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Gender discriminations: Issues of measurement and practices

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Abstract Gender discrimination is often seen through the lens of education, empowerment, Govt. schemes etc. But it begins within a family due to deeply rooted social norms and expectations about roles for different genders in patriarchal societies. The paper addresses measurement issues of gender discrimination and practices in failing to recognising boys and girls as individuals in an inclusive environment ensuring equal opportunity to grow, participate and thrive. Two inversely related indices Gender Inequality Index (GRI_{GM}) and Gender Similarity Index (*GSI*) are suggested satisfying desired properties. Each GRI_{GM} and *GSI* considers all indicators in different units, percentages, ratios, count data and can classify countries. Dimensions can be ranked based on relative importance i.e. $\frac{\Delta(GRI_{GM})}{\Delta D_i}$ or $\frac{\Delta(GSI)}{\Delta D_i}$. While *GSI* indicates current distance of a country from the ultimate goal of zero gender inequality, GRI_{GM} indicates progress made by female group and separately by male group. GRI_{GM} is preferred for methodological advantages. Investment in unbiased parenting skill, emotional literacy and gender sensitive community practices may go a long way to develop more egalitarian attitudes and shift from control to care, from silence to voice from protection to pride to materialise promises of gender equality into reality.

Keywords: composite index, gender inequality, multiplicative aggregation, cosine similarity, normal distribution, patriarchal norms

1. Introduction

Gender discrimination often begins within a family primarily due to deeply rooted social norms and expectations about roles for different genders in a patriarchal society. These norms define what it means to be a boy or a girl and often give rise to differential treatments to boys and girls in education, health, career choices, decision-making powers and unequal distribution of household income. Gender discrimination goes beyond the biological differences and is in fact, a social construct expecting children to conform to specific and limiting gender roles and expectations from a young age. Parents tend to allocate higher share of resources to boys with potential to become economically productive as adults unlike girls who leave the family after marriage implying loss of earnings. In other words, reliance on sons' income is more and non-reliance on the income potential of adult daughters result in gender bias in education and health which lead to higher income for an individual (Lahiri & Sharmistha, 2007). In almost every society, boys are encouraged to be strong and independent and girls are encouraged to be nurturing submissive and help in household chores as preparation to marriage. Early marriage for girls implies less expenditure of the parents which results in lower educational attainments of women and gender bias. Early marriage and associated lower educational attainments cause lower female participation in workplaces, which may lower returns to higher education.

Gender equality is the fundamental concept of human rights, Sustainable Development Goals (SDGs), principle in democratic constitutions of several nations (LeMoyne, 2011; United Nations, 2015; United Nations, 2019) is a way to foster socio-economic prosperity through equal opportunities, participation in decision-making, access to resources, education and employment (Dugarova, 2018). U-shaped curve concerning women workforce participation rate (WPR) and level of education was observed in India (Datta et al., 2020). In fact, gender inequality is not a problem of women only but it impacts children, families, and communities by depriving equal opportunities and basic rights. Thus, the entire society need to work together, even for each individual's own interest.

Despite various measures adopted to gender equality, the Global Gender Gap Report 2023 (World Economic Forum, 2023) showed existence of gender gaps in education, health, policies on socio-economic participations. Progress in reduction of overall gender gap in 146 countries was only 0.3% in 2023 from 2022. Assuming the rate of progress registered during 2006 to 2023, full reduction of gender gap in Political Empowerment may require around 162 years; 169 years for the Economic Participation and Opportunity gender gap, and 16 years for the Educational Attainment gender gap. However, time required to close the Health and Survival gender gap was not defined. Measurement framework of twin measures of gender equality namely Global Gender Parity Index (GGPI) and Women's Empowerment Index (WEI) were suggested recently (UNDP, 2025). GGPI and WEI consider four common dimensions viz. Life and good health; Education, Skill-building and knowledge; Labour

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and financial inclusion; Participation in decision-making. More women-centred WEI has an additional dimension in terms of freedom from violence. Chosen indicators under each dimension are also given. However, availability of data relating to the proposed indicators is a problem. Data gaps remain in other dimensions like violence against women, including psychological, social or economic violence. Moreover, new emerging gender issues are: social norms, digitalization and the environment.

Women empowerment aims at narrowing the gender gap, helping women to attain parity with men and enhancing their social standing and financial stability. Major drivers of women's empowerment and illustrative policies and initiatives taken by Govt. of India are:

- Education - Initiatives like Beti Bachao Beti Padhao (BBBP) for better female literacy rates and access to education for girls.

- Healthcare - Policy like Pradhan Mantri Matru Vandana Yojana (PMMVY) provides financial support to pregnant and lactating mothers, improves maternal and child health

- Economic empowerment – Programmes like National Rural Livelihood Mission and Stand Up provides financial assistance and entrepreneurial opportunities to women.

- Political participation is encouraged through reservations in local and legislative bodies.

- Initiatives on safety and security, skill development, social welfare, One-stop centre (OSC) offering a range of services, including police assistance, medical support, legal aid and counselling, psycho-social counselling, and temporary shelter to women in need, Pradhan Mantri Ujjwala Yojana (PMUY) to provide clean cooking fuel in the form of liquefied petroleum gas (LPG) to women from economically disadvantaged households, etc. further complement efforts to address gender gaps and promote women's empowerment across India.

The paper addresses measurement issues of gender discrimination and practices prevailed in India at grassroots in not recognising boys and girls as individuals in an inclusive environment ensuring equal opportunity to grow, participate and thrive irrespective of gender, background, ability, etc. The paper also suggests two inversely related composite indices viz. Gender Inequality Index (GRI_{GM}) and Gender Similarity Index (*GSI*) satisfying desired properties.

2. Literature survey

Using questionnaire in five parts, administered on small sample of males and females under lower-income and lower-middle-income groups covering limited geographical area, Sharma et al. (2023) found four factors that contribute to women's societal empowerment in India are education, economy, independence, and gender reversal. To assess preference for traditional gender roles, Friberg & Jahanlu (2024) used a battery of questionnaire and found that certain religion play role in preservation of conservative attitudes. However, distribution of ordinal scores of questionnaire were not normal and failed to satisfy the assumptions of analysis like *t*-test, MANOVA, etc. Summative scores of ordinal data with unknown distance between successive levels are not additive (Wu, 2007) and hence, arithmetic average of item scores is not meaningful (Helmut, 2006). *K*-point scales (*K*= 3, 4, 5 …) differ in mean, variance and influence item/test parameters more than the underlying variable (Lim, 2008). Moreover, *K*-point scales result in different distributions of test scores and different values of scale qualities like discriminating power, reliability, validity, etc. (Preston and Colman, 2000). Empirically, Maertens (2013) found that in rural India, perceptions of the parents towards ideal age of marriage affect significantly educational attainment of daughters, but not sons. In addition, educational aspirations were lower for girls compared to boys primarily due to social norms favouring early marriage of girls. However, aspirations were found to be sensitive to the perceived returns to higher education for boys, but not for girls.

Various composite indices have been proposed to measure gender inequality (or equality) at regional, national and global level. Such indices are not comparable due to non-uniform choice of indicators, dimensions, scoring methods, etc. Strength and limitations of various gender related indices (GRIs) were discussed (Barnat et al., 2019; di Bella and Suter, 2023). SDG-5 measures gender equality and empowerment of women through nine targets and 14 indicators. However, the indicator corresponding to Goal -5c considers whether a given country has systems in place to track and make publicly available information about budget allocations for gender equality and women's empowerment, fails to reflect the extent or quality of spending on gender equality and women's empowerment programs. Data availability for the indicator 5.3.2 is problematic. Data gaps exist across countries for the indicator 5.2.2. Internationally comparable data are not yet available for this indicator.

NITI Aayog of Govt. of India measures improvement in SDG-5 using six indicators (*www.niti.gov.in*). However, SDG-5 focusing on few woman-specific roles may not be comprehensive (Manandhar et al., 2018). Differential family expenditure for developing girls and boys affects justice in opportunities, leading to socio-economic inefficiency and inhibiting growth and global SDG (de Jong & Vijge, 2021). Simple method of aggregating indicators of SDG-5 was suggested by Chakrabartty (2023) where each of the indicators was expressed in terms of proportions which were combined to reflect overall proportion for a State/Union Territories at current period and helped to assess current status (achievement) of a country by computing combined proportion. The popular Gender Inequality Index (GII) (UNDP, 2018), is considered an improvement over earlier indices like, Gender-related Development Index (GDI), Gender Empowerment Measure (GEM) by United Nations, Social Institution and Gender Index (SIGI) by OECD, etc. Studies used indices like Global Gender Gap Index (GGI) (WEF, 2018), GII, and

SIGI on the same sample (Friberg & Jahanlu, 2024) despite different methodology adopted by such indices except that they all try to assess the extent to which women and men have equal rights and opportunities (Barnat et al., 2019).

GII is based on disadvantages of women in the following dimensions and indicators:

- Female empowerment - indicators are educational attainment measured by secondary level and above (SE_F) for females and parliamentary representation (PR) (PR_F) of females reflect women's access to power
- Economic activities - gender-specific labour force participation rates for male ($LFPR_M$) and female ($LFPR_F$).
- Reproductive health- maternal mortality ratio (MMR) (related to target 3.1 of SDG 3) and adolescent fertility rate (AFR) for early marriages which is related to SDG 3: Good Health and Well-being, particularly Target 3.7.

GII is computed by geometric mean of indicators for each dimension separately for men and women followed by average of direction of men and women by harmonic mean as follows:

Aggregation of indicators for dimensions by:

$$\text{Women group: } G_F = \sqrt[3]{[(\frac{10}{MMR}.\frac{1}{AFR})^{\frac{1}{2}}.(PR_F.SE_F)^{\frac{1}{2}}.LFPR_F]} \quad (1)$$

$$\text{Men group: } G_M = \sqrt[3]{[\,(PR_M.SE_M)^{\frac{1}{2}}.LFPR_M]} \quad (2)$$

followed by aggregating the indices across dimensions as:

$$G_{F,M} = \sqrt[3]{[\,(\overline{Health}.\overline{Empowerment},\overline{LFPR}]} \quad (3)$$

where $\overline{Health} = \frac{\sqrt{\frac{10}{MMR}.\frac{1}{AFR}}+1}{2}$; $\overline{Empowerment} = \frac{(PR_F.SE_F)^{\frac{1}{2}}+(PR_M.SE_M)^{\frac{1}{2}}}{2}$; and $\overline{LFPR} = \frac{LFPR_F+LFPR_M}{2}$

For a country, $0\ (equality) \leq GII \leq 1(extreme\ inequality)$ where higher GII indicates higher gender disparities.

However, GII is not beyond criticism primarily due to:

- Consideration of women-specific variables like MMR, AFR with no counterpart for men.
- Increase in MMR or AFR widen gender gap.
- Non-consideration of wage differences and indicators like unpaid works by women like housekeeping, care of children and family members, etc. at the cost of cutting leisure time and increased stress and physical exhaustions, discrepancy in asset ownerships, childcare support, gender-based violence and participation in community decision-making by women etc.
- Exclusion of asset ownership which is one of the important policy issues for fostering empowerment of women. The Guidelines for Producing Statistics on Asset Ownership from a Gender Perspective present a framework for measuring asset ownership from the perspective of gender equality (UNDSA, 2019).
- Lacks direction of the gender-gaps and does not facilitate finding relative position of men vis-à-vis women based on GII values (Permanyer, 2013).
- Parliamentary representation (PR) by women (PR_F) at national level excludes participations of women at local governments, community and public life, etc.
- Excludes the level of development of the country and thus, may not facilitate international comparisons.
- Method of combining the dimension scores may fail if score of a dimension is zero (say, zero PR of women).
- Even if $LFPR_M = LFPR_F$; $SE_M = SE_F$; $PR_M = PR_F$, values of GII could be different indicating penalizing region or country with bad reproductive health conditions for women.

3. Proposed Methods

Avoiding problems of scaling and normalization, selection of weights and reducing level of substitutability of *n*-number of dimensions Chakrabartty (2023b) considered vector $\boldsymbol{X_F} = (X_{F1}, X_{F2}, \ldots\ldots, X_{Fn})^T$ and vector $\boldsymbol{X_M} = (X_{M1}\ X_{M2}\ \ldots\ldots X_{Mn})^T$ where $X_{M,i} > 0;\ \ X_{F,i} > 0\ for\ i = 1.2.\ldots\ldots n$ and suggested Gender Inequality Index (GRI_{GM}) as multiplicative aggregation of unit-free ratios of $\frac{X_{Fi}}{X_{Mi}}$ i.e.

$$GRI_{GM} = \frac{X_{F1}, X_{F2}, \ldots\ldots\ldots, X_{Fn}}{X_{M1}\ X_{M2}\ \ldots\ldots\ldots X_{Mn}} \quad (4)$$

and Gender Similarity Index (*GSI*) as angular similarity between the vectors $\boldsymbol{X_F}$ and $\boldsymbol{X_M}$ as:

$$GSI = Cos\theta = \frac{X_F{}^T X_M}{\|X_F\|\|X_M\|} \quad (5)$$

Where $\|X_F\|$ and $\|X_M\|$ denote length of vectors $\boldsymbol{X_F}$ and $\boldsymbol{X_M}$ respectively and are obtained as $\|X_F\| = \sqrt{\sum_{i=1}^{n} x_{Fi}^2}$ and $\|X_M\| = \sqrt{\sum_{i=1}^{n} x_{Mi}^2}$. Here, $0 \leq Cos\theta \leq 1$ for acute θ.

Lower value of θ $\Longrightarrow$higher value of $Cos\theta$ $\Longrightarrow$ higher value of gender inequality in terms of GSI. $Cos\theta = 1 \Leftrightarrow \boldsymbol{X_F} = \boldsymbol{X_M}$ $\Longrightarrow$ no gender related difference in any dimension. Thus, $Cos\theta = 1$ is the ultimate goal. $Cos\theta$ is a measure of similarity. Measure

of gender inequality in terms of angular dissimilarity is given by $Sin\theta = \sqrt{1 - Cos^2\theta}$ where $0 \leq Sin\theta \leq 1$. Note that the index $GRI_{GM} = \prod_{i=1}^{n} \frac{X_{Fi}}{X_{Mi}}$ is equivalent to Geometric mean of the ratios i.e. $\sqrt[n]{\prod_{i=1}^{n} \frac{X_{Fi}}{X_{Mi}}}$

Inverse relationship between GRI_{GM} and *GSI* can be derived as follows:

$logGRI_{GM} = \sum_{i=1}^{n} logX_{Fi} - \sum_{i=1}^{n} logX_{Mi} = \log [\frac{\|X_F\|}{\|X_M\|}]$

Since $log\|X_F\| = \frac{1}{2}[2logX_{F1} + 2logX_{F2} + \cdots\ldots\ldots\ldots + 2logX_{Fn}] = \sum_{i=1}^{n} logX_{Fi}$

Taking antilog, $GRI_{GM} = \frac{\|X_F\|}{\|X_M\|}$

$$\text{Thus, } GRI_{GM}.GSI. = (\frac{\|X_F\|}{\|X_M\|})\left(\frac{{X_F}^T X_M}{\|X_F\|\|X_M\|}\right) = \frac{\sum_{i=1}^{n} X_{Fi}X_{Mi}}{\sum_{i=1}^{n} {X_{Mi}}^2} \quad (6)$$

Where slope of the relationship is different for different countries.

GRI_{GM} is multiplicative aggregation of ratios of all gender-gaps. GRI_{GM} >1 indicates that women are better off than men and GRI_{GM} <1 indicates the reverse. GRI_{GM} satisfies:

- GRI_{GM} of dimensions = GRI_{GM} of indicators which implies aggregation consistency.

- Reciprocity: If women have X% disadvantages over men, then men to have (100-X)% advantages over women i. e. $\frac{X_{F1},X_{F2},\ldots\ldots\ldots,X_{Fn}}{X_{M1}\,X_{M2}\,\ldots\ldots\ldots X_{Mn}} * \frac{X_{M1}\,X_{M2}\,\ldots\ldots\ldots X_{Mn}}{X_{F1},X_{F2},\ldots\ldots\ldots,X_{Fn}} = 1$

- For *m*-countries, mean and variance of $logGRI_{GM}$ can be found using $logGRI_{GM} = \sum_{i=1}^{m} logX_{F,i} - \sum_{i=1}^{m} logX_{M,i}$ and average GRI_{GM} for the world as antilog of $\frac{\sum_{i=1}^{m} \log (GRI_{GM_i})}{m}$

Each GRI_{GM} and *GSI* considers all indicators in different units, percentages, ratios, count data. Each index reduces trade-off among dimensions/indicators. Facilitates scoring of a dimension and finding:

- Relative importance of dimensions as change in the index due to unit change in the dimension $\frac{\Delta(GRI_{GM})}{\Delta D_i}$ or $\frac{\Delta(GSI)}{\Delta D_i}$,

- Identification of critical dimension which widens GRI_{GM} in the *t*-th period over *(t*-1*)*-th period i.e. $\frac{X_{F_{it}}}{X_{M_{it}}} < \frac{X_{F_{i(t-1)}}}{X_{M_{i(t-1)}}}$ implies *i*-th dimension is critical. Similarly, critical indicator (s) can be identified.

- Percentage progress registered by the *j*-th country in successive periods by $[\frac{GRI_{GM_{j(t-1)}} - GRI_{GM_{j(t)}}}{GRI_{GM_{j(t-1)}}}]$ *100. Similarly, the ratio $\frac{Cos\theta_t}{Cos\theta_{(t-1)}}$* 100 quantifies percentage progress or deterioration of a country in successive tears reflecting responsiveness of the measure.

- Finding world average and testing of statistical hypothesis of equality of mean of two countries or mean of a country at two time-periods using logarithmic transformation of the indices since $logarithm$ of GRI_{GM} = Sum of $logarithm$ of *n*-indicators for female group - Sum of $logarithm$ of *n*-indicators for male group, which becomes an additive model following lognormal distribution for large sample size (Alf and Grossberg, 1979) i.e. if X follows lognormal then log(X) follows normal and vice versa (Motulsky et al., 2025). Lognormal distributions are common when components of composite index are combined multiplicatively (Parkin and Robinson, 1992).

- Testing of null hypothesis H_0: $GRI_{GM}(Country\ 1) = GRI_{GM}$ (Country 2) or for a given country $H_0: GRI_{GM_t} = GRI_{GM_{(t-1)}}$ can be done using t-statistic computed on logarithm of indicators. However, direct testing of H_0: $Cos\theta_t = Cos\theta_{(t-1)}$ is not possible since distribution of Cosθ is not known.

- Each index can quantify responsiveness (changes with time) and can be computed separately for sub-groups like economically backward groups, religious groups, certain age-groups, rural-urban, etc.

- GRI_{GM} is preferred for being strictly monotonically increasing, aggregation of dimensions = Aggregation of indicators and satisfaction of time-reversal test, easy identification of critical areas and relative importance of the indicators or dimensions of the index.

4. Empirical illustration

Calculation of the proposed indices are illustrated by the following hypothetical data covering four indicators for each of country A and B are shown below table 1 and table 2.

5. Observations

Each ratio was less than one indicating higher privileges being enjoyed by males over females. The ratios showed wide variations across countries.

GRI_{GM} of country A, was higher than the same for country B. Same is true for *GSI.*

Rank of Country-A *was* higher than rank of Country – B in terms of GRI_{GM} and *GSI* also.

Table 1 Four indicators of Gender inequality in two countries.

Country↓ Indicators (in %) →	Female Group				Male Group			
	PR_F	Share of population with min. secondary education (SE_F)	$LFPR_F$	Asset Ownership (AW_F)	PR_M	Share of population with min. secondary education (SE_M)	$LFPR_M$	Asset Ownership (AW_M)
A	27.9	61.0	56.6	91.7	72.1	68.3	78.7	98.0
B	17.5	24.3	23.6	18.0	82.5	34.8	69.5	29.4

Table 2 Computation of GRI_{GM} and *GSI.*

Country	$\frac{PR_F}{PR_M}$	$\frac{SE_F}{SE_M}$	$\frac{LFPR_F}{LFPR_M}$	$\frac{AW_F}{AW_M}$	GRI_{GM}=$\prod_{i=1}^{n}\frac{X_{Fi}}{X_{Mi}}$	*GSI*=$Cos\theta_{X_F,X_M}$
A	0.38696	0.893119	0.71929	0.93571	0.23257	0.96486
B	0.21212	0.69828	0.33957	0.61224	0.03081	0.90311

Male group was better off than the female group for both the countries. But, gender inequality was higher in Country B than A.

GSI may not be increasing monotonically. If Asset Ownership of Female Group is increased from 18% to 19% for the country B, the GSI for that country gets reduced.

6. Limitations

- Assumes no missing data.
- The methods fail if score of an indicator is ≤ 0 .
- Introduction of a new indicator requires estimation of values of the same for the previous year.

7. Discussion

Absolute Gender gaps given by $|X_F - X_M|$ does not indicate which group is doing better. Better alternative is relative gaps expressed as disparity ratio$\frac{X_F}{X_M}$. Each of GRI_{GM} and *GSI* based on *n*-number of $\frac{X_F}{X_M}$ ratios, can rank and classify countries. Dimensions can be ranked based on relative importance i.e. $\frac{\Delta(GRI_{GM})}{\Delta D_i}$ or $\frac{\Delta(GSI)}{\Delta D_i}$. While *GSI* indicates current distance of a country from the ultimate goal of zero gender related inequality (Cos$\theta = 1$), GRI_{GM} may indicate progress made by female group and separately by male group. Inverse relationship between GRI_{GM} and GSI indicates that the two indices are likely to be correlated significantly with negative sign.

GRI_{GM} is strictly monotonic, less sensitive to the indicators, better handles the outliers and facilitates finding world average as antilog of $\frac{\sum_{i=1}^{m}\log(GRI_{GM_i})}{m}$, statistical testing and easy to interpret. Thus, GRI_{GM} is preferred for methodological advantages like aggregation consistency, reciprocity, satisfaction of time-reversal test, reciprocity i.e. X% disadvantages of women is over men, implies men to have (100-X)% advantages over women, etc.

However, real issues beyond policies, initiatives and measurements of gender equality are actual practices followed at grassroots in failing to recognising boys and girls as individuals in an inclusive environment ensuring equal opportunity to grow, participate and thrive irrespective of gender, background, ability, etc. Children across genders feel confident in an inclusive environment for boosting physical/mental well-being, fostering empathy among peers and achieving as per potentials. It is not about mere existence of opportunities for girls, but whether they are allowed and encouraged to avail them. In other words, uniformity between what we preach and what we practice every day in homes, school and communities.

Role of girls need to be changed from future wives or home caretakers and passive earners to financially independent individuals with strong educational attainments and participation in organised workforce with equality and dignity so as to facilitate development of human capital. Gender attitudes can be changed. Dhar et al. (2022) studied an intervention in India in terms of discussion and persuasion to reduce participants' support for restrictive gender norms and to increase their equality value and found that the intervention made gender attitudes more supportive of gender equality. Education and employment with decent pay for men and women could be the basic agents to change in belief that boys and girls deserve equal fairness, empathy and opportunity and raring of boys and girls consistently with no bias across gender at home, school and community.

8. Conclusions

Let us build a world where no child watches life from the side-lines. Every child deserved to dream, play and win. Investment in unbiased parenting skill, emotional literacy and gender sensitive community practices may go a long way to develop more egalitarian attitudes and shift from control to care, from silence to voice from protection to pride to materialise

promises of gender equality into reality. Empirical investigation of the proposed indices and their robustness could be taken as future studies.

9. Declarations

9.1. Ethical considerations

Not applicable.

9.2. Use of artificial intelligence (AI)

The author declares that no generative artificial intelligence (AI) tools were used in the preparation, analysis, or writing of this manuscript.

9.3. Conflict of Interest

The authors declare no conflicts of interest.

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