	37,7	27,81	6,049	GS 2020	21	37,3	70,1	52,22	7,699
HES 2013	29	35,4	57,4	46,88	4,576	PNPS 2013	20	29,4	66,8	49,35	9,053
HES 2014	26	39,2	57,7	46,80	4,423	PNPS 2014	17	7,7	69,0	49,02	12,666
HES 2015	28	38,9	57,9	47,52	4,218	PNPS 2015	18	18,2	71,4	50,81	10,468
HES 2016	25	39,0	57,7	48,10	4,351	PNPS 2016	17	8,3	70,7	49,02	13,961
HES 2017	29	39,4	57,4	47,82	4,338	PNPS 2017	20	32,1	67,4	49,60	8,700
HES 2018	23	39,5	57,6	48,53	4,529	PNPS 2018	15	28,6	65,8	50,24	9,789
HES 2019	27	40,0	57,4	48,49	4,445	PNPS 2019	16	39,2	65,6	51,79	7,521
HES 2020	21	40,3	58,3	49,30	4,715	PNPS 2020	13	40,5	63,6	51,09	6,971
GEI 2013	n.i.	n.i.	n.i.	n.i.	n.i.	GII 2013	28	37,7	61,4	49,85	7,174
GEI 2014	n.i.	n.i.	n.i.	n.i.	n.i.	GII 2014	28	38,1	62,4	49,55	7,517

	N	Min	Max	Mean	SD		N	Min	Max	Mean	SD
GEI 2015	28	50,0	82,6	62,50	8,774	GII 2015	28	38,2	62,4	50,11	7,606
GEI 2016	n.i.	n.i.	n.i.	n.i.	n.i.	GII 2016	28	37,9	63,6	49,70	7,680
GEI 2017	28	51,2	83,6	63,72	8,535	GII 2017	28	38,8	63,8	49,85	7,643
GEI 2018	28	52,2	83,8	64,56	8,435	GII 2018	28	37,6	63,3	49,61	7,463
GEI 2019	28	52,5	83,9	65,40	8,533	GII 2019	28	36,8	63,7	49,10	7,762
GEI 2020	28	53,4	84,0	65,97	8,530	GII 2020	28	36,0	62,5	47,39	7,665

BES – business enterprise sector, percentage; GS – government sector, percentage; HES – higher education sector, percentage; PNPS – private non-profit sector, percentage; GEI – gender equality index; GII – global innovation index.

The GEI data show that the indicator has been growing during the period (from 62 to 65 points) which denote progress of gender equality in the EU. Meanwhile GII indicator fluctuated around 50 points during the period, but decreased to 47 points in 2020.

The correlation analysis (Table 2) shows rather strong interrelation ($R =$ from 0,430 to 0,679 $p < 0,05$) between the indicators of women’s involvement in R&I activities in BES, GS, and HES. This finding suggests logical conclusion: the more women are involved in R&I activities in one sector, the more they are involved in other ones in the country. However, whereas the correlation coefficients elude maximum value 1 and the coefficients loose statistical significance in 2017, 2019, 2020, further explorations of the interrelations in broader socio-political and economical contexts would be useful.

Surprisingly, the correlation analysis did not reveal any statistically significant relationship between the indicators of women’s involvement in R&I activities in different sectors and the GEI (all $p > 0,01$). Perhaps this could be explained by the fact that this index consists of number of work-related indicators (i.e. FTE employment rate; duration of working life (years); employed people in education, human health and social work activities; ability to take one hour or two off during working hours to take care of personal or family matters; Career Prospects Index) which do not relate with women’s participation in R&I directly. However, it would be worthwhile to explore interrelation between separate components of the GEI and the indicators of women’s participation in R&I activities.

Table 2

Correlations between women’s involvement in different sectors, GEI and GII

	2013					2014				
	GS	HES	PNPS	GEI	GII	GS	HES	PNPS	GEI	GII
BES	,536**	,641**	-,250	n.i.	-,535**	,679**	,498*	-,301	n.i.	-,570*
GS		,541**	-,176	n.i.	-,588**		,538**	,015	n.i.	-,547**
HES			,188	n.i.	-,430*			,127	n.i.	-,490*
PNPS					,361					,332
GEI					n.i.					n.i.
	2015					2016				
	GS	HES	PNPS	GEI	GII	GS	HES	PNPS	GEI	GII
BES	,616**	,619**	-,098	-,013	-,547**	,589**	,550*	-,029	n.i.	-,565**
GS		,499**	-,245	-,051	-,418*		,430*	,118	n.i.	-,585**
HES			,042	-,076	-,341			,441	n.i.	-,346
PNPS				-,218	,171					,426
GEI					,023					n.i.
	2017					2018				
	GS	HES	PNPS	GEI	GII	GS	HES	PNPS	GEI	GII
BES	,514**	,494**	-,099	-,018	-,508**	,628**	,574*	,115	,116	-,462*
GS		,347	-,135	-,143	-,371		,425*	,171	-,161	-,425*
HES			,226	,007	-,390*			,364	,012	-,386
PNPS				-,128	,495*				-,307	,580*
GEI					-,009					,005

	2019					2020				
	GS	HES	PNPS	GEI	GII	GS	HES	PNPS	GEI	GII
BES	,448*	,617**	-,065	-,049	-,557**	,426	,561*	,099	,249	-,555*
GS		,329	,024	-,009	-,367		,469*	-,093	,068	-,261
HES			,265	,017	-,391*			,286	,072	-,422
PNPS				-,035	,641**				-,253	,488
GEI					,064					,093

** . Correlation is significant at the 0.01 level (2-tailed); * . Correlation is significant at the 0.05 level (2-tailed).

Analysis of correlation between the GII and women's involvement in the BES, GS and HES revealed a strong but negative relationships between these variables: from $R_s = -0,588$ $p < 0,01$ between GII and GS in 2013 to $R_s = -0,261$ $p < 0,01$ between GII and GS in 2020. Meanwhile correlation between the GII and women's involvement in the PNPS is positive and rather strong, especially in 2017 ($R_s = 0,495$ $p < 0,01$), 2018 ($R_s = 0,580$ $p < 0,01$), and 2019 ($R_s = 0,641$ $p < 0,01$). This finding suggests a tendency that the GII decreases as women's involvement in the BES, GS and HES increases and contrariwise. These results can be explained by the fact that Lithuania ranks high globally in the online creativity index (21st place), which consists of the following sub-indices: country-code TDLs/th pop 15–69 (21st place); wikipedia edits/mn pop. 15–69 (22nd place) and mobile app creation/bn PPP\$ GDP (8th place) (Dutta et al., 2022). Moreover, Lithuania ranks 21st in the world in ICT & organisational model creation (Dutta et al., 2022). Thus, Lithuania ranks so high in IT and STEM related fields, while there are not many women in these fields, and therefore there is a negative correlation with the GII.

The strong positive correlation between the GII and women's involvement in the PNPS in 2017–2019 might be interpreted in context of other indicators. For example, Lithuania is ranked 8th in the world in the Ecological Sustainability Index (Dutta et al., 2022). The environmental sustainability is directly linked to social innovation, which are most often found in a variety of non-profit organisations, where women compose majority.

Conclusions

The research sheds some light on peculiarities of interrelations between gender (equality) as one of the RRI dimensions and societal progression in gender equality and innovativeness on macro level. Succinct review of literature and previous studies in the field revealed that RRI concept, including gender (equality) as one of the RRI dimensions, still lacks empirical explorations based understanding. In general, RRI aims to move towards a broader innovation policy (Levidow & Neubauer, 2014; Stahl, 2013). Meanwhile gender (equality), as a component of the RRI, contributes to this by introducing new macro level concepts such as 'gendered innovations' (EC, 2013; Schiebinger & Schraudner, 2011), 'women's talents', 'women's economic power', other (Catalyst, 2004; McKinsey and Company, 2007), helping to move research from the theoretical level to the practical one.

Empirical analysis of peculiarities of interrelations between gender (equality) as one of the RRI dimensions and GEI and GII as macro level indicators revealed that women's involvement in different R&I sectors – i.e. BES, HES, GS and PNPS in 2013–2020 – had been increasing but very scarcely. Also GEI and GII had not changed significantly during the period. Moreover, indicators of women's involvement in R&I activities correlate with GII (mostly negatively though), but not with GEI. On the one hand, the findings provide some empirical evidence of interrelation between the indicators of women's involvement in R&I sectors and GII. However, on the other hand, in general, incompatibility of existent macro level indicators restrict in-depth explorations of the phenomena and ask for search for other indicators of macro-level processes in the countries.

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