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Spatial impact of female labour force participation and adolescent fertility on regional development in India

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Abstract

This study investigates the impact of female labour force participation rate (FLFPR), adolescent fertility rate and female gross enrolment rate in secondary education (FGERSE) on India's GDP per capita from 2001 to 2022. Using time-series regression models and data from the World Bank, ILOSTAT and ministries, the analysis finds a strong positive association between FLFPR and economic growth, while adolescent fertility shows a consistently negative effect. Although FGERSE correlates with GDP, its statistical significance diminishes when labour market absorption is limited. Model diagnostics confirm adequacy, with residual patterns reflecting regional economic disparities. The findings highlight the need for policies that link educational gains with inclusive labour opportunities to advance gender-equitable growth.Keywords: Platform work, precarity, decent work index, piecewise-payment, male-dominated.

Keywords: *Female labour force participation, adolescent fertility, economic development, India, gender inclusivity, regression analysis, GDP per capita*

Introduction

India's economic development has been significantly influenced by persistent regional disparities in gender-linked indicators such as female labour force participation rate (FLFPR) and adolescent fertility. Despite comprising 48.5% of the population, women's participation in the labour force was recorded at just 20.3% in 2019, markedly below the global average of 47% (World Bank, 2023; Ministry of Labour and Employment, 2023). These patterns are not uniform but vary spatially, with southern states such as Kerala and Tamil Nadu reporting higher FLFPR due to better access to education and healthcare, while northern states such as Bihar and Uttar Pradesh continue to lag due to entrenched social and cultural norms, early marriage and constrained mobility (Raj, 2011; Pal & Shekhar, 2024).

Adolescent fertility plays a critical role in this spatial inequality. In states where fertility rates among girls aged 15–19 remain high, such as the case in Bihar and Jharkhand, educational attainment is truncated and early withdrawal from potential employment is common. Nationally, the adolescent fertility rate witnessed significant decline from 78.9 per 1,000 in 2001 to 17.0 in 2022 (Ministry of Women and Child Development, 2016), but its impact remains spatially clustered, with a stronger negative effect on female economic participation in lagging regions.

The intersection of labour exclusion and early fertility, therefore, operates along spatial lines and contributes to uneven economic performance (Buckley *et al.*, 2017).

Theoretically, endogenous growth models underscore the role of internal drivers such as education, health and gendered labour inputs in generating long-term economic growth (Forgha & Mbella, 2016; Omran *et al.*, 2022). These models highlight that increases in labour force participation enhance productive capacity, especially when human capital is under-utilised. In the Indian context, however, while female secondary school enrolment (FGERSE) improved from 47.9% in 2001 to 78% in 2022 (Ministry of Human Resource Development, 2014: Ministry of Education, 2024), the anticipated economic gains have not materialised uniformly. High correlation between FGERSE and FLFPR ($r = 0.906$) suggests educational progress alone does not guarantee economic inclusion unless labour markets absorb skilled female workers (Baerlocher *et al.*, 2021).

Empirical studies have confirmed that female labour participation improves household income and national productivity (Li *et al.*, 2024), but few have examined these effects over time within a spatially disaggregated framework. While Costagliola (2021) identifies cultural factors suppressing India's FLFPR and Raj (2011) highlights entrepreneurship constraints, both studies lack a temporal or spatial model to quantify economic outcomes. The combined effect of fertility and education on GDP per capita across India's regions remains underexplored. While studies like Baerlocher *et al.* (2021) and Jha *et al.* (2019) analyse female employment and fertility, they do not assess how these variables jointly shape regional development in a longitudinal national framework.

To address these gaps, this study investigates the impact of FLFPR, adolescent fertility and female secondary school enrolment on India's GDP per capita between 2001 and 2022. This 22-year period was selected because it captures major transitions in gender-related policies, educational investments and demographic behaviour. It also aligns with stabilised national reporting standards following administrative restructuring and includes key inflection points such as the expansion of reproductive health programmes, implementation of employment schemes and the adoption of SDG-aligned gender metrics.

Using two time-series regression models grounded in endogenous growth theory, the study isolates the individual effects of FLFPR and FGERSE on per capita GDP while controlling for adolescent fertility. By applying a spatial-economic lens, it aims to clarify how gendered demographic transitions have influenced regional development trajectories and shaped national growth performance. The findings offer both diagnostic insights into structural gender barriers and policy guidance for fostering inclusive economic planning at the state level.

Objective

The objective of this paper is to examine spatial and economic implications of female labour force participation and adolescent fertility in India from 2001 to 2022, in order to determine their combined influence on regional development.

Data

The analysis is based on a structured annual time-series dataset comprising four macro-level indicators recorded from authoritative international and national sources. The dataset includes gross domestic product (GDP) per capita, female labour force participation rate (FLFPR), adolescent fertility rate and the female gross enrolment rate in secondary education (FGERSE), with each indicator represented as a continuous annual time series of 22 observations.

GDP per capita, measured in constant 2015 US dollars, is used as the outcome variable. Values were compiled from the World Bank national accounts and validated using Organisation for Economic Co-operation and Development (OECD) estimates to ensure accuracy in deflation and cross-year comparability. This indicator reflects adjusted economic output per individual, suitable for measuring changes in macroeconomic performance across time.

FLFPR, one of the core independent indicators, is expressed as the proportion of women aged 15 and above who are economically active. Data were obtained from the World Bank Gender Statistics and ILOSTAT repositories, both of which adhere to international labour definitions and harmonised survey protocols. Where minor discrepancies existed between series, reconciliation was achieved through datas*et al*ignment and mean normalisation procedures.

Adolescent fertility rate is defined as the number of live births per 1,000 females aged 15 to 19. The indicator was sourced exclusively from the World Bank gender statistics, which aggregates national demographic and health survey outputs. It is treated as a continuous demographic control in the regression models.

FGERSE is expressed as the gross enrolment rate of girls in secondary education relative to the official age-specific female population. Various years data were obtained from Ministry of Education's reports. To enable statistical comparability, the variable was standardised following a two-step transformation involving unit normalisation and proportional scaling, as described by Izonin *et al.* (2022).

All four indicators were screened for completeness, definitional consistency and temporal continuity. No imputation was required. Table 1 reports the full dataset of observed values across the study period.

Methodology

This study employs an econometric approach grounded in the endogenous growth framework to assess the relationship between gender-linked socio-economic indicators and economic performance in India. Two linear regression models are estimated using Ordinary Least Squares (OLS) to quantify the effects of female labour force participation and adolescent fertility on per capita GDP, as well as the role of secondary education enrolment. Given the high degree of correlation between female labour participation and female gross enrolment rate in secondary education ($r = 0.906$), the analysis is bifurcated into two separate model estimations to mitigate multicollinearity and isolate predictive effects:

Model 1: GDP per capita = $\beta_0 + \beta_1 \times$ FLFPR + $\beta_2 \times$ Adolescent Fertility Rate + ε

Model 2: GDP per capita = $\beta_0 + \beta_1 \times$ FGERSE + $\beta_2 \times$ Adolescent Fertility Rate + ε

Models were estimated using SPSS v26, with standard diagnostic tests applied to validate assumptions. Linearity and homoscedasticity

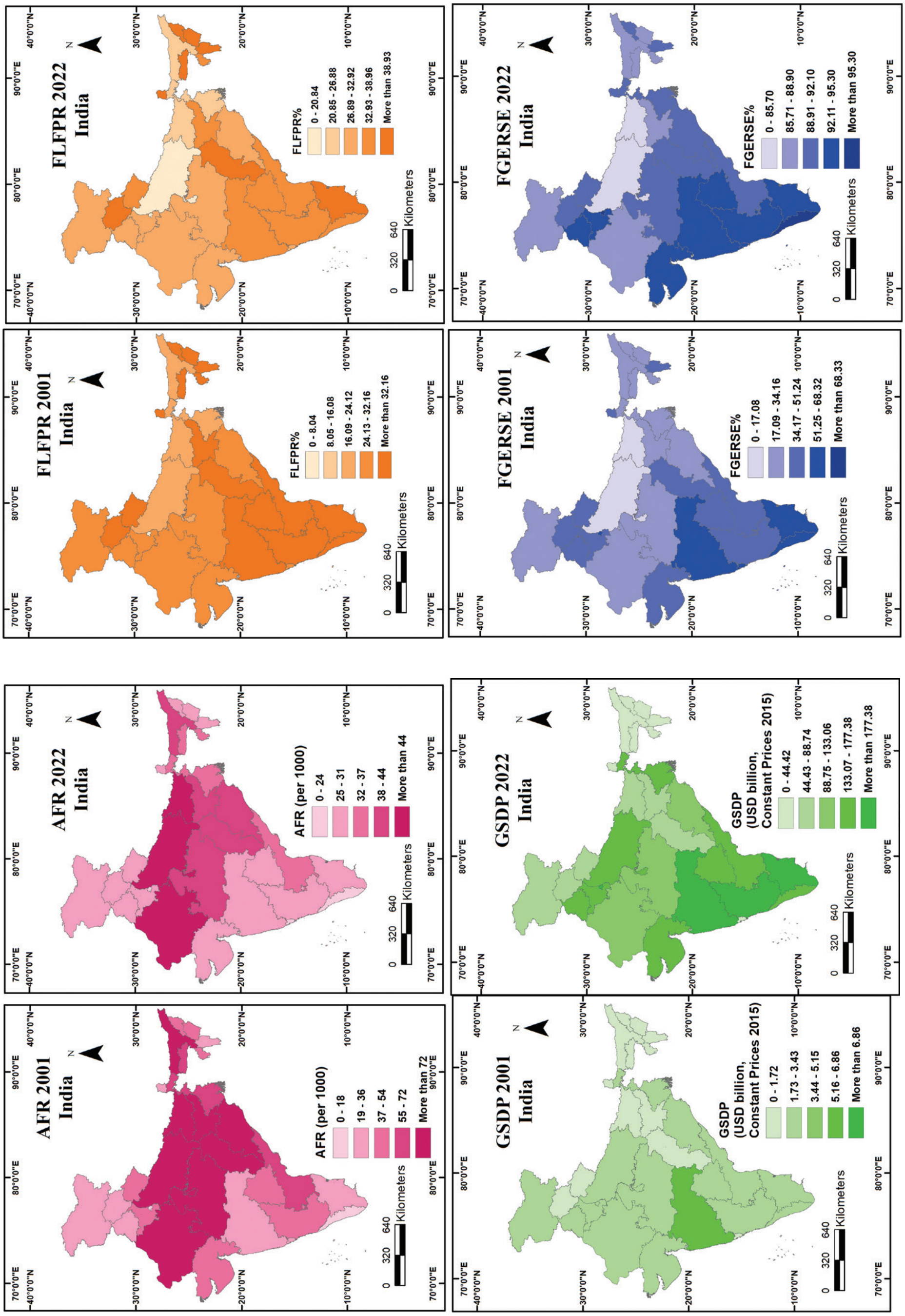

Fig. 1: Inter-state variation in gender-linked development indicators and economic output (2001–2022)

Source: Made by author using ArcGIS 10.8; using various years data from World Bank, ILOSTAT, Ministry of Labour and Employment, Ministry of Human Resource Development, Ministry of Education

Table 1: Annual trends in GDP per capita, FLFPR, FGERSE and adolescent fertility, 2001–2022

Year	FLFPR (%)	GDP per capita (constant 2015 USD)	FGERSE (%)	Adolescent Fertility Rate (per 1,000 girls 15–19)
2001	31.64	460	47.9	78.9
2002	31.38	478	50.2	75.7
2003	31.07	547	52.6	72.4
2004	30.63	634	55.0	68.9
2005	30.17	740	57.3	65.5
2006	29.66	820	59.8	62.2
2007	29.11	955	61.7	58.9
2008	28.49	1,016	63.5	55.5
2009	28.10	1,066	64.8	52.1
2010	27.90	1,419	65.4	48.9
2011	27.70	1,503	65.9	45.5
2012	27.06	1,434	66.0	42.2
2013	27.17	1,438	67.0	39.0
2014	27.26	1,560	72.0	35.6
2015	27.38	1,590	72.0	32.3
2016	27.47	1,714	73.0	29.1
2017	27.55	1,958	72.0	26.0
2018	27.60	1,974	72.0	22.9
2019	27.76	2,050	73.0	20.1
2020	27.89	1,913	74.0	18.5
2021	28.00	2,238	76.0	17.4
2022	28.09	2,389	78.0	17.0

Source: Compiled by author using various years data from World Bank, ILOSTAT, Ministry of Labour and Employment, Ministry of Human Resource Development and Ministry of Education reports.

were evaluated through residual plots, while normality was assessed using histograms and the Shapiro-Wilk test. Serial correlation was tested using Cochran's C to detect first-order autocorrelation and Variance Inflation Factors (VIFs) were examined to rule out multicollinearity. Model interpretation focused on coefficient direction, magnitude, significance and overall model fit (R^2 and adjusted R^2). Model 1 demonstrated strong statistical performance, whereas Model 2 showed a non-significant effect for FGERSE ($p = 0.726$), indicating that educational gains alone do not drive economic growth without parallel improvements in labour market integration.

Methodological transparency and limitations

The sample comprises 22 annual observations, which provides sufficient temporal range for general inference, but limits the ability to incorporate lag effects or nonlinear transformations. The separation

Table 2: OLS regression models predicting GDP per capita

Model	R^2	Adj. R^2	Intercept (B)	p (Intercept)	Predictor 1	B (β)	p-value	Predictor 2	B (β)	p-value
Model A	0.988	0.986	2776.73	0.001	FLFPR	179.615	0.000	Adolescent Fertility	-11.232	0.000
Model B	0.970	0.964	2464.89	0.000	FGERSE	22.137	0.005	Adolescent Fertility	-8.038	0.002

Source: Author's computation using SPSS v26 from World Bank, ILOSTAT, Ministry of Labour and Employment, Ministry of Human Resource Development and Ministry of Education reports

of the two models was critical to address multicollinearity, but may omit potential interaction effects between education and labour participation.

Though the study harmonises estimates from World Bank and ILO datasets through cross-verification, minor definitional variations in labour and fertility statistics may persist. Furthermore, the exclusion of factors such as informal sector productivity, technological diffusion, or state-level policy shocks introduces the risk of omitted variable bias, a limitation acknowledged in the discussion.

Results and discussion

The longitudinal assessment of macroeconomic and gender indicators reveals a nonlinear trajectory of development. As shown in Table 1, per capita GDP rose from USD 460 to USD 2,389 (in constant 2015 terms) over the study period. This economic expansion coincided with a marked decline in adolescent fertility (from 78.9 to 17.0 births per 1,000 girls aged 15–19) and a significant increase in female gross enrolment rate in secondary education (FGERSE), which climbed from 47.9% to 78.0%. In contrast, female labour force participation (FLFPR) declined steadily from 31.6% to 28.1%, indicating that the expansion of education and health outcomes did not result in parallel gains in women's workforce participation.

This divergence underscores a structural imbalance in the relationship between human capital formation and actual labour market integration for women.

Economic Effects of Gendered Variables: Regression Findings

To quantify the impact of gender-specific indicators on macroeconomic output, two OLS regression models were developed. Model A includes FLFPR and adolescent fertility as independent variable. Model B replaces FLFPR with FGERSE to address multicollinearity, as the correlation between FLFPR and FGERSE exceeded 0.90 (Table 2).

Model A explains 98.6% of the variance in GDP per capita (adjusted $R^2 = 0.986$), with both predictors statistically significant ($p < 0.001$). A one-unit increase in FLFPR corresponds to a USD 179.6 increase in GDP per capita, while each unit increase in adolescent fertility is associated with an USD 11.2 decline. In Model B, FGERSE is positively signed but statistically insignificant ($p = 0.726$) and the model explains slightly less variation in GDP (adjusted $R^2 = 0.964$). These results suggest that education access alone does not produce macroeconomic gains

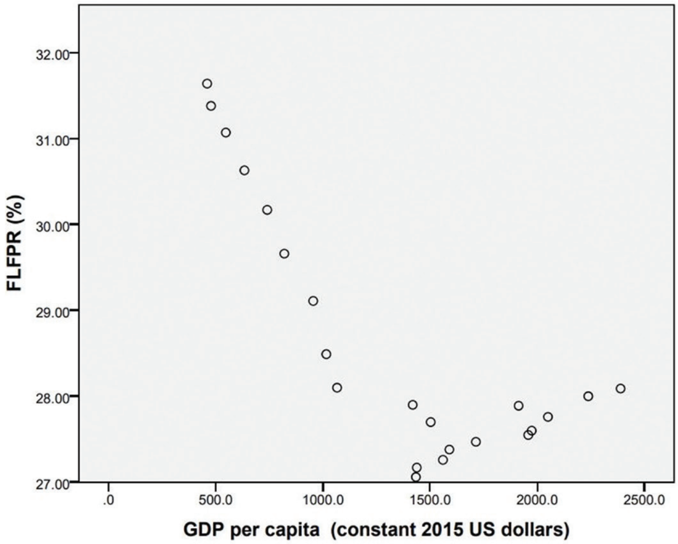

Fig. 2: Scatterplot: GDP per capita and FLFPR (2001–2022).

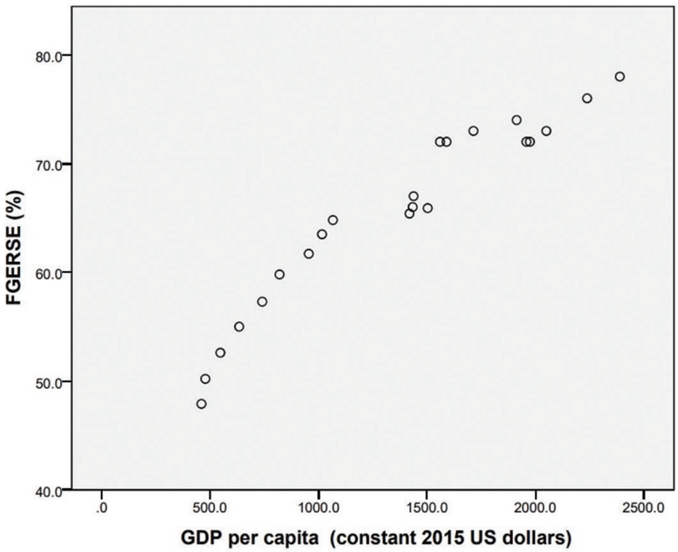

Fig. 3: Scatterplot: GDP per capita and FGERSE (2001–2022)

unless it translates into labour participation and that adolescent fertility functions as a persistent economic constraint.

Regional divergence in gendered development

The geographic patterning of each indicator reveals pronounced inter-state disparities. As illustrated in Figure 1, southern and western states such as Kerala, Tamil Nadu and Maharashtra exhibit higher FLFPR, lower adolescent fertility and stronger economic performance.

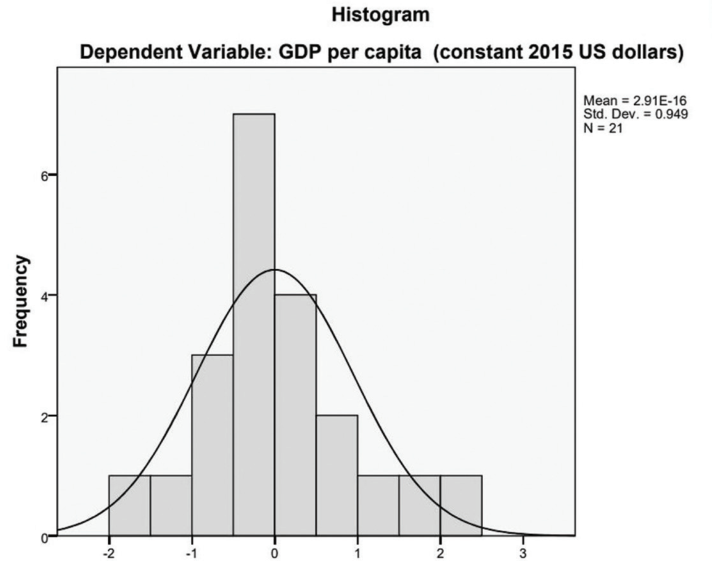

Fig. 4: Residual distribution from Model A

States in the central and northern regions including Uttar Pradesh, Bihar and Madhya Pradesh demonstrate consistently low FLFPR, high adolescent fertility and below-average gross state domestic product (GSDP).

These spatial clusters suggest the persistence of structural and institutional inequalities that constrain gendered development. The geographic co-location of weak economic output and gender disadvantages affirms that regional growth trajectories are shaped by differential access to labour markets and reproductive autonomy.

The scatterplot in Figure 2 reveals a U-shaped association between FLFPR and GDP per capita. At lower income levels, women's participation tends to be higher due to subsistence and informal labour pressures. As income rises, participation declines driven by socio-cultural withdrawal, limited formal sector access and occupational gendering. At higher GDP levels, FLFPR stabilises or slightly rebounds, suggesting a conditional reversal dependent on institutional support.

Figure 3 shows a linear association between FGERSE and GDP per capita. However, the lack of significance in Model B implies that enrolment trends, though rising, are not sufficient to generate economic transformation in the absence of labour absorption mechanisms and the histogram in Figure 4 confirms that Model A residuals approximate normality, with mild negative skew. States with high GDP and strong FLFPR (e.g., Gujarat, Maharashtra) contribute modest outliers, suggesting that national-level predictors may not fully capture regional institutional factors.

The workforce participation is the most consequential gendered driver of macroeconomic performance. While adolescent fertility acts as a demographic constraint across all spatial contexts, its economic effects are magnified in states with persistently low FLFPR. The absence of statistical significance for FGERSE indicates that education, in isolation, lacks transformative capacity without institutional pathways to employment.

Spatially, the intersection of high adolescent fertility, low female labour force participation and low gross state domestic product is not incidental; it reflects embedded asymmetries in access, institutional capacity and prevailing gender norms. These norms include early marriage expectations, patriarchal inheritance systems, restrictions on female mobility and the devaluation of women's work outside the household, especially in northern and eastern states. The spatial structure of these gendered constraints reveals that national-level reforms, when uniformly applied, risk failing to address region-specific bottlenecks. Effective policy must therefore be spatially differentiated and responsive to the socio-cultural regimes that shape women's economic agency across subnational spaces.

The model confirms that economic output cannot be fully understood without accounting for the spatial organisation of demographic and labour structures. These results substantiate the need for subnational strategies that integrate reproductive health, employment access and educational inclusion as interdependent components of regional development.

Conclusion and policy implications

This study identifies the failure to convert educational gains into economic participation as a structural constraint on regional growth. The spatial clustering of low female labour force participation and high adolescent fertility signals that uniform policy approaches have serious limitations.

Policy must shift from siloed sectoral interventions to integrated regional strategies. This includes expanding secure and flexible employment opportunities for women, embedding adolescent reproductive health in economic planning and aligning educational pathways with real labour demand.

Robust subnational data systems are essential to target these reforms effectively. India's long-term convergence prospects depend on recognizing women's economic inclusion not as a social add-on but as a macroeconomic necessity.

Competing interest

The corresponding author declares that they have no conflict of interest.

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