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Women's Contribution to Economic Growth in BRICS and Partner Countries: A Dynamic Modeling Approach

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Abstract
This study investigates the women's contribution in driving economic growth in BRICS countries using a dynamic panel approach. It examines fertility, women's education, and female labor participation, along with key macroeconomic controls, based on panel data from 14 countries over 2008–2022. The Generalized Method of Moments (GMM) is employed to address endogeneity and capture dynamic effects. The findings indicate that fertility, female labor force participation, and women's education significantly promote economic growth, underscoring the importance of demographic factors, employment, and human capital. The negative interaction between fertility and female labor participation reflects a trade-off between reproductive and productive roles. Additionally, growth remains positively associated with carbon emissions, indicating reliance on carbon-intensive development. These results highlight the need for gender-inclusive and sustainable growth strategies.
Keywords: Economic Growth, Women, Fertility Rate, Education, Women's Labor Participation, GMM, BRICS

Abstrak
Studi ini meneliti peran perempuan dalam mendorong pertumbuhan ekonomi di negara-negara BRICS menggunakan pendekatan panel dinamis. Studi ini mengkaji fertilitas, pendidikan perempuan, dan partisipasi angkatan kerja perempuan, bersama dengan kontrol makroekonomi utama, berdasarkan data panel dari 14 negara selama periode 2008–2022. Metode Momen Umum (*Generalized Method of Moments*/GMM) digunakan untuk mengatasi endogenitas dan menangkap efek dinamis. Temuan menunjukkan bahwa fertilitas, tingkat partisipasi kerja perempuan dan pendidikan perempuan secara signifikan mendorong pertumbuhan ekonomi, menggarisbawahi pentingnya faktor demografis, ketenagakerjaan dan modal manusia. Interaksi negatif antara fertilitas dan partisipasi angkatan kerja mencerminkan adanya pertukaran antara peran reproduktif dan produktif. Interaksi negatif antara fertilitas dan partisipasi angkatan kerja mencerminkan adanya pertukaran antara peran reproduktif dan produktif. Selain itu, pertumbuhan tetap berasosiasi positif dengan emisi karbon, menunjukkan ketergantungan pada pembangunan yang intensif karbon. Hasil ini menyoroti perlunya strategi pertumbuhan yang inklusif gender dan berkelanjutan.
Kata Kunci: Pertumbuhan Ekonomi, Perempuan, Tingkat Fertilitas, Pendidikan, Partisipasi Kerja, GMM, BRICS

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INTRODUCTION

Economic growth remains a fundamental indicator of a country's prosperity, commonly measured by gross domestic product (GDP), which reflects the aggregate output of production factors, including labor, capital, and technology (Mankiw, 2016). Among these, labor plays a crucial role, and its composition—particularly the contribution of women—has gained increasing attention in both theoretical and empirical literature. Women contribute not only through direct participation in the labor market but also through their roles in shaping household decisions, fertility behavior, and human capital formation, all of which have long-term implications for economic development.

A growing body of literature highlights the importance of women's education, fertility rates, and female labor force participation (FLFP) in influencing economic growth. Studies such as Becker (1993) emphasize that education enhances productivity and income, while fertility decisions affect the future supply and quality of labor. Empirical studies have also found mixed evidence regarding the role of FLFP, with some suggesting a positive contribution to growth (Cabeza-García et al., 2018; Karim et al., 2023; Sulaiman et al., 2024; Huang, 2024) while others indicate limited or even insignificant effects due to structural labor market constraints and gender inequality.

In addition to the women's contribution, another important factor influencing economic growth is carbon emissions. In the Environmental Kuznets Curve (EKC) analysis, countries in the development stage rely on high-emission industries as the mainstay of their economies. These countries are generally identified as developing nations (Vogel, 1999). The BRICS group, whose members are predominantly developing nations, has a firm commitment to addressing climate change caused by carbon emissions. This is outlined in the Declaration of the Eleventh BRICS Labor and Employment Ministers' Meeting. In this declaration, BRICS has acknowledged the existence of climate change caused by industries that intensively generate carbon emissions from their production processes.

Furthermore, economic activities dependent on high-emission industries can also threaten human health, including reproductive health, which is directly linked to fertility rates. An increase in carbon emissions will place pressure on women's reproductive health, subsequently leading to a decline in fertility rates. Such environmental pressures will ultimately constrain households' ability and desire to have children (Haq et al., 2023; Mu et al., 2025).

Thus, this study will consider a combination of factors influencing economic growth, such as the capital component represented by gross fixed capital formation, total labor force participation as a proxy for labor force capacity and intensity, the female labor force participation rate as a proxy for the contribution of female workers, and technological progress as measured by the number of internet users. These variables have been widely used in previous studies as influencing factors on economic growth (Ntamwiza & Masengesho, 2022; Dahal & Luitel, 2021; Choi & Yi, 2018).

Despite these contributions, several important gaps remain. First, existing studies often examine the effects of fertility, education, and female labor participation in isolation, without adequately capturing their interaction effects, which may reveal underlying trade-offs between women's reproductive and productive roles. Second, many studies rely on

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static or non-dynamic models, limiting their ability to capture both short-term adjustments and long-term equilibrium relationships. Third, there is limited integration of environmental factors, such as carbon emissions, into the analysis of women's contribution to economic growth, particularly in the context of developing economies. Finally, empirical evidence focusing on BRICS countries remains relatively scarce, despite their strategic importance as emerging economies facing both gender inequality and environmental challenges.

To address these gaps, this study employs a dynamic panel data approach using the Generalized Method of Moments (GMM) to analyze the contribution of women to economic growth in BRICS countries over the period 2008–2022. The GMM approach is used for its effectiveness in addressing the endogeneity issue (Wooldridge, 2001). This study incorporates not only key variables such as fertility, women's education, and FLFP, but also their interaction effects, alongside macroeconomic and environmental factors. The novelty of this research lies in (1) integrating interaction terms to capture structural trade-offs, (2) applying a dynamic modeling framework to distinguish short- and long-term effects, and (3) incorporating environmental dimensions into the gender–growth nexus within the BRICS context. By doing so, this study aims to provide a more comprehensive understanding of how women's roles interact with structural and environmental factors in shaping economic growth, while offering policy-relevant insights for achieving inclusive and sustainable development.

METHODOLOGY

This study employs a regression analysis method to examine the influence of independent variables on the dependent variable, both individually and collectively. The data used is panel data consisting of time-series data for the period 2008–2022 and cross-sectional data from 9 members of the BRICS countries are Brazil, Russia, India, China, South Africa, Indonesia, Iran, Egypt, and the United Arab Emirates. The BRICS 5 partners are Malaysia, Cuba, Kazakhstan, Bolivia, and Vietnam. The use of 2022 as the end year is based on data availability and balance across all sample countries. This aims to produce a balanced panel. This study uses secondary data sourced from the World Bank and UNDP. The study covers 15 years with 14 countries in the time series, resulting in a total of 210 observations.

The sample countries were selected using a purposive sampling technique. This selection was based on several considerations, including the economic relevance of these countries within the BRICS framework and its partner network, the availability and consistency of gender-related and macroeconomic data throughout the observation period, and the increasing role of women in economic and social development in developing countries. The BRICS countries and their partners were selected because they represent major emerging economies with significant demographic size, rapid economic transformation, and varying degrees of gender inclusion. These characteristics make the BRICS group an important context for examining women's contributions to development, particularly in labor force participation, human development, and economic growth. Furthermore, BRICS countries account for a large share of the world's population and economic output, making women's participation in these countries highly influential in global development trends.

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All collected data were subsequently transformed into logarithmic form to facilitate the interpretation of the elasticity of the resulting coefficients. As the research focuses on dynamic analysis, the general model employed incorporates lags of the dependent variable. The following is the general regression model used:

$$logEG_{it} = \beta_0 + \gamma logEG_{it-1} + \beta_1 logFER_{it} + \beta_2 logFLFP_{it} + \beta_3 logEDU_{it} + \beta_4(logFER_{it} x logFLFP_{it}) + \beta_5(logEDU_{it} x logFLFP_{it}) + \beta_6 logCO2_{it} + \beta_7(logCO2_{it} x logFER_{it}) + \beta_8 logLFPR_{it} + \beta_9 logGCF_{it} + \beta_{10} logIT_{it} + \varepsilon_{it}$$

Where:

EG	: Economic Growth (in billions of USD GDP)
FER	: Total Fertility Rate (births per woman)
FLFP	: Female Labor Force Participation (in percentage of total labor force participation)
EDU	: Women's Education (in Average Years of Schooling)
CO2	: Carbon Emission (in million tons of carbon dioxide equivalent)
LFPR	: Total Labor Force Participation (in percentage of total population ages 15-64)
GCF	: Gross Capital Formation (in billions USD)
IT	: Individuals Using Internet (in percentage of total population)
log	: Logarithm Operator
β_0	: Intercept
$\beta_1 ... \beta_{10}$	: Coefficient of Independent Variables
i,t	: Cross Sections and Time Series
γ	: Coefficient of Lag of Dependent Variable
t-1	: lag

Estimation in the GMM model can be performed if the Stationarity Test concludes a mixed stationarity type, the Cointegration Test concludes the existence of a long-run equilibrium relationship, and the Endogeneity Test concludes the existence of endogenous variables (Baltagi, 2005). Thereafter, GMM model estimation is performed using two types of estimation: First Difference GMM (FD-GMM) conducted by Arellano & Bond (1991) and Systemic-GMM (SYS-GMM) conducted by Blundell & Bond (1998). Afterward, both GMM models undergo the Sargan Test and the Arrelano-Bond Test. The Sargan Test is performed to assess the validity of the instruments used, while the Arrellano-Bond Test is used to ensure there is no second-order autocorrelation in the GMM residuals. Once both GMM models pass these tests, an unbiasedness test is conducted by comparing the estimation results of CEM, FEM, FD-GMM, and SYS-GMM. The best model is selected if the model has lag coefficients for the dependent variable that are between the lag coefficients of the CEM and FEM models (Nickell, 1981). After the GMM model is selected, the next step is to estimate the long-run effects and calculate the convergence rate. Estimation of long-run effects is performed to determine the influence of independent variables on the dependent variable in the long run, while the calculation of the convergence rate is performed to determine how quickly economic growth moves toward the long-run equilibrium level. We use several confidence levels (10%, 5%, and 1%) because not all statistical decisions have the same level of precision and consequences. This significance level (α) essentially indicates how much tolerance we have for error in hypothesis testing, particularly Type I error (rejecting H_0 when it is actually true).

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DISCUSSION AND FINDINGS

The GMM model requires mixed order of integration, where the data are stationary at the level and first-difference levels. The integration test aims to determine whether the variables are stationary at the level or first difference. The test is conducted in two steps: integration at the level (I(0)) and integration at the first difference (I(1)). This test uses the Augmented Dickey-Fuller test with Fisher approach. The null hypothesis indicates that the variables are non-stationary, and the alternative hypothesis indicates that the variables are stationary. The results of the unit root test are as follows.

Table 1
The Results of Unit Root Test

Variable	Modified Inv. χ^2	
	I(0)	I(1)
log_EG	0,0000	0,0000
log_FER	0,9663	0,0000
log_FLFP	0,1447	0,0000
log_EDU	0,1153	0,0000
log_FER_FLFP	0,8961	0,0049
log_EDU_FLFP	0,7422	0,0000
log_CO2	0,5790	0,0000
log_CO2_FER	0,9780	0,0000
log_LFPR	0,0029	0,0000
log_GCF	0,0000	0,0000
log_IT	0,0000	0,0000

Source: Output of STATA 17, 2026.

The unit root test results show that at the zero-order level (I(0)), several variables—including log_EG, log_LFPR, log_GCF, and log_IT—are stationary at the 5% significance level. Meanwhile, the variables log_FER, log_EDU, log_FLFP, log_CO2, and all interaction variables are stationary at the 5% significance level. Thus, it can be concluded that these variables have a mixed order of integration. Therefore, the next estimation will use the first-order level (I(1)).

In addition to mixed integration orders, the model must ensure that it has a long-term equilibrium. This is done using a cointegration test. This test aims to determine whether the model has a long-term equilibrium relationship. The test is conducted using the Kao Test, where the null hypothesis indicates no long-term equilibrium relationship and the alternative hypothesis indicates a long-term equilibrium. The following are the test results.

Table 2
The Results of Cointegration Tests

Type of Test	Statistic Value	P-Value
Modified Dickey-Fuller	-2,0859	0,0185
Dickey-Fuller	-2,5061	0,0061
Augmented Dickey-Fuller	-2,8341	0,0023
Unadjusted Modified Dikey-Fuller	-1,9073	0,0282
Unadjusted Dickey-Fuller	-2,4256	0,0067

Source: Output of STATA 17, 2026

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Based on Table 2, the P-values from the five statistical tests are below the significance level of 0.05. Therefore, the decision is to reject H_0 and accept Ha. It can be concluded that the variables in this study exhibit a long-run equilibrium relationship. Furthermore, the final test before comparing the estimation results is the endogeneity detection test. This test aims to detect the presence of a correlation between the error term and the independent variables used in the study. This test employs the Durbin-Wu-Hausman approach with the Two-Stage Least Squares protocol. The null hypothesis indicates that the variables are exogenous, while the alternative hypothesis indicates that the variables are endogenous. The following are the test results.

Table 3
The Results of Endogeneity Test

Variable	Durbin χ^2	Wu-Hausman F	P-Value of Durbin	P-Value of Wu-Hausman
log_FER	1,30719	1,23539	0,2529	0,2678
log_FLFP	0,006398	0,006006	0,9362	0,9383
log_EDU	0,134	0,12558	0,7143	0,7231
log_FER_FLFP	0,9066	0,855	0,3410	0,3563
log_EDU_FLFP	0,03674	0,0345	0,8480	0,8528
log_CO2	2,60654	2,47994	0,1064	0,1170
log_CO2_FER	0,0345	2,20968	0,1371	0,1492
log_LFPR	0,00181	0,00169	0,9661	0,9672
log_GCF	13,8628	14,004	0,0002	0,0002
log_IT	0,0836	0,785	0,7724	0,7796

Source: Output of STATA 17, 2026.

The results of the Durbin and Wu–Hausman tests indicate that most variables are exogenous. This is evidenced by P-values greater than 0,05. However, the log_GCF variable has Durbin and Wu–Hausman P-values of 0.0002, leading to the rejection of H_0. This indicates that log_GCF is proven to be endogenous. These results justify the use of an instrumental variables estimation model with a dynamic approach. Consequently, the model employs Generalized Method of Moments (GMM) estimation model to address the detected endogeneity. After the previous three tests justified the use of GMM, the next step is to compare the estimation result of several models. This test aims to identify the most efficient estimation model by comparing the estimation results of Fixed Effect Model (FEM), Common Effect Model (CEM), First Difference GMM (FD-GMM), and Systemic GMM (SYS-GMM). The most efficient model in this test is the one with a dependent lag coefficient that falls between the dependent lag coefficients of the CEM and FEM models. The following are the test results.

Table 4
The Results of Unbiasedness Test

Variable	CEM	FEM	FD-GMM	SYS-GMM
log_EG L1	0,945734***	0,704650***	0,710938***	0,945734***
log_FER	0,423059***	0,546138**	0,694726***	0,423059***
log_FLFP	0,125044**	0,295311*	0,332607*	0,125043**
log_EDU	0,028219	0,527508**	0,608407***	0,028219
log_FER_FLFP	-0,117383***	-0,116381*	-0,151412**	-0,117382***
log_EDU_FLFP	-0,012702	-0,116381*	-0,133939**	-0,012702
log_CO2	0,005034	0,123011***	0,120640***	0,005034
log_CO2_FER	-0,006120	-0,019282*	-0,018558*	0,006120

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Variable	CEM	FEM	FD-GMM	SYS-GMM
log_LFPR	0,025363	0,257968**	0,342371**	0,025363
log_GCF	0,039123**	0,119436***	0,125445***	0,039123***
log_IT	-0,003721	0,013206*	0,011258	-0,003721
Intercept	-0,382869	-1,901460*	-2,459388**	-0,382869

Asteriks (*, **, ***) significant at 10%, 5%, and 1%, respectively.

Source: Output of STATA 17, 2026

Based on Table 4, the lag coefficient value of the dependent variable FD-GMM is between the lag coefficient values of CEM and FEM, namely 0.70465005 < 0.71093798 < 0.94573437. This result indicates a strong and significant influence, which means that economic growth in the previous year significantly influences economic growth in the following year. Meanwhile, the SYS-GMM model has a lag coefficient identical to the CEM model 0,945734. The fact that the coefficient value is the same as the CEM model indicates that the SYS-GMM model has the same bias as the CEM model, meaning this model is unable to overcome the problem of endogeneity in the independent variables. Thus, FD-GMM has the lowest bias among the estimation models, provides the most efficient estimation results and effectively overcomes the detected endogeneity problem. This is in line with Nickell's (1981) bias, which provides an estimator with the smallest bias and adherence to the restriction properties, ensuring the model exhibits no downward bias in FEM and no upward bias in CEM.

Table 5
The Results of FD-GMM Model Estimation

Dependent Variable: log_EG				
Variable	**Coefficient**	**Std. Error**	**z**	**P-Value**
log_EG_L1	0,710938***	0,0329314	21,59	0,000
log_FER	0,694726***	0,2492486	2,79	0,005
log_FLFP	0,332607*	0,178886	1,86	0,063
log_EDU	0,608407***	0,2249623	2,70	0,007
log_FER_FLFP	-0,151412**	0,0620985	-2,44	0,015
log_EDU_FLFP	-0,133939**	0,0628894	-2,13	0,033
log_CO2	0,120640***	0,0212168	5,69	0,000
log_CO2_FER	-0,018581*	0,0105441	-1,76	0,078
log_LFPR	0,3423715**	0,1333852	2,57	0,010
log_GCF	0,1254454***	0,0163063	7,69	0,000
log_IT	0,011259	0,007032	1,60	0,109
Intercept	-2,459388**	0,8168677	-3,01	0,003
Wald χ^2	8150,25			
Prob > χ^2	0,0000			

Source: Output of STATA 17, 2026.

Based on the estimation results in Table 5, the resulting regression equation is as follows.

$$\begin{aligned}\Delta \log(EG)_{it} = & -2{,}459388 + 0{,}710938\ \Delta\log(\mathrm{EG})_{i,t-1} + 0{,}6947256\ \Delta\log(FER)_{it} \\ & + 0{,}332607\ \Delta\log(FLFP)_{it} \\ & + 0{,}6084069\ \Delta\log(EDU)_{it} - 0{,}1514122\ \Delta[\log(FER) \times \log\,(FLFP)]_{it} \\ & - 0{,}1339393\Delta\,[\log(EDU) \times \log(FLFP)]_{it} + 0{,}1206405\ \Delta\log(CO2)_{it} \\ & - 0{,}018581\ \Delta[\log(CO2) \times \log(FER)]_{it} + 0{,}3423715\ \Delta\log(LFPR)_{it} \\ & + 0{,}1254454\ \Delta\log(GCF)_{it} + \ 0{,}011259\ \Delta\log(IT)_{it} + \ \epsilon_{it}\end{aligned}$$

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The model demonstrates strong joint significance (Prob > χ^2 = 0.0000), confirming that the selected covariates jointly explain variations in economic growth. The positive and highly significant coefficient of the lagged dependent variable underscores pronounced dynamic persistence, indicating that growth trajectories in BRICS countries are strongly path-dependent rather than structurally transformative.

Fertility (log_FER), female labor force participation (log_FLFP) and female education (log_EDU) emerge as significant drivers of economic growth in the short run, reinforcing the centrality of demographic dynamics and human capital accumulation (Cabeza-García et al., 2018; Obiageli et al., 2022). This finding contrasts with Karim et al. (2023) and Cabeza-García et al. (2018), which found that fertility negatively impacts economic growth. This unexpected result may be linked to the ongoing demographic transition in BRICS countries, characterized by a persistent decline in fertility rates. As these economies move toward lower fertility regimes, the contribution of population growth to economic expansion becomes less pronounced and may even generate adverse effects through aging and dependency dynamics. Therefore, the estimated relationship may capture a more contemporary structural reality rather than contradicting theory. However, the significant effect of female labor force participation (log_FLFP) level suggests that increased participation alone is significantly to generate meaningful economic returns. Moreover, the moderate significant level of 10% indicates structural distortions that limit women's labor productivity. These structural distortions occur primarily in gender-based segmentation and insufficiencies in labor absorption. (Seguino, 2000; Klasen & Lamanna, 2009).

More critically, the negative and significant interaction terms (log_FER_FLFP and log_EDU_FLFP) reveal a persistent structural trade-off between women’s reproductive and productive roles. Rather than complementing each other, fertility, education, and labor participation appear to operate in tension, indicating that institutional frameworks have failed to reconcile these dimensions. This finding challenges the conventional assumption that improvements in women-related indicators automatically translate into growth-enhancing outcomes.

On the production side, carbon emissions, total labor force participation, and capital formation remain dominant and significant growth drivers, suggesting that BRICS economies continue to rely on input-driven expansion. The positive effect of carbon emissions, in particular, signals a continued dependence on carbon-intensive industrialization, raising concerns about the sustainability of current growth patterns (Vogel, 1999; Rigas & Kounetas, 2024). Furthermore, the significant negative effect of log_CO2_FER interaction, suggests that reliance on high-carbon industries has a significant influence in weaken the positive contribution of fertility. Meanwhile, the insignificance of technological variables indicates that the transition toward productivity-driven, innovation-led growth remains limited, which contrasts with the findings of a study by Appiah-Otoo & Song (2021) that revealed a significant influence of technological variables.

Taken together, the results suggest that economic growth in BRICS countries is still largely extensive rather than intensive, with women’s potential contributions constrained

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by unresolved structural and institutional barriers. Without addressing these underlying inefficiencies, the role of women in driving inclusive and sustainable growth will remain suboptimal.

Table 6
The Results of Sargan Test

χ^2	*P-Value*
157,5278	0,6483

Source: Output of STATA 17, 2026

Table 7
The Results of Arrelano-Bond Test

Order	z	*P-Value*
1	-2,6062	0,0092
2	-0,95001	0,3421

Source: Output of STATA 17, 2026

The results of Sargan Test on FD-GMM estimation results show a P-value of 0.6483, greater than the 5% significance level (α), thus rejecting the alternative hypothesis (Ha). Therefore, it can be concluded that the instruments used in the FD-GMM model are valid and produce unbiased parameters. Furthermore, the Arellano-Bond test results also show that the P-value for first-order autocorrelation is 0.0092 <α = 5%, and the P-value for second-order autocorrelation is 0.3421 >α = 5%. These results reject the null hypothesis for first-order autocorrelation and the alternative hypothesis for second-order autocorrelation. Therefore, the FD-GMM model does not contain second-order autocorrelation. Therefore, it can be concluded that the resulting FD-GMM model is feasible and valid.

After confirming the validity of the FD-GMM model, the next step is to conduct a long-run estimation of the model. The goal is to determine how the independent variables affect the dependent variable by considering lags as long-run effects. Here are the results.

Table 8
The Results of Long-Term Estimation

Variable	Coefficient	Std. Error	z	Critical z	P-Value
log_FER	2,403379***	0,8966408	2,6804258	1,959964	0,00735
log_FLFP	1,150642*	0,6584016	1,7476302	1,959964	0,08053
log_EDU	2,104762**	0,8542897	2,4637572	1,959964	0,01375
log_FER_FLFP	-0,523805**	0,2246594	-2,331553	1,959964	0,01972
log_EDU_FLFP	-0,463358*	0,2365638	-1,958703	1,959964	0,05015
log_CO2	0,417351***	0,0684368	6,098350	1,959964	0,00000
log_CO2_FER	-0,064280*	0,0349134	-1,841132	1,959964	0,06560
log_LFPR	1,184422**	0,4766994	2,4846314	1,959964	0,01297
log_GCF	0,433974***	0,0527084	8,2334903	1,959964	0,00000
log_IT	0,03895	0,0224062	1,7383581	1,959964	0,08215

Source: Output of STATA 17, 2026

The long-run estimation results show that fertility (FER) and education (EDU) are the main drivers of economic growth. The positive and statistically significant coefficient on fertility indicates that, in the long run, higher fertility contributes to economic growth, likely through expanding the labor force and increasing aggregate demand. Similarly, education exerts a positive and significant effect, confirming the importance of human

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capital in improving productivity and economic performance. In contrast, female labor force participation (FLFP) exhibits only weak significance, suggesting that its contribution to economic growth remains limited, potentially due to structural constraints such as labor market segmentation, informality, or limited access to quality job opportunities for women.

More importantly, the interaction term reveals the existence of a structural trade-off. The negative and significant coefficient on the log_FER_FLFP interaction indicates that higher fertility weakens the positive contribution of female labor force participation, reflecting a trade-off between reproductive roles and economic participation, women's labor market participation, and productivity, particularly in developing and emerging economies. These findings are also aligned with previous research that revealed the negative influence of fertility on female labor force participation in the ASEAN-5 countries (Nazah et al., 2021). Economically, this implies that when women allocate more time and resources to childcare and household responsibilities, their ability to participate fully and productively in the labor market declines, thereby reducing the overall contribution of female labor to economic growth. In the context of BRICS and partner countries, this condition may also indicate limited childcare support systems, unequal domestic labor division, and insufficient family-friendly labor market policies.

A similar pattern is observed for the log_EDU_FLFP interaction, suggesting that increases in female education do not fully translate into economic gains, possibly due to labor market mismatches or the underutilization of skilled female workers. Several empirical studies also report that although education generally increases women's labor force participation, the economic returns are often constrained by structural barriers, occupational segregation, and labor market inefficiencies (Eidhah & Shaheen, 2025). From an economic perspective, this finding indicates that higher educational attainment among women does not automatically guarantee productive employment opportunities. In many emerging economies, educated women may face barriers such as limited access to quality jobs, wage discrimination, skills mismatch, or cultural norms that restrict women's mobility and career advancement. As a result, the potential contribution of female human capital to economic growth remains suboptimal despite improvements in educational attainment.

Among the control variables, CO2 emissions, labor force participation (LFPR), and capital formation (GCF) positively and significantly influence economic growth, highlighting the role of economic activity, labor, and investment, while the insignificant effect of technology (IT) suggests that technology adoption has not yet played a substantial role in driving long-term economic growth.

CONCLUSION

This study concludes that women's contribution, reflected through fertility, female labor force participation, and education, plays an important role in promoting economic growth in BRICS countries both in the short and long term. The findings support neoclassical and human capital theories, emphasizing the importance of labor, investment, and human capital accumulation in driving economic development. However, the negative

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interaction effect between fertility and female labor force participation indicates the existence of structural trade-offs and gender-related barriers that limit women's optimal contribution to the economy. In addition, the insignificant effect of internet usage suggests that technological development has not yet been fully transformed into productive economic gains.

From a policy perspective, these findings highlight the need for more inclusive labor market policies, stronger support for work–family balance, investment in women's productive employment opportunities, and gender-responsive social protection systems. Furthermore, the positive relationship between carbon emissions and economic growth indicates that BRICS countries still rely on environmentally unsustainable growth patterns, emphasizing the importance of transitioning toward greener and more sustainable development strategies. However, the significance of female labor force participation (FLFP) at 10% level indicates quite structural efficiencies in the labor market, particularly those arising from persistent gender inequality that limits women's productivity. In other words, the issue lies not merely in the level of women's participation, but in the quality of their integration into the economic system.

Scientifically, this study contributes to the literature by integrating demographic, gender, and environmental dimensions into the analysis of economic growth in emerging economies. The study also enriches previous research by demonstrating that women's economic contribution is influenced not only by participation levels but also by structural conditions that shape the quality and effectiveness of their integration into the labor market.

Recomendation

BRICS countries should prioritize structural labor market reforms that enhance not only female labor force participation but also the quality and equality of women's employment by reducing gender discrimination and expanding access to formal jobs. At the same time, integrating family-friendly policies—such as parental leave and childcare support—is essential to address the trade-off between fertility and women's work. Investments in women's education must be aligned with labor market demands to ensure productive economic contributions, particularly through skill development in strategic sectors. Additionally, a transition toward a low-carbon economy is necessary to achieve sustainable growth. Future research should further explore cross-country differences, the quality of women's employment, and the role of institutional and gender-related policies in shaping economic outcomes.

Limitations

This study has limitations regarding its scope, which focuses only on BRICS countries in general. The use of the FD-GMM model technically eliminates the individual effects of each country. Thus, future research may further expand the analysis by using other econometric models capable of examining the individual effects of each country.

Suggestion

The results of this study underscore the importance of sustained investment in women's

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education and population management for policymakers. In this regard, policies are needed to reduce the trade-off between fertility and women's labor force participation through family policies and a gender-inclusive labor market. Furthermore, BRICS countries also need to undertake structural transformation toward a low-carbon economy so that economic activities do not continue to rely on high-carbon industries.

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