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ARTICLE

Innovation or social progress? An analysis of the predictors for worldwide advancement of gender equality

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Abstract

This paper aims to verify the relationship between innovation and social progress for the advancement of gender equality on a global level. Secondary data were collected on the Global Innovation Index (GII), the Social Progress Index (SPI), and the Global Gender Equality Index (GGGI) for the years 2020 and 2021. In the quantitative analysis, the multiple linear regression model was used in the open-source software R Studio. The results highlighted that social progress positively and significantly affects gender equality, although no correlation was found between it and innovation. By providing a comprehensive framework for evaluating factors related to closing the global gender gap, this study catalyzes increased public awareness of the issue and an important source of information for policymakers and stakeholders.

Keywords: Gender Equality. Innovation. Social Progress. Multiple Regression Analysis. R Studio.

Inovação ou progresso social? Uma análise dos fatores preditores para o avanço mundial da igualdade de gênero

Resumo

O presente artigo visa verificar a relação entre inovação e progresso social para o avanço da igualdade de gênero em esfera global. Para tanto, dados secundários foram coletados no Índice Global de Inovação (GII), no Índice de Progresso Social (SPI) e no Índice Global de Igualdade de Gênero (GGGI) dos anos de 2020 e 2021. Na análise quantitativa, utilizou-se o modelo de regressão linear múltipla por meio do *software* de código aberto R Studio. Os resultados evidenciaram que o progresso social afeta positiva e significativamente a igualdade de gênero, embora não se tenha encontrado nenhuma correlação entre esta e a inovação. Ao fornecer uma estrutura compreensível para avaliar os fatores relacionados à diminuição das lacunas globais de gênero, este estudo serve como um catalisador para uma maior conscientização pública a respeito do tema, além de representar uma importante fonte de informação aos formuladores de políticas públicas e demais públicos de interesse.

Palavras-chave: Igualdade de Gênero. Inovação. Progresso Social. Análise de Regressão Múltipla. R Studio.

¿Innovación o progreso social? Un análisis de los factores predictivos del avance global de la igualdad de género

Resumen

El presente artículo pretende verificar la relación entre innovación y progreso social para el avance de la igualdad de género en la esfera mundial. Para ello, se recopilaron datos secundarios del Índice Global de Innovación (GII), el Índice de Progreso Social (SPI) y el Índice Global de Igualdad de Género (GGGI) de los años 2020 y 2021. En el análisis cuantitativo, se utilizó el modelo de regresión lineal múltiple en el *software* de código abierto R Studio. Los resultados pusieron de relieve que el progreso social afecta positiva y significativamente a la igualdad de género, aunque no se encontró ninguna correlación entre esta y la innovación. Al proporcionar un marco exhaustivo para evaluar los factores relacionados con la disminución de la brecha mundial de género, este estudio sirve de catalizador para una mayor concienciación pública sobre el tema, así como de importante fuente de información para los formuladores de políticas públicas y otras partes interesadas.

Palabras clave: Igualdad de género. Innovación. Progreso social. Análisis de regresión múltiple. R Studio.

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INTRODUCTION

The international agenda has been incorporating the gender debate into development plans since the United Nations (UN) founding charter in 1945 (Sardenberg, 2018). Since then, mainly due to the creation of the UN's 17 Sustainable Development Goals (SDGs) in 2015, there has been a trend towards gender mainstreaming in discussions involving global development, particularly in favour of an agenda that gradually dissolves the social, historical and economically constructed bonds of inequality between men and women (Sardenberg, 2018). As this inequality has worsened following the impact of the novel coronavirus pandemic on global economic growth, a powerful discourse in favour of greater female participation in business has re-emerged as an essential factor not only for economic recovery after scenarios of crisis and global instability (Sajjad et al., 2020; World Economic Forum [WEF], 2021) but also for the social and cultural advancement necessary for long-term sustainable development (Azcona & Bhatt, 2020).

Such discourse brings direct implications to the Administration field and management practices involving public gender policies (Öjehag-Pettersson, 2017; Marcondes, 2019). In the scientific literature, while the role of innovation and social progress in increasing equality has been praised, this is still a relatively recent topic in the field of Organisational Studies (Bleijenbergh et al., 2018; Ferreira et al., 2015; Grosser & Moon, 2019). However, what predominates in the research published to date echoes this major phenomenon of gender mainstreaming found in the institutionalised discourse of international entities and bodies (Mariano & Molari, 2022) despite the obvious catastrophic consequences of traditional development models, which attempt to incorporate a gender perspective without considering its interface with technology, identity, science and society (Anderson et al., 2004; Figueiredo et al., 2020; Haraway, 2015; Haraway & Kunzru, 2000).

Thus, in order not to incur the "danger of a single history" (Adichie, 2019) or the production of localised knowledge that privileges a partial perspective on the actual relationship between gender equality, innovation and social progress (Haraway, 1988), this article aims to verify the relationship between these last two concepts and the advancement of gender equality from a macro-organisational perspective, as recommended by Alsos et al. (2013). To this end, secondary data retrieved from the Global Innovation Index (World Intellectual Property Organization [WIPO], 2020), the Social Progress Index (SPI, 2021) and the Global Gender Equality Index (GGGI) (WEF, 2021) were analysed in a quantitative approach that made use of a multiple linear regression model run in the open-source software R Studio.

Methodologically, this research fills the need for quantitative models that use empirical data updated by the world's leading socioeconomic indices (Ballesta et al., 2020; Meyer & de Jongh, 2018; Zhu et al., 2019), given that most scientific work has been conducted from a micro-organisational perspective centred on specific regions of the globe, using a single-case study design or a comparative study of multiple cases (Alsos et al., 2013; Laudano et al., 2019; Pinkovetskaia et al., 2019; Ribes-Giner et al., 2018).

In terms of theoretical and practical contributions, the role of women in intra-organisational and organisational types of innovation could be distinguished, revealing that the thematic triad that inspired this research is imbricated in structural power relations and normative frameworks that bias gender conceptions in today's development management practices. Therefore, policymakers must draw up social development plans in line with the new methodological approaches and new operationalisations of innovation, guided by the post-colonial and macro-organisational gender perspective glimpsed in this work.

LITERATURE REVIEW

Studies on gender equality in the Applied Social Sciences began to take shape with the work of Acker (1990, 1992), Alvesson and Billing (1992), Brown (1976), Hearn and Parkin (1983), Mills (1988), and Wolff (1977), going back to the roots of the feminist movement of the 1960s. This movement aimed at denouncing issues of division of labour, power, authority and sexuality within organisations (Nkomo & Rodriguez, 2019; Wilson, 1996). Over time, this trend of trying to explain the structural patterns that corroborated gender inequality at the micro- and macro-organisational levels has moved on to the intersectional

debate of issues relating to race, class, ethnic minorities and sexual diversity (Bleijenbergh et al., 2018; Holvino, 2008), religion (Arifeen & Gatrell, 2013), work-family relations in the insertion of women into the world of work (Ferreira et al., 2015; Linstead, 2000) and, more recently, the influence of these issues on corporate culture and responsibility (Grosser & Moon, 2019).

According to Haraway (1988), gender can be defined as a product of cultural and technological practices, not as a natural or biological fact. The author critically outlined a first approximation between what is understood today as technological innovation and the formation of gender, focussing on the cyborg figure. This encompasses a fluid and dynamic category shaped by subjects' experiences, desires, and interactions. These subjects, while being mediated by technology and the technical-scientific knowledge produced with the creation of machines, have the power to challenge (or reinforce) traditional gender roles and identities, offering new possibilities for self-expression and social transformation, or the reification of genderised subjects' consolidated roles (Haraway & Kunzru, 2000).

Such a post-colonial perspective is in line with the evolution of the discussion on gender and development that emerged in the 1990s, in which the term "women" was dropped to emphasise the cultural and historical construction of gender based on the sexual division of labour (Hirata, 2009, 2018). The latter refers to the power relations that organise societies around inequality, without focusing on class relations between men and women and their respective impacts on development (Mariano & Molari, 2022). Whereas the previous "women and development" perspective had a Marxist orientation that obliterated the social construction of gender to the detriment of the struggle between classes – which affects men and women indistinctly –, the "gender and development" perspective began to investigate why and how social relations between the sexes place men in the productive sphere and women either in the reproductive sphere or in the subordinate productive sphere (Mariano & Molari, 2022).

In the context of this work, it is worth questioning why men are given a more critical role in development while women, even though they are part of corporate boards and actively participate in economic progress, remain invisible to some sectors of society (Paradis, 2019). For Haraway and Kunzru (2000), the solution to this conundrum lies precisely in the hybrid figure of the cyborg insofar as technology and science offer a space of resistance to be used to challenge dominant forms of power and control, mobilising oppressive systems and creating possibilities for social transformation.

For Haraway et al. (2000, p. 149), the term "cyborg" refers to "[...] a cybernetic organism, a hybrid of machine and organism, a creature of social reality as well as a creature of fiction." The authors argue that there are two ontological levels of construction of the cyborg: one literal, i.e. the materialised cyborg, configured through the techno-scientific complex, and the other metaphorical, created by contemporary narratives with the intention of challenging binary roles, thus being politically progressive and oppositional. For Haraway (1988), no human body or being is stable or natural, as it is constructed in the hybridity and liminality of the being's relations with other beings, human and non-human (technologies and/or machines and animals, for example). In this sense, human bodies are seen as complex and dynamic configurations of biological mass, other people's bodies, discourses, practices, ideas, and material objects – each element contributing to the other in an interdependent way. In other words, we understand our bodies and ourselves through technologies, just as our bodies and ourselves also give meaning to and configure technologies through the enactments of everyday life (Lupton, 2013).

Hence, the cyborg is revisited in this work as a means of emphasising the interconnection between the collaborations of technoscience, whose direct by-product lies in technical-industrial innovation, and the body assemblages it shapes, which affect well-being and social progress concerning gender equality (Haraway, 1988; Haraway et al., 2000). As long as the cyborg remains an icon of aggressive and masculinised technophilia, i.e. as an "impartial" and inevitable product of the models of innovation we see today (Jensen, 2008; Squires, 2000), its transgressive liminality will lose the chance to challenge the myths of technoscience in its project to destabilise the narratives around the perfect and complete body, often masculinised, and to challenge the reproduction of cultural binary oppositions as if they were essential and natural (Haraway & Kunzru, 2000).

Driven by the transition from the Millennium Development Goals (MDGs) to the SDGs, this view is at the heart of gender mainstreaming, which disconnected the idea of women as mere beneficiaries of development promoted by men and began to associate the concept of gender with other social problems, referring to the intersectionality discussed earlier (Fukuda-Parr, 2016; Mariano & Molari, 2022).

The concept of social progress then takes on a gender connotation due to the achievement of social justice in various areas of general interest to society, which admittedly affects women the most, since the unpaid family and community care work they perform is devalued (Paradis, 2019). Thus, in addition to the right to land, the fight against poverty, malnutrition and hunger, the fight against environmental degradation and the housing crisis, there are also problems intrinsically intertwined in the gender debate, such as child marriage, early or forced pregnancy, sexual violence, among others. In general, Mariano and Molari (2022, p. 831) argue that "[...] feminisms from the Global South have contributed to incorporating visions of gender justice into the scope of human development", following an approach that Azcona and Bhatt (2020) have called inequality, gender, and sustainable development.

The empirical literature on the subject follows this approach. For Bando (2019), for example, gender equality promotes social development by curbing income inequality between men and women. Similarly, Falk and Hermle (2018) stated that a more equal availability of material resources between men and women would contribute to greater economic and social development in 76 countries through gender-related individual preferences in the utilisation of productive resources. In a previous study, Tesch-Römer et al. (2007) found a close relationship between the sense of social well-being experienced by citizens in more than 50 countries and cultural values towards more inclusive access to financial and educational resources between men and women. Thanks to this, many modern authors attribute a greater perception of social progress to the advancement of public policies at local, regional, and global levels in different countries, which aim to ensure a more equitable entry of women into higher education (Clavero & Galligan, 2021; Cruz, 2019; Laoire et al., 2021; O'Connor & Irvine, 2020; Silva & Prestes, 2018).

Given these findings, we present the first hypothesis that the statistical model adopted in this study set out to test:

H1. There is a positive and significant relationship between social progress and gender equality.

Accordingly, beyond the initial relationship between gender equality and social progress, empirical studies have confirmed Haraway's (1988) original impressions of the intersection between these two and advances in technological innovation. Presented in the literature as a predictor of increased economic growth in industries, innovation is a phenomenon studied mainly at the intra-organisational level as a strategic resource capable of ensuring the maintenance of companies' competitive advantage over time (Alsos et al., 2016). However, considering the potential negative impacts resulting from firms' innovation, the role of women has been particularly praised as a way of acting on society's grand challenges and rethinking organisations in the transition from obsolete production models that do not keep pace with efforts to preserve the environment and social well-being in the unbridled pursuit of technical transformation (TM & Joseph, 2021).

The first academic work on technical transformation was attributed to Schumpeter (1959), who focused on great inventions as the driving force behind the economic development of nations. His work defines innovation as new combinations of production factors to deliver goods or services to society, which can occur by introducing new production processes, opening up new markets, exploiting new sources of raw materials or restructuring an entire industry (Schumpeter, 1959). The author's most outstanding contribution to the discussion is his expansion of the classic economic assumptions guiding the study of entrepreneurship in the 1930s (Vale, 2014). He included the agents responsible for innovation in the understanding of any competitive advantage that could be obtained and, after all, disregarding individuals as actors in the processes, organisations and systems that drive innovation ends up making gender issues invisible (Alsos et al., 2016).

Hence, several studies have advanced the discussion of the relationship between gender equality and innovation (Alsos et al., 2013), suggesting that the presence of women in leadership roles has proven to be relevant in the dissemination of a corporate culture geared towards innovation in both developed and developing countries (Dai et al., 2019; Ritter-Hayashi et al., 2019; Wu et al., 2021). The same applies to directing strategies aimed at sustainable innovation (Nadeem et al., 2020) and combating climate change (Loarne-Lemaire et al., 2021). Furthermore, the encouragement of public policies to promote gender equality in developed nations, such as Canada and Sweden, has also had a significant impact on leveraging innovation macro-ecosystems (Rowe, 2018) and on innovation in the scientific environment (Nielsen et al., 2018; Otero-Hermida & García-Melón, 2018).

All these studies have established that the advancement of gender equality is reflected in the innovation efforts undertaken by companies and countries. Thus, the second hypothesis that this research sought to test was the following:

H2. There is a positive and significant relationship between innovation and gender equality.

It is worth noting that, despite the alignment of the aforementioned studies with the proposed discussion between "gender and development", as seen in Haraway (1988), there are also divergent views that call into question the positive relationship between the variables indicated. This is due to the growing criticism of the perverse effects of technological innovation on the environment (Figueiredo et al., 2020; Haraway, 2015), as well as the worsening of social problems (Vergès, 2020), since both ratify a colonialist and instrumentalised view of women in the face of welfare policies towards global development. In addition, there is evidence that women themselves reproduce practices of exclusion and violence in corporate environments with high demands for productivity and innovation (Moura & Santos, 2023).

Therefore, considering the existence of such tensions in the literature on the subject – which further emphasises the relevance of this research in seeking to clarify the disagreements in the correlation between the constructs addressed in this section – and recognising that there is already a validated index for predicting and explaining innovation outputs at the national level (Galdino, 2019; C. B. D. Souza et al., 2023), the following section justifies the choice of materials that make up this paper's statistical model and elucidates the methodology employed for its manipulation.

MATERIALS AND METHODS

Materials

The Global Innovation Index or GII aims to measure each country's innovation capacity and efficiency levels based on a set of data collected annually according to a series of innovation determinants (inputs and outputs) – WIPO (2020). While innovation inputs are made up of five pillars representing economic characteristics that favour innovative activities – institutions, research and human capital, infrastructure, market sophistication, and business sophistication –, innovation outputs correspond to the results of these activities and are distributed across two pillars, namely: knowledge and technology, and creativity (WIPO, 2020). Each pillar has three other sub-indices, also made up of specific indicators, totalling 80 in the 2020 report.

This index was chosen as an independent variable in this study because it provides up-to-date records of labour activities performed by women in senior positions through the "females employed with advanced degrees" indicator, which is part of the "business sophistication" innovation input (WIPO, 2020), as shown in Box 1.

Box 1
GII dimensions

Primary Dimension (Seven Aspects)	Secondary Dimension (21 Aspects)
1. Institutions	1. Political environment 2. Regulatory environment 3. Business environment
2. Human capital and research	4. Education 5. Tertiary education 6. Research and development (R&D)
3. Infrastructure	7. Political environment 8. Regulatory environment 9. Business environment

(Continue)

Primary Dimension (Seven Aspects)	Secondary Dimension (21 Aspects)
4. Market sophistication	10. Credit 11. Investment 12. Trade, competition, & market scale
5. Business sophistication	13. Knowledge workers 14. Innovation linkages 15. Knowledge absorption
6. Knowledge and technology outputs	16. Knowledge creation 17. Knowledge impact 18. Knowledge diffusion
7. Creative outputs	19. Intangible assets 20. Creative goods and services 21. Online creativity

Source: Elaborated by the authors based on WIPO (2020).

In turn, the Social Progress Index or SPI has been published since 2013 by the Social Progress Imperative. This non-profit organisation tries to stimulate improvements and direct actions towards 51 social and environmental indicators to measure social progress among 149 countries, which includes 98% of the world's population (E. Souza, 2020). Its indicators are divided into three dimensions: basic human needs, support for well-being and opportunity. For clarification, see Box 2.

Box 2
SPI Dimensions

Primary Dimension (Three Aspects)	Secondary Dimension (12 Aspects)
1. Basic human needs	1. Nutrition and basic medical care 2. Water and sanitation 3. Shelter 4. Personal safety
2. Foundations of wellbeing	5. Access to basic knowledge 6. Access to information and communications 7. Health and wellness 8. Environmental quality
3. Opportunity	9. Personal rights 10. Personal freedom and choice 11. Inclusiveness 12. Access to advanced education

Source: Elaborated by the authors based on the SPI (2021).

This index covers four categories that are fundamental to the subject of this research, namely: I) the existence of exclusive social and environmental indicators that do not focus on purely economic aspects; II) the inclusion of the item "results" instead of "inputs" (as seen in the previous index) to measure the achievement of quality of life effectively and not just the efforts made by countries in this regard; and III) its practical purpose, which makes its data useful for government leaders, professionals, companies and civil society in implementing public policies in favour of collective well-being (Social Progress Imperative, 2021).

Finally, the GGGI was designed by the World Economic Forum (WEF) in 2006 to compare which countries have managed to overcome the main obstacles to the low participation of women in politics and the public sector, as well as in private enterprise (WEF, 2021).

Its most significant advantage over other indices comes from its methodology neutralising the scoring of indicators favouring women over men, such as the increase in the world birth rate for women (WEF, 2021). Moreover, 13 of the 14 variables used to create the index come from raw data made publicly available by various international bodies, such as the International Labour Organisation (ILO), the United Nations Development Programme (UNDP) and the World Health Organisation (WHO). Through a robust and multi-dimensional calculation, this makes it possible to uncover how countries divide their resources and opportunities between the male and female population, regardless of the general levels of these resources and opportunities (WEF, 2021). A summary of the main indicators used in the GGGI can be found in Box 3.

Box 3
GGGI dimensions

Primary Dimension (Four Aspects)	Secondary Dimension (14 Aspects)
1. Economic participation and opportunity	1. Labour force participation rate [%] 2. Wage equality for similar work [survey, 1-7 scale] 3. Estimated earned income [PPP, int.$] 4. Legislators, senior officials and managers 5. Professional and technical workers [%]
2. Educational attainment	6. Literacy rate [%] 7. Enrolment in primary education [%] 8. Enrolment in secondary education [%] 9. Enrolment in tertiary education [%]
3. Health and survival	10. Sex ratio at birth [%] 11. Healthy life expectancy [years]
4. Political empowerment	12. Women in parliament [%] 13. Women in ministerial positions [%] 14. Years with female head of state [last 5]

Source: Elaborated by the authors based on WEF (2021).

We chose to use only the aggregate values of each index to compose the statistical model proposed in this paper, in order to achieve the objective of the study, i.e., to generate a macro-organisational analysis, instead of a localised or comparative analysis of the various dimensions of innovation and social progress in each country present in the indices. Likewise, we took into account the difficulties that the coronavirus SARS-CoV-2 pandemic imposed on the progress of policies against gender inequality in the world (Madgavkar et al., 2020) in the cross-sectional time orientation (Kumar, 2014) that guided the selection of years in the reference indices. These years were marked by greater domestic violence (O'Donnell et al., 2021), more cases of femicide (Weil, 2020), a higher unemployment rate for this group compared to men (Profeta, 2021) and a higher incidence of psychological problems, such as postpartum depression (Stepowicz et al., 2020), burnout syndrome among female health professionals (Tuna & Özdin, 2021) and education professionals (Copková, 2021), as well as emotional overload due to the disproportionate division of domestic labour (Bahn et al., 2020).

METHODS

The methodological approach adopted in this research was quantitative (Bryman & Bell, 2015), deductive and descriptive (Kumar, 2014), and used the multiple linear regression method, as it allows the behaviour of one variable to be assessed in relation to others without incurring in any deterministic cause and effect relationship. This is particularly appropriate when there is more than one explanatory variable interfering in the behaviour of the dependent one (Fávero & Belfiore, 2017). The dependent variable was the GGGI, and the independent variables, also called "explanatory" (Fávero & Belfiore, 2017), were the SPI and the GII. Since the first index is based on a range of 0 (zero) to 1 (one) for each country assessed, adjustments were needed to standardise the values on a scale of 0 (zero) to 100 (one hundred).

The data was processed in Microsoft Excel, aiming to standardise the names of the countries described in the different sources and remove from the aggregated component base those that contained missing data (N/A). For generalisation, the 129 countries that submitted data for the three indices were included in the inferential statistical model, without differentiating their level of development.

Subsequently, as a tool for statistically analysing cross-sectional data (Kumar, 2014), the R Studio software was used, with the support of the lmtest, car, dplyr, rstatix, ggpur, QuantPsyc, psych and scatterplot3D packages. The latter was employed to generate a 3D graph to illustrate the model. Table 4 summarises the tests used to validate the assumptions of the multiple linear regression model.

To validate the bases and the method chosen, it was first necessary to identify the normality of the residuals distribution and estimate the correlation between the study variables. The Shapiro-Francia test was used to certify the normality of the data, as it is more appropriate for the size of this sample (Fávero & Belfiore, 2017).

The variance inflation factor (VIF) statistical test was applied to ensure the absence of multicollinearity. Multicollinearity occurs when the explanatory variables have very high correlation indices to the point where the relationship between the variables becomes linear. To test the incidence of this phenomenon, in general, a VIF statistic of less than or equal to 10 (ten) is considered a reference value, with the existence of multicollinearity being conditioned for values above this limit (Fávero & Belfiore, 2017; Hair et al., 2009).

To check for the absence of heteroscedasticity after the assumption of normality, the Breusch-Pagan test was used (Fávero & Belfiore, 2017). According to the authors, the homoscedasticity of the residuals is the constancy of their variance along the explanatory variable (Fávero & Belfiore, 2017). The results and analyses from each test are presented in the following section.

Box 4
Summary of model assumptions

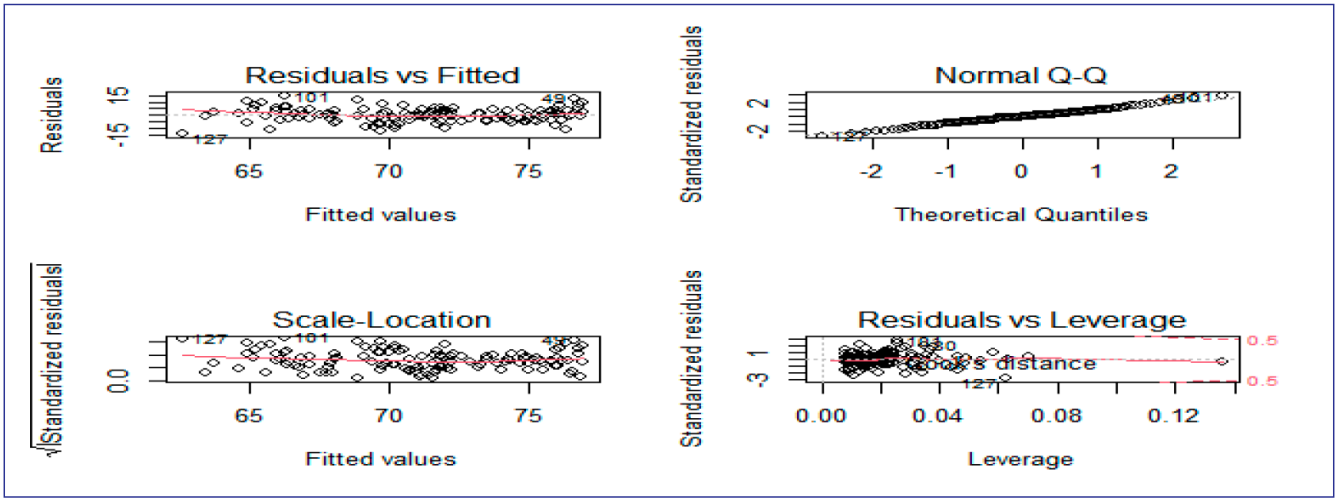
Assumption	Test Form	Function Syntax in R Studio
Normality of residuals	Shapiro-Francia	shapiro.test(resid(modelo))
Homoscedasticity of residuals	Breusch-Pagan test	bptest(mm, data=dados) # pacote lmtest
Absence of multicollinearity	Pearson Correlation Test and VIF	cor(dados[,2:k]) vif(modelo)
No serial autocorrelation	Durbin-Watson test	dwtest(mm, data=dados)
Removal of non-relevant explanatory variables	StepAIC test	stepAIC(mod.inicial, scope = list(upper=mod.inicial, lower = mod.simples), direction = "backward")

Source: Elaborated by the authors based on Fávero and Belfiori (2017).

PRESENTATION AND DISCUSSION OF RESULTS

The first model containing the three variables showed high linearity, with a normal distribution of the residuals (p-value = 0.9139; confirming H0 for a normal distribution with a p-value greater than 0.05) – Fávero and Belfiore (2017).

Graph 1
Graphical analysis of the model using the PAR (MFROW = C(2,2)) and PLOT (MOD) packages

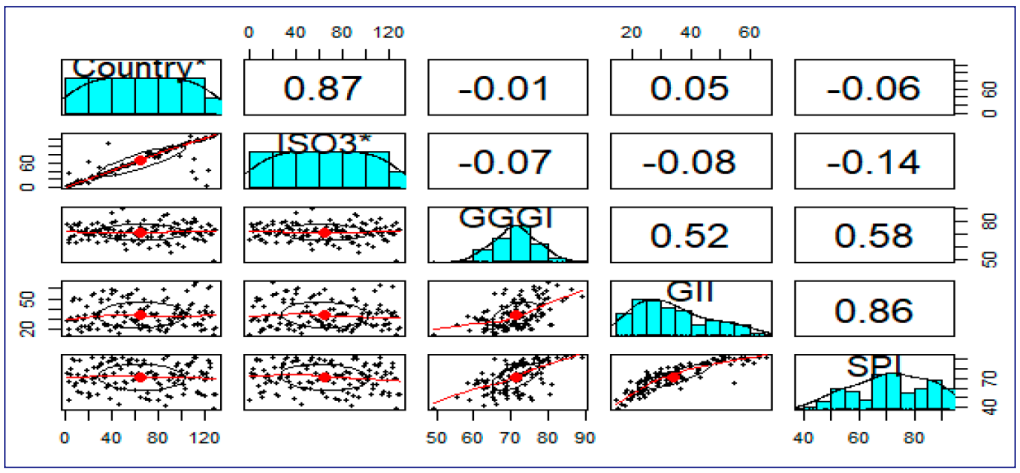


Source: Elaborated by the authors.

The summary(rstandard(mod)) function showed that there were no outliers or influential points in the model, as the minimum value calculated was -2.6833749 (minimum allowed: -3) and the maximum was 2.8030416 (permitted maximum: +3). The median value close to 0 (0.0269819) also confirmed the absence of outliers (Fávero & Belfiore, 2017).

Next, the Breusch-Pagan test was used, as the distribution was normal. The yielded value was 0.4497, confirming H0 for a p-value greater than 0.05 (Fávero & Belfiore, 2017). The Durbin-Watson test, which measures the autocorrelation of the data, returned a p-value of 0.206, also within the expected range to confirm H0. So far, all these assumptions are similar to those of simple linear regression, differing only in relation to the additional analysis of multicollinearity, which presupposes very strong collinearity between the independent variables (Fávero & Belfiore, 2017). Two independent variables cannot have a very strong relationship with each other; this should only occur in relation to the dependent variable (Fávero & Belfiore, 2017). Checking this using the VIF, we obtained 3.956507 for the GII variable and 3.956507 for the SPI variable, which is acceptable for a cut-off score 10 (Fávero & Belfiore, 2017).

Graph 2
Pearson correlation index, complementary to VIF, by PAIRS.PANELS(DATA) package



Source: Elaborated by the authors.

The next step was to focus on the value of the adjusted R square to obtain the percentage of the variation in the data that can be explained by the model (Fávero & Belfiore, 2017). According to Field et al. (2012), the adjusted R square has sufficient reliability, as it increases as more variables are added to the model, even if they are irrelevant, making it necessary to corroborate its analysis with the AIC and BIC tests. Even so, Fávero and Belfiore (2017) comment that the adjusted R square is the most suitable for multiple regression analysis, as it can assess models with different numbers of independent variables, assuming that the most reliable model will be the one with the highest adjusted R square. In this case, the first model with two independent variables (GII and SPI) returned an adjusted R square of 0.3307. The second, which kept only SPI in a simple regression analysis, resulted in 0.3354, thus suggesting that this model would be ideal.

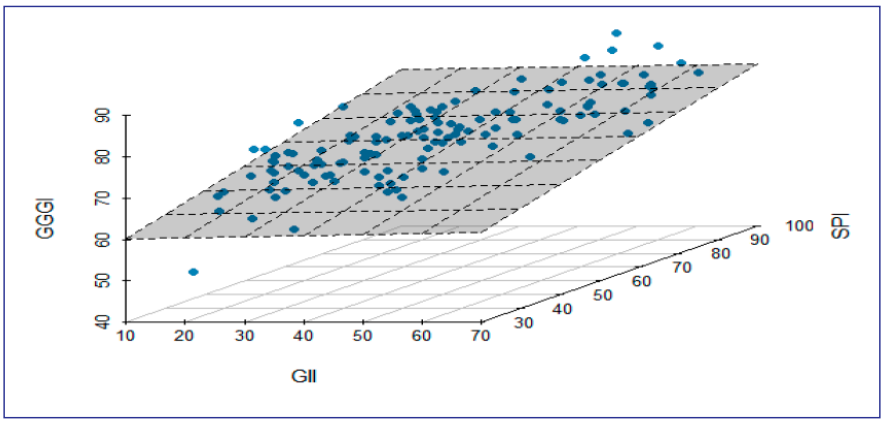
On the other hand, according to the AIC and BIC tests, the lower the result, the better, so both tests also favoured model 2, with only the "social progress" variable. See values in Graph 3.

Accordingly, the standardised coefficient (lm.beta function, from the QuantPsyc package) signalled which of the variables had the greatest impact on the model as a predictor of the independent variable, returning 0.54251095 for SPI and 0.04755909 for GII: the higher value being more associated with the dependent variable.

As a graph is usually drawn up to visualise the data at the end of the simple linear regression model, Field et al. (2012) recommend doing the same with the multiple linear regression model. However, as there are not just two variables, one independent and the other dependent, as in the simple model, what can be created is a 3D graph (Field et al., 2012).

Graph 3

Graphical display of the multiple linear regression model containing the three function variables Graph <- SCATTERPLOT3D(DATA$GGI ~ DATA$GII + DATA$SPI, PCH = 16, ANGLE = 30, COLOR = "STEELBLUE", BOX = FALSE, XLAB="GII", YLAB="SPI", ZLAB="GGGI") GRAPH$PLANE3D(MOD, COL="BLACK", DRAW_POLYGON = TRUE)



Source: Elaborated by the authors.

Finally, the MASS package's stepAIC function was used to check which variables would be excluded from the model because they were less significant in predicting the dependent variable. As the previous tests suggested, the simple linear regression model relating only the GGGI variable to the SPI was the one that remained.

As a result, H1 ("There is a positive and significant relationship between social progress and gender equality") was confirmed. At the same time, H2 ("There is a significant positive relationship between innovation and gender equality") was refuted, with the null hypothesis prevailing. In an attempt to explain the positive and significant relationship between social progress and gender equality (the first hypothesis of this study), Shilling (1991) had already anticipated, with his seminal notes, the extent to which social inequalities are constructed by and in genderised bodies. Based on the three main types of capital discussed by Bourdieu (1986) – namely economic, social, and cultural capital – Shilling (1991) adds "embodied capital" as more than just a sub-type of cultural resource invested in the human body (Bourdieu, 1986). For Shilling (1991), embodied

capital would condition an individual's agency capacity in the production of cultural and economic capital, as well as guide the achievement and maintenance of their status, thus becoming the main constituent of their ability to intervene in the social sphere and in everyday life itself.

When it comes to gender, the author points out that there is a dialogical relationship in the construction of female and male bodies over time and space since the production of physical capital takes place in moments of sport and leisure, in activities that confine classes to certain localities, which have shared symbolic values (Shilling, 1991). By "locations", Shilling (1991) means the material circumstances that contextualise individuals' lives in such a way as to distance them to a greater or lesser extent from economic and financial needs and bring them closer to material or financial "will" (Bourdieu, 1986). Depending on the locality, therefore, individuals have access to unequal opportunities to acquire the physical capital that is most valued in society, given that its initial accumulation requires an investment of their free time and economic capital. Social progress would then be a way of circumventing the structural inequality inherent in these "locations", so as to reduce the time of financial need and make it possible for both sexes to start accumulating.

Furthermore, a reversal of unequal localities would also interfere with the conversion of this physical capital along the three types of capital already known, since the other side of this dialogical process ratifies the participation of other human bodies in the same preconfigured activities as belonging to a given gender or social class (Shilling, 1991). This means, for example, that women's participation in society is not only constructed discursively, as in development policies analysed from a phenomenological perspective, but also spatially and physically, to the extent that this social group has its possibilities for building economic capital segregated to certain product or service markets. Women's cultural capital is limited to the formal education model they receive, and their social capital are often conditioned by the relationships that family members or previous types of capital have allowed them to establish outside their immediate circle of contact.

In line with these propositions, modern theorists such as Sajjad et al. (2020) argue that, in addition to these aspects helping to denigrate the condition of women's work in relation to men's work towards development, gender differences also end up being transferred to class distinctions between women themselves, as those who belong to the middle and upper classes reproduce patterns of gender inequality, trying to partially hide their subordination through the commodification of domestic work, which is mainly carried out by other racialised women from lower classes (Ávila & Ferreira, 2020; Carvalho & Santos, 2021).

In this context, it is necessary to dig deeper into the extent to which social progress can act on the inequalities generated by women from different classes while retaining a positive and significant relationship with gender equality. As seen in the aggregate indices used in this study, there are dimensions in the GGGI (especially in primary dimensions 1 and 2) and the SPI (especially in secondary dimensions 5, 6, 10, and 12) that reproduce places of privilege. While new women increase statistics for having access to basic resources, others increase indices' rates for having access to leadership positions and political participation due to a need for more progress. In both cases, despite not equally, social progress has been made, which broadens the debate around a "feminist economy" in favour of building a less unequal embodied capital between genders. The priority of this economy would be to re-signify the social responsibility of care by creating a network of solidarity around the valorisation of essential goods for life as a way of promoting sustainable development (Azcona & Bhatt, 2020; Manea et al., 2021).

Conversely, the prevalence of H1 in the statistical model also sheds light on a direct consequence of the current embodiment of capital, namely the growing phenomenon of the feminisation of poverty (Bradshaw et al., 2018; Chant, 2020). In this sense, it is questionable whether social progress does not foster greater gender equality simply because women constitute the largest vulnerable population contingent and not because they receive differentiated attention from the current development policies practised by most countries (Madgavkar et al., 2020). In this regard, it is known that they are the most affected by global crises, armed conflicts, climate change and poor health in terms of sexual and reproductive rights (O'Donnell et al., 2021; Profeta, 2021). Although there is currently an excessive instrumentalisation of the "feminine" in social welfare policies, it is debatable whether the social progress that has now been achieved falls under the perspective of "family development" – under which women would only be beneficiaries of development – or whether it reflects the perspective of "women in development" – until then centred on class relations established in the workplace – to finally legitimately incorporate the gendered power relations that organise the work performed by men and women (Mariano & Molari, 2022).

What can be stated, in fact, is that the consolidation of global development involves a process of gender mainstreaming, whereby social factors become fundamental to achieving less unequal living conditions in society as a whole (Labrecque, 2010; Mariano & Molari, 2022). This process occurs straightforwardly once social actions are necessarily addressed to gender issues, thus resulting in a more equal embodiment of physical capital (Azcona & Bhatt, 2020), as well as indirectly, since the majority of the population in a subordinate position within the sexual division of labour remains female and inevitably benefits from social actions of general interest (Hirata, 2009, 2018).

In any case, Fukuda-Parr (1999, p. 3) had already commented that, more than the economic aspects, gender inequality affects "[...] human outcomes in terms of the choices and opportunities a person has," which is in line with the findings in the consulted literature. In fact, a real gender equality would essentially transcend what is understood as the reversal of the pay gap between men and women (or gender pay gap reversal). While this concept suggests that economic equity arises from women not being responsible for care duties (Waite, 2017; Winchester & Browning, 2015) and from fairer labour relations (Bahn et al., 2020), gender equity would actually involve mobilising social structures through international cooperation, local partnerships and investments aimed at reforming systems that still legitimise vulnerability (Stepowicz et al., 2020; Tuna & Özdin, 2021), insofar as they do not develop mechanisms for redistributing tangible and intangible resources that effectively intervene in these same structures (Copková, 2021).

Hence, as Haraway (1988, 2015) predicted, social progress is not a linear objective or a one-dimensional notion of advancement, since this would only reinforce the ideas of domination, exploitation, and exclusion present in the arrangement of localities that condition an unequal embodiment of contemporary physical capital. Social development, therefore, needs to be accompanied by "speculative fiction" and "situated knowledge" through the creation of alternative corporeal narratives that challenge existing norms and structures, while also considering the importance of the perspectives and experiences of different social groups. In a nutshell, for Haraway and Kunzru (2000), social progress does not simply mean moving towards a predetermined future, because deconstructing the foundations of inequality aims to constantly question and reimagine structures based on the figure of the cyborg. In other words, promoting the ethics of care between human and non-human beings is one of the fundamental guiding principles for an approach of "companionship" and collaboration between new ways of living and inhabiting the world.

The refutation of H2, in turn, means that although several scholars have recently signalled that gender equality contributes to an increase in innovation in countries (Dai et al., 2019; Manea et al., 2021; Nadeem et al., 2020; Nielsen et al., 2018; Otero-Hermida & García-Melón, 2018; Ritter-Hayashi et al., 2019; Wu et al., 2021), 2021), cultural, political, and social aspects can still prevent nations that support technological development with massive investment in digital innovation and infrastructure from enjoying the same level of gender equity found in countries that invest in social policies, even without an innovation-orientated business ecosystem (Ghosh & Ramanayake, 2021; Østby et al., 2016). Recent international reports confirm this finding and indicate that, even in nations with an open political system, such as Japan, France, and Hungary, the innovation ecosystem found in these countries are among the most significant exogenous factors that end up inhibiting gender equality, mainly due to the lack of access to funding and credit for women to open start-ups (Mastercard, 2020). This partly explains that social progress over the last three years has occurred more quickly in developing countries that have taken initiatives to encourage the greater inclusion of women in the local economy, such as Gambia, Sierra Leone, Tunisia, Ethiopia, and Nepal (E. Souza, 2020). Only minor positive variations were observed in other developing economies that did not adopt measures related to gender equality in response to the pandemic. This is the case of Egypt, which showed an overall change from 4.1 per cent in 2019 to 4.3 per cent in 2020, and Bangladesh, which went from 4.3 per cent in 2019 to 4.5 per cent in 2020 (Mastercard, 2020).

The findings also corroborate a challenge to the hegemonic discourse found in open political systems with a neoliberal economy stating that "Innovation represents a solution for the economic and social progress of society" or even that "Economic progress necessarily leads to social progress." Such a discourse would prove incoherent in the face of economies with closed political regimes which, despite being economically advanced, still have a restrictive culture in terms of access to essential resources such as education, health and entry into the world of work for those who, in fact, could leverage more inclusive economic development, contributing to social well-being, as highlighted in the studies by Falk and Hermle (2018) and Tesch-Römer et al. (2007).

Another issue revealed by our findings refers to the structural gender inequality in access to innovation programmes. In the best-case scenario, in these same societies, businesswomen are more constantly associated with intra-organisational innovation and less with organisational innovation (Chen et al., 2021; Filculescu, 2016). This context can also be seen in the dimension covered by the GII, through the "females employed with advanced degrees" indicator, which presents the female workforce with professional qualifications as an asset of innovative companies. This is aggravating in developing countries, such as Brazil and China, where the unequal distribution between female and male labour can also influence the level of innovation that industries can achieve without, however, generating any social return so that greater inclusion of women in the technical labour market results in an improvement to this group's, or their families, quality of life, as the study by Chen et al. (2021) illustrates. This study showed a tendency towards greater innovation in female-intensive industries in Chinese regions where there was no significant population contingent of male labour to replace them. The author thus extrapolated work relations to explain how gender ideology around intra-organisational innovation is also linked to the theory of organisational change, i.e. he demonstrated who, in fact, can be responsible for participating in transitions towards innovation within organisations (Chen et al., 2021).

At the same time, the social division of labour, historically marked in Western civilisation by a technicist, capitalist and patriarchal system (Hirata, 2009, 2018), still contributes to the low inclusion of women in segments that require greater knowledge in the area of STEM (Science, Technology, Engineering, and Mathematics) (Corneille et al., 2019; Jebsen et al., 2022; O'Connell & McKinnon, 2021; Saucerman & Vasquez, 2014). As an example, we cite the innovation of technological products for the creation of patents (Tahmooresnejad & Turkina, 2022) or even the creation of startups directly linked to the area of technology (Shinnar et al., 2017; Villaseca et al., 2020). In this process of women entering specialised areas of organisational innovation, it is not uncommon to find women who need to remain married to obtain investments with a high perception of risk due to the widespread view that a couple's venture (copreneurship) gives predominantly male investors greater confidence in females' ability to lead and manage innovation in order to leverage results and produce accelerated growth that results in a rapid return on initial capital (Kuschel & Lepeley, 2016).

Similarly, it is not uncommon for women from socio-economically vulnerable backgrounds in developing countries, such as low-income rural women in Ethiopia, to be motivated to enter this type of organisational innovation because of a larger discourse around "entrepreneurship for development", despite the numerous barriers of entry (Cummings & Lopez, 2022). In this case, even though they obtain personal benefits from their business – financial independence, empowerment, and social recognition –, they still bear the negative consequences of their "boldness", such as emotional pressures related to the uncertainty surrounding their security, stress, limited social life and fear of debt and poverty (Cummings & Lopez, 2022). Thus, a new facet of organisational innovation that hinders gender equality lies in the emotional cost involved in the pro-innovation initiative since, even if they present successful results and promote progress in the personal and supposedly social spheres, women entrepreneurs in emerging countries only reinforce the gender roles stipulated by the dominant logic of power, masking, and fortifying places of fragility where there should be emancipation. This way of instrumentalising women is similar to that discussed in intra-organisational innovation, in that women are called upon to occupy so-called "highly strategic" positions for international development plans (Labrecque, 2010), which leads them to the illusion of satisfying immediate gender insertion needs. However, they end up mechanically reproducing exclusionary models of social organisation (Moura & Santos, 2023).

Consequently, these structural aspects are at the heart of the inequalities that make it impossible for women to access innovation in its traditional form – hegemonic, commercialised, and exclusionary, albeit economic and productive. This means that this cannot be expected to have an effect on gender disparity, contrary to the dialogue proposed between the variables at the beginning of the study, based on Haraway and Kunzru's figure of the cyborg (2000). It is therefore worth considering the dangers that a possible reinforcement of these institutionalised practices in the social macrostructure represents for the development of the human capital of future generations of women. In other words, they will be able to experience greater equality with their male peers through social progress; however, they will not be able to do so through the advancement of innovation since this still represents a system of domination demarcated by the interactions and flows of technical knowledge and global interest, fuelled by advances in information technology (Shearmur, 2012). Therefore, women subjected to the intra-organisational type of innovation will end up conditioning new contingents of this group not to be part of the type of innovation accepted as the one that supposedly drives modern societies towards the SDGs – namely organisational innovation –,

which is the second major critical reflection that this research has allowed to unveil. In this reflection, the aim was not only to highlight what has already been achieved with the presence of women in the organisational environment through the long struggle for material and moral rights by the feminist movement. As with the organisational literature interpreted from a gender perspective, we highlight what can still be changed so that these barriers do not limit the course that innovation can take towards more egalitarian, sustainable and economically prosperous societies.

FINAL CONSIDERATIONS

This study aimed to check whether innovation and social progress could be considered predictors of the advancement of gender equality on a global scale, which proved true only for the second independent variable, i.e., social progress. This result led to the inference that countries investing in a robust innovation infrastructure are not necessarily helping to legitimise greater opportunities for female participation and emancipation in global economic and social development. This fact is relevant in guiding public policies that are more geared towards the inclusion of women in the organisational macro-structure and in debating certain hegemonic discourses whose indiscriminate encouragement of innovation would inevitably lead to more egalitarian and inclusive societies. Alternatively, the contribution of advances in innovation to social progress itself, linked to the current perspective of "gender and development," is also called into question, as discussed in the section dedicated to the theoretical framework.

As a limitation, due to its generalist orientation, this study did not look at the possible effects of variations between the various dimensions contained in the indices on the dependent variable, which could perhaps contribute to a more detailed analysis of which factors relating to social progress contribute most to gender equality. However, this limitation did not invalidate the findings reported. One of this research's future directions is to analyse each index's components individually and test their effects on the dependent variable. In this context, it would also be interesting to assess whether there is a positive and significant relationship between the independent variables "social progress" and "innovation" and, if not, to analyse how the indicators dialogue with discussions on "gender and development."

Expanding on this proposal, it is recommended that other aggregate variables be included in future quantitative study models by macro-regions of the world, in order to re-dimension the gender differences between the global North and South through comparative analysis with panel data. As Connell (2014) pointed out, there are significant differences between the feminisms developed by each hemisphere, with the Global South being the one that has contributed most to incorporating social justice into international development plans. The normative frameworks and structural factors at play in the power relations observed in the production of knowledge on gender must, therefore, be unravelled to avoid "Western" feminisms themselves reverberating a monolithic production of women from the "First World" as opposed to those from the "Third World", and once again incurring the danger of a single or partial story regarding the relationship between the variables discussed here.

Finally, it should be noted that the quantitative model operationalised by this work offers a valid framework for analysing the factors related to closing the global gender gap. It serves as a catalyst for greater public awareness of the issue, as well as representing an important source of information for public policymakers and other stakeholders, adding a genderised perspective to the literature on innovation that allows us to debate the apparent duality that exists in the segregation of female representation in intra-organisational innovation.

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Thiago Cavalcante Nascimento: Conceptualization(Supporting); Formal Analysis (Supporting); Investigation (Supporting); Methodology (Supporting); Writing- review & editing(Supporting).

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DATA AVAILABILITY

The entire dataset supporting this study's results has been made available in the Zenodo repository and can be accessed at https://doi.org/10.5281/zenodo.8370557

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