Gender differences in preferences and gender equality are yet unrelated: a replication of Falk and Hermle (*Science*, 2018)

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Abstract

This study replicates and extends the article of Falk and Hermle published in Science (2018), where the gender differences in economic preferences were related to economic development and gender equality of the countries. In the original paper, the authors use the data from the Gallup World Poll 2012, which included the Global Preference Survey conducted on almost 80000 people in 76 countries all around the world. The dataset covers almost 90% of the world population representation, with each country having around 1000 participants and answering questions related to their time preference (patience), altruism, willingness to risk-taking, negative and positive reciprocity, and trust. The study has successfully replicated the distribution of gender differences in economic preferences across countries. However, during the replication, several methodological flaws of the original study regarding the relation of gender differences to gender equality were identified and further investigated by us. First, we revealed a strong and statistically significant correlation between economic development and gender equality indexes itself. We argue that this correlation diminishes the role of the strong relationship between economic preferences and gender equality as the main result of the original article if the relation is not controlled on economic development. Second, the joint gender equality index proposed by the authors was found to have an architecture with imbalanced factors which quantify the level of gender equality and involves non-validated and previously not reported indicators, giving no proof that this index performs better than any of the other existing indicators. Third, we further conducted the conditional analysis using as gender equality index the Global Gender Gap Index from the World Economic Forum, and the Gender Inequality Index and the Gender Development Index from the United Nation Development Programme. The analysis confirmed the strong and statistically significant association of gender differences with economic development conditioned on gender equality. However, the evidence for the association of gender differences with gender equality, when conditioning on economic development, was found to be weak. A more detailed investigation of single preferences further confirmed such a conclusion, demonstrating mild and statistically significant association for only two preferences out of 18 preference-gender equality index combinations. Our results suggest the absence of evidence of an association between economic preferences and gender equality given the data available, current methodology, and existing indexes to measure gender equality. We also highlight and reveal the importance of the validation and investigation of indexes used as a proxy for gender equality estimation for the scientific discourse on the fundamental theories of the socio-economic organization, policy-makers and advisors.

1. Introduction

Gender differences in the economic behaviors, such as happiness (Schneider *et al.* 2012), competition (Croson & Gneezy 2009; Gneezy *et al.* 2009; Klonner *et al.* 2021), or work preferences (Beblo & Görges 2018) have been studied in sociology, psychology and economics for many decades. Any scientific knowledge in this regard and its relation to gender inequality is used nowadays as arguments and counter-arguments for decision and policy-making. In turn, gender inequality topics are becoming an integral part of the agenda for many public and private institutions and organizations, and it is essential for the stakeholders to reveal, estimate, monitor, and prevent gender inequalities on individual, group and country levels.

The study of gender differences on a world scale per se is challenging. One of the challenges that hampers the progress is the lack of large and heterogeneous datasets across different social groups and countries. The Gallup World Poll 2012 included a Global Preference Survey conducted on almost 80000 people in 76 countries all around the world that aimed to fill this gap: covering nearly 90% of the world population representation, with each country having around 1000 participants answering questions related to their time preference (patience), altruism, will of risk-taking, negative and positive reciprocity, and trust. The dataset provides a unique insight into the economic preferences of a heterogeneous number of people.

The article that conducted the analysis of this dataset was published in the Quarterly Journal of Economics (Falk *et al.* 2018). It focused on general questions about the economic preferences distributions in different countries, exploring several covariates from the Gallup World Poll. The subsequent article (Falk & Hermle 2018a), replicated in this work, focused explicitly on the gender differences arising from the previous study and reported the evidence for the relationship between gender differences in economic preferences, economic development, and gender equality across many countries. The authors propose two competing hypotheses to be tested: the first one is that the gender differences will decrease for more economically developed and gender-equal countries, because social roles related to gender are attenuated. The second hypothesis is that, on the contrary, for more economically developed and gender-equal countries, the gender differences will increase because the gender-neutral goal of subsistence is removed and thus people can pursue their real preferences. Their analysis shows a positive correlation of gender differences in preferences with economic development (expressed as Log GDP p/c) and with the gender equality of the countries, thus, as the authors conclusion goes, favoring the hypothesis that predicts the increase of the differences as women and men obtain sufficient access to the resources to develop and express their intrinsic preferences independently. However, the important relation of the economic development and gender equality indexes was only mentioned in the original text without detailed investigation. Besides, the authors composed a joint measure of gender equality of different countries using two officially recognized indexes to measure gender equality (WEF Global Gender Gap and UNDP Gender Inequality Index), together with two other less complete indicators, providing little to no discussion about the validity and robustness of their approach, and without establishing a link to the existing literature with this regard. The present work is dedicated to close this methodological flaw and rise awareness about possible implications on the results and drawn conclusions regarding the relationship between gender differences in economic preferences and gender equality.

In this study, first, we conduct a pure replication of the article in R-language to obtain gender differences in economic preferences from the available datasets. Second, we analyse the relation between economic development and gender equality, and the joint gender equality index that was used by the original authors, highlighting the related problematic and importance of usage of established indexes and conditional analysis. Finally, we demonstrate that findings on relation between gender differences and economic development lack of evedence and not not hold when the conditional analysis is used together with established gender equality indexes.

2. Results

Gender differences on economic preferences: replication of the original analysis

In this section, we briefly describe the methodology of the original article and provide information on the replication to obtain gender differences in economic preferences and match our analysis with the results of the original article (that we denote as a pure replication).

To conduct the replication, we requested the Gallup World Poll data. The full dataset is under restricted access: education level and household income quintile on the individual level of the participants are not available in the open access version (for more information see Appendix, Section 2, "Data Collection, Cleaning, and Standardization"). As the Falk & Hermle (2018a) article addresses the gender differences, the main focus is on that individual variables provided in the dataset (education level, income quintile, age, and subjective math skills) are taken as control variables, meaning that the presence of these may not affect the result of the correlation (Falk & Hermle 2018b). To access the gender differences in each economic preferences the following model was used::

$$p_i = \beta_1^c \text{female}_i + \beta_2^c \text{age}_i + \beta_3^c \text{age}_i^2 + \beta_4^c \text{subjectiveMathSkills}_i + \epsilon_i$$

This results in 6 models – one for each preference measure, p_i – having intercept and 4 coefficients, each of them being related to the variable in the formula above. The coefficient for the dummy variable "female", β_1^c, is used as a measure of the country-level gender difference. Therefore, in total, we have 6 coefficients that represent the preference differences related to the gender for 76 countries. To summarise the gender differences among the six economic preferences, a principal component analysis (PCA) is performed on the gender coefficients. The PCA is a dimensionality-reduction technique which allows to "reshape" the 6 coefficients into other mixed components that maximize the variance. The first component of the PCA has then been used as a summary index of average gender differences in preferences.

We managed to replicate the analysis and to obtain the gender differences in the economic preferences at the country level (for details, see Table 1 in the Appendix). In addition to this, as the diagnostic of the linear regressions revealed a presence of non-normality, we ran an analysis based on robust linear regression instead of ordinary linear regression to insure the the following effects don't lead to any biases in the results. The results in the following tables are denoted as "replication", when the method of the linear regression was OLS as in the original paper, and "extended" when the robust linear regression was instead performed.

Relation between gender differences, economic development and gender equality

To study the effect of both GDP p/c and gender equality at the same time, one should incorporate all three variables into the multiple linear regression with both factors as explanatory variables, like:

$$\text{avgGenderDiff}_{\text{country}} = \alpha + \beta_1 \log\text{GDPpc}_{\text{country}} + \beta_2 \text{genderEquality}_{\text{country}}$$

Alternatively, to separate the contribution of the gender differences regressed on economic development, one can perform a regression conditioning on the gender quality indicator and then conditioning on economic development (Log GDP p/c). The theorem from Frisch–Waugh–Lovell (Frisch & Waugh 1933; Lovell 1963) guarantees that the coefficients found from this conditional analysis are the same as the ones found for a regression of the gender differences on both economic development and gender equality index of the countries.

The correlation between economic development and gender equality indexes plays a central role in investigating the relation of gender differences to them. The fact that the two variables are not independent is well-known and subject to many studies (Duflo 2012; World Economic Forum 2015). To check the correlation between economic development and gender equality of the countries analysed in the study, we regressed the Log GDP p/c and joint Gender Equality Index used by authors in the original article, together with other two gender quality indexes used by the authors, the Global Gender Gap Index from the World Economic Forum Global Gender Gap Report 2015 (abbreviated to WEF GGGI), the Gender Inequality Index from the United Nation Human Development Report 2015 (UNDP GII). Additionally, we checked the correlation also for an

index, the UNDP Gender Development Index (GDI), that we will later use for the extended analysis. The correlation between economic development expressed in Log GDP p/c and gender equality indexes in the countries is very strong (see also Fig. 1): for the Gender Equality Index, we found r = 0.5440, p-value < 0.0001; for WEF GGGI, r = 0.2926 and p-value = 0.013; for UNDP GII, r = 0.8542 and p-value < 0.0001; and for the UNDP GDI, a correlation of r = 0.5316 with p-value < 0.0001.
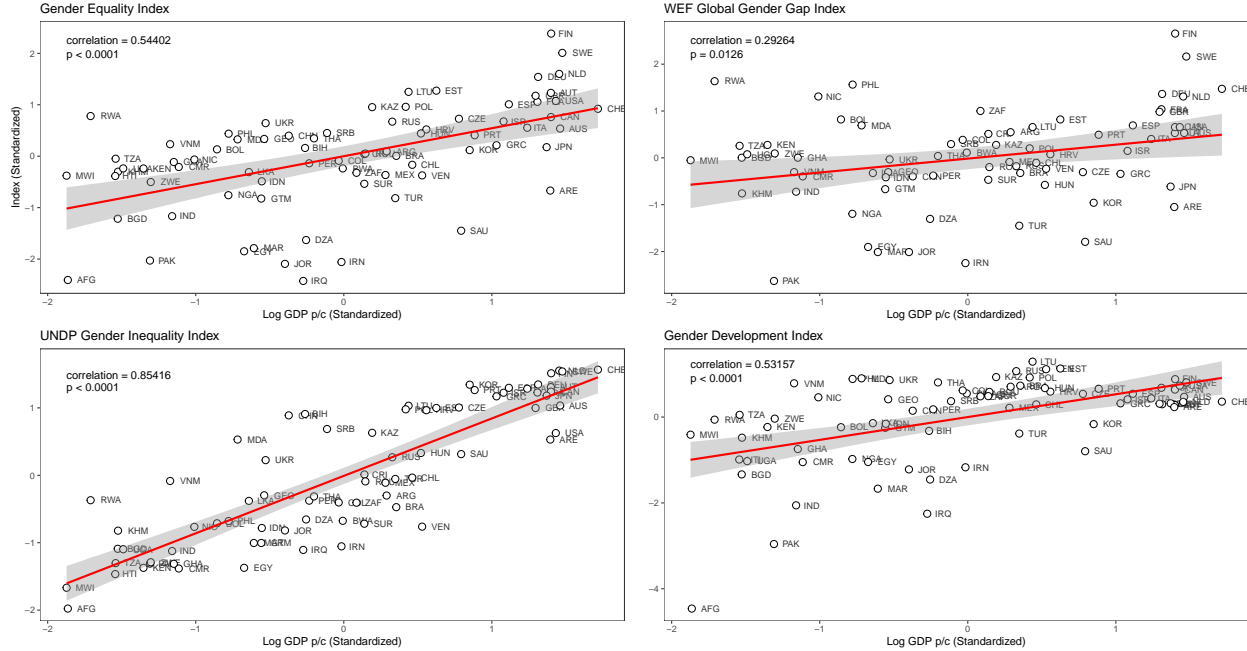

Figure 1: Correlation between gender equality indicators and economic development by country. Note that only the countries participating in the original study are presented.

Gender equality indexes and related problematics

As already anticipated, the authors in the original article composed a joint measure of gender equality that they denoted as Gender Equality Index (GEI). To reveal its actual structure, we visualized its composition using a diagram shown in Figure 2. The authors built this joint measure by using the Principle Component Analysis technique on four gender-equality indicators, and taking the first component as a proxy of gender equality. Two of these indicators are indexes officially approved by international organizations, the WEF GGGI, and the UNDP GII; one widely used measurable, the ratio of female and male labor force participation, taken from the World Bank database; and lastly, an indicator, newly constructed by the authors, the time since women suffrage, with the data taken from the Inter-Parliamentary Union Website, presumably to track long-term influences of the guaranteed right to vote as a proxy of gender equality. The WEF GGGI has a total of fourteen sub-indexes, grouped and weighted into four categories: economic participation and opportunity, political empowerment, educational attainment, and health and survival. The UNDP GII follows a similar logic to cover the same categories describing different aspects of the human life, but using only five sub-indexes in total: two for health and reproduction-related issues, and three others for the remaining categories.

The UNDP GII has been criticized by several authors (Anand & Sen 1995; Permanyer 2013; Klasen 2017). This index is said to be very highly related to the economic development, as it includes reproductive health indicators that can penalize less-developed countries, and it has a "inexistent" measure of welfare loss of inequality, because it is based on a calculated gender equality measure that is reported nowhere. One of the coefficients that has a highest priority (~30% of the sub-index) in calculation of the economic participation and opportunity, called "wage equality between men and women for similar work" – indicating how much
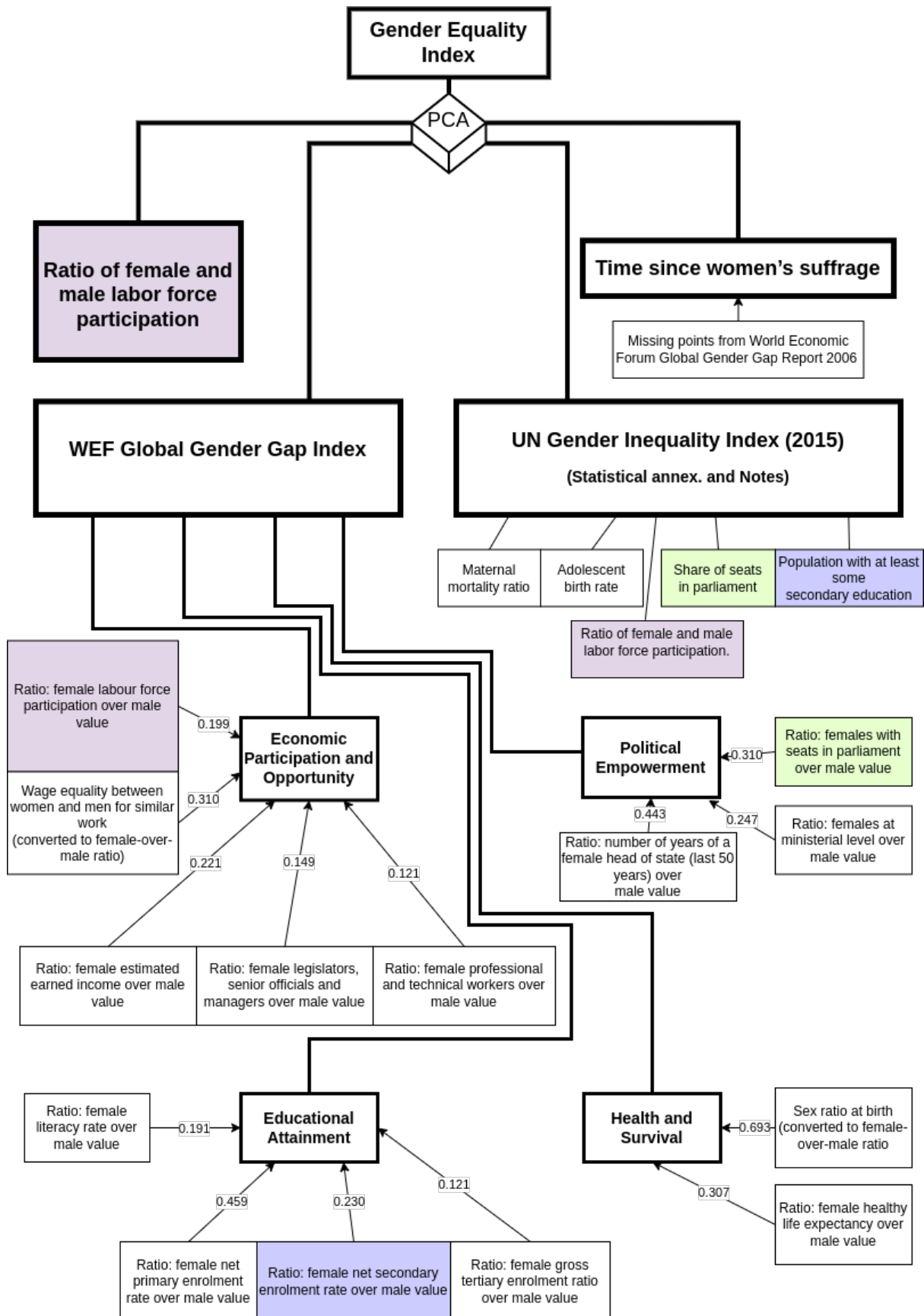
Figure 2: Gender Equality Index decomposed in its sub-indexes.

women receive with respect to men for the same work – is based on a best experts' guess, not corrected on the difference in occupation (Halkos *et al.* 2021). Instead, the power and limitation of WEF GGGI index remains mostly undiscussed in the academic literature, with a few exceptions (Barns & Preston 2010; Piper 2019). The index is thought to be the least dependent to the economic development of a country, since it measures the gap between male and female access to resources and opportunities (World Economic Forum 2006). Still, as the result of the previous section suggests, this dependence is there and not negligible. Despite the identified limitations these indexes remain the most homogeneous and standardised estimates of gender inequality on the world scale.

Along with WEF GGGI and UNDP GGI, other indexes exist, such as the Gender Development Index already introduced in the previous paragraph, that was discussed first in Klasen (2017) and recently introduced in the UNDP report. It captures three dimensions in terms of health, knowledge and living standards, separately for male and female (as it is defined as the ratio of the Human Development Index for female divided by the male one). The life expectancy, expected years of schooling and mean years of schooling, and GNI per capita are calculated within these dimensions. We include this index in the further analysis too.

The question why the GEI built from the PCA is better or at least not worse than the widely used indexes such as WEF GGGI and UNDP GII was unanswered in the original article. As one can see in Fig. 2, the components of the GEI used in the original study contains repetitions. The two indexes WEF GGGI and UNDP GII share three sub-indexes, here indicated with different colors: ratio of female and male labor force participation (purple), share of seats in parliament (green) and enrollment into secondary education (blue). As a third variable to construct the GEI, the authors used the ratio of female and male labor force participation, already included into the previous two indexes. If it is true that PCA technique permits to aggregate the indexes even in presence of high correlations between them, in the present case, such a procedure leads to the imbalance and prioritization of these specific repetitive indexes (especially female and male labor force participation) over other factors, that were already balanced in the design of WEF GGGI and UNDP GII indexes.

Furthermore, the "time since women suffrage" index was introduced by authors to track long-lasting effects of the right to vote. This is based on the assumption that during the course of the time development has always a positive effect and its magnitude is proportional to the time since women suffrage was established. Worthy to mention also the question about suffrage and race, that for many countries is strongly connected (Carruthers & Wanamaker 2015; Yang 2020). It can be argued that, even after the right to vote, many discriminating laws were still in presence, and the alignment of law together with executive branch of the government and elimination of discrimination takes more time – for example, despite to the right to vote, the right to work can be suppressed for several decades. This assumption that suffrage played a long lasting effect on the balance in gender equality sounds reasonable but requires further investigation to be used as a robust estimator.

Based on the identified methodological flaws and absence of validation and justification, we doubt the possibility to use the GEI as a reliable proxy for gender equality. Therefore, we will use GEI only to match the replication with the original analysis. The new analysis will use only the established indicators WEF GGGI, UNDP GII and GDI, in their relationship to the gender differences in economic preferences and the economic development.

Conditional analysis of gender difference and their relationship to economic development and gender equality

In this section, we explore the correlation of the summarised gender differences to the economic development and gender equality indicators WEF GGGI, UNDP GII and GDI using a conditional analysis. As can be seen in Fig. 3, the gender differences are strongly and statistically significantly correlated with the economic development when the conditional analysis is performed on the single gender equality indicators, thus indicating that the economic development of a country seems to play a key role in the measured gender differences in the economic preferences. On the contrary, the correlation of the gender differences to the gender equality indexes of the country, conditioned on the economic development, is only statistically significant for

WEF GGGI conditioned on Log GDP p/c (p-value = 0.0241), while for UNDP GII and GDI the correlation is not statistically significant.
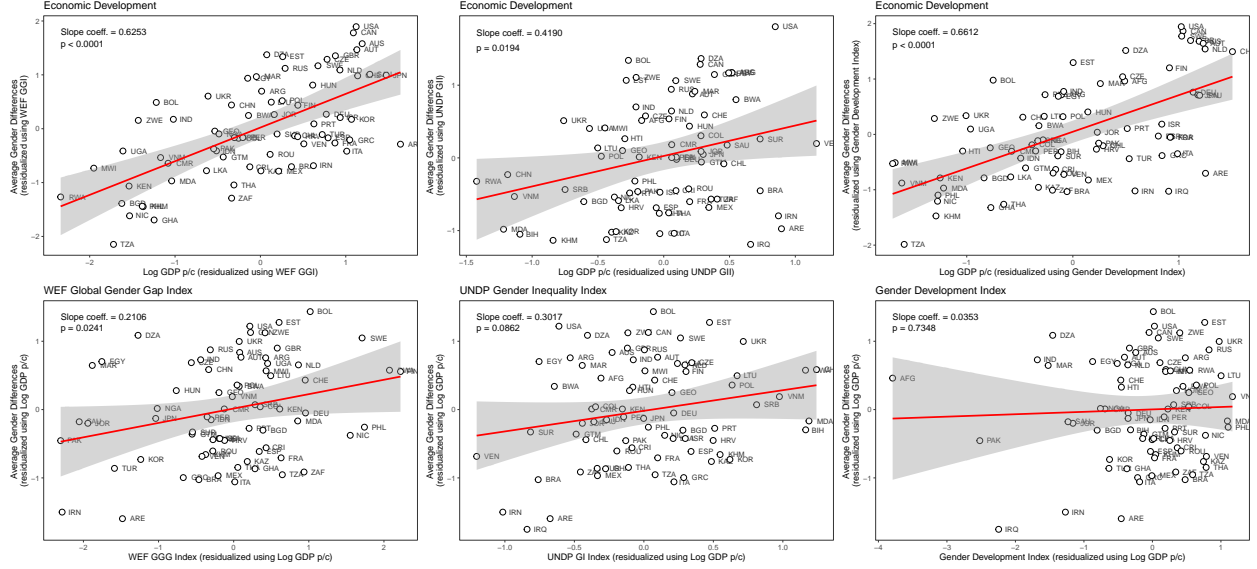

Figure 3: On the top row, gender differences are regressed on the economic development conditioned on gender equality, for the different indicators (WEF GGGI, UNDP GGI and GDI). On the bottom row, the corresponding values of gender differences regressed on the gender equality indicator conditioned on economic development.

To investigate the role of economic development and gender equality on single preferences, we performed the same analysis without aggregating preferences into a single measure. As one can see in Table 1, alongside with the results of aggregated gender differences, the economic development still has in most cases a strong and statistically significant correlation to the single preferences when conditioned on the gender equality of the country.

Table 1: **Gender differences in economic preferences related to Log GDP p/c conditional on the gender equality indicators**, regressed on each single economic preference gender difference coefficient. The robust linear regression is used. Reported are the correlation terms and their significance levels: ≤ 0.001 (***), ≤ 0.01 (**), ≤ 0.05 (*).

Variable	WEF GGGI	UNDP GII	UNDP GDI
Trust	0.5174***	0.1930	0.5045***
Altruism	0.5255***	0.3527***	0.4477***
Positive Reciprocity	0.2898*	0.2054	0.1870
Negative Reciprocity	0.3974**	0.0706	0.3858***
Risk Taking	0.3469**	0.0262	0.3199**
Patience	0.3742**	0.1046	0.3337**

Table 2 summarises the results of the regression of the gender differences in single economic preferences with relation to gender equality indexes conditioned on economic development. No statistically significant correlations were observed for the gender equality indexes to single preferences, except the two cases of WEF GGGI-Altruism combination and of the UNDP GII-Risk Taking. Thus, no reliable association between the gender differences in economic preferences and gender equality indexes is found.

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Table 2: **Gender differences in economic preferences related to gender equality indicators, conditional on Log GDP p/c**, regressed on each single economic preference gender difference coefficient. The robust linear regression is used. Reported are the correlation terms and their significance levels: ≤ 0.001 (***), ≤ 0.01 (**), ≤ 0.05 (*).

Variable	WEF GGGI	UNDP GII	UNDP GDI
Trust	0.1325	0.2160	0.0794
Altruism	0.3561**	-0.0421	0.1021
Positive Reciprocity	0.0396	-0.0402	0.1978
Negative Reciprocity	0.1680	0.1742	-0.1033
Risk Taking	0.0349	0.2192*	-0.0261
Patience	0.2312	0.1705	0.0812

3. Discussion and conclusions

In the present article, we replicated the results of the work by Falk & Hermle (2018a) that related gender differences in economic preferences to economic development and gender equality. The main finding of the original article can be summarised as follows. The authors used Gallup World Poll 2012 Global Preference Survey to measure the gender differences in economic preferences across 76 counties a joint index that summarizes the differences in all six preferences at the same time, and Log GDP p/c as a proxy of economic development. While for gender equality, several indexes were introduced, including a newly composed joint measure for gender equality (Gender Equality Index, reported as GEI). As the main result of the study, the authors reported a large and statistically significant association of gender differences with Log GDP p/c (r = 0.67, p-value < 0.0001) and the GEI (r = 0.56, p-value < 0.0001), as it was reflected in *Research article summary* and graphical abstract. The authors also conducted a conditional analysis to isolate the impact of economic development and the GEI. The association was found of smaller magnitude but still rather strong and statistically significant (r = 0.53, p-value < 0.0001) when gender differences were related to Log GDP p/c conditioned on the GEI, and moderate and statistically significant (r = 0.32, p-value = 0.003) when relating with the GEI and conditioning on Log GDP p/c. The authors concluded that the evidence indicates that higher levels of economic development and gender equality favor the manifestation of gender differences in preferences across countries, *highlighting the critical role of availability of material and social resources, as well as gender-equal access to these resources, in facilitating the independent formation and expression of gender-specific preferences* (Falk & Hermle 2018a).

Given the importance of these findings and their impact, and the impressive size and complexity of the entire analysis, it is of high value to conduct a detailed reconstruction of the methodology and analysis, checking the robustness of assumptions and inferences. As a first milestone, we performed a pure replication, obtaining the gender differences in economic preferences from the Gallup World Poll 2012 Global Preference Survey, using the same methodology as in the original article. Unfortunately, the dataset is publicly available only in preprocessed form (the qualitative and quantitative items of the questionnaires are already mixed and standardized) and partially restricted (two control variables are missing). To some extent, this hampered the replication's comparison with the original findings. Nevertheless, the extracted gender differences were close to the ones from the original article. In addition, we ran the same analysis using robust regression instead of ordinary linear regression as the data revealed signs of non-normality and outliers, but no significant changes in the distribution of gender differences in economic preferences were observed.

As the next step, we investigated the indexes used to estimate economic development and gender equality and their relation. First, we revealed a very strong association between Log GDP p/c and the Gender Equality Index built by the authors (r = 0.5440, p-value < 0.0001), and other indexes approved by international organizations such as WEF Global Gender Gap Index, UNDP Gender Inequality Index and UNDP Gender

Development Index (r = 0.2926, p-value = 0.013; r = 0.8542, p-value < 0.0001; r = 0.5316, p-value < 0.0001, respectively). In the light of this strong relationship and correlation between gender differences and Log GDP p/c, one should conclude that only the conditional regression with control on Log GDP p/c may uncover the separate role of gender equality on gender differences.

Then, we analyzed the Gender Equality Index built by the authors and investigated its single components. Several methodological flaws were identified, questioning the validity of the procedure of its construction. The GEI was composed of four other indicators: two are widely used indicators coming from the WEF and the UNDP (the WEF Global Gender Gap Index and the UNDP Gender Inequality Index), which in turn are built from 14 and 5 sub-indicators respectively; one is the ratio of female-to-male labor force participation; and lastly, a newly constructed type of indicator based on years since women were granted suffrage in a country. Our analysis revealed that both WEF GGGI and UNDP GII indicators already contain the ratio of female-to-male labor force participation and have common sub-indicators related to the share seats in parliament and secondary education. The additional use of the female-to-male labor force participation as a third component for the GEI remains unclear, as it prioritizes this factor over all other factors included in indexes that lead to their unbalance. In addition, the index constructed by authors by standardization of the years since women suffrage lacks justification and validation. Based on these findings and the absence of clear procedures in the original article, we concluded that there is no evidence that the Gender Equality Index built with PCA performs better (or not worse) than existing indexes. We argue that the use of *ad hoc*, not validated indicators such as the Gender Equality Index in gender equality studies leads to virtually no possibility to compare the results of such studies with other research in domain conducted on global and local scales. Thus, in further analysis, we focused on the existing and widely accepted indicators of gender equality.

The gender equality indexes used in this analysis (WEF Global Gender Gap Index, UNDP Gender Inequality Index, and UNDP Gender Development Index) have themselves certain limitations that were discussed by several authors, and are far from being complete representation of gender inequality (Anand & Sen 1995; Barns & Preston 2010; Permanyer 2013; Klasen 2017; Piper 2019; Klonner *et al.* 2021). Despite critics, these indexes are likely the best estimates for the state of gender equality on a global scale in a regular, standardized, and systematic way. We proceeded with examining the gender differences in their relation to economic development and gender equality using these indexes and conditional analysis. We found a large and statistically significant association of gender equality preferences with economic development conditioning on WEF GGGI and UNDP GDI (r = 0.6253, p-value < 0.0001, and r = 0.6612, p-value < 0.0001, respectively), while for UNDP GII the association was somewhat smaller and with a larger p-value (r = 0.4190, p-value = 0.0194), but still statistically significant at the 5% confidence-level. On the other hand, when conditioning on economic development, no correlation for UNDP GII and GDI with the summarised gender differences was found. Only for the WEF GGGI, the correlation was found to be weak (r = 0.21) with a statistical significance below the 5% (p-value = 0.024).

We further analyzed how single-gender differences are related to economic development and gender equality. Along with the results for combined gender differences, large and statistically significant associations were demonstrated when we tested the association between gender differences with Log GDP p/c conditioning on WEF and GDI. Interestingly, no preferences except "altruism" demonstrated any relation with Log GDP p/c when conditioning on UNDP. Furthermore, among six economic preferences and three gender equality indexes, no statistically significant association between economic preferences and Log GDP conditioning on the gender equality index was found, except for "altruism" (r = 0.3561; p-value = 0.006) conditioning on WEF and "risk-taking" (r = 0.2192; p-value = 0.045) when conditioning on UNDP, demonstrating the only support of the presence of association of single-gender differences in economic preferences and gender equality.

To sum up, gender equality indexes and economic development expressed in Log GDP are strongly correlated variables; thus, the association between gender differences in economic preferences and gender equality indexes should be determined by conditioning on economic development. Our conditional analysis suggests that only a mild and sparse association between gender differences in economic preference and gender equality exists (only one preference over six), and the magnitude of the correlation coefficient is at-least two-fold smaller than the association of gender differences and the economic development conditioning on gender equality indexes. Given these results of the reproduction analysis, we conclude that the evidence is not sufficient to support an association between economic preferences and gender equality.

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