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Empowering economic growth through female labor force participation in central Asia: Evidence from regression and dynamic analyses

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ABSTRACT

Female labor force participation plays a significant role in driving the economic development of a country across various sectors. The previous literature suggests that increasing female labor force participation contributes to economic growth, the sector-specific impact remains unclear. The current study addresses this gap by analyzing female employment at both aggregate and sectoral levels, focusing on agriculture, industry, and services—on the economic growth of Central Asian economies from 1995 to 2022. Using a combination of regression techniques—including pooled OLS, fixed effects, and random effects models—and dynamic analytical approaches, the study addresses key issues of reverse causality and endogeneity through the adoption of the system GMM model. In addition, this study uses stationarity tests, including the Breitung and Das, IPS, and Pesaran tests, which reveal a mixed order of integration. The results of regression analysis show that total female labor force participation positively contributes to economic growth, while corruption negatively affects it. Sector-specific analysis result reveals that female participation in agriculture and services significantly enhances economic growth, whereas participation in the industrial sector has a detrimental impact. These results highlight the essential need for targeted policies to improve female labor force participation in high-growth sectors, mitigate the negative effects in the industrial sector, and address corruption. The study offers valuable insights into the role of female labor force participation in shaping economic growth in Central Asia.

1. Introduction

Females have been involved in all phases of production for many years around the world. Women used to be the main caretakers for the family, but now they have the dual responsibilities of supporting the family and working for pay (Feng et al., 2018). One way to describe global trends is that they show a rather stable correlation between female labor market involvement and the economic development stage. The IMF (2018) states that more women working will promote economic development by raising productivity and labor force participation. The increase in education and skills among females have enhanced productivity, leading to greater female labor force participation, which in turn has contributed significantly to economic expansion (Fernández, 2013). However, female participation in the agriculture, industry, and services sectors varies according to their skills and education levels, which influences their income and contributes to economic progression. Therefore, this study contributes to the literature by examining the relationship between female employment and economic growth in Central Asian economies, a region often overlooked in previous studies.

Moreover, this study provides a sectoral analysis of female employment in agriculture, industry, and services sectors, offering a more nuanced understanding of its impact on economic growth.

Regional variations in male-female labor force participation gaps arise from factors such as disparities in sub-regional economies, organizational transformations, labor market opportunities, fertility decline, spiritual and traditional values, and the balance between waged and unwaged jobs for women. In 2015, female labor force participation was 35 % in South Asia and 64 % in East Asia and the Pacific—the highest globally (ADB, 2015). However, in 2023, the female labor force participation in South Asia decreased to 32 % (World Bank, 2024). The gender gap is stark in South Asia, with 77.9 % of men and only 32.1 % of female in the workforce (World Economic Forum, 2024). The rates of female labor force participation in Central Asia exhibit considerable variation, with noteworthy disparities within countries. According to the World Bank's 2023 report, Kazakhstan's female labor force participation rate aligns closely with the regional average for Europe and Central Asia, where approximately 50.6 % of women and 66 % of men are active in the workforce. In Kazakhstan, female labor force

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participation was 48.75 % of the total labor force in 1995, rising to 49.17 % by 2023 (World Bank, 2025). In contrast, Tajikistan and Uzbekistan have some of the lowest female labor force participation rates in the region, alongside some of the widest gender disparities. This is largely due to traditional gender norms, limited access to economic opportunities, and employment-related restrictions. In 1995, female labor force participation rates in Tajikistan and Uzbekistan were 35.5 % and 38.3 %, respectively. By 2023, this rate had risen to 38.5 % in Tajikistan but declined to 36.05 % in Uzbekistan. In Tajikistan and Uzbekistan, women face pronounced wage inequality, largely driven by occupational segregation and their concentration in lower-paid, less formal sectors. In contrast, Kyrgyzstan and Kazakhstan exhibit comparatively narrower gender wage gaps, reflecting more balanced sectoral employment and greater female participation in higher-paying occupations (Press, 2023).

In Central Asia, female employment across agriculture, industry, and services varies significantly by country, largely shaped by each nation's economic structure. In countries like Tajikistan and Uzbekistan, women are heavily represented in the agricultural sector. In 1995, 7.53 % of the female labor force participated in the agricultural sector in Uzbekistan, increasing to 8.14 % by 2022 (WDI, 2024). Female roles in agriculture are often informal, with limited access to land ownership and high-value crops compared to men. In Central Asia, female employment in the industrial sector is limited, as these jobs often demand physical strength or specialized skills that are less accessible to women. Consequently, men occupy the majority of industrial positions (Ogasawara, 2023). In Kazakhstan, a more industrialized economy supports a slightly higher female presence in manufacturing and industry compared to other Central Asian countries. However, women continue to face limitations in accessing higher-paying or leadership roles within this sector. In 1995, 10.6 % of Kazakhstan's female workforce was employed in the industrial sector, increasing to 12.01 % by 2024 (Bureau of National Statistics of Kazakhstan, 2025). Female are increasingly employed in the service industry, particularly in sectors like retail, healthcare, and education, which are often viewed as more socially acceptable fields for female workers (Kabeer, 2021). This trend is especially pronounced in Kazakhstan and Kyrgyzstan, where urbanization and rising levels of female education contribute to higher female participation in service roles (Kredina et al., 2024). However, compared to male-dominated industries, these positions typically offer lower wages, and female frequently face barriers to advancing into management and leadership roles (Blau and Kahn, 2017).

Central Asia has a unique historical precedent of high female labor force participation, largely due to Soviet-era policies that actively promoted female employment, education, and professional development (Khitarishvili, 2016). However, following the collapse of the Soviet Union, many of these advancements eroded, leading to a resurgence of traditional gender norms that now restrict female access to stable, high-paying jobs. At the same time, the region faces a growing demographic challenge, as labor markets struggle to absorb an expanding workforce (Laruelle and Peyrouse, 2015). In countries like Tajikistan, Kyrgyzstan, and Uzbekistan, large-scale male migration for work has left female as key economic agents within their households and local economies, yet their potential remains underutilized. As Central Asian economies increasingly integrate into global trade and investment networks, female roles in the workforce are evolving, but the transition from state-controlled to market economies has created new inequalities (Mukhamediyev and Khitakhunov, 2016). Without targeted policies to support female employment in high-growth sectors, women risk being further marginalized, limiting both their economic empowerment and the region's overall development potential.

Based on the above discussion, the well-documented benefits of female labor force participation for economic growth, gender disparities remain a persistent challenge in Central Asia, particularly in Tajikistan and Uzbekistan. Traditional gender norms, sectoral segregation, and economic barriers restrict female access to stable and high-paying jobs, limiting their contribution to economic development. While previous

research has examined the relationship between female employment and economic growth, most studies have focused on developed or developing countries, overlooking the unique socio-economic conditions of Central Asian economies. In conclusion, there is significant fluctuation in female workforce participation at both aggregate and disaggregate levels across various sectors, including agriculture, industry, and services. While previous literature suggests that increased female labor force participation contributes to economic growth, it remains unclear which sector has the most significant impact. This study aims to examine the effects of female labor force participation, both at the aggregated level and disaggregated level (across specific sectors), on economic growth in Central Asian economies from 1995 to 2022. To address this, the study employs both regression analysis and dynamic analysis. Additionally, to mitigate issues of reverse causality and endogeneity, the study utilizes the system GMM model. Finally, the comprehensive findings of this study may inform valuable policy recommendations aimed at enhancing economic growth through increased female labor force participation.

The paper is structured as follows: Section 2 reviews past studies on female labor market participation and economic growth. Section 3 outlines the study's methodological approaches. Section 4 presents the results and discussion, while Section 5 concludes with policy recommendations.

2. Literature review

Women's participation in the labor force has emerged as a critical and widely debated issue in recent years. A substantial and growing body of research has examined the relationship between female labor force participation and economic growth across various national and regional contexts, highlighting its significance for inclusive and sustainable development. Khan et al. (2021) provided country-specific evidence demonstrating how increased female labor input contributes to improved national economic performance. Similarly, Jemiluyi and Yinusa (2021) offered quantitative elasticity estimates of the relationship between female labor force participation and economic growth in African economies. Meanwhile, Dahlum et al. (2022) adopted a comparative, cross-national approach to examine variations in the gender-growth nexus across different countries. Research conducted in developed countries confirms that high levels of female employment have been a significant contributor to their economic success (Sajjad et al., 2020; Ciobanu et al., 2019). Several studies suggest that promoting gender equality and enhancing women's participation in the labor force play a vital role in fostering economic growth (Akhtar et al., 2023). In addition to women's labor force participation, previous studies have explored a range of factors affecting economic growth, such as gender equality, women's entrepreneurship, human capital, physical capital, and demographic variables. Lechman and Okonowicz (2013) highlighted women's entrepreneurship and gender equity as transformative pathways for fostering socio-economic development. Kumari (2018) emphasized the relative importance of external factors—such as trade and exports—and structural drivers in shaping economic outcomes, within which women's contributions through human capital play a vital role. Meanwhile, Ibourk and Elouaouri (2023) integrated gender-related variables into broader demographic and physical capital frameworks, offering insights into the complex interplay of multiple growth determinants. Over the past several years, labor force participation has been recognized as a crucial determinant of economic growth.

2.1. Global female labor force participation and economic growth

A widely held view among scholars is that high levels of female employment constitute a key driver of economic growth in developed countries, clearly indicating that achieving high economic growth is closely linked to women's participation in the labor force. Fodor and

Glass (2018) confirms the economic benefits experienced by the European Union after the unlocking of female employment, particularly dramatic growth in Spain and Italy. Meanwhile, Wamboye et al. (2015) studied the role of female employment in thirty-nine least-developed countries, where findings highlight the need for structural changes to improve women's access to employment lead to improve the growth. Akhtar et al. (2023) revealed that more women's participation in the workforce and increased trade openness contribute to rapid economic growth in the Malaysian economy. The findings emphasize improving the institutional quality in developing countries to facilitate greater female involvement in economic progress. Moreover, the role of female employment has always been a prominent topic in developing Asian countries. For instance, Su et al. (2019) explored whether the female labor force participation rate could drive economic growth in Asian countries. The results were consistent with U-shaped, demonstrating an initial decline followed by sustained high growth rates. Gök and Ünlüoğlu (2024) conducted an empirical analysis of the FDI inflows and its impact on female labor participation in a case of 109 countries categorized into high-income and low-income, respectively. The outcomes found that FDI inflows positively and significantly affect the female workforce participation rate in low-income countries, thereby highlighting the importance of developing this sector for sustainable growth. Furthermore, given the central role of agriculture in the development of least-developed countries, women's active participation in this sector can play a vital role in fostering economic growth. Even in the absence of significant advancements in FDI and urbanization, increased female participation in agriculture can still drive economic growth. Ali et al. (2021) with impressive results in the case of Pakistan. Several studies emphasize that education plays a vital role in enhancing individuals' ability to obtain stable and meaningful employment. Such as Naftaly (2024) suggests that education positively impacts women's participation in the workforce, thereby contributing to growth patterns. Studies confirm the need for policymakers to facilitate strategies where women can adapt easily and compete equally in the job market with a man while removing any existing barriers in the process (Chiplunkar, 2024; Mohammed, 2023; Lăzăroiu et al., 2017; Fahlevi et al., 2023). The rapid expansion of urban populations contributes to the acceleration of globalization, which is considered a key factor in creating employment opportunities for women and enhancing their participation in the labor force (Nica et al., 2023; Voumik et al., 2023; Lazaroiu, and Rogalska, 2023).

2.2. Methodological advances

A range of econometric techniques has been utilized to examine the relationship between female employment and economic growth, considering the impact of other contributing factors. Different studies adopt varying regression techniques, with each producing significant findings based on the chosen analytical framework. For instance, Gök et al. (2024) investigated the impact of FDI inflows on total female employment using panel data analysis. The study applied the system GMM approach to a panel of 109 countries, which were categorized into two groups based on their levels of female labor force participation; high-performing and low-performing countries. The findings revealed a contrasting relationship across the two groups. In high-performing countries, FDI inflows had a negative and statistically significant effect on female labor force participation. Conversely, in low-performing countries, FDI inflows exerted a positive and statistically significant influence. In the case of cross-country studies, Hossain et al. (2022) found the GMM to be an effective technique. Similarly, Nica et al. (2023) applied the Quantile Regression approach to analyze the data for the last 30 years. The application of Autoregressive Distributive Lag (ARDL) techniques is widely recognized for its high reliability in confirming the existence of long-term relationships between indicators, which gave significant results in research by Voumik et al. (2023). Moreover, Irfan et al., (2022) employed fully modified OLS regression analysis along

with advanced techniques, with results supporting the findings obtained through ARDL. When it comes to analyzing the short-term relationship, particularly in time series data, ARDL remains an excellent choice (Ahmad et al., 2024a; Ruiters and Charteris., 2020) giving prominent results. In the case of cointegrated relationships, Fully Modified Ordinary Least Squares (FMOLS) is widely applied to estimate long-term relationships between economic growth and female employment (Mose, 2024; Ahmad et al., 2024b). In addition to the estimation techniques mentioned above, Han et al. (2020) utilized the Instrumental Variables method to address the endogeneity. However, some of the advanced techniques such as spatial models are notably absent leaving a significant gap for novel contributions to the literature.

2.3. Research gap

Although the link between women's employment and economic growth has been widely examined, this study offers a novel contribution by filling key gaps in the current body of research. First, the prior research that centers mainly on developed or least-developed nations, this study focuses on Central Asian economies, a region often neglected despite its distinct socio-economic characteristics and the important potential of women's contribution to economic growth. Second, while much of the existing literature examines female employment in aggregate terms, this study takes a disaggregated level, providing a deeper insight into how women's labor force participation in agriculture, industry, and services sectors influences economic growth. Third, several prior studies rely on basic econometric methods like OLS, FMOLS, or ARDL, which frequently overlook the problem of heterogeneity. In order to address this limitation, this research employs spatial econometric models combined with the system GMM approach, which enhances the robustness of the results by mitigating endogeneity and reverse causality concerns. Beyond its theoretical contributions, the study also offers actionable policy insights, guiding governments in designing gender-inclusive economic reforms, labor policies, and investment strategies that can enhance female labor force participation and drive sustainable economic growth in Central Asia.

3. Methodology

3.1. Theoretical framework

The relationship between female labor force participation and economic growth has been extensively explored in economic theory. Classical and modern growth theories suggest that labor is a fundamental driver of economic development (Lowe, 1954; and Aghion et al., 1998), while gender-based economic theories highlight the role of female employment in fostering productivity and innovation (Olu-Owolabi et al., 2020). Moreover, the endogenous growth theory emphasizes the role of human capital—especially education, skills, and labor force participation—in driving long-term economic growth (Ehrlich et al., 2017). This theory aligns with the argument that improvements in female labor force participation, particularly in higher-skilled sectors like industry and services, enhance productivity and innovation, which leads to sustained economic growth. Similarly, increasing female labor force participation enhances economic growth by expanding the workforce, improving household incomes, and fostering innovation (Halim et al., 2023). As female labor force participation increases in an economy, it enhances industrial development by expanding the productive workforce, fostering innovation, and improving overall efficiency (Ogbuabor et al., 2023). This, in turn, contributes to higher economic growth by boosting output, increasing income levels, and promoting sustainable economic development. In addition, high levels of corruption deter both domestic and foreign investment by fostering uncertainty, increasing business costs, and eroding trust in institutions, ultimately hindering economic growth (Osei-Assibey et al., 2018). Investors favor stable and transparent environments, making corruption a key driver of capital

flight.

3.2. Empirical models

This study is based on production functions, which fundamentally originate from capital and labor. The mathematical formulation is presented as follows:

$$Q = f(K, L) \quad (1)$$

Furthermore, this study emphasizes female labor force participation. Therefore, Eq. (1) is transformed into the basic Solow model, which is typically represented as:

$$Y = K^\sigma (AL)^{1-\sigma} \quad (2)$$

In Eq. (2), Y represents the output, K denotes capital, and L signifies labor. A represents affluence, indicating total factor productivity, while σ denotes the capital share in the production of a given product. Now, female labor force participation is introduced into Eq. (2) as a factor influencing the effective labor supply, as outlined below:

$$TLP = L_m + \theta L_f \quad (3)$$

In Eq. (3), TLP represents the total labor force participation of a country, where L_m denotes male labor force participation and L_f represents female labor force participation. The parameter θ captures the productivity weight of female labor relative to male labor. Thus, by combining Eqs. (2) and (3) and incorporating female labor force participation, the new production function is expressed as:

$$Y = K^\sigma (A(L_m + \theta L_f))^{1-\sigma} \quad (4)$$

In this regard, the present study empirically investigates two econometric models. The first model, presented in Eq. (5), is an aggregate model of economic growth, focusing on total female labor force participation. The second model, detailed in Eq. (2), is a disaggregated economic growth model, that examines female labor force participation across three specific sectors: agriculture, industry, and services.

The coefficients α and β represent the elasticity estimates of GDP growth (GDPG), the dependent variable measuring economic growth. The explanatory variables include TFE, representing total female employment; FDI, foreign direct investment; GFCF, gross fixed capital formation; and URB, the level of urbanization. In Eq. (6), the model is further disaggregated by sector, where FEA denotes female employment in the agricultural sector, FEI represents female employment in the industrial sector, and FES refers to female employment in the services sector. This study considers corruption as one variable to assess its impact on economic growth in the presence of female labor force participation. In highly corrupt economies, women face greater discrimination in hiring, wage negotiations, and career advancement. Such imbalances weaken government efficiency, deter investment, and ultimately hinder economic growth.

$$GDPG_{i,t} = \alpha_0 + \beta_1 TFE_{i,t} + \beta_2 GFCF_{i,t} + \beta_3 FDI_{i,t} + \beta_4 CORR_{i,t} + \beta_5 URB_{i,t} + \mu_{i,t} \quad (5)$$

$$GDPG_{i,t} = \alpha_0 + \beta_1 FEA_{i,t} + \beta_2 FEI_{i,t} + \beta_3 FES_{i,t} + \beta_4 GFCF_{i,t} + \beta_5 FDI_{i,t} + \beta_6 CORR_{i,t} + \beta_7 URB_{i,t} + \mu_{i,t} \quad (6)$$

3.3. Data description

This study utilizes annual data from 1995 to 2022 for a panel of five Central Asian economies: Uzbekistan, Kazakhstan, the Kyrgyz Republic, Tajikistan, and Turkmenistan. The key variable of interest is economic growth, measured by the annual GDP growth rate. Independent variables include total female employment as a percentage of total employment, female employment in agriculture, industry, and services,

control of corruption, the annual urban population growth rate, and gross fixed capital formation as a percentage of GDP. Data for all variables, except corruption, is sourced from the World Bank Database (WDI, 2024), while data on corruption is obtained from the Worldwide Governance Indicators (WGI, 2024). The reason for limiting our dataset to 2022 is due to the availability and consistency of sector-wise disaggregated female labor force data across all Central Asian economies. Table 1 presents a description of the variables, including their definitions and data sources.

3.4. Cross-sectional dependence test

Breusch and Pagan (1980) introduced the Lagrange Multiplier (LM) test statistic as a method for detecting cross-sectional dependence. The LM test statistic is derived by estimating the panel data model specified in Eq. (7) as:

$$Y_{i,t} = \alpha_i + \delta_i x_{i,t} + \mu_{i,t} \quad (7)$$

In this context, i represents the cross-sectional, and t denotes the time dimension. The vector $x_{i,t}$ includes the explanatory variables, while α_i and δ_i correspond to the intercepts and slope coefficients, respectively. The LM test statistic is then computed as follows:

$$LM = X \sum_{i=1}^{N-1} \sum_{j=i+1}^N \vartheta_{ij}^2 \leftrightarrow Y_{N(N-2)/2}^2 \quad (8)$$

Here, ϑ represents the sample estimate of the pairwise correlation between residuals, calculated from the individual OLS estimation of the

Table 1
Discription of the variables.

Variables	Variables Definition and their Measures	Sources
Economic Growth (GDPG)	It shows a GDP growth as an annual percentage	WDI 2024
Total Female Employment (TFE)	It measures female labor force participation as a percentage of total employment, highlighting its contribution to overall economic productivity and growth.	WDI 2024
Female Employment in Agriculture (FEA)	It is measured as female employment in the agricultural sector as a percentage of total female employment, indicating the share of female working in agriculture relative to overall female labor participation.	WDI 2024
Female Employment in Industry (FEI)	It is measured as female employment in the industrial sector as a percentage of total female employment, reflecting the proportion of female engaged in industrial activities relative to overall female labor participation.	WDI 2024
Female Employment in Services (FES)	Female employment in the services sector as a percentage of total female employment, indicating the share of female working in the services industry relative to overall female labor participation.	WDI 2024
Gross Fixed Capital Formation (GFCF)	It is measured as gross fixed capital formation as a percentage of GDP, reflecting the contribution of investments in fixed assets to overall economic expansion.	WDI 2024
Foreign Direct Investment (FDI)	It represents net inflows of foreign direct investment as a percentage of GDP, indicating the extent to which foreign investments contribute to the overall expansion of the economy.	WDI 2024
Control of Corruption (CORR)	It represents the estimated value of control of corruption, measuring the effectiveness of governance in reducing corruption and its impact on economic growth.	WGI 2024
Urbanization (URB)	It measures urban population growth as an annual percentage of the total population, indicating the rate at which the urban population is expanding relative to the overall population.	WDI 2024

above Eq. (7). However, Pesaran (2021) argues that the conventional LM test is unsuitable for large panels, especially in cases where the time dimension (X) increases to infinity before the cross-sectional dimension (N) does. For such large panels, Pesaran (2021) introduces a scaled version of the LM test, formulated in Eq. (9).

$$CD_{lm} = \sqrt{\frac{1}{N(N-1)} \sum_{i=1}^{N-1} \sum_{k=i+1}^N (X\theta_{i,k}^2 - 1)} \quad (9)$$

In this context, the CD statistic represents the test under the null hypothesis of no cross-sectional dependence. However, when N is large and X is small, the CD test can exhibit significant size distortions, affecting the reliability of its results. Pesaran (2021) proposes a test designed for panel data where both time dimension and N are infinity, regardless of the order in which they increase. Unlike the LM test, which relies on squared correlation coefficients, this approach uses pairwise correlation coefficients directly, as shown in the following Eq. (10).

$$CD = \sqrt{\left(\frac{2X}{N(N-1)}\right) \left(\sum_{i=1}^{N-1} \sum_{k=i+1}^N \vartheta_{i,k}\right)} \quad (10)$$

To address issues of heterogeneity and cross-sectional dependence in panel data analysis, particularly when studying macroeconomic factors, it is essential to test for both stationarity and CS dependency. This test can lead to biased and unreliable results, complicating the interpretation of relationships among economic variables. Consequently, advanced econometric techniques that account for CS dependency and heterogeneity are necessary for more robust and reliable findings. To assess CS dependency within the panels used in this study, four specific tests have been employed, first the Pesaran scaled LM test (2004), second the Breusch and Pagan LM test (1980), third Friedman CS dependency, and fourth Frees' dependence test. This study uses panel data which may repeat the observations for each entity and ignoring the individual effects (especially using pooled OLS) can lead to omitted variable bias. Therefore, Breusch-Pagan LM test helps to verify if such effects exist. These tests collectively provide a comprehensive examination of cross-sectional dependence within the dataset.

3.5. Unit root tests

Pesaran (2007) developed the cross-sectionally augmented IPS (CIPS) statistic, which is calculated by averaging the individual cross-sectionally augmented Dickey-Fuller test statistics across the panel. The formula for the CIPS statistic is mentioned in Eq. (11) as:

$$CIPS = \overline{(t)} N^{-1} \sum_{i=1}^N t_i \quad (11)$$

In Eq. (11), t_i represents the CADF statistic for the i^{th} cross-sectional unit, where N is the number of cross-sectional units, and t is the time dimension.

3.6. Panel cointegration test

After the checking of the unit root test, the subsequent step is to examine the presence of cointegration among the variables in both models. To achieve this, two cointegration tests have been utilized namely, the Kao residual cointegration test, and the Pedroni cointegration test. The Kao residual cointegration test, based on Kao (1999), assumes a common cointegrating vector across all panels. The second test, the Pedroni cointegration test (1999, 2004), allows for panel-specific cointegrating vectors and enables the autoregressive coefficients to differ across panels. Pedroni's method distinguishes two approaches: "between-dimension tests," based on pooled statistics, and "within-dimension tests," which rely on group panel statistics.

3.7. GMM estimation

In the dynamic system of labor economics, shifts over time—such as changes in economic policies, labor regulations, or unforeseen external shocks—introduce heterogeneity into the system. In addition, there is a potential for reverse causality between female labor force participation and economic growth. On one hand, higher economic growth can create more employment opportunities for female, encouraging greater participation in the labor market. On the other hand, an increase in female labor force participation can drive economic growth by expanding the productive workforce and enhancing overall economic productivity. Using the Pooled OLS estimator on data with inherent heterogeneity/reverse causality may lead to misleading results, as this estimator assumes uniform relationships across all observations and thus only captures average associations between variables. To address these issues, the study employs panel versions of the two-step System GMM. The two-step System GMM estimator effectively controls for the joint endogeneity of explanatory variables by utilizing internal instruments. To ensure model reliability, the presence of autocorrelation is tested following the approach by Arellano and Bond (1991), while the Sargan-Hansen test is used to check for instrument overidentification. These diagnostics help confirm the validity of the model and the appropriateness of the instrument set, ensuring robust results. The two-step version of the GMM estimator operates in the following Eqs. (12 & 13):

$$GDPG_{i,t} = \alpha_0 + \beta_1 GDPG_{i,t-1} + \beta_2 TFE_{i,t} + \beta_3 GFCF_{i,t} + \beta_4 X_{i,t} + \mu_{i,t} \quad (12)$$

$$GDPG_{i,t} = \alpha_0 + \beta_1 GDPG_{i,t-1} + \beta_1 FEA_{i,t} + \beta_2 FEI_{i,t} + \beta_3 FES_{i,t} + \beta_4 GFCF_{i,t} + \beta_5 X_{i,t} + \mu_{i,t} \quad (13)$$

where α_0 is the coefficients to be estimated in the Eqs. (8) and 9, $X_{i,t}$ is the vector of other control variables (FDI, CORR, URB).

4. Results and discussion

The primary aim of this study is to examine the impact of female labor force participation on economic growth at an aggregate level. Subsequently, the study disaggregates total female labor participation into the agricultural, industrial, and services sectors to analyze which sector's female labor force participation contributes most significantly to the economic growth of Central Asian economies. Initially, descriptive statistics are calculated for all variables, with results presented in Table 2. The mean of GDPG, TFE, CORR, FDI, GFCF, URB, FEA, FEI, and FES, is 5.38, 3.1, -1.11, 4.62, 25.8, 1.72, 39.05, 13.20, and 47.7 respectively.

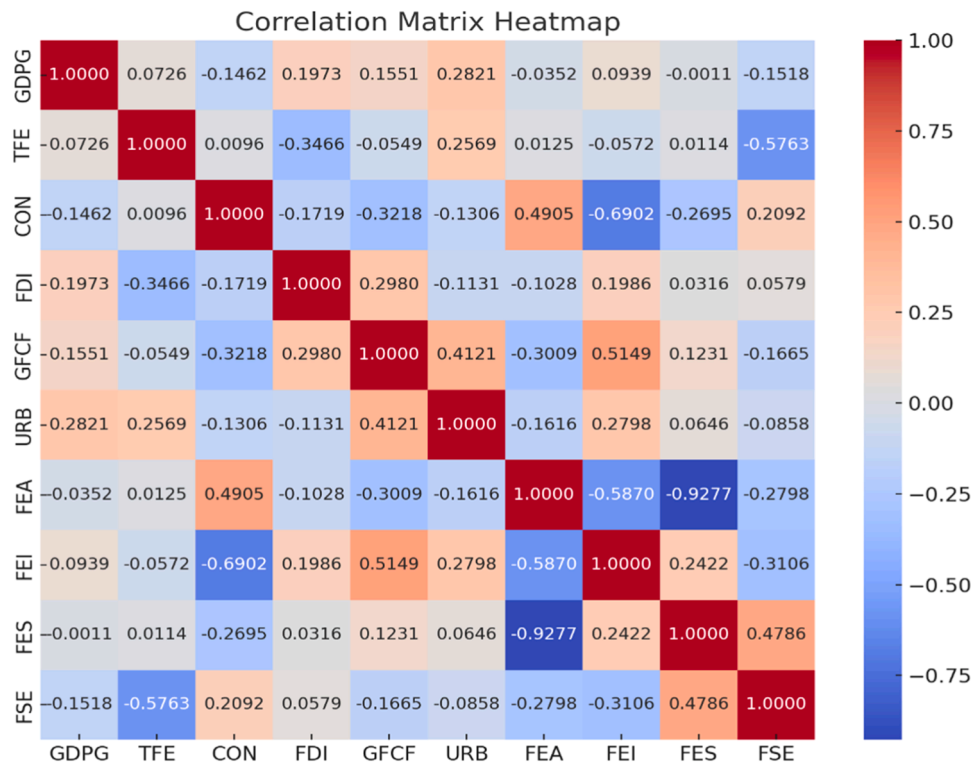
Table 3 presents the results of the correlation matrix, used to assess potential multicollinearity among variables. The findings confirm that none of the variables are strongly correlated over time, indicating minimal risk of multicollinearity that could bias regression outcomes. These results support the decision to proceed with further analysis to achieve the study's objectives. Additionally, Fig. 1 shows the heatmap of

Table 2
Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
GDPG	140	5.377673	4.869147	-16.7	16.5
TFE	140	3.091406	2.706595	0.3393557	8.348298
CORR	140	-1.114256	.2876677	-1.445981	1.04823
FDI	140	4.629371	4.048154	-4.854847	22.52356
GFCF	140	25.89282	9.929263	6.295737	68.18716
URB	140	1.727877	1.074683	-2.02448	3.777233
FEA	140	39.05426	17.96885	11.13309	79.42043
FEI	140	13.20253	6.916143	4.423935	27.27927
FES	140	47.74321	14.99371	15.93917	76.87029

Table 3
Correlation matrix.

	GDPG	TFE	CORR	FDI	GFCF	URB	FEA	FEI	FES
GDPG	1.0000								
TFE	0.0726	1.0000							
CORR	-0.146	0.0096	1.0000						
FDI	0.1973	-0.346	-0.171	1.0000					
GFCF	0.1551	-0.054	-0.321	0.2980	1.0000				
URB	0.2821	0.2569	-0.130	-0.113	0.4121	1.0000			
FEA	-0.035	0.0125	0.490	-0.102	-0.300	-0.161	1.0000		
FEI	0.0939	-0.057	-0.690	0.1986	0.5149	0.2798	-0.587	1.0000	
FES	-0.001	0.0114	-0.269	0.0316	0.1231	0.0646	-0.927	0.2422	1.0000

**Fig. 1.** Heatmap of correlation matrix.

the correlation matrix.

The results of cross-sectional dependence are presented in Table 4. This study employed three distinct cross-sectional dependence tests: the Breusch-Pagan LM and Pesaran tests, the Friedman test, and the Frees test. Findings from these tests indicate that the alternative hypothesis of no cross-sectional dependence is accepted at the 1 % and 10 % significance levels. These results suggest that shocks occurring in one Central Asian country may be transmitted to other countries in the region.

The next step in the panel data analysis involves testing for the order of integration. To achieve this, three unit root tests were applied: the Breitung and Das test, the CIPS test, and Pesaran's unit root test. The results, summarized in Table 5, show a mixed order of integration. Specifically, GDPG and FEI are stationary at the 1 % and 10 % significance levels, respectively, while the remaining variables become stationary after first differencing, at the 1 %, 5 %, and 10 % significance

Table 4
Cross-sectional dependence.

Cross sectional Dependency Tests	Test Values	P-values
Breusch-Pagan LM and Pesaran Test	5.094	0.0000
Friedman Test	49.439	0.0000
Frees' Test	0.161	0.0924

levels. Given this mixed order of integration, the analysis can proceed with panel estimations.

Following the stationarity tests for all variables, the next step is to examine the existence of a long-run relationship among the variables. This study employs two-panel cointegration tests, namely, those developed by Pedroni (1999, 2004) and Kao (1999). The results, presented in Table 6, show the outcomes of the Kao and Pedroni cointegration tests for both the aggregated and disaggregated forms of Eqs. (1) and (2), as outlined in the methodology section. Both tests indicate that for each group, the null hypothesis of no cointegration is rejected at the 1 % or 5 % significance level, confirming a long-term association in both equations.

This study employs both regression and dynamic analysis methods. For the regression analysis, three approaches are used: POLS, fixed effects, and random effects models. For the dynamic analysis, the two-step system GMM is applied. Table 7 presents the regression results for the aggregated model, while Table 8 shows the results at the disaggregated level. In the POLS model, the variables TFE, FDI, and URB are statistically significant at the 1 % and 5 % levels, positively influencing economic growth. The results indicate that a 1 % increase in total female labor force participation corresponds to a 51 % increase in economic growth in Central Asian economies. The literature suggests that female

Table 5
Unit root tests.

Variables	Level			First Difference		
	Breitung and Das	IPS	Pesaran	Breitung and Das	IPS	Pesaran
GDPG	−0.7252	−6.5694***	−3.833***	−1.5952**	−9.6837***	−5.366***
TFE	−1.7663	−1.8138	−1.860	−1.9788*	−4.2510***	−2.165*
CORR	−0.7310	−0.0064	−1.344	−4.6478***	−4.7687***	−3.500***
FDI	−2.0709	−0.4003	−2.289	−6.2710***	−7.2647***	−4.378***
GFCF	−0.5482	0.6817	−1.997	−2.4418***	−3.5595***	−3.724***
URB	−0.4725	−0.3781	−2.033	−1.5889*	−5.6121***	−3.286***
FEA	−0.2394	−0.4204	−2.061	−1.1558*	−1.6232*	−2.054*
FEI	−0.3023	−1.7300*	−1.671	−1.2936*	−2.5207**	−3.091***
FES	−0.1636	0.2275	−1.869	−1.1105*	−1.0384*	−2.614**

Note: ***, **, and * shows a 1, 5 and 10 percent level of significant.

Table 6
Kao and Pedroni cointegration tests.

Kao Cointegration Test		
	Statistic	P-value
Modified Dickey–Fuller t	−6.9025	0.0000
Dickey–Fuller t	−8.5354	0.0000
Augmented Dickey–Fuller t	−6.4097	0.0000
Unadjusted modified Dickey–Fuller t	−13.5102	0.0000
Unadjusted Dickey–Fuller t	−9.8647	0.0000
Pedroni Cointegration Test		
Modified Phillips–Perron t	1.8455	0.0325
Phillips–Perron t	−3.5664	0.0002
Augmented Dickey–Fuller t	−4.4075	0.0000

Table 7
Panel regression analysis results of aggregated model.

Variables	Aggregated POLS	Aggregated FE	Aggregated RE
TFE	0.510*** (2.30)	0.402* (1.70)	0.510* (1.76)
CORR	−5.235*** (−3.34)	−6.904*** (−4.27)	−5.235*** (−3.72)
FDI	0.273** (2.13)	0.166** (2.31)	0.273*** (2.60)
URB	1.408*** (2.82)	1.964*** (3.81)	1.408*** (3.41)
GFCF	−0.031* (−1.75)	−0.021 (−0.41)	−0.031* (−1.66)
Constant	−2.958 (−0.99)	−7.400 (−1.54)	−2.958 (−1.05)
Observations	140	140	140
R-squared	0.741	0.824	0.782

Robust t-statistics in parentheses.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

labor force participation enhances the effective labor supply, boosting production and economic output (Klasen and Pieters, 2015). Su et al. (2019) found similar outcomes, supporting the present study's results. While FDI brings capital, technology, and expertise to the domestic market, it fosters industrial growth and drives economic development (Mody, 2004). Moreover, urbanization improves access to education, healthcare, and jobs, enhancing human capital, which directly and indirectly boosts a country's economic growth (Nguea, 2023). Similar results were reported by Yuldashev et al. (2023). However, it remains unclear which specific sector of female labor force participation—agriculture, services, or industry—contributes most to economic growth. This sectoral breakdown will be explored in the next table (Table 8). Additionally, the coefficient for corruption is statistically significant at the 1 % level and negatively impacts economic growth in Central Asian economies. The results indicate that a 1 % increase in corruption is associated with a 52 % decrease in economic growth in this region. Corruption creates uncertainty, discouraging domestic and

Table 8
Panel regression analysis results of disaggregated model.

Variables	Disaggregated POLS	Disaggregated FE	Disaggregated RE
FEA	0.057** (1.94)	0.014 (0.17)	0.057* (1.73)
FEI	−0.172* (−1.75)	−1.827*** (−4.79)	−0.172* (−1.74)
FES	0.172* (1.75)	1.827*** (4.79)	0.172* (1.74)
CORR	−5.357*** (−4.18)	−6.496*** (−4.46)	−5.357*** (−3.71)
FDI	0.295** (2.35)	0.144 (1.36)	0.295*** (2.91)
URB	1.509*** (3.25)	2.638*** (5.22)	1.509*** (3.85)
GFCF	−0.023 (−0.56)	0.024** (2.53)	0.023** (2.49)
Constant	2.256 (0.62)	18.199** (2.53)	2.256 (0.63)
Observations	140	140	140
R-squared	0.632	0.625	0.701

Robust t-statistics in parentheses.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

foreign investment, which slows economic growth in Central Asia (Pomfret, 2021). The recent study by Uddin et al. (2023), which examined a panel of 65 countries, also found a negative impact of corruption on economic growth. These results align closely with our findings, further reinforcing the adverse effect of corruption on economic development across diverse economies. Lastly, the coefficient of gross fixed capital formation is marginally significant and shows a negative impact on economic growth in Central Asian countries in the aggregated model. This unexpected negative association may be attributed to inefficiencies in capital allocation, where investments are not directed toward productive sectors or are undermined by weak governance and institutional quality (Akobeng, 2017). As a result, gross fixed capital formation fails to translate into sustainable economic growth in the region.

Table 8 presents the results of disaggregating total female labor force participation into the agricultural, services, and industrial sectors. The findings indicate that female labor force participation in the agricultural and services sectors has a statistically significant and positive impact on economic growth. This implies that increased female participation in these sectors contributes positively to the economic growth of Central Asian economies. In most Central Asian countries, agriculture and services are key drivers of economic activity. In nations where agriculture constitutes a significant share of GDP, higher female participation in this sector can enhance agricultural productivity, leading to increased food production and rural development (Gollin, 2010). Similarly, the services sector often experiences rapid expansion in developing economies like those in Central Asia. Female participation in this sector can support various industries, including education, healthcare, trade, and tourism,

generating value-added income and driving economic modernization (Lechman and Popowska, 2020). However, female labor force participation in the industrial sector is statistically significant at the 1 % and 10 % levels, showing a negative impact on the economic growth of Central Asian economies. The results suggest that an increase in female labor force participation in the industrial sector is associated with a decline in economic growth in these economies. The industrial sectors in Central Asian economies may still suffer from low productivity, driven by outdated technologies, inefficient management practices, and limited innovation. Female are often concentrated in low-skilled, low-wage roles within these industries, which contribute minimally to overall economic growth. This occupational segregation limits their productivity and economic potential, as these roles typically involve limited access to training, technology, and upward mobility (Borrowman and Klasen, 2020). Moreover, such employment is often informal or precarious in nature, offering minimal job security, social protection, or long-term career development. Consequently, even as female labor force participation increases numerically, its impact on economic growth remains constrained due to the underutilization of women's capabilities in more productive and high-value-added sectors (Kabeer, 2021; Khan et al., 2025). Furthermore, FDI, urbanization, and investment positively influence the economic growth of Central Asian economies. In contrast, corruption exerts a negative impact, hindering sustainable development and economic progress in the region.

This study employs the two-step system GMM approach to address the issues of endogeneity and reverse causality. Female education is utilized as an instrumental variable to strengthen the analysis. The findings from the GMM estimation are consistent with the results obtained through standard regression analysis, providing robust evidence. In Table 9, Column 1 presents the results for the aggregate level of total female employment, which demonstrates a positive impact on economic growth in Central Asian economies. Column 2 disaggregates total female employment into three sectors: agricultural, industrial, and services. The results reveal that female employment in the agricultural and services sectors contributes positively to economic growth in Central Asia. However, female employment in the industrial sector is found to have a

negative impact on economic growth. Diagnostic tests further validate the strength and reliability of the instruments used. The Kleibergen-Paap rk LM statistic confirms that the model is not under-identified, while the Cragg-Donald Wald F statistic indicates that the instruments are sufficiently strong. Together, these tests underscore the robustness of the model in addressing potential endogeneity issues.

5. Conclusion and policy suggestions

The study addresses the significant fluctuations in female labor force participation and the unstable economic growth observed in Central Asian economies. Specifically, it aims to examine the impact of female labor force participation—both at an aggregate level and across disaggregated sectors such as agriculture, industry, and services—on economic growth in the region from 1995 to 2022. To achieve this, the study employs both regression and dynamic analytical approaches. For the regression analysis, it utilizes pooled OLS, fixed effects, and random effects models to estimate the relationships. Furthermore, to address potential issues of reverse causality and endogeneity, the study adopts the system GMM model, ensuring more robust and reliable results. Three different stationarity tests were employed in the analysis: the Breitung and Das test, the IPS test, and the Pesaran test. The results from these tests indicate a mixed order of integration, with variables being stationary at both levels and first differences. At the aggregate level, the findings from both the regression analysis and the system GMM model demonstrate that total female labor force participation positively impacts the economic growth of Central Asian economies, while corruption exerts a negative influence on growth. However, at the disaggregated level, the results reveal sector-specific variations: female labor force participation in the agricultural and services sectors significantly enhances economic growth, whereas participation in the industrial sector negatively impacts economic growth in the region.

Central Asian governments should prioritize investments in tailored training programs and microfinance initiatives to empower female in the agriculture and services sectors. These programs should aim to enhance productivity, foster entrepreneurship, and promote sustainable growth in these high-potential areas. Additionally, vocational training programs must be developed to equip women with the skills required for higher-value roles in the industrial sector, enabling them to contribute more effectively to economic development. To further support female labor force participation in the industrial sector, it is essential to implement workplace reforms that promote gender equity. Policies such as enforcing equal pay, providing comprehensive maternity benefits, and ensuring safe working conditions will make industrial jobs more accessible and appealing to women. Most importantly, policymakers should address the pervasive issue of corruption, which negatively impacts economic growth. Implementing robust anti-corruption measures, such as e-governance platforms, can enhance transparency, accountability, and the efficient utilization of resources, thereby fostering a more inclusive and growth-oriented economic environment.

This study has several research limitations. First, although this study covers the period from 1995 to 2022, the availability of data (particularly regarding disaggregated female employment by sector) vary across countries and years. This inconsistency may affect the robustness and comparability of the estimations. Second, while we used system GMM approach to address endogeneity concerns, the reliability of the results depends on the validity of the instruments and the assumption of no second-order serial correlation. These methodological assumptions may not be fully satisfied in all cases, which could influence the accuracy of the findings. In addition to this, the current study also offers several gaps for future research. First, this study provides the important insights on the relationship between female labor force participation and economic growth in Central Asia, it is important to note that the results represent average regional effects. The Central Asian economies differ significantly in their structural characteristics. For instance, Tajikistan and Uzbekistan have relatively low female labor force participation rates

Table 9
Two-step system GMM results.

Variables	Aggregated	Disaggregated
L.GDPG	0.579*** (5.54)	0.484*** (4.29)
TFE	0.490*** (2.29)	
FEA		0.008** (2.65)
FEI		−0.041*** (−2.91)
FES		0.041*** (2.91)
CORR	−1.476*** (−5.22)	−1.800*** (−5.54)
CON	−0.461*** (−3.28)	−0.641*** (−3.82)
FDI	0.004** (2.06)	0.050** (2.71)
GFCF	−0.020** (−2.49)	−0.022*** (−2.71)
URB	−0.032 (−0.22)	0.035 (0.23)
Constant	1.612* (1.97)	2.969*** (2.98)
Kleibergen-Paap rk LM statistic	21.210 (0.0000)	14.314 (0.0005)
Cragg-Donald Wald F statistic	3501.0	1614.92
Arellano-Bond Test (1)	0.000	0.003
Arellano-Bond Test (2)	0.326	0.739

t-statistics in parentheses.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

and wider gender disparities, whereas Kazakhstan exhibits much higher participation rates. Such heterogeneity may lead to variations in the strength and even the direction of the estimated relationships across countries. Although the empirical strategy of this study accounts for potential cross-sectional dependence to address common shocks and regional spillovers, it does not fully capture these structural differences. Future research should focus on the country-specific analyses could provide a more nuanced understanding of the mechanisms at work. Second, further research could examine the role of informal and unpaid female labor (particularly in rural and agricultural sectors) which is often underrepresented in official statistics but constitutes a significant portion of women's economic contributions. Incorporating these dimensions would provide a more comprehensive and nuanced understanding of the gender-growth nexus in the region.

CRedit authorship contribution statement

Zebo Kuldasheva: Software, Resources, Methodology. **Maaz Ahmad:** Writing – original draft, Investigation, Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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