Towards 2030 UN Agenda on Sustainable Development Goals: Technical Challenges in Measuring the Gender Inequality for Asia Pacific

Bhavya Aggarwal and Lekha S Chakraborty

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Bhavya Aggarwal[1], Lekha Chakraborty

Abstract

Against the backdrop of UN 2030 Sustainable Development agenda, this paper analyses the measurement issues in gender based indices constructed by UNDP and suggests alternatives for choice of variables, functional form and weights. Despite their relevance, the composite indices like Gender Development Index (GDI) and Gender Empowerment Measure (GEM) have been criticized for their technical flaws and later replaced with Gender Inequality Index (GII). While GII conceptually reflects the loss in achievement due to inequality between men and women in three dimensions-health, empowerment and labour force participation – we argue that the assumptions and the choice of variables to capture these dimensions remain inadequate and erroneous, resulting in the partial capture of gender inequalities. Since the dimensions used for GII are different from HDI, we cannot say that a higher value of GII represents loss in HDI due to gender inequalities. However, while it is debatable the advantages of using GII over GDI (GDI is equally distributed equivalent of HDI which measures gender gap in three dimensions of human development-health, education and command over economic resources), one of the main drawbacks of using GII is that along with the inequality indicators of women vis-à-vis men, it also takes absolute indicators that are defined specifically for women- like maternal mortality rate (MMR) and adolescent fertility rate (AFR). The corresponding values for men for these absolute variables are taken as 1 which is unrealistic and leads to overestimation of the gap between women and men's health standards. The technical obscurity remains how to interpret the index by combining women specific indicators with indicators that are defined for both. GII is a partial construct as it has not captured many significant dimensions of gender inequality. Though this requires a data revolution, we tried to reconstruct GII in the context of Asia-Pacific using three scenarios: (i) improving the set of variables incorporating unpaid care work, pay gap, intra-household decision making, exposure to knowledge networks and feminisation of governance at local levels; (ii) constructing a decomposed index to specify the direction of gender gaps and (iii) an alternative index using Principal Components Index (PCI) for assigning weights. The choice of countries under the three scenarios is constrained by data paucity. The results revealed that UNDP GII overestimates the gap between the two genders and using women specific indicators leads to a fallacious estimation of gender inequality. The estimates are illustrative. The implication of the results broadly suggests a return to GDI for capturing the gender development, with an improvised set of choices and variables.

Keywords: Gender Inequality, Unpaid Work, Human Development, Composite Indicator

JEL Classification: D63, J16, J31, O15

[1]The authors are respectively 2015 Summer Intern at National Institute of Public Finance and Policy, New Delhi, and PG Scholar, Birla Institute of Technology and Science (BITS) Pilani, Goa; and Associate Professor, National Institute of Public Finance and Policy, New Delhi. This paper is derived from the NIPFP Summer Internship collaboration of authors, May-June 2015. This is the revised version of the paper invited for presentation at the UNDP session of EY International Congress on "Growth, Inequality and Poverty" at Ankara. Special thanks are due to the anonymous referees. The usual disclaimer applies.

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The UN document, "*Transforming Our World: the 2030 Agenda for Sustainable Development*" agreed to by member states sets an aspiring vision for post-2015, determined to "work for a significant increase in investments to close the gender gaps and strengthen support for institutions in relation to gender equality and the empowerment of women at the global, regional and national levels. …" (para 20). However, globally a data revolution is required to capture the inequalities in gender sensitive human development, and in turn to construct appropriate measurement indices. This challenge is indeed tangible and methodological.

In measuring gender sensitive human development, the economic growth used in early empirical literature had constraints in capturing the wider aspects of well- being and the contingent process of development. Noorbakhsh (1998) noted that the criticisms against using economic growth as the proxy for assessing human development can be traced back to the UN Report, 1954. Since then, the array of literature in favour of social indicators to measure human development has resulted in the collation of data on a spectrum of socio-economic indicators across countries, which has inevitably resulted in the attempts to construct the composite indices of human development and gender inequality (Hicks and Streeten, 1979; Morris, 1967, Adelman and Morris, 1967, UNRISD, 1972, UNDP 1995).

Lately, there are many econometric models that analyze the relationship between gender inequality and economic growth. But the statistics and indices about gender inequalities are not enough to consider such empirical links with economic growth (Ferrant, 2009; Anand and Sen 1995; Dijkstra 2002). Beyond measuring the aggregate affluence, United Nations Development Program (UNDP) was the pioneer in constructing gender related indices. The 1995 Human Development Report introduced two gender based indices- Gender-related Development Index (GDI) and Gender Empowerment Measure (GEM). These were the first composite indices designed to reflect gender disparities in capability deprivation at a global level and were widely used by many researchers across the globe for studying gender disparities between women and men.

Owing to the conceptual and methodological problems identified by the researchers in the calculation of these indices, 2010 HDR introduced a new measure of gender inequality, the Gender Inequality Index (GII). This index was designed to capture women's disadvantage in three dimensions- reproductive health, empowerment and economic activity. It reflects the loss in achievement due to inequality between men and women. An index of 0 implies that both the genders fare equally in all three select dimensions, whereas an index of 1 implies complete inequality. This paper examines the shortcomings of the existing GII and suggests an alternative choice of variables, functional forms and methodology to construct a gender inequality index in the context of Asia Pacific. The choice of countries is constrained by data paucity.

The paper is organized into five sections. Section I deals with the theoretical and methodological issues in measuring gender inequality. Section II critically analyses GII; while Section III provides a critical take on the variables used by UNDP and suggest a new set of variables. Section IV deals with the GII construction using an alternative set of variables with the same functional form. Section V suggests the decomposed indices using a new set of variables. Section VI presents the GII estimates for Asia Pacific calibrated from the Principal Component analysis. Section VII concludes.

I Theoretical and Methodological Issues in Measuring Gender Inequality

A process of enlarging people's choices and raising the level of well-being is defined as human development. Conceptually, these choices can be infinite. These choices can vary intertemporally and spatially. From the infinite set of choices, UNDP had selected three dimensions as the most critical and socially valuable, consists of the choice to lead a long and healthy life; the choice to acquire knowledge and be educated; and to have access to resources needed for a decent level of living are identified as three most critical and socially valuable (UNDP (various years), Human Development Reports).

The Human Development Index [HDI] is a gender-neutral index of the basic capabilities in three dimensions of human development: geometric mean of selected dimensions of health, education and income. Inequality adjusted Human Development Index adjusts the Human Development index for inequality in each dimension across the entire population. Like HDI, it is calculated using geometric mean but using inequality-adjusted dimension indices. Inequality adjusted Human Development Index [IHDI] takes into account the achievements in terms of health, education and income by discounting each dimension's average value according to its level of inequality. Under perfect equality, HDI will equal IHDI. In cases of inequality, IHDI will fall below HDI. The difference between IHDI and HDI is the loss to human development due to inequality. IHDI is calculated for 145 countries by UNDP. Life expectancy is distributed across a group of subjects who have shared a particular event like distribution presented over different age intervals, whereas years of schooling and income are distributed across individuals.

The steps to calculate the Inequality-adjusted Human Development Index are the following fourfold:

1. *Measuring inequality in the dimensions of the Human Development Index.*

The inequality measure, A, is defined as $1 - \frac{g}{\mu}$ where g is the geometric mean and μ is the arithmetic mean of the distribution. Symbolically,

$$A_x = 1 - \frac{\sqrt[n]{X_1 \ldots\ldots X_n}}{\bar{X}}$$

A_x for each variable, i.e. life expectancy, mean years of schooling and disposable income per capita, are calculated separately. It is to be noted that negative and zero incomes are replaced by the minimum value of the bottom 0.5 percentile of the distribution.

2. *Adjusting the dimension indices for inequality.*

Symbolically, the inequality adjusted dimension index of HDI (I_x^*) is as follows.

$$I_x^* = (1 - A_x).I_x$$

where A_x is the corresponding inequality measure for different dimensions and I_x is the HDI index without incorporating inequality. IHDI accounts for the full effect of income inequality.

3. Combining the dimension indices to get the final IHDI

IHDI is the geometric mean of the three dimension indices- education, health and income per capita-and symbolically as follows:

$$IHDI^* = \sqrt[3]{(I^*_{Health} . I^*_{Education} . I^*_{Income})}$$
$$= \left(\sqrt[3]{[(1 - A_{health}).(1 - A_{Education}).(1 - A_{Income})]}\right).HDI$$

The loss in HDI is calculated as follows:

$$Loss\ in\ HDI\ \% = 1 - \left(\sqrt[3]{[(1 - A_{health}).(1 - A_{Education}).(1 - A_{Income})]}\right)$$

The disadvantage of using IHDI is that it is not association sensitive. It does not capture overlapping inequalities. Therefore we should obtain the data from a single survey.

4. Coefficient of Human Inequality

The Coefficient of Human Inequality is the weighted average of inequalities in health, education and income and is given as follows:

$$Coefficient\ of\ human\ inequality = (A_{health} + A_{Education} + A_{Income})/3$$

When the values of$A_{Education}$, A_{Income} and A_{health} are comparable, loss in HDI and coefficient of human inequality are very close; but when the inequalities differ in magnitude, the loss in HDI tends to be higher than the coefficient of human inequality.

Gender Inequality Index (GII) came into existence in 2010 for measuring the inequalities in gender development. Prior to GII, the Gender Development Index (GDI) was constructed by UNDP to measure the gender development since 1995. The GDI used the same variables as HDI, but adjusted for the degree of disparity in achievement across genders. The average value of each of the component variables is substituted by "equally distributed equivalent achievements". The equally distributed equivalent achievement (X_{ede}) for a variable is taken as that level of achievement that if attained equally by women and men would be judged to be exactly as valuable socially as the actually observed disparate achievements. Lahiri, et al

(2003) noted that taking an additively separable, symmetric and constant elasticity marginal valuation function with elasticity 2, the equally distributed equivalent achievement X_{ede} for any variable X turns out to be as follows.

$$X_{ede} = [\, n_f \,(1/X_f) + n_m \,(1/X_m)]^{-1}$$

where X_f and X_m are the values of the variable for females and males, and n_f and n_m are the population shares of females and males. X_{ede} is a 'gender-equity-sensitive indicator'(GESI). Thus, for this chosen value of 2 for constant elasticity marginal valuation function, GDI is computed as follows.

Symbolically,

$$GDI = \{L_{ede} + (2/3 \times A_{ede} + 1/3 \times E_{ede}) + Y_{ede}\}/3.$$

Gender Inequality Index, which replaced GDI since 2010, reflects gender based disadvantage in mainly three dimensions: (i) Reproductive Health proxied by maternal mortality ratio (MMR) and adolescent fertility rate (AFR).[2] Empowerment is proxied by the share of parliamentary seats held across gender (PR) and attainment of secondary education (SE). The economic activity is proxied by the labor market participation rate (LFPR), which measures the participation of men and women in the market economy.

Gender Inequality Index (GII) reflects the loss in development due to inequality across genders. An index of 0 implies women and men fare equally whereas an index of 1 implies that one of the two genders fares as poorly as is possible. The first step involves in the calculation of GII is treating zeros and extreme values, i.e., the outliers. GII is calculated by taking the geometric mean across the dimensions and because the geometric mean cannot be calculated for zero values, a minimum of 0.1 percent is set for all the components. The maximum value for the maternal mortality rate is taken as 1000 deaths per 100,000 births and minimum value is 10 per 100,000 births. A higher maternal mortality rate suggests poor maternal health. After treating zeros, if any, we aggregate across dimensions within each gender group using geometric means. As the reproductive health variables are used, the aggregation formula for men and women is different.

[2] Maternal Mortality Rate is defined as the number of female deaths per 100,000 live births annually, from any cause related to, or aggravated by pregnancy or its management. AFR is the number of births per 1000 women aged 15-19.

$$Gf = \sqrt[3]{\left(\sqrt{\left(\frac{10}{MMR}\cdot\frac{1}{AFR}\right)}.\sqrt{(PRf.SEf)}.LFRPf\right)}$$

The rescaling by 0.1 is required to take into account the truncation of the maternal mortality ratio minimum at 10.

For males, the formula is as follows:

$$Gm = \sqrt[3]{\left(1.\sqrt{(PRm.SEm)}.LFRPm\right)}$$

Once the geometric mean of the three dimensions that determine the inequality index is taken, the next step is to aggregate across gender using harmonic means. The argument for using harmonic mean is that it captures the inequality between women and men and further adjusts for association between dimensions but it is open to criticisms (Hawken and Munck, 2012).

The HARM index is as follows:

$$HARM(Gf, Gm) = \left(\frac{((Gf)^{-1} + (Gm)^{-1})}{2}\right)^{-1}$$

Before calculating the final index, a composite index is calculated using the geometric means of the arithmetic means. This step is to give equal weights to both the genders and then aggregating it across the various dimensions, i.e. health, empowerment and economic activity.

The composite index is as follows:

$$G(\overline{f}, \overline{m}) = \sqrt[3]{\left(\overline{Health}.\overline{Empowerment}.\overline{LFPR}\right)}$$

Where

$$\overline{Health} = \frac{\left(\sqrt{\left(\frac{10}{MMR}\cdot\frac{1}{AFR}\right)} + 1\right)}{2}$$

$$\overline{Empowerment} = \frac{\left(\sqrt{(PRf.SEf)} + \sqrt{(PRm.SEm)}\right)}{2}$$

$$\overline{LFPR} = \frac{(LFPRf + LFPRm)}{2}$$

Symbolically, the gender inequality index (GII) is as follows:

$$\text{GII} = 1 - \frac{HARM(Gf, Gm)}{G(\overline{f}, \overline{m})}$$

Higher the value of GII, higher is the gender gap and the loss in potential of human development. Hence in order to utilize all our resources fully, we need to bridge this gender gap.

II: Critical Analysis of GII

There are many conceptual and methodological problems associated with using GII for the measurement of gender inequality. There has been an ongoing debate on the choice of variables used for the formulation of gender indices. One of the main constraints in using the variables that completely capture the essence of the various dimensions is the lack of availability of sex-disaggregated data across the globe. Because the parameters are not the same in different nations and the scope of data collection also varies, it is very difficult to come up with variables that are uniform in all the nations. But Hawken and Munck (2010) pointed out data availability was not seen as a constraint for the construction of GII and that new data can be generated to measure certain indicators that are considered central to an index's overarching concept.

We argue that the assumptions and the choice of variables to capture the dimensions – health, empowerment and economic activity- in GII remain inadequate and erroneous. One of the main drawbacks of using GII is that along with indicators of women vis-à-vis men, it also takes absolute indicators that are defined specifically for women (like MMR and AFR). It leads to conceptual problems in interpreting GII. In other words, taking only women specific indicators leads to an index that measures women's well-being and status in the society whereas incorporating indicators comparable for men and women; we can construct a gender inequality measure that can be used to assess the relative well- being of women. As

Permanyer (2013) points out, an increase in MMR and AFR systematically represents a worsening of gender inequality levels while, on the other hand, decreases in women's education or LFP do not necessarily represent a worse state of affairs as long as men's education and LFP decrease by the same amount. Also, the corresponding value of MMR and AFR for men is taken as 1 which is far from realistic and leads to overestimation of the gap between women and men's health standards.

Yet another problem with using indicators like reproductive health is that it penalizes low income countries as health standards are usually low in developing countries. While the proponents of the index might rightly argue that it makes sense to penalize those countries with bad reproductive health conditions for women, it is fair to say that countries' performance in those areas is influenced by a myriad of factors other than gender-related issues (Permanyer, 2013). This calls for variables that are broader and capture the health standards of both the sexes equally.

Paucity in the construction of GII with regard to empowerment variable is that it only takes the share of women in the parliamentary seats at national level; and ignores women's representation in local governance and intra-household decision making. It is pertinent to incorporate variables like share of parliamentary seats in national and local levels of governance and percentage of women participating in intra-household decision making as a measure of empowerment. And along with indicators for education attainment and decision making, exposure to basic facilities like newspaper and television can be used as a variable to capture knowledge and networking for the measurement of empowerment across genders.

The third sub-indicator of the GII is the labour force participation which measures the involvement of men and women in the paid work. But we know that housework, childcare and care of elderly relatives represent women's unpaid work- indispensable financial benefit to the entire economy (Bartuskova and Kubelkova, 2014). Yet it fails to capture the care economy where women are typically overrepresented. Owing to the importance of unpaid work and the differences in representation of genders in SNA and extended SNA activities, it is desirable to incorporate the unpaid work in the gender inequality index.

Integrating care economy into GII remain nil even across countries with time use statistics. It is interesting to recall Becker (1965), in a paper titled "A Theory of Allocation of Time", published in the Economic Journal, where he noted that "throughout history the amount of time spent at work has never consistently been much greater than that spent at other activities. Economic development has led to a large secular decline in the work week so that today time spent at work is less than a third of the total time available. Consequently, the allocation and efficiency of 'nonworking' time may now be more important to economic welfare than that of working time. Yet the attention paid by economists to the latter dwarfs any paid to the former."

The prime reasons for the lack of integrating time use statistics into GII are twofold. One, the time use survey itself is not conducted at a macro level in many developing countries. In many countries, the time series data of time is unavailable. Two, the process of labour force participation statistics itself is highly partial as it does not incorporate unpaid care. Though the conceptual discussions on work force participation highlighted the significance of giving thrust to the statistical invisibility of unpaid care economy in framing the policies through integrating it in gender related indices, it is seldom translated at empirical levels.

Time use statistics can be divided into three categories: SNA activities (that get included in GDP calculations), extended SNA activities (that do not get included in GDP but should be included in the satellite accounts) and residual non-SNA activities. UNDP 1995 report presented that US $ 16 trillion of global output is statistically invisible and within that, US $ 11 trillion was the contribution of women in unpaid care economy. The attempt of United Nations Statistical Division (UNSD) in extending the production boundary of the Systems of National Accounts (SNA), 1993 has led to the calculation of extended SNA in time use surveys and the integration of unpaid care work into the national accounting system as satellite accounts.

The time diary method is often used in preparing the time budget statistics. This method provides a retrospective chronological account of recent twenty-four hour periods of the respondent's time use. Researchers then code the responses using a standard list of economic and non-economic activities. Researchers encountered two problems in constructing unpaid care work. One challenge is to get the economic activity in utils (i.e., units utilized) of time, while the second challenge is to impute the market price or market wages to time (Chakraborty, 2014). Beneria (1992) suggested that imputing price to time is an output method of valuing unpaid care, while imputing wages to time spent on unpaid care is an input method. Researchers encountered problems in getting the specified wage data and frequently used the lowest wage in the wage hierarchy in the market economy to valuate the unpaid care economy. We will consider the valuation estimates of unpaid care economy in the GII estimate in the next section.

III. Choice of Variables

In this section, we discuss the variables used in the existing GII for capturing the three dimensions - health, empowerment and economic activity - and their limitations, and suggest a new set of variables for computing GII. The existing GII variables and an alternative choice of variables for GII are collated in Table 1.

For capturing health, while HDI and GDI used life expectancy at birth, GII incorporated reproductive health variables, viz., MMR and AFR. The drawback of using life expectancy as an indicator of health is that it does not provide any information on the quality of life. AFR and MMR are also not appropriate as indicators of health when we are dealing with gender based inequality as they are defined specifically for women; and the corresponding value for men is taken as 1, indicating the highest standard which is far from realistic. Hence, we propose a more broad proxy for health that will capture the health of both the sexes equally – Under Five Survival Rates and Healthy Life Expectancy (HALE) at birth (years).

Under Five Survival Rate is defined as the probability per 1000 that a new born baby will live before reaching age five. This is an important indicator as it captures the gender discrimination in terms of access to health care and nutritional disadvantage. It is a biological advantage that survival of girl child more than boy. However, this biological advantage is neutralized by gender discrimination. Excess number of female deaths per thousand live births in spite of the biological advantage that women get indicates some sort of gender bias in most of the countries and therefore is used as a proxy for health in the measurement of inequality.

Table 1: Choice of Variables for the Alternative Gender Inequality Index

Dimension	**GII : existing variables**	**Alternative GII variables**
Health	1.Maternal Mortality Rate (MMR) 2.Adolescent Fertility Rate (AFR)	1.Under Five Survival Rate (USR) 2.Healthy Life Expectancy (HALE)
Empowerment	1.Share of Parliamentary Seats (PR) 2.Attainment of Secondary Education (SE)	1.Share of Parliamentary Seats at National and Sub-national Levels (PRN and PRL) 2.Attainment of Secondary Education (SE) 3.Intra Household Decision making (IHDM) 4. Share of women exposed to knowledge media and networks (NM).
Economic Activity	1.Labor Market Participation Rates (LFPR)	1.Labor Force Participation Rates (LFPR) 2. Contribution in Paid and Unpaid Work (T) in hours. 3.Wage Rate (W)

Under- Five Survival Rate is calculated by subtracting the number of deaths per 1000 before the age of 5 and the source of our data is UNICEF from where obtained the under- five mortality rates. We have chosen under-five survival rates in place of under-five mortality rates because under-five mortality rate is an example of index of negative indicator. Higher value of mortality rate signifies lower level of health standards and hence lower welfare. For all the other indicators we have used, a higher value always signifies a higher welfare. Hence we incorporate under-five survival rate for uniformity.

The reason for using HALE in place of Life Expectancy is that it is adjusted for the health standards of an individual and therefore captures the quality of life in some respect. The difference in healthy life expectancy (HALE) should give some idea about the standard of health care facilities across all the countries and across gender. The data for HALE is organized from UN data for the year 2012. HALE is much less than Life Expectancy for almost all Asia-Pacific nations indicating lack of health facilities and difference in access to these facilities across genders. The difference in Life Expectancy across gender also indicates the wide gap in health facilities across genders.

Empowering women and encouraging them to participate in economic life is essential for equity and efficiency. Given the complexity of its definition, it is not an easy task to measure the concept of "empowerment". The indicators used for this analysis are attainment of secondary education (SE), representation at national and local levels of government, intra-household decision making and a proxy for the number of women exposed to knowledge media and networks. Considering the data collection methods are not uniform across different nations, the proxy used for these indicators might be different and in some cases absent. Therefore we compare only India and New Zealand to study the variation in inequality standards due to these indicators of knowledge media and networking.

The variables relate to intra-household decision making and the share of women exposed to knowledge media and networks are organized from latest round of National Family Health Survey (NFHS) conducted in India. According to the report, only 37% of the women participate in decision making related to matters like health care, large household purchases, making purchases for daily household needs and visiting family or relatives. Also, only 65% of the women are exposed to knowledge and media networks like newspapers, magazines, television, radio or cinema as opposed to 82% of males who have access to these.

The assumption we used to compute the intra-household decision making variable is that the share of men participating in intra-household decision making is 100 per cent. This is because even in households (India), where women participate in decision making, there is no decision for which a majority of currently married women alone are the decision makers. Only 15 per cent of women have a savings account that they use themselves. The intra-household decision making variable is thus constructed based on the survey by NFHS, where they asked married women who make their decisions on health care, large household purchases, daily household needs and visiting their family or relatives.

While comparing the empowerment variable in other countries, a similar dimension might not be available due to difference in methods of conducting surveys but we use a close approximation. For instance, for India, the share of Parliamentary seats for women at local levels is assumed to be 33%. While for New Zealand, share of parliamentary seats for women at the local level is 33% for city council, 37% for community board, 30% district council and 21% regional council. We take the average of these values and get women's share in local government in New Zealand as of 2013 as 30.25%. The data is organized from the Department of Internal Affairs – Local election statistics, New Zealand.

The representation of women and men in different tiers of government is used as a variable for empowerment because the position has great power to influence the government policies and participate in the decision making of the parliament. But representation at national levels cannot alone capture the decision making power and we have therefore incorporated representation at local levels to access the share of power and decision making in important policies. This is based on the belief that women's participation at some level of politics will positively affect future political activity of other women (Bartuskova and Kubelkova 2014).

GII used labor force participation rates for the measurement of economic activity. Higher levels of labor force participation leads to economic and financial independence. Though a very important indicator, it ignores the contributions of women in unpaid work and leads to undervaluation. It also ignores the wage gap between women and men for the equal work. Therefore we incorporate the measurement of care economy sectors in the index of gender inequality using "time use surveys". In order to get wage differentials, we take the mean monthly earrings of employees from ILO database for various sectors and then take its contribution based on the contribution of that sector to the GDP of the nation, i.e. 17% Agriculture, 26% Industry and 57% Service sector in case of India. For all other countries in Asia Pacific countries, data from HDR reports are taken.

The valuation of the unpaid care economy is based on shadow pricing the agricultural wage for India and New Zealand. It is to be noted that Time Use Surveys are conducted by different agencies in different countries. Hence the choice of activities selected for "extended Systems of National Accounts" (ext-SNA) might be a little different. Therefore the figures for different countries on unpaid care economy might not be fully comparable.

The data paucity thwarts us from including more countries with entire new set of variables. However, we computed GII using alternative methodology for 24 countries in Asia Pacific, using a subset of new variables suggested where data is available. For illustration, we have computed GII using all the variables we have suggested, however limited to New Zealand and India due to data constraints.

IV. Constructing GII using New Choice of Variables

In this section, we construct GII using new set of variables and compare it with the existing GII. The dimensions used for our construction remain the same as UNDP GII – health, empowerment and economic activity. However, we shall be proposing the alternative set of variables in constructing the GII, as indicated in Table 1. We use the same achievement matrix (using new variables) for the calculation of GII as used by UNDP and study the gap between the two values. The aggregation methodology used for the calculation of the new GII is also the same. Incorporating these variables, we can better account for gender inequality indicated by the difference in the two values.

GII reflects gender based disadvantage in mainly three dimensions-health, empowerment and economic activity. Before aggregating the variables across dimensions within each gender group, we calculate the separate indices for the three dimensions using the new variables.

Health = $\sqrt{USR_f.HALE_f}$ and $\sqrt{USR_m.HALE_m}$

Empowerment = $\sqrt[3]{(\sqrt{PR_{Nf}.PR_{Lf}}).SE_f.NMf.IHDM_f}$ and $\sqrt[3]{(\sqrt{PR_{Nm}.PR_{Lm}}).SE_m.NMm.IHDM_m}$

Economic Activity = $\left(\frac{LFPR_f.T_{Mf}}{1.T_{Cf}}\right) * \ln(W_f)$ and $\left(\frac{LFPR_m.T_{Mm}}{1.T_{Cm}}\right) * \ln(W_m)$

After getting the separate indices for men and women, we aggregate those across dimensions within each gender group using geometric means as suggested by UNDP.

$$Gf = \sqrt[3]{\left(\sqrt{USR_f . HALE_f} . \sqrt[3]{\left(\sqrt{PR_{Nf} . PR_{Lf}}\right) . SE_f . NMf . IHDM_f} \ . \left(\frac{LFPR_f . T_{Mf}}{1 . T_{Cf}}\right) * \ln(W_f)\right)}$$

and for males, it is given by:

$$Gm = \sqrt[3]{\left(\sqrt{USR_m . HALE_m} . \sqrt[3]{\left(\sqrt{PR_{Nm} . PR_{Lm}}\right) . SE_m . NMm . IHDM_m} . \left(\frac{LFPR_m . T_{Mm}}{1 . T_{Cm}}\right) * \ln(W_m)\right)}$$

The next step is aggregating across genders using Harmonic means to adjust for association between dimensions.

The index is:

$$HARM(Gf, Gm) = \left(\frac{((Gf)^{-1} + (Gm)^{-1})}{2}\right)^{-1}$$

For giving equal weights to both the genders, we take the arithmetic mean and then aggregate it across dimensions given by:

$$G(\overline{f}, \overline{m}) = \sqrt[3]{\left(\overline{Health} . \overline{Empowerment} . \overline{LFPR}\right)}$$

where

$$\overline{Health} = \frac{\left(\sqrt{USR_f . HALE_f} + \sqrt{USR_m . HALE_m}\right)}{2}$$

$$\overline{Empowerment} = \frac{\left(\sqrt[3]{\left(\sqrt{PR_{Nf} . PR_{Lf}}\right) . SE_f . NMf . IHDM_f} + \sqrt[3]{\left(\sqrt{PR_{Nm} . PR_{Lm}}\right) . SE_m . NMm . IHDM_m}\right)}{2}$$

$$\overline{LFPR} = \frac{\left(\left(\frac{LFPR_f . T_{Mf}}{1 . T_{Cf}}\right) * \ln(W_f) + \left(\frac{LFPR_m . T_{Mm}}{1 . T_{Cm}}\right) * \ln(W_m)\right)}{2}$$

Finally, GII is given by:

$$\text{GII} = 1 - \frac{HARM(Gf, Gm)}{G(\bar{f}, \bar{m})}$$

Table 2: GII with New Variables: Illustrative Estimates

	Health			
	USR		**HALE**	
Male	0.949		56	
Female	0.945		59	
(F+M)/2	$\frac{\left(\sqrt{0.949 * 56} + \sqrt{0.945 * 59}\right)}{2} = 7.37$			
	Empowerment			
	PR_N	**PR_L**	**SE**	**NM**
Male	0.891	0.67	0.504	0.61
Female	0.109	0.33	0.266	0.39
(F+M)/2	$\frac{\left(\sqrt[3]{(\sqrt{0.891*0.67}).(0.504).(0.61)} + \sqrt[3]{(\sqrt{0.109*0.33})*0.266*0.39}\right)}{2}$=0.494			
	Economic Activity			
	LFPR	**T_M**	**W_M (ln)**	**T_C**
Male	0.809	6.51	8.966	0.86
Female	0.288	3.08	7.73	5.86
(F+M)/2	$\frac{\left(\frac{0.809*6.51*8.966}{0.86}+\frac{0.288*3.08*7.73}{5.86}\right)}{2}$=28.035			

Source : Author's computations

Table 2 provides the illustrative estimates for India using the methodology and choice of variables suggested above. Incorporating these variables, we get the new value of GII for India as 0.5168. Hence our assumption that the former GII overestimates the gap between the two genders was correct and we can say that using women specific indicators leads to an erroneous estimation of gender inequality.

Table 3: Comparing GII Values: Illustrative Estimates

Country	Existing GII	GII (with new choice of variables)
India	0.61	0.5168

Source: Author's computations

The GII has been constructed to satisfy the assumption of symmetry in gender gaps. It means that the direction of gender gaps, whether they favor women or men is not taken into account. For example, an index of 0.61 or o.51 does not specify if the situations are in favor of men or advantageous to women. These estimates should be read with caution and should not be used for policy formulations. This calls for a need of decomposed indices so that we can interpret the direction of inequality in various dimensions. But it has several limitations in terms of decomposing it into subcomponents and cannot be used for interpretation and policy recommendations. We therefore suggest a decomposed index that can be used to study the direction of gender gaps and can be used for detailed exploration of the internal structure of the index, which we would attempt in section IV.

IV. Constructing Decomposed Index

A few technical problems were identified in section III while constructing GII, its functional form, choice of variables and interpretation of the final index. We therefore suggest a decomposed index that is easy to interpret and can be used to study the direction of gender gaps. Permanyer (2013) also pointed out the importance of a decomposed index saying it is useful for a precise and detailed exploration of the internal structure of the index and contributes to transparency. Similar functional form was used in Permanyer (2010), Beneria and Permanyer (2010), and Klasen and Schuler (2011).

The functional form we suggest is as follows:

$$GRS = \prod_{i=1}^{n} \left(\frac{x_i}{y_i}\right)^{w_i}$$

Men are better off ⟵ 1 ⟶ Women are better off

x_i and y_i denote the average women's and men's achievement levels in indicator i for n given indicators. Π denotes multiplication and w_i are the weights given to the indicator i. The weights represent the relative importance of an indicator w.r.t to others. The interpretation of GRS is simple: Whenever GRS >1, women are on an average better off than men and when GRS<1, men fare better than women on an average. It has the further advantage of being decomposable by dimensions to see how genders are doing across various dimensions. We propose that we use this functional form for a composed index that will give the aggregate value of GII and three decomposed indices, for each of the dimensions to study the relative achievements of genders in health, empowerment and economic activity separately.

A range of statistical procedures have been developed in order to ascertain an appropriate weighing scheme. One of those is Principal Component Analysis (PCA), which we would attempt in section V. However in this section, we theoretically categorized weights as used by HDI, GEM and many other socio-economic indices. We divide our indicators into three component areas- health, empowerment and economic activity. While each of the three main dimensions has equal weight in producing the final index score, each indicator within them does not. We use geometric means for aggregation across dimensions and indicators for a given dimension also. This analysis is carried out for Asia-Pacific economies that have carried out time use surveys. As the proxy for intra-household decision making is different in various countries and not available for all the countries, we exclude this variable for now. The new GII is represented as follows.

Inequality Index $=\sqrt[3]{\left(\overline{\overline{Health}}.\overline{\overline{Empowerment}}.\overline{\overline{Economic\ Activity}}\right)}$

Where

$$\overline{\overline{Health}} = \sqrt{\frac{HALE_f}{HALE_m}.\frac{USR_f}{USR_m}}$$

$$\overline{\overline{Empowerment}} = \sqrt[3]{\sqrt{\frac{PR_{Nf}}{PR_{Nm}}.\frac{PR_{Lf}}{PR_{Lm}}}.\frac{SE_f}{SE_m}.\frac{NM_f}{NM_m}}$$

$$\overline{\overline{Economic\ Activity}} = \left(\frac{LFPR_f.T_{Mf}.\ln(W_{Mf})}{LFPR_m.T_{Mm}.\ln(W_{Mm})}\right).\left(\frac{T_{Cm}}{T_{Cf}}\right)$$

Therefore using these intermediate indices, we get a total of 4 indices that can interpret the relative achievement levels of men and women component wise and in aggregate terms.

From the formulae used above, it is clear that all the variables have different weights in the composite index. While HALE and USR have weights of 1/6 each; SE and NM have weights of 1/9 and PR at national and local levels together contribute to 1/9 of the total index.

Similarly, labor force participation when multiplied with the wage and time measures the value of the market economy and the contribution of both the genders to the market economy. It is assumed that males and females "participate" in extended SNA activities, however small the contribution might be in case of men. The compensation for extended SNA activities is assumed to be agricultural wage. Before calculating the indices, the variables are normalized using $\frac{value-min}{max-min}$ approach so that all the value lies in the range of 0 and 1.

The valuation for extended-Systems of National Accounts (SNA 1993) activities is carried out using the global substitute method of using the lowest wage in the wage hierarchy in the market economy. The data was not ready to use "specialized wage substitute method" to value the unpaid care sector. Therefore using these intermediate indices, we get a total of 4 indices that can interpret the relative achievement levels of men and women component wise and in aggregate terms. From the formulae used above, it is clear that all the variables have different weights in the composite index. While HALE and USR have weights of 1/6 each; SE, NM and IHDM have weights of 1/12 and PR at national and local levels together contribute to 1/12 of the total index.

The value of decomposed and composite indices for India and New Zealand are given in the Table 4. These values can be used for better interpretation and formulation of future policies.

Table 4: GII: Decomposed Indices: Illustrative Estimates for India and New Zealand

Country	**Health Index**	**Empowerment Index**	**Economic Activity Index**	**Composite Index (Gender Inequality Index)**
India	1.0242	0.4359	0.0213	0.2119
New Zealand	1.0144	0.7618	0.2623	0.5874

Source: Author's computations

As we compare the value of India and New Zealand, we notice that New Zealand women are better off than women in India in all three dimensions of health, empowerment and economic activity. While they are also doing better off than men in terms of health, the gap between the achievement levels of men and women is also not very significant in terms of empowerment and opportunities. But in terms of economic activity, wage gap and unpaid work, women still lag far behind men and there is a need for policies to account for this unpaid work. On the other hand, India is far worse than New Zealand in terms of labor force participation, economic activity and empowerment index. This implies that India require more policies to involve women in decision making and in market economy with equal opportunities and equal pay for the work done, to bridge this gender gap.

IV. Constructing GII Using Principal Components Analysis

Gender inequality is a multidimensional concept which cannot be quantified easily, as it is a process determined by the interaction of multiple variables. We use principal components estimation to assign weights and estimate the relevant components to construct the GII.

The weight assigned to the variables is significant to maximise the information from the data to incorporate in the index construction. We collated the data of causal variables of gender inequalities. Each causal variable relates to a particular dimension of gender inequality. In the first stage, the data is trichotamised into three dimensions: health, empowerment and labour force participation, which defines gender inequality. The variables in these three components may contain significant correlation. The final issue is how to aggregate over the range of different variables to derive a uni-dimensional measure of gender inequality.

We use Principal Component Analysis for assigning weights to different variables. Principal Component Analysis is a multivariate statistical technique used to reduce the number of variables in the data set into a smaller number of dimensions. PCA creates uncorrelated indices where each component is a linear weighted combination of the initial variables. For example, from a set of variables X1 through to Xn,

$$PC1 = a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + \cdots + a_{1n}X_n$$

$$\vdots$$

$$PCm = a_{m1}X_1 + a_{m2}X_2 + a_{m3}X_3 + \cdots + a_{mn}X_n$$

where amn represents the weight for the mth principal component and the nth variable. The weights for each of the principal components are given by the eigen vectors of the correlation matrix. The variance for each of the principal components is explained by the eigen value (λ) of the corresponding eigen vector. In other words, the eigen values are the variances of the principal components. The components are ordered so that the first component (PC1) explains the largest possible amount of variation in the original data. As the sum of the eigenvalues equals the number of variables in the initial data set, the proportion of the total variation in the original data set accounted by each principal component is given by λ i/n. The second component (PC2) is completely uncorrelated with the first component, and explains additional but less variation. Each component captures an additional dimension in the data, while explaining smaller and smaller proportions of the variation of the original variables. The number of principal components extracted is usually decided by the user and usually the components with eigen value of greater than one are selected for consideration.

As we can see from the Table 5, the first Principal Component has maximal overall variance. The second principal component has maximal variance among all unit length linear combinations that are uncorrelated to the first principal component. All the nine components combined contain the same information as the original variables, but the important information is partitioned over the first three components because they explain roughly 85% of the total variance. Therefore we can say that PCA is just a linear transformation of the data. The PCA shows two panels. The first panel shows the eigen values of the correlation matrix in the decreasing order. The corresponding eigen vectors are listed. The eigen values are the variances of the principal components. Therefore we can say that the first principal component explains 46.895 of the total variance and the second component explains 22.60% of the total variance.

Table 5: PCI Eigen values and Cumulative Estimates

Comp	Eigenvalue	Difference	Proportion	Cumulative
Comp1	4.22011	2.18654	0.4689	0.4689
Comp2	2.03357	.704314	0.2260	0.6949
Comp3	1.32926	.625078	0.1477	0.8425
Comp4	.704181	.302355	0.0782	0.9208
Comp5	.401826	.187182	0.0446	0.9654
Comp6	.214644	.155674	0.0238	0.9893
Comp7	.0589702	.0289046	0.0066	0.9958
Comp8	.0300657	.0226949	0.0033	0.9992
Comp9	.00737078	.	0.0008	1.0000

Source: Author's computations

In our estimation, the principal components are uncorrelated in the correlation matrix for the three principal components. We can say that these three components (PC1, PC2 and PC3) contain roughly 84% of the total information (Table 5). As the first three components explain the maximum variance in the data, we can list just these components as shown in Table 6.

Table 6: Construct 1: Composite GII using PCI

Country	**PC1**	**PC2**	**PC3**	**Composite Index**
Australia	1.6810	-0.4146	0.3366	0.8992
India	1.0261	-0.5547	0.5062	0.5170
China	1.5623	-0.5242	0.3904	0.8111
New Zealand	1.6962	-0.3579	0.3496	0.9252
Japan	1.5023	-0.7260	0.2445	0.6990
Pakistan	0.8444	-0.4697	0.6692	0.4631
Korea	1.4686	-0.6417	0.3283	0.7162
Bangladesh	1.3685	-0.5277	0.4938	0.7169
Cambodia	1.1997	-0.6559	0.6946	0.6192
Thailand	1.7308	-0.6943	0.2967	0.8460
Mongolia	1.7293	-0.6512	0.2192	0.8440

Source: Author's computations

For these principal components we take the value 0.3 as the threshold. In our estimation, the first component is sensitive towards secondary education, exposure to knowledge networks, labour force participation, wage and time use data[3]. This implies that nearly 46% of the information is sensitive to these variables. Similarly PC2 is sensitive to Under Five survival rates, Healthy life expectancy and Share of Parliamentary seats at National and local levels. Therefore PCA helps us determine the weights of each of the variables and dimensions and its effect on the index. The final index is given by: (0.4689/0.8425)* PC1+ (0.2260/0.8425)*PC2+ (0.4689/0.8425)*PC3, where PC1, PC2 and PC3 are given by the sum of the eigen vectors that have values >0.3. Based on PCA, the index for the selected 11 countries is given in Table 6.

Table 7: Construct 2: Composite GII using PCI

Country	PC1	PC2	PC3	Composite Index
Australia	1.4196	0.8133	-0.1626	0.8711
India	1.0624	0.5029	-0.3921	0.5575
China	1.4081	0.6832	-0.249	0.8077
New Zealand	1.4289	0.8052	-0.1132	0.8849
Japan	1.3046	0.8475	-0.3952	0.7714
Pakistan	1.0107	0.4041	-0.2998	0.5263
Korea	1.325	0.7388	-0.3437	0.7619
Bangladesh	1.3085	0.661	-0.2991	0.7421
Cambodia	1.4752	0.4491	-0.3195	0.7554
Thailand	1.4086	0.7579	-0.3452	0.8068
Mongolia	1.4198	0.8638	-0.3582	0.8396
Indonesia	1.2607	0.6878	-0.313	0.7238
Lao People's Dem. Rep	1.5146	0.5498	-0.2321	0.8238
Malaysia	1.2427	0.7546	-0.3635	0.7227
Myanmar	1.5496	0.8325	-0.4586	0.8686
Nepal	1.4384	0.4346	-0.0976	0.7861

[3] . The correlation matrices of construct 1 and 2; and the eigen values of construct 2 are not given in the paper, however available on request.

Papua New Guinea	1.5034	0.4683	-0.4744	0.7377
Philippines	1.2954	0.8719	-0.1985	0.8205
Singapore	1.3663	0.7564	-0.237	0.8118
Vietnam	1.4601	0.7478	-0.2372	0.8539
Bhutan	1.4405	0.7886	-0.4363	0.8093
Kazakhstan	1.4372	0.8677	-0.3167	0.8588
Sri Lanka	1.1488	0.8102	-0.4432	0.6752

Source: Author's computations

The criteria for selecting the countries in Asia Pacific were the availability of data. The Construct 1 incorporated all GII variables we have decided (Table 6), while construct 2 with larger set of countries excluded variables relate to time use, exposure to knowledge services and feminisation of governance at local level due to data constraints (Table 7).

The results revealed that UNDP GII overestimates the gap between the two genders and found that using women specific indicators leads to an erroneous estimation of gender inequality. One of the major findings is that incorporating the time use leads to shift in the rankings of various countries. Because women are disproportionately over represented in extended SNA activities and if we take their contribution into account, many countries like Thailand and Mongolia fare really well when it comes to gender equality. Singapore, Japan and Korea are a few examples where the inequality index worsens after taking into account the unpaid care economy. India and Pakistan still remain the countries with maximum disparity even after incorporating time use and exposure to other services. The rank of Pakistan further falls after taking into account the wage differentials. In some cases like Myanmar where women outperform men in most of the indicators, only the share of parliamentary seats (a crucial indicator for studying gender inequality) leads to its lower rankings among other Asian-Pacific countries. Singapore with an overall rank of 15 as suggested by HDR falls significantly after taking into account the wage gap. It is way behind countries like Bhutan, Viet Nam, Cambodia, Nepal and China.

V. CONCLUSION

The paper analyses the developments in UNDP's gender related indices and suggests a few alternatives for incorporating improved choice of variables, functional forms and weights. While GII conceptually reflects the loss in achievement due to inequality between men and women in three dimensions- health, empowerment and labour force participation, we argue that the assumptions and the choice of variables to capture these dimensions remain inadequate, resulting in the partial capture of gender inequalities. Since the dimensions used for GII are different from HDI, we cannot say that a higher value of GII represents loss in HDI due to gender inequalities.

Yet another drawback of using GII is that along with the inequality indicators of women vis-à-vis men, it also takes absolute indicators that are defined specifically only for women. The corresponding values for men for these absolute variables are taken as 1 which is unrealistic and leads to overestimation of the gap between women and men's health standards. Yet another technical obscurity is how to interpret the index constructed by combining women specific indicators along with the other indicators that are available for both the genders. The GII is a partial construct as it has not captured significant dimensions of gender inequalities.

Given these caveats of existing GII, we try to reconstruct GII in the context of Asia Pacific using various scenarios. The results revealed that UNDP GII overestimates the gap between the two genders and found that using women specific indicators leads to an erroneous estimation of gender inequality. Yet another major finding is that incorporating unpaid care economy using the time use statistics in GII leads to significant shift in the rankings of various countries. The estimates are illustrative. The implication of the results broadly suggests a return to GDI for capturing the gender development, with an improvised set of choices and variables.

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