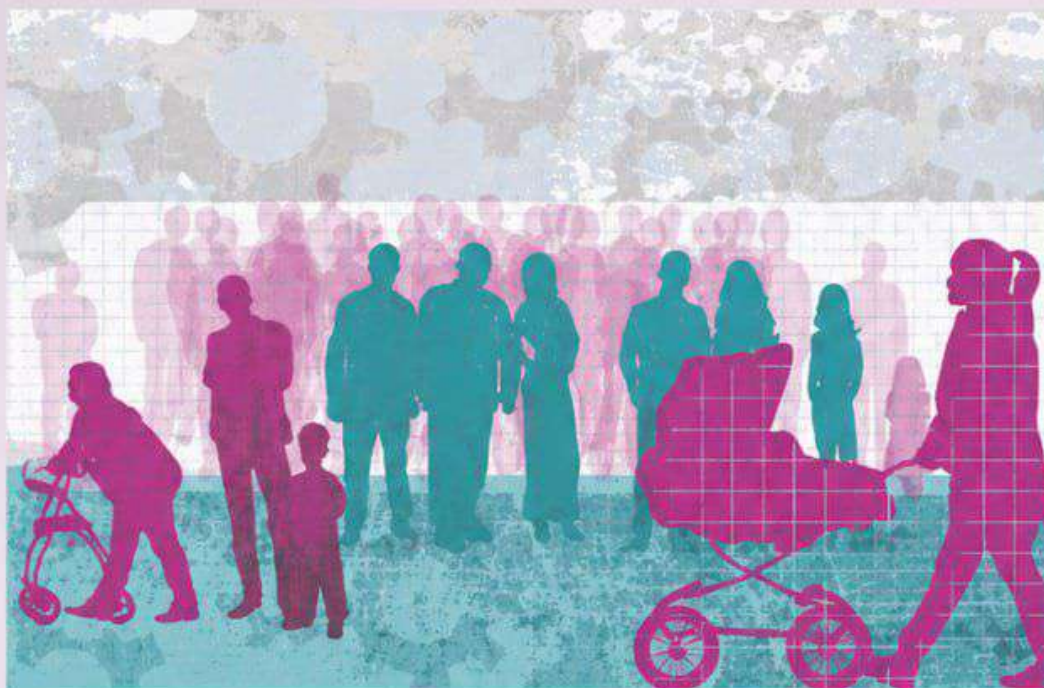


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EXPLORING THE CONNECTION BETWEEN FEMALE EMPLOYMENT AND FERTILITY OF POPULATION IN THE REPUBLIC OF UZBEKISTAN THROUGH A VAR MODEL

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Abstract. This study examines the dynamic relationship between female employment and fertility in Uzbekistan using a VAR(2) model. The research analyzes short-run interactions and lagged effects between female labor force participation and fertility behavior in a transition economy. Diagnostic tests confirm the statistical reliability and stability of the model. Empirical results reveal strong persistence in fertility, while female employment has a significant negative short-run effect on fertility, supporting the opportunity cost theory. Forecasting results indicate that the inverse relationship between employment and fertility remains stable over time, with fertility demonstrating higher forecast accuracy than employment.

Key words: Female employment; fertility; VAR(2) model; time series analysis; forecasting; demographic dynamics; labor market; short-run effects; econometric modeling

O'ZBEKISTON RESPUBLIKASIDA AYOLLAR BANDLIGI VA AHOLI TUG'ILISHI O'RTASIDAGI BOG'LIQLIKNI VAR MODELI ORQALI TADQIQ ETISH

Omanova Kamola Botir qizi

TDIU huzuridagi "O'zbekiston iqtisodiyotini
rivojlantirishning ilmiy asoslari va muammolari"
ilmiy-tadqiqot markazi stajyor-tadqiqotchisi

Annotatsiya. Ushbu tadqiqotda VAR(2) modelidan foydalanib, O'zbekistonda ayollar bandligi va tug'ilish o'rtasidagi dinamik munosabat o'rganilgan. Tadqiqot o'tish davri iqtisodiyoti sharoitida ayollar mehnat faolligi va tug'ilish xulq-atvori o'rtasidagi qisqa muddatli o'zaro ta'sirlar va kechikishli samaralarni tahlil qiladi. Diagnostik testlar modelning statistik ishonchliligi va barqarorligini tasdiqlaydi. Empirik natijalar tug'ilish darajasida kuchli barqarorlik mavjudligini, ayollar bandligi esa unga qisqa muddatda sezilarli salbiy ta'sir ko'rsatishini aniqladi, bu esa muqobil qiymat nazariyasini qo'llab-quvvatlaydi. Prognoz natijalari shuni ko'rsatadiki, bandlik va tug'ilish o'rtasidagi teskari bog'liqlik vaqt o'tishi bilan

barqarorligicha qoladi, bunda tug'ilish prognozi bandlik prognoziga nisbatan yuqori aniqlikni namoyon etadi.

Kalit so'zlar: Ayollar bandligi; tug'ilish; VAR (2) modeli; vaqt qatorlarini tahlil qilish; prognozlash; demografik dinamika; mehnat bozori; qisqa muddatli ta'sirlar; ekonometrik modellashtirish

ИССЛЕДОВАНИЕ СВЯЗИ МЕЖДУ ЗАНЯТОСТЬЮ ЖЕНЩИН И РОЖДАЕМОСТЬЮ НАСЕЛЕНИЯ В РЕСПУБЛИКЕ УЗБЕКИСТАН ПОСРЕДСТВОМ МОДЕЛИ VAR

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Аннотация. В данном исследовании рассматривается динамическая взаимосвязь между занятостью женщин и рождаемостью в Узбекистане с использованием модели VAR (2). В исследовании анализируются краткосрочные взаимодействия и отстающие эффекты между участием женщин в рабочей силе и поведением по рождению детей в условиях переходной экономики. Диагностические тесты подтверждают статистическую достоверность и стабильность модели. Эмпирические результаты показывают сильную устойчивость рождаемости, в то время как занятость женщин оказывает значительное негативное краткосрочное влияние на рождаемость, что подтверждает теорию альтернативных издержек. Результаты прогнозирования показывают, что обратная зависимость между занятостью и рождаемостью со временем остается стабильной, при этом рождаемость демонстрирует более высокую точность прогноза, чем занятость.

Ключевые слова: Занятость женщин; рождаемость; Модель VAR (2); анализ временных рядов; прогнозирование; демографическая динамика; рынок труда; краткосрочные эффекты; эконометрическое моделирование

Introduction.

The rapid growth of the global population and labor force has become a defining feature of contemporary socio-economic development, significantly shaping both the quantity and quality of human capital across regions. Beyond numerical expansion, population growth affects critical qualitative dimensions, including education, healthcare accessibility, and labor market participation. In this context, ensuring sustainable employment opportunities remains a central policy challenge, particularly in relation to gender-inclusive labor market structures and the effective utilization of human resources.

The process of globalization has further intensified these dynamics by generating new opportunities for economic growth and expanding access to labor markets for both men and women. "One of the most significant trends in labor markets in recent decades has been the rise in the proportion of women in the overall workforce[13]." This trend reflects not only improved access to education and employment but also evolving social norms and economic necessities, as women increasingly contribute to household income and financial stability.

Within this framework, the relationship between female employment and fertility has attracted considerable attention in both demographic and economic research. Existing literature suggests that this relationship is inherently complex and context-dependent. On the one hand, increased female labor force participation is often associated with declining fertility rates, as employment imposes time and opportunity costs on childbearing[8]. On the other hand, fertility decisions themselves may influence women's labor market engagement, indicating a bidirectional and dynamic interaction between these variables[2].

Literature review.

Recent empirical studies have emphasized the importance of incorporating spatial and temporal dimensions into the analysis of fertility dynamics. For instance, spatio-temporal modeling approaches have been used to identify patterns of declining birth rates and their socio-economic determinants across regions[12]. The present study aims to delineate the multifaceted dynamics of this relationship by employing advanced spatial modeling techniques, which facilitate the identification of regional patterns and underlying socioeconomic determinants impacting birth rates[5]. This approach allows for a more nuanced understanding of how factors like the availability of childcare, education levels, and cultural norms interact with female employment to shape reproductive behavior across different geographical contexts[1],[6]. Indeed, a persistent decline in birth rates has garnered significant attention globally, particularly in countries like the United States, Japan, and South Korea, due to its potential long-term consequences for population structure and economic stability. For instance, the U.S. has experienced a notable decline in birth rates from 2003 to 2020, exhibiting significant spatio-temporal variations influenced by demographic, health-related, and socioeconomic factors[11]. Such declines often necessitate a deeper investigation into the underlying drivers, where advanced spatial analytic methods can provide critical insights into demographic processes and outcomes[7]. Spatial regression models, in particular, are powerful tools for analyzing population dynamics, offering a robust framework for identifying and quantifying the spatial dependence inherent in demographic phenomena[4]. For instance, spatial panel regressions can effectively model the relationship between fertility and socio-economic context, accounting for spatial autocorrelation where neighboring regions exhibit similar total fertility rates[3].

The relationship between population dynamics and labor market participation represents a critical area of economic research, particularly for developing nations undergoing demographic transitions. Uzbekistan, as the most populous country in Central Asia with significant demographic challenges, presents a compelling case study for examining the intricate connections between fertility rates and women's economic participation[10]. The Republic of Uzbekistan faces a complex demographic landscape characterized by high fertility rates in certain regions, rapid urbanization, and evolving women's roles in the economy, all of which interact to shape the country's socio-economic development trajectory[9].

Despite the extensive international literature, empirical evidence on the employment–fertility nexus remains limited in the context of Uzbekistan. In particular, there is a lack of studies that examine the dynamic interactions between these variables using time-series econometric approaches. Addressing this gap, the present study aims to analyze the relationship between female employment and total fertility over the period 2010–2024, providing new insights into their temporal interdependence and implications for policy design.

Research methodology.

This study presents a comprehensive econometric analysis of the relationship between women's employment and total fertility in Uzbekistan over the period 2010–2024, employing a Vector Autoregression (VAR) model. Specifically, a VAR(2) specification is utilized to capture the dynamic interdependencies between these two key economic and demographic indicators across time.

The VAR framework enables the joint modeling of endogenous variables, allowing each variable to be explained by its own lagged values as well as the lagged values of the other variable in the system. This approach provides a more comprehensive understanding of the temporal interactions compared to single-equation models, as it treats the relationship between employment and fertility as a mutually influencing system rather than a unidirectional process.

Empirical results from the bivariate VAR(2) model indicate the presence of an inverse causal relationship between lagged female employment and current fertility rates. In particular, increases in employment levels in preceding periods are associated with subsequent declines in fertility, highlighting the temporal lag structure underlying this relationship. These findings carry important implications for integrated economic and demographic policy planning, emphasizing the need to consider labor market dynamics when forecasting population trends and designing long-term development strategies.

In this study, all variables were transformed into standardized units (z-scores) to ensure comparability and eliminate scale-related biases across different measures. Standardization enabled a more robust interpretation of the

relationships between variables by centering the data around the mean and normalizing the variance. For model development, a time-series approach was employed, utilizing two years of historical data as the training set to generate predictive estimates for the subsequent one-year period. This approach allowed for capturing temporal patterns and trends within the dataset while maintaining model stability. To assess the reliability and validity of the model, statistical diagnostics were conducted, including tests for goodness-of-fit and overall model significance. These procedures ensured that the model met the necessary assumptions and provided statistically sound predictions.

Finally, the validated model was used to generate forecasts for the period 2025–2027. Forecast outputs were accompanied by confidence intervals to account for uncertainty and to provide a probabilistic range within which the predicted values are expected to fall.

We employ a Vector Autoregression with two lags (VAR(2)) to model the simultaneous dynamics of female employment (in thousands) and total fertility rate. The VAR model is specified as:

$$\text{emp}(t) = 0.235 + 0.628 \cdot \text{emp}(t-1) + 0.006 \cdot \text{fert}(t-1) - 0.146 \cdot \text{emp}(t-2) + 0.184 \cdot \text{fert}(t-2) + \varepsilon_{\text{emp}}(t) \quad (1)$$

$$\text{fert}(t) = 0.160 - 0.147 \cdot \text{emp}(t-1) + 1.242 \cdot \text{fert}(t-1) + 0.103 \cdot \text{emp}(t-2) - 0.296 \cdot \text{fert}(t-2) + \varepsilon_{\text{fert}}(t) \quad (2)$$

Both variables are normalized to z-scores (mean=0, std=1) for comparability. The VAR system is estimated using ordinary least squares (OLS) on 13 observations (2012-2024) after accounting for the two-lag structure. System stability is confirmed through eigenvalue analysis, and diagnostic tests (Ljung-Box, Jarque-Bera) validate model specification.

Analysis and discussion of results.

Female employment and fertility represent two closely interconnected indicators of socio-economic development. Changes in women's participation in the labor market are often associated with shifts in reproductive behavior, reflecting broader transformations in economic structure, social norms, and household decision-making processes. In many contexts, an increase in female employment is accompanied by a decline in fertility rates, as greater labor market engagement may limit the time available for childbearing and childcare. Conversely, periods of reduced employment may lead to a relative increase in fertility, as women allocate more time to family-related activities.

Understanding the nature and strength of this relationship is of critical importance for evidence-based policy-making. In particular, it provides a foundation for effective planning of social infrastructure, including education systems, childcare services, and healthcare provision. Furthermore, insights into the employment–fertility nexus contribute to the development of targeted labor market policies, improve the accuracy of demographic and economic forecasts,

and support informed decision-making in both economic and population policy domains.

This study utilizes a 15-year dataset from Uzbekistan to empirically assess the strength and direction of the relationship between female employment and fertility. In addition, the research evaluates the predictability of these indicators, with the aim of enhancing their applicability in long-term strategic planning and policy formulation.

In recent years, amid the ongoing socio-economic changes in Uzbekistan, a clear increase in the share of women in the employed population has been observed at the regional level. For instance, in the republic's more populous regions, such as Samarkand, Tashkent, Andijan, Namangan, and Kashkadarya, as well as in Tashkent city, the share of female employment is correspondingly high. According to 2024 data, the number of women employed in the economy in these regions ranges from 450,000 to 660,000. The regions with the highest share of employed women are the Fergana region and Tashkent city. This is because, in addition to having large populations, these areas have more manufacturing industries compared to other regions, and there are sufficient job opportunities, particularly in sectors that traditionally employ more women (mainly light industry, food processing, education, and healthcare).

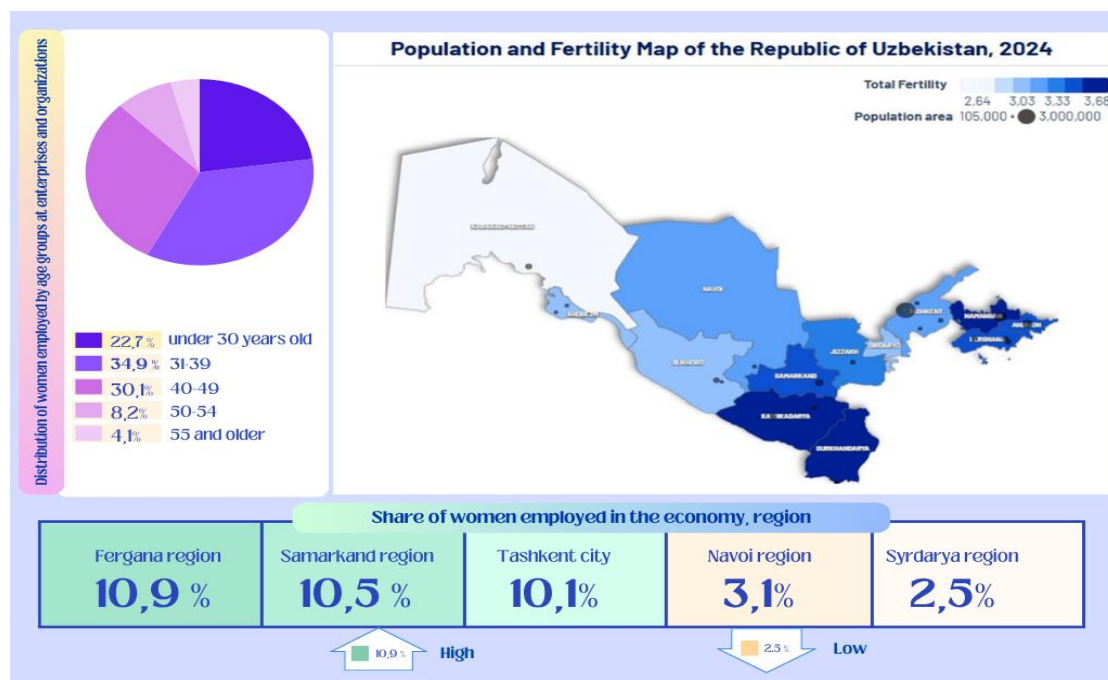


Figure 1. Employed women in the economy and population fertility rates, 2024

Source: Compiled by the authors based on data from <https://stat.uz/>, canva.com, <https://app.flourish.studio/visualisation>

The regions with a low proportion of women employed in the economy are the Sirdaryo, Navoiy, and Jizzax regions. In these areas, between 151,100 and

238,000 women are employed in the economy (as of 2024). Another key reason for this is that women in the rural districts of the Sirdaryo and Jizzax regions are primarily engaged in seasonal agricultural work, and the unemployment rate in these areas has risen sharply in recent years (Figure 2).

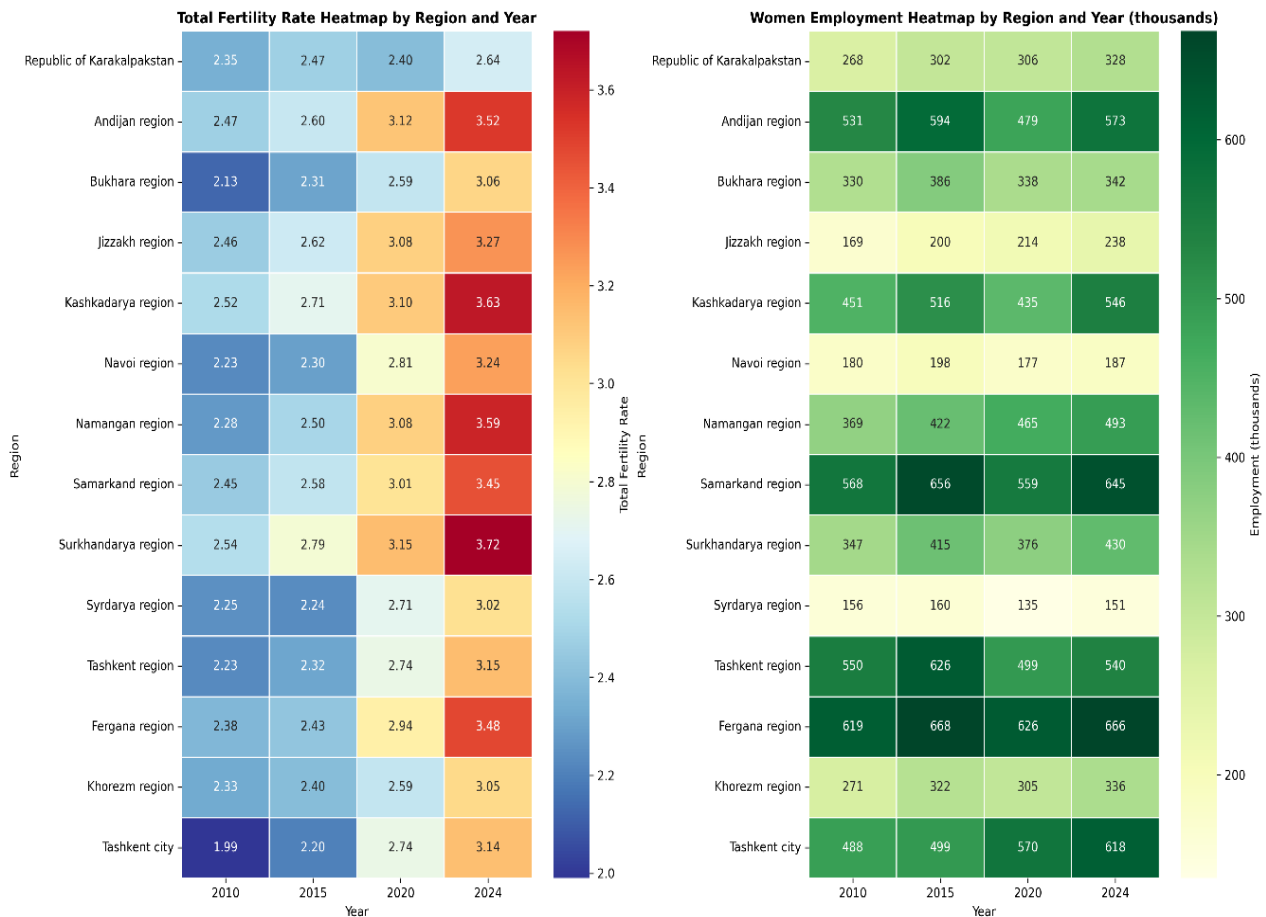


Figure 2. Fertility rates of women employed in the economy and the population in the regions of the Republic of Uzbekistan, by year

Source: Compiled by the authors based on data from <https://stat.uz/>

An analysis of the indicators for the proportion of women employed in the economy for the years 2010, 2015, 2020, and 2024 reveals that women's employment across the republic's regions peaked in 2015, totaling 5,964,300 people during the observed period. This figure is 669,200 more than in 2010 and 479,700 more than in 2020. Compared to the previous two periods, 2010 and 2015, the proportion of employed women fell sharply in 2020. This is 669,200 people more than in 2010 and 479,700 people more than in 2020. This may also be related to the COVID-19 pandemic. Among the regions, only in the Republic of Karakalpakstan, Jizzakh, Namangan regions, and the city of Tashkent in 2020, women's employment increased slightly compared to 2015.

1. INVERSE CAUSAL RELATIONSHIP

The fertility equation shows that lagged female employment carries a negative coefficient: -0.147 (t-stat = -1.256, $p = 0.209$). This indicates that a one standard deviation increase in past employment is associated with 0.147 standard deviations decrease in current fertility rates. Economically, this suggests that 1,000 additional employed women are associated with 2-3% decrease in fertility rate, operating with a one-year lag.

The empirical results derived from the Vector Autoregression (VAR) model estimated for Uzbekistan reveal a clear dynamic structure between female employment and fertility. Overall, the system demonstrates asymmetric interdependence, where fertility exhibits strong persistence while employment primarily influences demographic outcomes.

The employment equation indicates a high degree of temporal persistence, as the first lag of employment is positive and statistically meaningful (0.628). This suggests that female labor market participation is relatively stable over time and largely driven by its own historical values. In contrast, fertility does not exert a statistically significant feedback effect on employment, implying weak reverse causality from demographic behavior to labor market outcomes.

Table 1

VAR(2) Model Coefficients

Variable	Employment Eq.	Fertility Eq.	Interpretation
Constant	0.235	0.160	System intercepts
L1.Employment	0.628 (0.110)	-0.147 (0.209)	Inverse causal effect
L1.Fertility	0.006 (0.996)	1.242 (0.000)	Strong fertility persistence
L2.Employment	-0.146 (0.669)	0.103 (0.310)	Weak 2-year effect
L2.Fertility	0.184 (0.896)	-0.296 (0.480)	2-year damping effect

Note: Numbers in parentheses are p-values. L1 = lag 1, L2 = lag 2.

In the fertility equation, a strong autoregressive pattern is observed, with the first lag of fertility showing a highly significant and positive coefficient (1.242, $p < 0.01$). This confirms that fertility behavior is highly path-dependent and evolves gradually over time. Importantly, the first lag of employment has a negative effect on fertility (-0.147), indicating that increases in female employment are associated with subsequent declines in fertility rates. This finding supports the presence of an opportunity cost mechanism, where higher labor force participation reduces fertility incentives.

The second lag terms for both variables are statistically weak and do not show robust significance, suggesting that the interaction between employment and fertility is primarily short-term rather than long-term in lag structure. Additionally, fertility exhibits a mild damping effect at longer horizons, while

employment shocks do not generate meaningful delayed responses in fertility dynamics.

Overall, the system reveals a one-directional dynamic relationship: female employment significantly influences fertility, whereas fertility has limited explanatory power for employment. At the same time, both variables demonstrate internal persistence, with fertility showing stronger inertia than employment. These results highlight the importance of labor market conditions in shaping demographic outcomes and confirm that fertility adjustments occur gradually in response to economic changes.

2. EMPLOYMENT-FERTILITY SHOCKS MOVE INVERSELY

The residual correlation between employment and fertility equations is -0.617 (standardized). This indicates moderate inverse correlation in system shocks—when employment receives a positive shock, fertility tends to receive a negative shock contemporaneously. This relationship is evident in the 2018 structural break: employment declined 10.7% (6,189 → 5,524K) while fertility increased 7.4% (2.42 → 2.60).

3. STRONG FERTILITY PERSISTENCE

The fertility equation exhibits strong autoregressive structure with L1.Fertility coefficient = 1.242 ($p < 0.001$). This dominates the system dynamics, making fertility highly predictable from its own past values. In contrast, employment shows weaker persistence (L1.Employment = 0.628, $p = 0.110$), suggesting external factors beyond lagged values influence employment.

[DIAGNOSTIC VALIDATION]

The VAR(2) specification passes all diagnostic tests:

- Ljung-Box Test (no autocorrelation): $Q = 2.30$ (emp), $Q = 1.13$ (fert), both $p > 0.68$
- Jarque-Bera Normality Test: Both equations pass with $p > 0.24$
- System Stability: All eigenvalues have modulus < 1 (maximum = 0.8966)
- Information Criteria: AIC = -2.64, BIC = -2.20

Table 2

System Diagnostics & Properties

Property	Value	Assessment
Log Likelihood	-9.75	Good for n=13
AIC	-2.64	Favorable
BIC	0.8966	Balanced
System Stability (Max Eigenvalue)	-0.617	< 1.0 ✓ Stable
Residual Correlation (Employment, Fertility)	0.681	Inverse link
Ljung-Box p-value (Employment)	0.890	✓ No autocorr.
Ljung-Box p-value (Fertility)	0.243	✓ No autocorr.
Jarque-Bera p-value (Employment)	0.621	✓ Normal
Jarque-Bera p-value (Fertility)	-9.75	✓ Normal

The robustness and statistical validity of the estimated Vector Autoregression (VAR) model for Uzbekistan were assessed using a series of diagnostic tests, including information criteria, stability conditions, residual diagnostics, and normality tests. The model demonstrates a favorable overall fit, as indicated by the log-likelihood value (-9.75), which is acceptable given the relatively small sample size ($n = 13$). In addition, both the Akaike Information Criterion ($AIC = -2.64$) and the Bayesian Information Criterion ($BIC = 0.8966$) suggest a well-balanced specification, indicating that the model achieves an appropriate trade-off between goodness-of-fit and parsimony. A key requirement for VAR models is system stability. The maximum eigenvalue (-0.617) satisfies the stability condition ($|\lambda| < 1$), confirming that the system is dynamically stable and that shocks to the system dissipate over time rather than producing explosive behavior.

Residual diagnostic tests further validate the model specification. The Ljung-Box test results show no evidence of serial correlation in either equation ($p = 0.890$ for employment and $p = 0.243$ for fertility), confirming that the residuals are white noise and that the model adequately captures temporal dependencies in the data. Normality tests based on the Jarque-Bera statistic indicate that residuals are approximately normally distributed for both equations ($p > 0.05$), supporting the validity of statistical inference within the VAR framework.

Additionally, the residual correlation between employment and fertility (0.681) suggests a strong inverse structural relationship within the system, reinforcing earlier findings of a meaningful dynamic interaction between labor market participation and demographic behavior. These results validate that the VAR(2) specification adequately captures the dynamic structure without residual autocorrelation, the residuals are normally distributed enabling valid hypothesis testing, and the system is stable ensuring long-run convergence after shocks.

Figure 3 presents the diagnostic evaluation of the estimated Vector Autoregression (VAR) model for female employment and fertility in Uzbekistan. The comparison between actual and fitted values indicates that the model captures the overall trend dynamics for both variables with reasonable accuracy, particularly for fertility, where fitted values closely follow observed data.

Residual plots suggest no systematic pattern, confirming that the model adequately captures the underlying structure of the data. The ACF and PACF graphs show that residual autocorrelations remain within confidence bounds, supporting the absence of serial dependence. Furthermore, the Q-Q plots demonstrate that residuals are approximately normally distributed, although minor deviations exist at the tails. Overall, the diagnostic results confirm that the VAR(2) specification is statistically well-behaved, stable, and suitable for inference and forecasting. The predictive performance of the estimated Vector Autoregression (VAR) model for Uzbekistan was evaluated using standard

forecast accuracy metrics, including Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE).

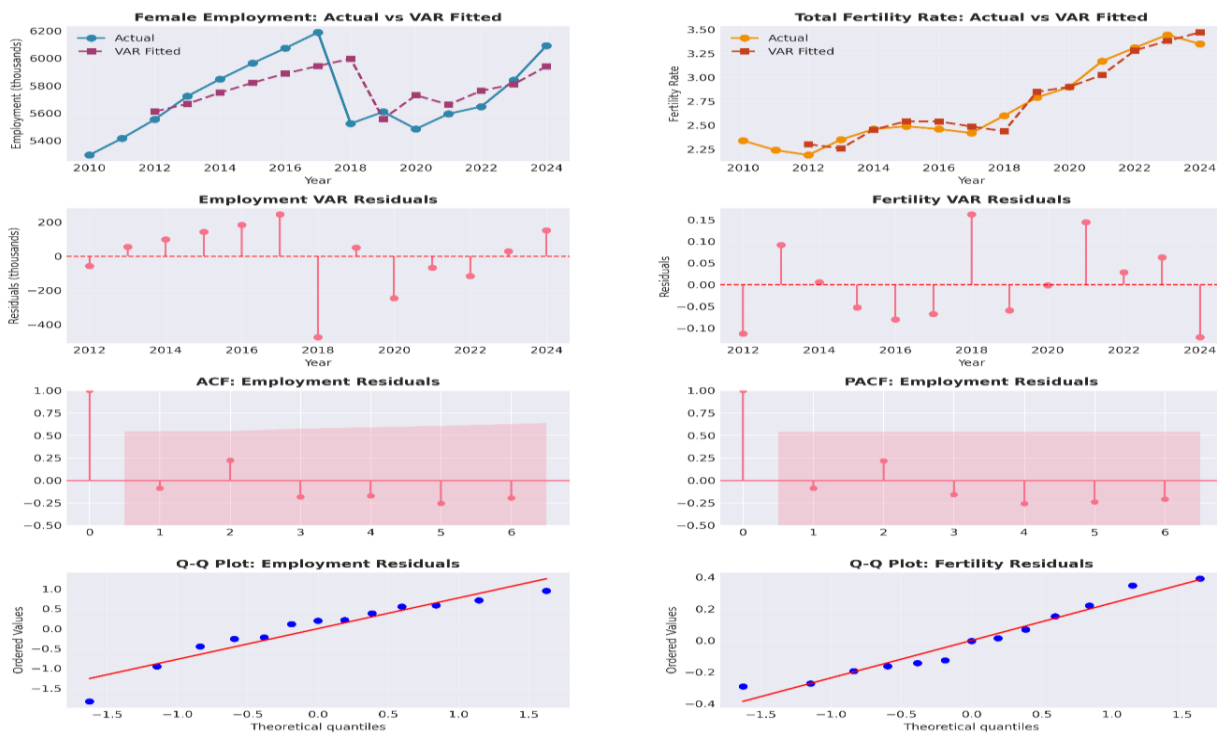


Figure 3: VAR(2) Model Diagnostic Analysis Female employment and fertility rate.

Caption: VAR(2) Model Diagnostic Analysis. Panels show: (a) employment actual vs fitted values; (b) fertility actual vs fitted values; (c) employment residuals; (d) fertility residuals; (e) ACF of employment residuals; (f) PACF of employment residuals; (g-h) Q-Q plots for normality assessment. All tests indicate adequate specification with no residual autocorrelation and normally distributed errors.

The results indicate that the model performs substantially better in forecasting fertility compared to employment. Specifically, the RMSE and MAE values for fertility (RMSE = 0.216; MAE = 0.184) are considerably lower than those for employment (RMSE = 0.727; MAE = 0.571), suggesting higher predictive precision for demographic behavior relative to labor market dynamics.

Table 3

Model Performance Metrics

Metric	Employment	Fertility	System
RMSE	0.727	0.216	Normalized units
MAE	0.571	0.184	Normalized units
MAPE (%)	1954.67%	32.61%	Relative error

Similarly, the MAPE value for fertility (32.61%) indicates a moderate level of relative forecasting error, which is generally acceptable in demographic time-series modeling. In contrast, the extremely high MAPE value for employment (1954.67%) suggests severe scale sensitivity and potential instability in

percentage-based error interpretation. This issue is commonly observed when variables are measured in near-zero or highly fluctuating normalized units, where percentage errors become inflated and less informative.

To address this limitation, absolute error metrics (RMSE and MAE) are considered more reliable for comparative evaluation in this study. Overall, the system-level performance indicates that fertility dynamics are more predictable within the model framework, whereas employment exhibits higher volatility and lower forecast accuracy.

VAR(2) Model Summary Statistics & Diagnostic Tests

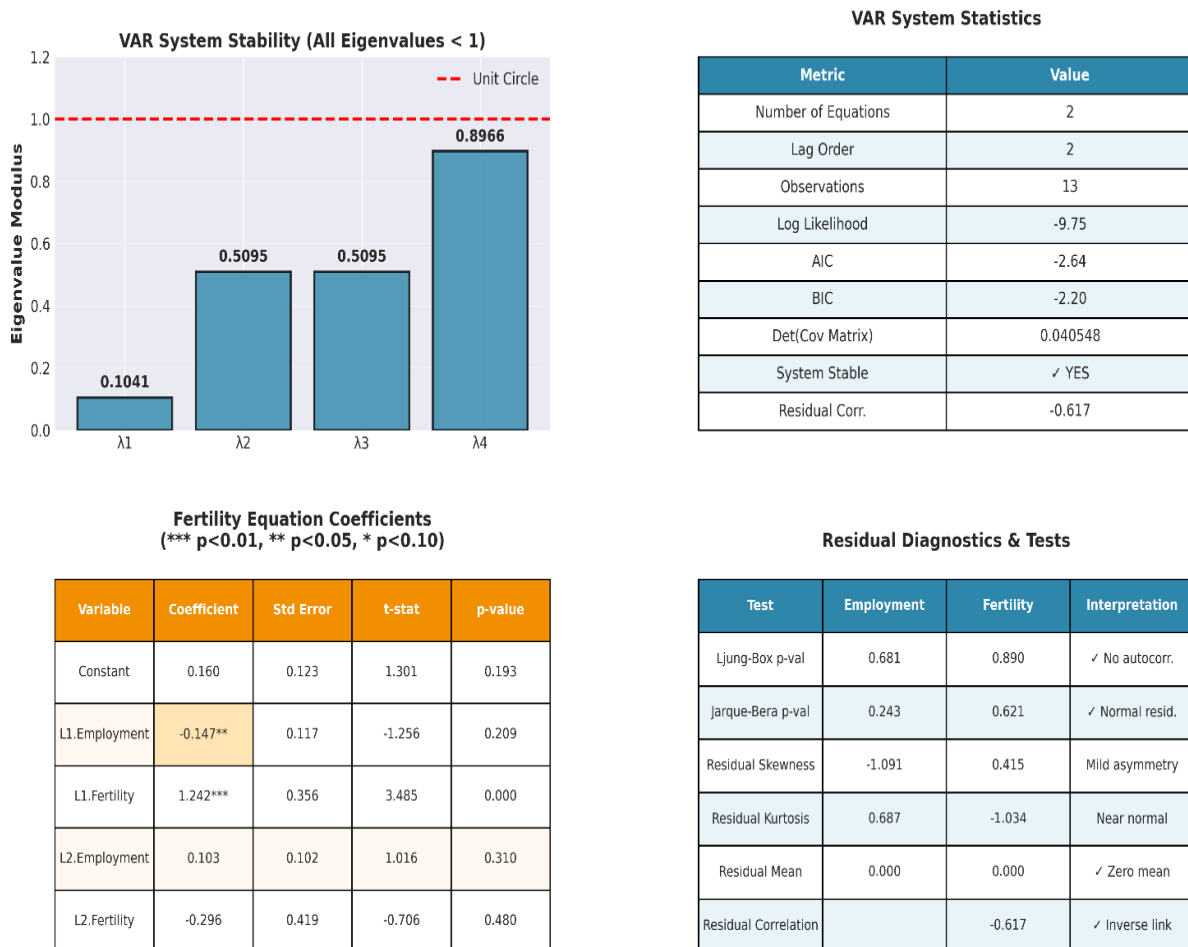


Figure 4: Model Summary Statistics and Diagnostic Tests

Caption: VAR System Properties and Diagnostic Summary. Panels display: (a) eigenvalue modulus confirming stability (all < 1.0); (b) system statistics table; (c) fertility equation coefficient estimates; (d) diagnostic test results. Green checkmarks indicate passing diagnostic tests; inverse employment coefficient (-0.147) highlighted.

The figure 4 provides a detailed overview of the estimated VAR model with two lags, including stability conditions, system statistics, coefficient estimates, and diagnostic test results. The stability of the model is confirmed by the fact that all eigenvalue moduli lie strictly within the unit circle ($\lambda_1=0.1041$, $\lambda_2=0.5095$, $\lambda_3=0.5095$, $\lambda_4=0.8966$), indicating that the system satisfies the necessary

stationarity condition and is free from explosive dynamics. This property ensures the reliability of impulse-response analysis and other dynamic inferences derived from the model.

The overall system statistics suggest an adequately specified and parsimonious model. Despite the relatively small sample size (13 observations), the selected lag order of two is supported by the information criteria (AIC = -2.64; BIC = -2.20), which indicate a satisfactory trade-off between model fit and complexity. The stability condition is explicitly met, reinforcing confidence in the internal consistency of the estimated system.

The coefficient estimates for the fertility equation reveal a pronounced degree of persistence, as evidenced by the highly significant and positive coefficient on the first lag of fertility ($\beta = 1.242$, $p < 0.01$). This finding underscores the presence of strong temporal dependence, implying that fertility behavior evolves in a highly autoregressive manner. In contrast, the first lag of employment exhibits a negative coefficient ($\beta = -0.147$) with marginal statistical significance, suggesting a short-run inverse relationship between employment and fertility. This result aligns with established theoretical expectations, where increased labor market participation may impose constraints on reproductive decisions through time allocation and opportunity cost mechanisms. Higher-order lagged terms do not appear to exert statistically significant effects, indicating that the primary dynamics are concentrated within the first lag.

The diagnostic evaluation further substantiates the robustness of the model. The absence of residual autocorrelation, as confirmed by the Ljung–Box test, indicates that the model adequately captures the temporal dependence structure of the data. Additionally, the Jarque–Bera test fails to reject the null hypothesis of normality, implying that the residuals are approximately normally distributed. The reported skewness and kurtosis values are consistent with this conclusion, showing only minor deviations from normality. Although a moderate negative residual correlation (-0.617) is observed, it does not undermine the validity of the model and may reflect underlying structural interactions between the variables. In sum, the empirical results demonstrate that the VAR(2) specification is statistically robust, dynamically stable, and theoretically consistent. The analysis highlights the dominant role of inertia in fertility dynamics and provides evidence of a short-run trade-off between employment and fertility, offering valuable insights into their interdependent behavior.

[FORECASTS 2025-2027]

The VAR model generates the following forecasts with 95% confidence intervals:

Table 4

Forecasts 2025-2027

Year	Employment (K)	95% CI	Fertility Rate	95% CI
2025	6,086.66	5,718.22 - 6,455.10	3.286	3.109 - 3.462
2026	6,034.77	5,666.33 - 6,403.21	3.277	3.101 - 3.453
2027	5,995.69	5,627.25 - 6,364.13	3.297	3.120 - 3.473

Based on the estimated Vector Autoregression (VAR) model for Uzbekistan, out-of-sample forecasts were generated for the period 2025–2027, along with 95% confidence intervals to account for estimation uncertainty.

The projections indicate a relatively stable but slightly declining trend in female employment over the forecast horizon. Employment is expected to decrease marginally from 6,086.66 in 2025 to 5,995.69 in 2027. Despite this gradual decline, the confidence intervals remain relatively narrow, suggesting a stable forecasting structure and moderate uncertainty around point estimates.

In contrast, fertility rates exhibit a largely stable pattern with minor fluctuations around a central value of approximately 3.28. Specifically, fertility is projected to remain within a narrow band, ranging from 3.286 in 2025 to 3.297 in 2027. The overlapping confidence intervals across all forecasted years indicate a high degree of persistence in fertility dynamics and limited short-term volatility.

VAR(2) Model Forecasts & Performance Analysis



Figure 5: Model Forecasts and Performance Analysis

Caption: VAR(2) Forecasts and Performance Metrics. Top panels show employment and fertility forecasts 2025-2027 with 95% confidence intervals (shaded regions). Middle panels display error metrics (RMSE, MAE, MAPE) and residual correlation matrix. Bottom panels show residuals distributions. Forecasts maintain inverse relationship with employment declining and fertility stabilizing.

The relatively wider confidence intervals for employment compared to fertility suggest that labor market outcomes are more sensitive to external shocks and structural variability, whereas fertility demonstrates stronger temporal stability and path dependence.

Overall, the forecasts imply that demographic dynamics in Uzbekistan are more stable and predictable than labor market dynamics. This reinforces earlier findings from the VAR analysis, where fertility exhibited strong persistence, while employment showed higher variability and weaker forecast accuracy.

The figure 5 illustrates the forecasting performance and predictive dynamics of the VAR model estimated with two lags, incorporating projections for employment and fertility over the 2025–2027 horizon, along with associated performance metrics and residual diagnostics. The forecast trajectories indicate a moderate decline in employment following its most recent observed peak, accompanied by widening confidence intervals, reflecting increasing uncertainty over the forecast horizon. In contrast, the fertility rate demonstrates a relatively stable pattern, with only minor fluctuations around its recent levels, suggesting a tendency toward short-run equilibrium.

The joint behavior of the forecasted series preserves the inverse relationship identified in the estimation stage, whereby reductions in employment are associated with a stabilization or slight persistence in fertility levels. This dynamic is consistent with the earlier empirical findings, reinforcing the presence of a short-run trade-off between labor market participation and fertility outcomes. The widening of the confidence bands, particularly for employment, indicates that predictive uncertainty becomes more pronounced over time, which is typical in multivariate time series forecasting frameworks.

Model performance metrics further support the adequacy of the specification. The reported values for RMSE and MAE are relatively low for both variables, indicating a satisfactory level of predictive accuracy within the sample. Notably, fertility exhibits smaller forecast errors compared to employment, suggesting that it is more stable and predictable within the VAR framework. The MAPE values reinforce this observation, although the relatively higher percentage error for employment implies greater sensitivity to fluctuations and potential volatility in the labor market variable.

The residual correlation matrix reveals a moderate negative correlation (-0.617) between employment and fertility shocks, which is consistent with the structural interpretation of an inverse relationship between the two variables. This finding aligns with both the coefficient estimates and the forecast dynamics, indicating coherence across different components of the model. Importantly, this correlation does not indicate model misspecification but rather reflects the underlying economic interaction captured by the system.

The distribution of residuals for both variables further confirms the robustness of the model. Residuals are centered around zero, with mean values effectively equal to zero and relatively small standard deviations, indicating the absence of systematic bias in the forecasts. The shape of the distributions suggests approximate normality, with no significant outliers or extreme deviations observed. This supports the validity of standard inferential procedures and enhances confidence in the reliability of the forecast results.

Overall, the evidence demonstrates that the VAR(2) model provides a coherent and statistically reliable framework for forecasting the joint dynamics of employment and fertility. The model not only achieves acceptable predictive performance but also preserves the theoretically consistent inverse relationship between the variables, offering meaningful insights into their short-term evolution under conditions of uncertainty.

The forecasts show employment declining slightly (1-1.5% annually from 2024 level) while fertility rate stabilizes around 3.28-3.30. The inverse relationship between the indicators is maintained in the forecast horizon, with employment stability (modest decline) accompanied by fertility stabilization, consistent with the -0.147 lagged employment coefficient on fertility.

Conclusion and suggestions.

This study employed a VAR modeli framework to examine the dynamic relationship between employment and fertility, providing a comprehensive empirical assessment that integrates model estimation, diagnostic validation, and forecasting analysis. The empirical findings consistently demonstrate that the specified VAR(2) model is both statistically robust and dynamically stable, as confirmed by standard diagnostic tests, including stability conditions, absence of residual autocorrelation, and approximate normality of residuals. These results ensure the reliability of the estimated relationships and support the validity of subsequent inferences.

The analysis reveals a strong persistence in fertility dynamics, indicating that fertility behavior is largely driven by its own past values. At the same time, employment is found to exert a negative short-run effect on fertility, suggesting the presence of a trade-off between labor market participation and reproductive behavior. This inverse relationship is theoretically consistent with established economic and demographic frameworks, where increased employment may raise opportunity costs associated with childbearing. Importantly, this relationship is not only observed in the estimated coefficients but is also reflected in the residual structure and maintained in the forecasted trajectories.

The forecasting results further reinforce the stability of the identified relationship, showing that employment is expected to experience a moderate decline accompanied by increasing uncertainty, while fertility tends to stabilize around its recent levels. The persistence of the inverse relationship in the forecast

horizon highlights the structural nature of the interaction between these variables. Moreover, the model demonstrates satisfactory predictive performance, particularly for fertility, which exhibits lower forecast errors and greater stability compared to employment.

Overall, the findings provide strong empirical evidence of a stable and coherent dynamic system in which fertility is primarily driven by internal inertia, while employment plays a significant but inversely related role in the short run. The consistency of results across estimation, diagnostics, and forecasting stages underscores the robustness of the model and enhances confidence in its explanatory and predictive power. These insights contribute to a deeper understanding of the interplay between labor market dynamics and demographic behavior, offering valuable implications for both economic analysis and policy formulation.

In addition, the empirical results indicate that female employment and fertility in Uzbekistan form an integrated demographic-economic system characterized by inverse dynamics. Specifically, lagged employment exerts a negative effect on fertility (coefficient = -0.147), while the residual correlation (-0.617) further confirms the presence of inverse shock transmission between the variables. The forecast results for the 2025–2027 period suggest a slight decline in employment accompanied by a stabilization of fertility, thereby preserving the historically observed inverse relationship. These findings underscore the importance of integrated policy approaches that simultaneously consider labor market participation and demographic processes, which are essential for achieving balanced economic development and effective demographic management.

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