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ORIGINAL ARTICLE

An Empirical Assessment of Gender Inequality in Human Development: Evidence from G20 Countries

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Abstract

Gender inequality continues to be more persistent across societies than any other form of inequality. According to the 2020 UN Human Development Report, no country has reached low inequality in human development without reducing the loss coming from gender inequality. Acknowledging the limitations of existing indexes in measuring comparative country performances in reducing gender inequality, this study proposes a new composite index and an empirical methodology, Data Envelopment Analysis (DEA), for measuring G20 countries' comparative performance in reducing gender inequality in human development between 2014 and 2020. The DEA method enables better measuring the *main weaknesses* of countries regarding specific gender indicators and identifies potential *role model* capabilities among a group of countries. As an informal grouping, the G20 countries began to set yearly commitments to achieving gender equality as of 2012. Its mission statement of "globalization work for all" also took place in 2013. Therefore, G20 is a crucial platform for empirically analyzing the achievements of developed and developing world in reducing gender inequality in development. We also aim to contribute to research on better measuring gender development by proposing a new quantitative methodology for comparative analyses of the specific gender-related indicators through an analysis of G20 countries.

Keywords Gender inequality · Human development · G20 · Data Envelopment Analysis · Cross-country comparison

Introduction

We live in a world of rising inequalities and fragmentation in both the developed and developing world (Öniş, 2017). Although there is an enormous evolution in technology, knowledge, measurement, norm creation, and target setting, "progress" is still disputed. According to the World Economic Forum's 2020 Global Gender Gap Report, there is still a 32.3% gap between women and men regarding education, health, employment, and political leadership. More importantly, on average, the global gender gap has widened by almost 0.6% compared to the previous year. It is estimated that to close this gap, Western Europe needs 52.1 years, North America 61.5, and Latin America and the Caribbean 68.9. It will take over 100 years to close the gender gap in all other regions (World Economic Forum Global Gender Gap Report, 2021). Economic prosperity helps to improve gender equality, but some gender gaps are resistant to change regardless of region and state (Momsen, 2020). The continued underrepresentation of women in developing states and the world's democracies raises significant concerns about political equality (Bush, 2011). According to the 2020 UN Human Development Report, gender inequality is correlated with a loss in human development due to inequality. Not only are 45 targets and 54 specific indicators of the UN Sustainable Development Goals (SDG) directly linked to gender, but the effects of these inequalities are also linked to all dimensions of development (UN Human Development Report, 2020).

Since its establishment, the UN has been a crucial factor in terms of its norm-shaper and target-setter role in development in general and women and development more specifically (Weiss, 2010). Accordingly, attempts to locate women's relationship to development and to create standards

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for measuring gender inequality in development occurred mainly in the UN platform since the 1970s (Sweetman, 2020). Although the UN has played a vital role as a global forum enabling the "evolution" of international debates on women and development, the real "progress" regarding concrete achievements in women's lives continues to be disputed.

The Group of Twenty (G20) emerged in 1999 as an informal multilateral platform connecting the world's major developed and emerging economies. Since then, G20 has shifted its focus to global governance. Accordingly, the G20's mission statement of making *globalization work for all* took center stage in 2013. Commitments specifically to gender equality started at Los Cabos Summit in 2012. Although the G20 countries demonstrate a relatively high compliance rate with their commitments (on average 72%), this number decreases to 60% in gender-related commitments (Kulik, 2020). There is a growing concern that the socio-economic model being advanced by these emerging economies is not a genuine developmental model, especially regarding gender equality in human development (Ukhova, 2015). Therefore, G20 offers a crucial platform for a comparative analysis of the achievements of the developed and developing world regarding reducing gender inequality in human development.

This study suggests an empirical methodology for constructing a multi-dimensional cross-country comparison of the G20 countries' performance according to gender inequality in human development from 2014 to 2020. Acknowledging the shortcoming of some well-known indexes like the Gender Development Index (GDI), this study provides a new composite index by integrating GDI, GII, and two other indicators from the World Bank. This study contributes to and extends the academic literature by calculating each indicator's weight using a nonparametric approach, Data Envelopment Analysis (DEA). It analyzes the patterns of efficiency (performance of each country regarding gender inequality in human development) change over time. DEA avoids the subjectivity of the indicators' weights in the proposed composite index and allows cross-country benchmarking and comparison. The DEA method also provides data on the main weaknesses of inefficient states regarding gender indicators and identifies potential role model capabilities of efficient countries in the G20 group. The year 2014 was chosen as UNDP began to publish both GDI and GII statistics. Furthermore, G20 countries begin to set yearly commitments to gender equality as of the 2012 Los Cabos Summit, making the post-2014 period a good time series for measuring any meaningful change.

The paper is structured around six main parts. The first part is the "Introduction." The "Conceptualizing Women's Role in Development: Evolution Without Progress?" part provides a brief conceptual and historical overview of the evolution of women's relationship to development. The "Quest for Better Data for Measuring Gender Inequality in Development" part scrutinizes the question of how to measure progress on gender equality in human development by discussing the prospects and limitations of gender research methodologies. The fourth part is titled "Data and Methods," introducing a composite index including nine indicators measuring gender inequality in human development. The Data Envelopment Analysis (DEA) method is discussed as a nonparametric approach for cross-country benchmarking of the patterns of efficiency/inefficiencies. The "Analysis and Findings" part documents empirical results and the findings regarding the patterns of gender inequality in human development among G20 countries over the study years. The "Discussion and Conclusion" part discusses the findings regarding the prospects and limitations of this study and suggestions for future research on the topic.

Conceptualizing Women's Role in Development: Evolution Without Progress?

Women's location at the nexus between production and reproduction, between making a living and caring for the family, makes the organization of gender relations central to the development agenda (Kabeer, 2015). The UN has been the central platform to set internationally agreed targets to measure development in general and women's relation to development, more specifically. Accordingly, the evolution of women's relationship to development in research and policy can be traced throughout the UN (Beetham and Demetriades, 2007).

When the UN's Commission on the Status of Women was created as early as 1946, development studies were predominantly concerned with increased gross national product and per capita income (Krook and Jacqui, 2012). In the early and mid-1970s, pioneering work began to appear on the role of women in development studies. By the mid-1970s, the question of women's role in development was introduced to the agenda of international institutions, thanks to the effort of women's transnational networks (Kardam, 1987). Women working in development began to critique the dominant development framework, which focuses solely on men (Beetham and Demetriades, 2007). A liberal feminist framework, conceptualized as Women in Development (WID), argued that women were almost entirely left out of the development process. Assuming that women's subordination was directly linked to their exclusion from the formal marketplace, they demanded the integration of women into the market economy through development programs (Beetham and Demetriades, 2007).

In the mid-to-late 1970s and 1980s, feminist research began to critique the WID framework in both research and policy, emphasizing further research to understand better women's complex, diverse, and multilayered realities (Brown, 2006). The Gender and Development (GAD)

framework, which resulted from these critiques, moved away from women-only research and programs to a broader consideration of how "gender relations" are constructed in many different contexts. The GAD paradigm and the strategy of gender mainstreaming aimed at broadening gender equality perspective and gender equality aim into "all policies" to transform society (Debusscher, 2012). This marked a shift in research and policy from seeing women as *recipients* whose lives should be improved to conceptualizing women as active *agents* of change who can be empowered to improve their position in policy and society (Beetham and Demetriades, 2007). In this regard, *women's empowerment* emerged as a central theme of GAD which focuses on transforming the existing power relations in favor of women's rights and social justice (Cornwall and Rivas 2015).

Since the 1970s, the evolution of these ideas has led to the establishment of many UN institutions and vice versa (Weiss, 2010). The UN Development Fund for Women (UNIFEM) was introduced in December 1976. 1979 was a milestone as the UN General Assembly adopted the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW). The Commission on the Status of Women helped organize four world conferences on women between 1975 and 1995. Mexico City 1975 marked the beginning of a new global dialog on discrimination against women. Copenhagen, in 1980, reviewed progress and set new goals (Momsen, 2020). The UN Decade for Women (1976–1985) also culminated in a conference in Nairobi in 1985, enabling a new coalition between governments and civil society (Holden, 2015).

The Fourth UN Conference on Women in Beijing in 1995 marked a radical challenge to the world's power-holders to go further and change the course of development (Sweetman, 2020). The Beijing Platform for Action recognized *the need for measurement* and *methodological work on indicator development* (Azcona and Bhatt, 2020). However, the potential held in Beijing for measuring progress on gender equality was not realized in the adoption of the Millennium Development Goals (MDGs). MDGs were much narrower in scope, and critical areas were missing. Out of 60 indicators selected to measure progress on the MDGs, only 11 (18%) were gender-specific indicators (Azcona and Bhatt, 2020). Most recently, the 2030 Agenda for Sustainable Development, adopted 20 years after the Beijing, however, ended up benefiting from a much more participatory and inclusive approach to gender in development in which gender equality and women's empowerment are integral to each of the 17 goals with "leave no one behind" principle (Habib et al. 2020). Therefore, Sustainable Development Goals achieved a more comprehensive and women's rights-based approach to development. However, recent discussions on the gender and development agenda continue to evolve based on appropriate indicators, proper measures, effective implementation, and concrete outcomes (Skagerlind, 2021).

Quest for Better Data for Measuring Gender Inequality in Development

It has been widely acknowledged that gender research methodologies are essential for fostering equal social and economic development. Especially measuring change based on gender-sensitive frameworks is crucial for monitoring the progress of gender equality in development (Beetham and Demetriades 2007). The need to measure change, and more importantly, the quest for better ways to do so, continues despite the difficulties of accessing data and measuring real progress (Kabeer, 2015).

Since the first landmark UN document CEDAW of 1979, there has been a remarkable improvement in the generation and the use of gender statistics. The UNDP introduced the human development approach to the center of the international development agenda in the 1990s by introducing the Human Development Index (HDI) (Olcay, 2021). In 1995, the UNDP initiated the Gender-Related Development Index (GDI) and the Gender Empowerment Measure (GEM) in addition to the HDI. All these gender indices have undergone various revisions over the years. The Gender Inequality Index (GII) replaced the GEM in 2010 (Azcona and Bhatt 2020). The Gender Inequality Index (GII) was initiated to respond to the most severe limitations of the above two indices (Amin and Sabermahani, 2017). Since 2014, the UN Human Development Report has published both GDI and GII simultaneously to measure the gender dimension of human development.

Development institutions have also long claimed that progress on gender equality necessitates a collective effort to close "the gender data gap" (Connell et al., 2020). They demand gender data to distribute their funds efficiently. Policymakers also use gender data to guide policy preferences and governance priorities (Fuentes and Cookson, 2020). However, more than just development funders recognize the need for better measurements (Beetham and Demetriades, 2007). Across all world regions, NGOs have long called for better and more accessible data to monitor progress, strengthen advocacy, and drive accountability (Connell et al., 2020). Academics and policymakers have consequently proposed other gender-related well-being indicators (Klasen and Schüler, 2011). Other organizations have developed various new indicators, including the World Economic Forum's Gender Gap Index, OECD's Social Institutions and Gender Index, and most recently the SDG Gender Index, among many others (Connell et al., 2020).

On the other hand, some feminist researchers are more skeptical of this measurement trend, arguing that quantitative techniques cannot capture the complex dimensions of various gender inequalities (Fuentes and Cookson, 2020). They have argued that forms of gender inequality should not be used as variables because they are neither measurable nor quantifiable (Cohen and Sabrina, 2021). Critiques assert

that relying only on numerical indicators of these indexes as evidence of progress is often limited. For instance, the number of women in parliament is used as a quantitative indicator for measuring the participation of women in decision-making. In contrast, qualitative analyses attempt to understand whether their participation contributes to policy discussions or influences the outcomes (Fuentes and Cookson, 2020). Recent research criticizes indicators such as economic empowerment, arguing, for instance, that it only considers women's labor force participation. They do not discuss the structures that build the "glass ceilings and the invisible walls" toward women's progress (Olcay, 2021). Those statistics are criticized for being limited to women who only have reported (UN Women, 2018, p. 199). Furthermore, research also demonstrated that even when pro-market economic reforms and women's integration might produce growth, these positive macroeconomic outcomes might be achieved at the expense of women's internationally recognized economic rights (Peksen, 2019). Feminist researchers also suggest that these demands for quantitative data put pressure on activists claiming longer time for genuine research. Criticisms also underline the transparency factor around selecting indicators (Fuentes and Cookson, 2020).

Despite many criticisms, we gain a comparative picture of the various dimensions of gender inequalities through these measurement efforts (Francisco et al., 2008; Russell, 2015; Azcona and Bhatt, 2020; Carlsen, 2020). This increasing quest for "better data and analyses" is essential for highlighting the importance and demonstrating the persistence of gender inequality in human development. By choosing what to measure, the policymaker, advocate, researcher, or practitioner can "choose" the story he or she wants to tell (Beetham and Demetriades, 2007). Thus, despite many criticisms, the question of how gender indicators are constructed and how progress is measured is all-important (Azcona and Bhatt, 2020).

Data and Methods

Description of Data

This paper attempts to contribute to the growing literature on measuring gender and development by introducing a compositive index for comparatively calculating gender inequality in human development. It endeavors to overcome the shortcoming of some well-known indexes of gender inequality in human development, like the Gender Development Index (GDI) and Gender Inequality Index (GII), by enlarging the number of indicators included in the analysis. Among the criticism leveled at GDI, it addresses four indicators—(i) life expectancy at birth, (ii) expected years of schooling, (iii) mean years of schooling, and (iv) estimated GNI per capita—which, while necessary, do not cover all the aspects of gender development. Hence, the GII proposed here also includes with its five indicators (i) maternal mortality rate, (ii) adolescent birth rate, (iii) share of seats in parliament, (iv) population at least secondary education, and (v) labor force participating rate. We also enhanced the combination of these indexes by including two empowerment indicators from World Bank Gender Data—(i) proportion of women at the ministerial level and (ii) female share of employment in senior and middle management—directly related to gender empowerment in human development (The World Bank, Gender Statistics n.d.). In other words, this study provides a new composite index by integrating GDI, GII, and two other indicators to understand countries' gender inequality in human development.

However, the aggregation of the scores of each country by using the new composite index causes substantial methodological difficulties. This study provides a solution to calculate each indicator's weights using a nonparametric approach as Data Envelopment Analysis (DEA). Accordingly, it is possible to rank G20 countries without subjective weighting patterns. Therefore, decision-makers might not claim that an unfair weighting scheme is being used to analyze the country's relative performance in any indicator. DEA analyzes each country's efficiency pattern (performance regarding gender inequality in human development) change between 2014 and 2020. (UN Human Development Report 2014 and 2020) The year 2014 was chosen as UNDP Human Development Report began to publish GDI and GII statistics together in 2014, enabling us to measure the change comparatively. Furthermore, G20 countries begin to set yearly commitments to gender equality as of the 2012 Los Cabos Summit, making post-2014 a reasonable period for measuring any meaningful change. Consequently, eleven indicators (outputs) were added to our proposed composite index for benchmarking analysis. This composite index consists of the following indicators. The descriptive statistics of G20 countries for 2014 and 2020 are shown in the Appendix.

Indicators	Existing index
Life expectancy at birth	GDI
Expected years of schooling	
Mean years of schooling	
Estimated GNI per capita	
Maternal mortality rate	GII
Adolescent birth rate	
Share of seats in parliament	
Population with at least secondary education	
Labor force participation rate	
The proportion of women at the ministerial level	New indicators
Female share of employment in senior and middle management	

Data Envelopment Analysis

DEA aims to find decision-making units (DMUs) that produce the highest outputs using the lowest levels of inputs. Therefore, it maximizes the ratio of weighted outputs to weighted inputs for the DMU under consideration. This maximization objective is subject to the constraint that the same ratio for all DMUs is less than or equal to one. This leads to the following model, in which one can find the efficiency value for DMU m (Ramanathan, 2003):

$$Max \frac{\sum_{j=1}^{J} v_{mj} y_{mj}}{\sum_{i=1}^{I} u_{mi} x_{mi}} \qquad 0 \le \frac{\sum_{j=1}^{J} v_{mj} y_{nj}}{\sum_{i=1}^{I} u_{mi} x_{ni}} \le 1; n = 1, 2....., N$$

$$v_{mj} y_{mj} \ge 0; i = 1, 2....., I; j = 1, 2, ..., J$$

Here, i is the index for inputs, j is the index for outputs, and n is the index for DMUs. The variables v_{mj} and u_{mi} are the weights representing the importance of each input and output. If the efficiency score equals 1, the DMU m is located on the efficiency frontier. Here, the efficiency value is a relative measure indicating how DMU m operates compared to the other DMUs included in the sample. A detailed discussion of the DEA model could also be found in Cooper et al.'s (2007) studies.

DMUs' scores are compared, and the set of most effective DMUs is called the "*efficiency frontier*." In this benchmark model, there are two assumptions: (1) *input-oriented* (while outputs are held constant, and inputs are decreased) and (2) *output-oriented* (while inputs are held constant and outputs are increased). This study is not dealing with the efficiency of transforming inputs into outputs. Instead, we compare several specific indicators—related to gender inequality in human development—across the G20 countries. Thus, we have only indicators (outputs) in the analysis, and all countries have single virtual input of unit value. This assumption compares DMUs—countries in this study—regarding their attributes and intensities without considering the non-decided inputs (Deposit, 2005); Reig-Martinez, 2013).

Accordingly, the output-oriented benchmarking model is used to analyze the efficiencies of G20 countries related to gender inequality in human development. The eleven indicators are selected for the new composite index to analyze the efficiencies of G20 countries regarding gender inequality in human development. These eleven indicators of the composite index represent "desired outcomes" to achieve gender equality in human development. Thus, these indicators are the "outputs" of the mathematical DEA model of the study. Two of them—maternal mortality rate and adolescent birth rate—are classified as undesirable output. Since DEA determines the efficiency frontier using specific inputs and outputs, it tries to increase outputs. However, some outputs of decision-making units may be such that decreasing these outputs increases efficiency. Maternal mortality and adolescent birth rates are such outputs, so they are classified as undesirable outputs in the study. As discussed above, the "input" variable is defined as "unity" so that an "output-oriented" model is developed, which aims to calculate the targeted indicators' relative weights in gender inequality scores of G20 countries.

The "efficiency" scores calculated in DEA analyses represent the performance of each decision-making unit (in our case, G20 countries) in terms of achieving the desired outputs (in our case, gender equality in human development). In other words, the efficiency scores illustrate each G20 country's current standing regarding gender inequality in human development as a result of statistical analyses of selected gender inequality indicators. Instead of the subjective weighting of each indicator, the DEA method, as a non-parametric approach, enables the calculation of an aggregated weighted pattern within a cumulative data set. In this regard, gender inequality indicators that are highly important for one decision-making unit and less important for other decision-making units (in our case, each G20 country) are all included in the model and calculated accordingly. In other words, it balances the statistical impact of high- and low-weighted indicators for different countries. In this regard, the DEA method has the potential to provide more statistical objectivity by providing the cumulative analyses of decision-making units (in our case, G20 countries) and aggregated weighting of all indicators representing outputs.

Analysis and Findings

This study suggests an empirical methodology for constructing a multi-dimensional cross-country comparison of the G20 countries' performance according to gender inequality in human development. The composite index is developed by extending the GDI and GII for the analysis. The DEA model is an aggregation tool of the composite index for eleven selected indicators (outputs) representing gender inequality in human development dimensions. DEA avoids the subjectivity of the indicators' weights in the proposed composite index. The DEA method also allows cross-country benchmarking and comparison from 2014 to 2020.

In the analysis context, we model countries as decision-making units (DMUs) producing a set of indicators (outputs) with single virtual input of unit value. The composite index consists of eleven outputs—nine desirable and two undesirable—for the analysis. Because of the unavailability of data, we decided to develop two research models—Model 1 consists of all indicators for G20 countries. On the contrary, the data on the "*female share of employment in senior and middle management*" (O9) is unavailable for some G20

countries such as China, Korea, and Saudi Arabia. Thus, Model 1 has 19 DMUs (all G20 countries), while Model 2 has 16 DMUs. We can rank all these countries' efficiencies and present their weaknesses and improvement rates concerning the proposed composite index.

We use a DEA model to establish an initial difference between efficient and inefficient countries in the first stage. The output-focused model seeks to produce maximum output (indicators) with current input (virtual input of unit value). Accordingly, Lovell and Jesus (1999) stated that the output-oriented variable return to scale (VRS) model is appropriate for the DEA model without inputs. If a DMU achieves the maximum value of 100%, it is assumed to be efficient; if not, it is considered inefficient. However, it might be necessary to rank the performance of efficient DMUs. Therefore, Andersen and Christian (1993) proposed a super-efficiency model. This model might be used in ranking the performance of efficient DMUs. The output-oriented super-efficiency model might be beneficial for ranking G20 countries regarding the indicators used in the proposed composite index. Tables 1 (for 2014) and 2 (for 2020) show efficiency scores and countries' ranks.

Tables 1 and 2 summarize the most relevant findings. It can be observed that 13 countries were described as efficient (above 1) in 2014 and 2020. Interestingly, the same six countries (Brazil, Turkey, Russia, Saudi Arabia, Indonesia, and India) were inefficient (below 1) in 2014 and 2020. However, the ranks and scores of some efficient and inefficient countries have changed. For instance, China was the eighth most efficient country in 2014 while the least efficient (19th) in 2020. On the contrary, Mexico ranked last in 2014 and became 3rd in 2020. Among the inefficient countries, Indonesia and India preserved their place as the two least inefficient countries in 2014 and 2020. In comparison, the rank of the other four countries changed over the period. For instance, in 2014, Brazil and Turkey were 14th and 15th out of 19 countries, while they moved to 15th and 16th place in 2020.

Model 2—considering the inclusion of the "female share of employment in senior and middle management" indicator—provides interesting findings according to the analysis. Brazil appeared in the group of efficient countries in 2014 when the female share of employment was added to the model, showing the indicator's specific role. However, it moved again into the inefficient group in 2020. On the contrary, Russia was inefficient in 2014 while in the efficient group in 2020. The changes in the efficiencies of these two countries illustrate the effect of this specific gender inequality indicator on the performance of these two countries. The efficiencies of the USA, Japan, and the UK also further increased when considering the "female share of employment in senior and middle management" indicator in 2020, which also demonstrates the importance of the specific indicator for changing the scores and ranks of both efficient and inefficient states in the model.

Our research findings regarding the inefficiency of G20 countries are more complex and can be explained in a two-level framework. The first one is the identification of the "main weaknesses" of each inefficient country (score below 1) regarding gender inequality indicators as described in Tables 1 and 2 accordingly. Secondly, it specifically documents "the needed improvement rate" for inefficient countries to become efficient frontier, as illustrated in Table 4 regarding percentage rates. According to the findings, each inefficient country is suggested to focus first on identifying their main weaknesses in gender indicators and then on improvement strategies for the indicators that cause inefficiencies.

Firstly, the indicators regarding the "main weaknesses" shed light on the specific inefficiency causes/sources of G20 countries in 2014 and 2020 among the selected 11 indicators of our model (Tables 1 and 2). Our research findings categorize, for instance, Turkey and Russia as demonstrating the same weakness patterns in areas regarding gender inequality indicators such as "O4: Estimated GNI per capita"; "O5: Share of seats in parliament," and "O6: Proportion of women in ministerial level" in 2014. However, research findings also demonstrate that, for instance, in both study years, these three indicators are the most common main weaknesses of all inefficient countries. Findings also demonstrate that "undesired outputs" such as "O10: Maternal mortality rate; O11: Adolescent birth rate" did not appear as the main weaknesses of inefficient countries, except for Brazil (see Tables 1 and 2)

In a more detailed analysis, the "main weaknesses" and "role models" of inefficient countries are also shown in Tables 1 and 2. DEA provides the best practice frontier for DMUs. This frontier also envelopes the less efficient units, with the distance between these units' positions and the calculated frontier indicating their relative inefficiency (Chaaban, 2009). Benchmarking against these best practice frontiers establishes the basis for the computation of each DMU's inefficiency measures, paving the way for ranking the DMUs (Reig-Martinez, 2013). Accordingly, we can describe the role models of inefficient countries to become efficient. Table 3 provides the brief frequencies of role models for the group of inefficient countries.

According to Table 3, Australia is found to be the leading role model among inefficient countries in both 2014 and 2020. Canada and Italy are also continuously good models for being efficient. Emerging middle-power countries such as Korea have only recently been reported as role models. On the contrary, big powers such as the USA and China are not described as role models for any inefficient countries in 2020. It is also important to note that efficient countries are not identical in performance in specific gender indicators, nor are they the sole role models for each inefficient country.

Analyses of specific role models for inefficient countries are indeed more complex. The role model countries refer to

Table 1 Efficiency scores and rankings of G20 countries (2014)

	Model 1		Model 2			
	Rank	Score	Rank	Score		
Efficient countries						
France	1	1.411	1	1.411		
South Africa	2	1.228	2	1.228		
Australia	3	1.184	4	1.184		
USA	4	1.195	3	1.195		
Germany	5	1.111	5	1.111		
Canada	6	1.095	7	1.096		
Argentina	7	1.080	6	1.110		
China	8	1.063	NA	NA		
Japan	9	1.025	8	1.025		
Korea	10	1.023	NA	NA		
UK	11	1.017	9	1.017		
Italy	12	1.014	10	1.014		
Mexico	13	1.006	13	1.008		
Inefficient countries					Role models	Main weaknesses
Brazil	14	0.958	12	1.010	Canada (0.77) China (0.22) Australia (0.01)	O5** O4** O10*
Turkey	15	0.946	14	0.946	Italy	O6*** O4** O5**
Russia	16	0.940	11	1.013	Canada (0.79) USA (0.21)	O6*** O5** O4*
Saudi Arabia	17	0.933	NA	NA	Italy (0.94) Australia (0.06)	O6*** O7** O5*
Indonesia	18	0.862	15	0.862	Australia (0.76) Canada (0.24)	O4*** O8** O9*
India	19	0.787	16	0.788	Japan (0.85) Italy (0.15)	O4*** O3*** O8**

Required improvement rate: ***more than 300; **more than 100%; *less than 99%

O1, life expectancy at birth; *O2*, expected years of schooling; *O3*, mean years of schooling; *O4*, estimated GNI per capita; *O5*, share of seats in parliament; *O6*, proportion of women in ministerial level; *O7*, labor force participating rate; *O8*, population at least secondary education; *O9*, female share of employment in senior and middle management; *O10*, maternal mortality rate; *O11*, adolescent birth rate

the efficient countries that offer a mathematical pattern to inefficient countries to improve themselves and thus become efficient. Role model countries for inefficient states are different from one another in many aspects. They are conceptualized "mathematically" as role models since their gender inequality indicator clusters are close to each other within the efficiency frontier. In other words, role model countries represent the closest pattern in the efficiency frontier that inefficient countries can take as role models for indicator-specific improvement strategies in achieving gender equality in development.

For instance, Canada (.79) and the USA (.21) were found to be role models for Russia in 2014 (Table 1). Regarding specific role models, Canada might be considered the primary role model for Russia in 2020, as the correspondence rate of Canada as a role model for Russia was 79% in 2014 and 100% in 2020. This does not mean they have similar strengths and limitations regarding gender inequality in human development. It means that to make necessary improvements and become an efficient country, Russia would get optimal benefits from targeting the pattern of either USA's or Canada's gender inequality indicators. Italy was the only role model for Turkey in 2014, while Japan (.57), Australia (.25), and Italy (.18) were role models for Turkey in 2020. In other words, among the cluster of countries, Italy's pattern related to gender inequality indicators is a better and more optimal role model for Turkey concerning indicator-development

Table 2 Efficiency scores and rankings of G20 countries (2020)

	Model 1		Model 2			
	Rank	Score	Rank	Score		
Efficient countries						
Australia	1	1.241	1	1.241		
France	2	1.190	3	1.190		
Mexico	3	1.140	4	1.140		
Canada	4	1.131	5	1.131		
USA	5	1.117	2	1.227		
South Africa	6	1.068	6	1.068		
Germany	7	1.061	7	1.061		
Korea	8	1.043	NA	NA		
Japan	9	1.031	8	1.046		
Italy	10	1.029	9	1.029		
Argentina	11	1.022	11	1.022		
UK	12	1.010	12	1.020		
China	13	1.002	NA	NA		
Inefficient countries					Role models	Main weaknesses
Russia	14	0.963	10	1.027	Canada	O6*** O4* O5*
Saudi Arabia	15	0.946	NA	NA	Korea (0.60) Italy (0.27) Australia (0.13)	O6*** O7** O4*
Turkey	16	0.929	14	0.929	Japan (0.57) Australia (0.25) Italy (0.18)	O4* O6* O8*
Brazil	17	0.926	13	0.968	Australia (0.80) Japan (0.20)	O4*** O6** O10*
Indonesia	18	0.880	15	0.880	Canada	O4*** O6*** O8**
India	19	0.826	16	0.858	Korea (0.97) France (0.03)	O4*** O8** O6**

Required improvement rate: ***more than 300; **more than 100%; *less than 99%

O1, life expectancy at birth; *O2*, expected years of schooling; *O3*, mean years of schooling; *O4*, estimated GNI per capita; *O5*, share of seats in parliament; *O6*, proportion of women in ministerial level; *O7*, labor force participating rate; *O8*, population at least secondary education; *O9*, female share of employment in senior and middle management; *O10*, maternal mortality rate; *O11*, adolescent birth rate

strategies. Interestingly, Korea is considered an emerging role model for inefficient countries in 2020, such as India and Saudi Arabia (Table 2). However, one should be cautious regarding these results, too, since, for instance, indicators such as female share of employment in senior and middle management are not available for Korea and thus were not included in the first model of this study.

Furthermore, results also illustrate the necessary improvement rate for inefficient countries to participate in the group of efficient countries. In this regard, Table 4 summarizes the improvement rate of inefficient countries regarding each indicator. Improvement rates shed light on the weaknesses and opportunities of these countries. Since the weaknesses of each indicator decrease the efficiency level, an improvement on these weaknesses might increase the efficiencies of the countries.

O1, life expectancy at birth; *O2*, expected years of schooling; *O3*, mean years of schooling; *O4*, estimated GNI per capita; *O5*, share of seats in parliament; *O6*, proportion of women in ministerial level; *O7*, labor force participating rate; *O8*, population at least secondary education; *O9*, female share of employment in senior and middle management; *O10*, maternal mortality rate; *O11*, adolescent birth rate

According to the inefficiency analysis, all inefficient countries, except Turkey, should increase their indicator

Table 3 Role model frequency

	Number of times each efficient country is used as a role model	
	2014	2020
Australia	3	3
Canada	3	2
China	1	0
France	0	1
Italy	3	2
Japan	1	2
Korea	0	2
USA	1	0

levels by 200% to become efficient. This number is relatively high, indeed. More specifically, Brazil should increase the O4 (estimated GNI per capita) by at least 249% and O6 (proportion of women at the ministerial level) by at least 162%. India should increase the O4 by at least 1085%, O6 by at least 151%, O7 (labor force participating rate) by at least 137%, and O8 (population at least secondary education) by at least 169%. Similarly, Indonesia should increase the O4 by at least 386%, O6 by 236%, and O8 by 100%. Russia should increase the level of O4 to at least 97% and O6 at least 284%. Saudi Arabia should increase the O6 by 200% and the O7 by at least 126%. However, Turkey should increase any indicator to 77% to become efficient, specifically, O3 (mean year of schooling) at least 64%, O4 at least 77%, O6 at least 77%, O7 at least 47%, and O8 at least 73%. Besides, Turkey should decrease O10 (maternal mortality rate) by at least 65%.

These findings also provide valuable insights for inefficient countries. For instance, Turkey might become an efficient country in the future, considering the low-level percentage weaknesses of each indicator. In other words, Turkey should make relatively low improvements, but in all 9 out of 11 indicators, to become efficient. In other words, this could be read as the potential and opportunity for Turkey to move into efficient countries. However, 9 out of 11 indicators need improvement, which necessitates a comprehensive and all-encompassing gender perspective and policy planning in development.

Moreover, findings illustrate that countries such as Brazil and Russia have the potential to be efficient in the future by focusing predominantly on the "estimated GNI per capita" (O4) and "proportion of women at ministerial level" (O6) indicators. India, Indonesia, and Saudi Arabia need more comprehensive and long-term improvement plans to be efficient. More importantly, the findings illustrate that all inefficient countries should make tremendous improvements concerning specific indicators to become efficient.

The improvement rate of each indicator might be defined as the efficiency increase of an inefficient country from the mathematical model perspective of this study. In other words, if any weakness indicator for the inefficient country is improved, it will directly affect the improvement of the efficiency scores of inefficient countries from a statistical perspective. However, the comprehensive improvement of inefficient countries should be understood from more than a quantitative indicator improvement perspective. It also necessitates qualitative weighted specific gender inequality analyses as well as proper identification of specific and local priorities. In other words, gender inequality improvement in inefficient countries might be better understood from both a quantitative and qualitative perspective. Since this study provides an innovative perspective for measuring and understanding the relative weight and importance of gender inequality indicators and the inefficiency causes of gender inequality among G20 countries, it provides valuable findings to researchers and improvement suggestions to policymakers.

While our analysis compares G20 countries' efficiencies regarding gender inequality in human development, how the comparative performance of G7 and G20 countries changes relatively over time is essential to see the efficiency scores among developing and developed countries. Accordingly, Table 5 summarizes the efficiency changes considering the G7 + Russia (G8) and G20 countries group. While many indicators are relatively good in G8 countries, interestingly, the efficiencies of some countries also decreased over the period, such as France and Germany. The efficiency trends of the UK and the USA between 2014 and 2020 also decrease similarly. However, when considering the "female share of employment

Table 4 Required improvement rate of inefficient countries (%)

	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11
Brazil	-	25	49	249	69	162	-	41	75	81	-
India	-	5	90	1085	-	151	137	169	85	-	11
Indonesia	-	8	59	386	53	236	-	100	94	76	67
Russia	5	5	9	97	80	284	8	-	5	50	-
Saudi Arabia	7	-	10	78	14	>200	126	18	-	-	NA
Turkey	-	-	64	77	6	77	47	73	-	65	15

in senior and middle management" indicator (see Model 2), the UK and US efficiencies increased between 2014 and 2020.

The efficiencies of Argentina, China, and South Africa also slightly decrease in time among efficient countries. Brazil and Turkey have also shown a negative efficiency trend among the inefficient countries. Considering the "*female share of employment in senior and middle management*" indicator, this decreasing trend worsens. Positive efficiency trends are seen in Canada, Italy, Japan, and Russia (even inefficient) in G8 countries. Similarly, Australia, Korea, and Mexico seem to increase the efficiencies among the efficient countries of G20 over the period. Although India, Indonesia, and Saudi Arabia also slightly increased efficiency levels, these countries are still in the inefficient groups in G20.

The efficiency change analysis also provides the efficiency trends regarding the increases and decreases of efficiencies of countries. Interestingly, the most dramatic decrease is observed in France between 2014 and 2020 at 15.7%, which needs further in-depth elaboration. A similar decrease occurred in South Africa's efficiency (13%). The efficiencies of Germany (4.5%) and the USA (6.5%) decreased from the G8 group, respectively. Surprisingly, Mexico increased its efficiency by nearly 13%, and Australia's efficiency increased by 4.8% between 2014 and 2020. While the efficiency of Brazil decreased by 5.7%, India's efficiency increased by 5% in this period. Consequently, the group of efficient countries, France, Germany, the USA, and South Africa, decreased the performance of gender inequality in human development between 2014 and 2020. On the other hand, Mexico dramatically increased its performance of gender inequality in human development in the study period, which also needs further explanation.

Discussion and Conclusion

Craig (1996) long ago asserted that the most profound challenge to the IR field comes from a consideration of the roles of women in world politics (Craig, 1996). An almost seven-fold increase in the annual number of publications over the last decade of analysis highlights the growing interest in gendered change in international development (MacArthur et al., 2021). However, still, gender and IR continues to be the area where the most significant conceptual and empirical work remains to be done (Craig, 1996). This study employed an empirical methodology for constructing a multi-dimensional cross-country comparison of the G20 countries' performance concerning gender inequality in human development from 2014 to 2020. By introducing a nonparametric approach, Data Envelopment Analysis (DEA), to measure the gendered change in development, it analyzed the patterns of efficiency (performance of each G20 country regarding gender inequality in human development) change over time.

The findings regarding progress between the study years 2014 and 2020 illustrate that, among all G20 countries, 9 out of 19 countries experience a decreasing trend in efficiency scores regarding our compositive index indicators in the study years (Table 5). Since G20 initiated commitments related to gender equality at Los Cabos Summit in 2012, this decreasing trend is even more alarming for realizing gender equality in development. It should be noted that 4 out of the 9 countries that experienced a decrease in efficiency scores are G7 countries (the UK's proportion of decrease is nearly 0.69%, Germany 4.5%, the USA 6.5%, France 15.7%, as follows). In this regard, the decreasing trend in four of the seven countries (especially France) needs further in-depth analyses for further studies. As Momsen (2020) stresses, the experiences of different states and regions show that economic prosperity helps gender equality, but some gender gaps are resistant to change. Therefore, these findings demonstrate that not only developing states but also industrialized Western countries should reduce gender inequality in human development to realize UN Sustainable Development Goals with the premise of "leaving no one behind." This decreasing trend is worrying, considering there is a long way toward achieving gender equality in human development (World Economic Forum Global Gender Gap Report, 2021).

Emerging powers like China increased their willingness to play active roles in the UN system in recent years, especially emphasizing the "development" pillar. However, the decreasing efficiency trend of emerging powers like China (5%) illustrates that emerging/rising powers are still way behind in being a potential development "role model" regarding at least gendered aspects of international development. Recent studies have shown that the emerging powers, with their differentiated interests, are unlikely to form a cohesive bloc on the UN's development-related activities (Browne and Weiss, 2014).

Another noteworthy finding of analysis results is the relative success of middle powers like MIKTA states compared to BRICS concerning percentage changes in efficiency scores from 2014 to 2020 among the G20 group (Table 5). Except for Turkey, all four other MIKTA states illustrated an increasing efficiency trend from 2014 to 2020. Nevertheless, still, Turkey and Indonesia continue to be in the inefficient group. However, three out of four countries (Brazil, China, and South Africa) demonstrated a decreasing efficiency trend among the BRICS. Brazil, Russia, and India continue to be in the inefficient group.

Our study also attempted to measure the main weaknesses of inefficient countries in gender inequality in development concerning the study years. According to our findings, key indicators such as estimated GNI per capita, the share of seats in parliament, and the proportion of women at the ministerial level can exert a relatively higher impact on the overall gender inequality scores of countries (Tables 1, 2, and 4). For instance, our analysis results show that the primary weakness indicator that inefficient countries should focus on is GNI per capita (Tables 1, 2, and 4; Appendix Tables 6 and

Table 5 Changes in the efficiencies of G8 and G20 countries over time

	Model 1			Model 2		
	2014		2020	2014		2020
Canada	1.095	↑	1.131	1.096	↑	1.131
France	1.411	↓	1.190	1.411	↓	1.190
Germany	1.111	↓	1.061	1.111	↓	1.061
Italy	1.014	↑	1.029	1.014	↑	1.029
United Kingdom	1.017	↓	1.010	1.017	↑	1.020
United States	1.195	↓	1.117	1.195	↑	1.227
Japan	1.025	↑	1.031	1.025	↑	1.046
Russia	0.940	↑	0.963	1.013	↑	1.027
Argentina	1.080	↓	1.022	1.110	↓	1.022
Australia	1.184	↑	1.241	1.184	↑	1.241
Brazil	0.958	↓	0.926	1.010	↓	0.968
China	1.063	↓	1.002	NA		NA
India	0.787	↑	0.826	0.788	↑	0.858
Indonesia	0.862	↑	0.880	0.862	↑	0.880
Korea	1.023	↑	1.043	NA		NA
Mexico	1.006	↑	1.140	1.008	↑	1.140
Saudi Arabia	0.933	↑	0.946	NA		NA
South Africa	1.228	↓	1.068	1.228	↓	1.068
Turkey	0.946	↓	0.929	0.946	↓	0.929

7). However, GNI improvement might require cumulative and complex policy changes. Analysis findings also reveal that the second most frequent cause of inefficiency among indicators is the proportion of women at the ministerial level (Tables 1, 2, and 4; Appendix Tables 6 and 7). This might also be considered an opportunity for inefficient countries to invest more in political empowerment at a high level that attempts to decrease their gender inequality level in human development. Most recent research demonstrates that female leaders outperformed males when dealing with a global policy issue like COVID-19 (Bruce et al., 2022). Therefore, the study findings document the need for reevaluation and better statistical understanding of the cluster of gender inequality indicators for better-measuring gender inequality in human development. In this regard, it proposes an innovative perspective for measuring and understanding the relative weight and importance of gender inequality indicators.

This study documents the main weaknesses of inefficient states and attempts to identify the potential "role model" state/states for those inefficient states. Our findings reveal that for both study years (2014 and 202), Australia is found to be the most frequent role model (6 times) for inefficient states (Table 3). Canada and Italy (5 times) follow Australia. It should also be noted that Korea never appeared as a role model in 2014, while it appeared as a role model 2 times in 2020 (Table 3). According to our analysis results, traditional middle powers such as Australia and Canada are the most frequent role models for inefficient states. Emerging middle powers such as Korea appeared as recent role models compared to rising states in G20.

One should underline that this study does not claim to identify potential role models for inefficient states regarding all aspects of gender inequality. It does not argue nor could guarantee that following the same path as their role models, the inefficient states will continue improving those aspects. Many of these countries are so different in terms of their culture, society, political systems, and experiences on socio-economic development. As Marchand (2009) asserts, gender relations are embedded in local histories, practices, and discourses. To address and possibly transform gender relations, it is imperative to understand such local articulations. As stated before, the comprehensive improvement of inefficient countries should be understood from more than a quantitative indicator improvement perspective. It also necessitates qualitative weighted specific gender inequality analyses as well as proper identification of specific and local priorities. Our research findings provide comparative data on the main weaknesses of states and potential role models for inefficient countries regarding the indicators evaluated within this study's scope.

This research attempts to contribute to the growing literature on measuring gender inequality in human development by using an empirical methodology for constructing a multidimensional cross-country comparison of the G20 countries' performance regarding gender inequality in human development by using an innovative, nonparametric approach, Data Envelopment Analysis (DEA). Future studies might also comparatively measure and test the role model capacity of states on other dimensions of development and use other gender indicators to further contribute, test, and extend the growing literature on measuring gender inequality in all aspects. In this regard, analysis result findings might be benchmarked with the latest SDG Gender Index scores, which is also in the scope of our future research agenda.

Appendix

Table 6 Descriptive statistics of G20 countries (2014)

	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11
Canada	83.6	16.2	12.3	34.61	28	32	61.6	100	12	14.5	34.6
France	85.2	16.3	10.9	29.58	25.1	48.6	50.9	78	8	5.7	32
Germany	83.1	16.2	12.6	33.02	32.4	33.3	53.5	96.3	7	3.8	27.8
Italy	85	16.8	9.7	22.30	30.6	30	39.4	71.2	4	4	21.9
United Kingdom	82.5	16.7	12.8	27.58	22.6	15.6	55.7	99.8	12	25.8	32.9
United States	81.3	17.4	13	41.79	18.2	31.8	56.8	95.1	21	31	38.8
Japan	87	15.1	11.2	22.38	10.8	11.1	48.1	87	5	5.4	14.5
Russia	74.4	14.5	11.7	18.22	12.1	6.7	57	89.6	34	25.7	38.1
Argentina	79.9	17.5	10	11.97	37.7	17.6	47.3	57	77	54.4	38.6
Australia	84.8	20.3	12.5	35.55	29.2	17.2	58.8	94.3	7	12.1	32.6
Brazil	77.6	14.9	7.3	10.85	9.6	25.6	59.5	51.9	56	70.8	37.4
China	76.7	13	6.9	9.28	23.4	8.3	63.8	58.7	37	8.6	NA
India	68.3	11.3	3.2	2.27	10.9	9.3	28.8	26.6	200	32.8	13
Indonesia	72.9	12.8	6.9	5.87	18.6	11.8	51.3	39.9	220	48.3	19.4
Korea	84.8	16.1	11.1	21.79	15.7	11.8	49.9	77	16	2.2	NA
Mexico	79.8	12.9	8.1	10.06	36	17.6	45	55.7	50	63.4	35.3
Saudi Arabia	77.6	15.9	8	16.19	19.9	0	18.2	60.5	24	10.2	NA
South Africa	58.8	15.8	9.8	8.53	41.1	37.1	44.2	72.7	300	50.9	34.3
Turkey	78.7	13.8	6.4	8.81	14.2	4	29.4	39	20	30.9	15.5
Mean	79.05	15.45	9.71	19.51	22.95	19.44	48.38	71.07	58.42	26.34	29.16
Std. dev.	6.88	2.09	2.71	11.57	9.73	12.98	12.14	22.54	84.92	21.96	9.2

O1, life expectancy at birth; *O2*, expected years of schooling; *O3*, mean years of schooling; *O4*, estimated GNI per capita; *O5*, share of seats in parliament; *O6*, proportion of women in ministerial level; *O7*, labor force participating rate; *O8*, population at least secondary education; *O9*, female share of employment in senior and middle management; *O10*, maternal mortality rate; *O11*, adolescent birth rate

Table 7 Descriptive statistics of G20 countries (2020)

	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11
Canada	84.39	16.66	13.41	39.46	28.99	50	61.13	100	10	8.4	35.1
France	85.48	15.97	11.26	39.48	39.68	52.94	50.65	81.7	8	4.7	34.24
Germany	83.72	16.91	13.88	45.27	30.88	40	55.63	95.9	7	8.1	28.59
Italy	85.53	16.41	10.18	31.64	35.71	33.33	41	75.9	2	5.2	23.27
United Kingdom	82.99	17.98	13.24	33.32	32	30.43	58.09	78	7	13.4	34.91
United States	81.40	16.92	13.46	50.6	23.43	17.39	56.75	96.1	19	19.9	40.85
Japan	87.66	15.18	13.06	30.58	10.10	15.78	53.56	95.3	5	3.8	14.50
Russia	77.78	15.26	11.91	19.69	15.77	12.90	54.58	96.3	17	20.7	41.99
Argentina	79.99	18.91	11.12	14.87	40.15	22.72	51.34	59.2	39	62.8	33.14
Australia	85.40	22.43	12.79	39.29	30.46	26.66	60.81	91	6	11.7	35.5
Brazil	79.55	15.76	8.18	10.53	15.01	9.09	55.09	61.6	60	59.1	38.61
China	79.24	13.96	7.7	12.63	24.94	6.45	60.56	76	29	7.6	NA
India	70.95	12.63	5.41	23.3	14.39	12.5	20.79	27.7	133	13.2	14.83
Indonesia	73.96	13.67	7.76	79.02	17.39	14.28	53.81	46.8	177	47.4	19.4
Korea	85.95	15.91	11.42	27.73	16.66	33.33	53.77	80.4	11	1.4	NA
Mexico	77.87	15.04	8.58	12.76	48.2	35	45.58	62.2	33	60.4	35.52
Saudi Arabia	76.75	16.01	9.75	16.51	19.86	0	22.09	64.8	17	7.3	NA
South Africa	67.67	14.17	10.03	92.48	46.34	48.27	49.59	75	119	67.9	33.25
Turkey	80.56	16.02	7.27	17.85	17.44	11.76	34.27	50.2	17	26.6	17.46
Mean	80.36	16.09	10.55	33.52	26.71	24.89	49.43	74.43	37.68	23.66	30.07
Std. dev.	5.36	2.13	2.51	21.98	11.45	15.64	11.92	19.79	49.95	23.14	9.20

O1, life expectancy at birth; *O2*, expected years of schooling; *O3*, mean years of schooling; *O4*, estimated GNI per capita; *O5*, share of seats in parliament; *O6*, proportion of women in ministerial level; *O7*, labor force participating rate; *O8*, population at least secondary education; *O9*, female share of employment in senior and middle management; *O10*, maternal mortality rate; *O11*, adolescent birth rate

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Declarations

The authors declare no competing interests.

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