

DETERMINANTS OF FEMALE LABOR FORCE PARTICIPATION IN SELECTED CIS COUNTRIES

Nigar Huseynli

*Assistant Professor, Department of Economic and Technological Sciences,
Azerbaijan State University of Economics (UNEC)
ORCID: 0000-0001-7817-6485*

ABSTRACT

Today, women's participation in the labor force remains at lower levels compared to men. In this study, the effects of female labor force participation (FLFP) on economic development are examined by considering selected Commonwealth of Independent States (CIS) member countries. This study examines various factors affecting women's labor force participation. In particular, the impact of factors such as economic growth and unemployment on female labor force participation is one of the widely discussed topics in the literature. However, in this study, more specific socioeconomic factors such as education level (undergraduate and postgraduate), fertility rate, urbanization level, and the share of wage and salaried workers that may affect female labor force participation were also considered and analyzed. The study was conducted on data collected for CIS countries between 2002-2023, and Granger causality test was used in the empirical analysis. The findings show that there are significant relationships between some factors, while no significant causality relationship was found between other factors. This situation shows that women's labor force participation is a multidimensional phenomenon, and the impact of each factor may occur in different ways. In addition, the results emphasize that a careful approach should be adopted in the design of policies and strategies.

Keywords: *female labor force participation, labor economics, CIS countries, Granger causality*

JEL Classification: J16, J21, J22, J24, C33

INTRODUCTION

Economic development is important for the continuity, prosperity, and stability of societies. It is possible to say that the workforce plays an important role in ensuring development. Women constitute half of the world's population. The presence of women in labor markets, which constitute a significant portion of the workforce, is important in ensuring development. In order to ensure sustainable development on a global or regional scale, women need to take part in labor markets by using their qualities and talents. It is possible to say that productivity potential is more effective in countries where women are more involved in labor markets.

Women have participated in economic activities in various forms and statuses throughout history, depending on the conditions and characteristics of each period. Women's participation in working life as paid workers only occurred with the Industrial Revolution. Women's

participation in the labor market as paid workers brings with it many problems. Women who show their presence in the labor market are subject to discrimination by employers due to their gender. Due to the prejudice that women's basic characteristics will prevent many jobs from being done, women can face intense obstacles and difficulties when they apply for jobs that do not fit their gender roles.

The direct or indirect impact and importance of educated women on society can be understood by their success in the business field and the values they bring to the country. It is known that the market before today was subject to a patriarchal system and that women worked more in areas such as labor and cheap labor in the sector. In order to develop a qualified, ahead of the times society and to have a sustainable life, and it is important for them to be employed for this.

Countries where women are not included in the labor market will not be able to achieve sustainable development. The increasing influence of women in working life has positive effects on economic growth and the value and position of women in society and family, thus contributing to the socio-cultural development of a country (Parlaktuna, 2020). Women experiencing discrimination is both a violation of human rights and an obstacle to economic development. After the industrial revolution, it is seen that discrimination in this regard has decreased and the principle of equality has been adopted with the regulations made in the economy and working life. However, despite these regulations, discrimination continues for different reasons (Dalkıranoglu, 2006). In order for women to work actively in the business field, it is necessary to prevent discrimination and favoritism.

In general, it is well established that many factors affect female labor force participation. This study focuses on a limited but theoretically motivated set of these factors: education level (undergraduate and postgraduate), the share of wage and salaried workers, the urbanization rate, and the fertility rate. In this study, the relationship between these factors and FLFP was examined for four selected CIS countries: Azerbaijan, Moldova, Russia, and Uzbekistan. These four countries were selected because (i) they provide a continuous, comparable World Bank time series for all study variables over 2002-2023, which is not available for every CIS member state, and (ii) together they represent distinct sub-regions of the CIS space (South Caucasus, Eastern Europe, and Central Asia), so that the diversity of post-Soviet labor market trajectories is reflected in the sample. The study consists of introduction, theoretical background, methodology, empirical analysis, and conclusion sections. In the theoretical background section, prior studies on the determinants of FLFP are reviewed and the specific hypotheses tested in this study are introduced. Finally, an evaluation is made in light of the empirical findings in the conclusion section. The study aims to contribute to the literature by examining the predictive relationships between the selected factors and FLFP for this group of CIS countries using the Granger causality framework.

THEORETICAL BACKGROUND

The literature on female labor force participation (FLFP) spans several theoretical and empirical strands. This section reviews that literature thematically, organized around the

specific determinants examined in this study, rather than study by study, and concludes by identifying the gap that the present study addresses.

Theoretical foundations

Human capital theory provides the central theoretical starting point for this study: individuals earn more and perform better in the labor market as a result of the knowledge and skills acquired through education and work experience, which raises the opportunity cost of remaining outside the labor force (Becker, 1964). A complementary strand of theory examines gender discrimination directly. Esteve-Volart (2004) modelled gender discrimination as either the complete exclusion of women from the labor market or their exclusion from managerial positions and showed that both forms reduce economic growth: the former by lowering GDP per capita directly, and the latter by distorting the allocation of talent between managerial and unskilled positions. In both cases, discrimination is associated with lower female schooling relative to men, reinforcing the theoretical link between education and FLFP that motivates this study's first hypothesis. A separate strand of the literature considers the relationship running in the other direction: several studies frame women's economic participation and broader social development as mutually reinforcing, with rising development strengthening women's economic and social status, which in turn feeds back into further development (Şimşek, 2008).

Education and female labor force participation

A substantial body of research documents a positive association between women's education and their labor force participation. Karabıyık (2012) and Özer and Biçerli (2003) find that women's workforce participation closely tracks their educational attainment and identify two theoretical channels: individuals with higher education can command higher wages, which raises the cost of staying out of the labor market, and education itself represents an investment whose costs are recouped through labor market entry. Besamusca et al. (2015) similarly document women's economic contribution across a large cross-country sample. King and Hill (1993) extend this argument to the societal level, arguing that women's education benefits not only individuals but families and society as a whole, and that depriving women of education imposes broader social costs. Özsoy (2012) links rising female education directly to poverty reduction and GNP growth. At the country level, Abdulloev, Gang, and Yun (2014) examine the joint role of international migration and education in shaping the gender gap in labor force participation in Tajikistan and find that both factors are significantly associated with the gap, underscoring that the education-FLFP relationship can be moderated by other structural factors such as migration.

Fertility and female labor force participation

Fertility is one of the most consistently studied determinants of FLFP, generally found to reduce participation through the time and care demands of childbearing and childrearing. De la Rica and Ferrero (2003), studying married women in Spain, show that failing to account for unobserved characteristics affecting both fertility and participation decisions biases estimates of fertility's effect downward, understating its true negative impact on participation. Lee and Lee (2014) reach a comparable conclusion for Japan, showing that regional variation in births

is associated with variation in women's subsequent labor market activity, and that access to childcare moderates this relationship.

Urbanization, household structure, and female labor force participation

The relationship between urbanization and FLFP is more context-dependent in the literature than the relationship for education or fertility. Korkmaz (2012) highlights that rural and urban women face structurally different participation decisions: unpaid family workers in rural areas can often combine childcare with work, whereas urban women must weigh the wage they can earn against the cost of paid childcare, making urban participation more sensitive to relative wages and childcare costs. Kızılgöl (2012) finds that education, household income, dependency ratios, home ownership, and age all shape the participation of married and single women differently in urban versus rural areas, and that having children reduces participation in urban areas while increasing it in rural areas, consistent with Korkmaz's (2012) argument about differing childcare arrangements. Evidence from urban China further shows that urban FLFP trends are not uniform: Maurer-Fazio, Hughes, and Zhang (2007) find that urban labor force participation rates fell for both genders between 1990 and 2000, but fell faster for women, and faster still for ethnic-minority women, indicating that urbanization interacts with ethnicity and gender rather than having a uniform positive or negative effect on FLFP.

Wage employment, economic structure, and female labor force participation

Cooray, Gaddis, and Wacker (2012) examine the effect of foreign direct investment (FDI) and trade openness on FLFP across 80 developing countries and find, contrary to much of the country-case-study literature, that both FDI and trade are generally associated with lower FLFP. This result illustrates that broader economic integration does not automatically translate into higher female employment, and that the relationship between economic structure and FLFP depends on the specific channels through which integration affects labor demand. In the CIS context specifically, Huseynli (2023) documents the close relationship between foreign investment, capital accumulation, and oil and gas sector revenues in Azerbaijan, illustrating that CIS labor markets are shaped by a distinct mix of local, foreign, and joint-venture employers, a structural feature that may condition how wage employment translates into FLFP in this study's sample. At the individual level, Croda, Ekaterini, and Ioannis (2011), using German panel data for 1990-2007, find that married women's participation decisions show strong persistence over time (state dependence) alongside significant fertility effects, while temporary and permanent non-labor income have comparatively small effects, evidence that once women enter or exit the labor force, economic incentives alone are not the only, or even the primary, determinant of their subsequent participation.

Structural change and the feminization-U hypothesis

A separate literature examines whether FLFP follows a predictable trajectory as economies develop. Gaddis and Klasen (2014) re-examine the widely cited "feminization U" hypothesis, which posits that FLFP first falls and then rises over the course of economic development, structural change, and rising education. They find that empirical support for a universal U-shaped pattern is weak and highly sensitive to the data and estimation method used and conclude that there is no single "iron law" governing FLFP; instead, initial conditions,

social norms, sector-specific structural change, and policies that directly promote female employment are more important drivers than any presumed secular development path. This finding motivates the country-specific, rather than pooled, approach taken in the present study. Related to this, Ganguli, Hausmann, and Viarengo (2014) examine gender gaps in education and labor force participation across 40 countries and find considerable cross-country heterogeneity in the size and evolution of these gaps; critically, they show that the labor force participation gap cannot be fully explained by the education gap alone, reinforcing the case for examining multiple determinants jointly, as this study does.

Regional and cross-cutting evidence

Some studies extend the analysis of women's economic participation beyond direct labor market indicators. Özdemir, İlkay, and Seda (2012) examine female employment in the context of transition economies, directly relevant to the CIS setting of this study, and emphasize that transition-specific institutional changes shaped women's employment trajectories differently than in market economies with a longer history. Du et al. (2022) extend the concept of women's independence beyond the labor market to environmental decision-making in China, finding that while women can exercise substantial "political wisdom", their formal political power remains limited, a reminder that labor market participation is only one dimension of women's broader economic and social autonomy, and that the FLFP determinants examined in this study should not be read as a complete account of women's economic empowerment.

Synthesis and research gap

Taken together, the literature reviewed above shows a reasonably consistent, theoretically grounded expectation that education raises FLFP and fertility lowers it, operating primarily through opportunity-cost and time-constraint mechanisms, respectively. In contrast, the effects of urbanization and of wage employment and economic integration on FLFP are considerably less consistent across studies and country contexts, depending on how urbanization interacts with childcare arrangements, ethnicity, and local labor demand, and on the specific channel (FDI, trade, or domestic wage employment) considered. The feminization-U literature further indicates that FLFP does not follow a single universal development path, strengthening the case for country-specific rather than pooled analysis. However, the great majority of the empirical studies reviewed above focus either on a single, non-CIS country (Türkiye, Spain, Japan, Germany, China, Tajikistan) or on large, heterogeneous cross-country panels; comparative, country-by-country time-series evidence on the determinants of FLFP for post-Soviet CIS economies specifically is scarce. This is the gap the present study addresses: by applying a common empirical framework, ADF unit root testing, Johansen cointegration, and Granger causality within a VAR, to four CIS countries individually, this study provides comparative, country-specific evidence on the predictive relationships between education, fertility, urbanization, and wage employment on the one hand and FLFP on the other, for a region that remains underrepresented in this literature.

METHODOLOGY

Data set

This study examined the predictive relationship between FLFP and various socioeconomic factors. In particular, the effects of women's educational attainment (at least completed lower secondary, and at least Bachelor's or equivalent), the fertility rate, the urbanization rate, and the share of wage and salaried workers on FLFP were investigated. The dataset used in the study covers the period 2002-2023 and was obtained from the World Bank platform. In this context, the aim was to analyze the predictive relationships between these factors and FLFP.

Although it was initially intended to include all countries in the CIS group, data sets for some countries were not available. Therefore, only four CIS countries were included in the analysis. Despite this limited data set, the findings are considered important in understanding the effects on the female employment rate. Despite the lack of data, the study aims to evaluate the effects of socioeconomic factors on female labor force participation through analysis conducted on certain countries.

Analysis method

The Granger causality test is a statistical method that analyzes the ability of a variable to predict the future values of another variable in time series data. This test is used to determine whether there is a causal relationship between two time series. Granger (1969) emphasized the importance of examining the causal relationship between variables in econometric modeling in the 1960s when he developed this method. Although the Granger causality test is aimed at detecting a statistical relationship, it requires a careful approach in terms of correctly revealing causality.

The equations below represent a general structure used to describe the relationship between two time series. Such equations are particularly used in time series analysis, such as the Granger causality test. Both equations contain observations where a variable (y_t and x_t) is dependent on the values of previous time periods and on each other.

$$y_t = \sum_{i=1}^n a_i x_{t-i} + \sum_{j=1}^n \beta_j y_{t-j} + u_{1t} \quad (1)$$

$$x_t = \sum_{i=1}^n \lambda_i x_{t-i} + \sum_{j=1}^n \delta_j y_{t-j} + u_{2t} \quad (2)$$

In the Equation 1, y_t is modeled depending on the lagged values of x_t and the previous y_t . Here:

- The coefficients x_{t-i} and a_i indicate how y_t has responded to past values of x_t .
- $\sum_{j=1}^n \beta_j y_{t-j}$, i_t expresses how past y_t values affect y_t .
- U_{1t} is the error term of the model and represents the random effects in the system.

The Equation 1 similarly models x_t depending on the past values of x_t and y_t .

Here:

- $\sum_{i=1}^n \beta_i y_{t-i}$, i_t describes how x_t is affected by previous values of x_t .
- $\sum_{j=1}^n \delta_j y_{t-j}$ shows how past y_t values affect x_t .
- U_{2t} represents the error term of the model.

Such equations show the dynamic relationship between two variables. In the first equation, it is stated that the variable y_t depends on x_t and past y_t values, while in the second equation, it is stated that the variable x_t depends on past x_t and y_t values. In such models, the Granger causality relationship of each variable on the other can be tested.

For example:

- If past values of x_t significantly predict y_t , then x_t can be considered as Granger cause of y_t .
- Similarly, if past values of y_t also significantly predict x_t , then y_t can be considered as Granger cause of x_t .

Granger causality testing uses statistical tests such as t-tests and F-tests to determine whether such a causal relationship exists.

It should be emphasized that Granger causality is a statistical, predictive concept: it tests whether the past values of one variable improve the prediction of another variable's future values, not whether one variable is the structural or “real” cause of the other in an economic sense. Findings from this test are interpreted accordingly throughout this study.

Based on the theoretical background above, the study tests the following variable-specific hypotheses regarding predictive (Granger) relationships with FLFP:

- H_1 : *Higher education (undergraduate and postgraduate attainment) is expected to Granger-cause higher FLFP, as higher education raises the opportunity cost of not working (Becker, 1964; Özer, & Biçerli, 2003).*
- H_2 : *A higher fertility rate is expected to Granger-cause lower FLFP, reflecting the time and care burden associated with childbearing (De la Rica, & Ferrero, 2003; Lee, & Sing, 2014).*
- H_3 : *Urbanization is expected to Granger-cause higher FLFP, through greater access to job opportunities and infrastructure in urban areas (Kızılgöl, 2012).*
- H_4 : *A higher share of wage and salaried workers is expected to Granger-cause higher FLFP, and a bidirectional relationship is plausible as rising FLFP can itself expand the wage-employed workforce.*
- H_5 : *For each hypothesis, the corresponding null hypothesis (H_0) is that the variable does not Granger-cause FLFP.*

ANALYSES AND RESULTS

In this study, the predictive relationship between female labor force participation (FLFP) and various socioeconomic factors was examined. In particular, the effects of education level (at least Bachelor's or equivalent, and at least completed lower secondary), the share of wage

and salaried workers, the fertility rate, and the urbanization rate on FLFP were analyzed. The data set was obtained from World Bank data for the period 2002-2023 for the selected CIS countries (Azerbaijan, Moldova, Russia, and Uzbekistan). In the first step, the stationarity status of each time series was examined using the ADF (Augmented Dickey-Fuller) test. This test checks whether the series have a constant mean and variance over time. As a result, it was determined that the series for Azerbaijan, Moldova, and Russia became stationary after first differencing, i.e., they are integrated of order one, $I(1)$. For Uzbekistan, however, some series (notably the education-attainment variables) only became stationary after second differencing, i.e., $I(2)$. Because the Johansen and standard Granger framework assumes variables are integrated of the same, typically $I(1)$, order, the presence of $I(2)$ variables in the Uzbekistan data is a methodological limitation: cointegration and causality results for Uzbekistan should be interpreted with additional caution, since $I(2)$ variables can distort estimated long-run relationships if not treated separately (e.g., via a second-difference and $I(2)$ cointegration procedure).

After determining that the series were stationary, the Johansen cointegration test was applied to examine the existence of long-run relationships among the variables. The Johansen test determines whether the time series share a common long-run equilibrium relationship. Subsequently, the Granger causality test was employed to investigate the direction of causal relationships between female labor force participation and other socioeconomic factors. Since the primary objective of this study is to identify long-run relationships and the direction of causality rather than to estimate the dynamic responses of the variables, a separate VAR model was not estimated. This approach is considered sufficient to address the research objectives.

In this study, it is first necessary to determine whether the data are stationary before conducting the cointegration and Granger causality analyses. Therefore, the Augmented Dickey-Fuller (ADF) test was employed to examine the stationarity properties of the variables and to determine their order of integration.

According to the test results obtained, the ADF test statistic was found to be smaller in absolute value than the critical values at 1%, 5% and 10% significance levels. In this case, it was concluded that the series were not stationary. In other words, the test results show that the series did not have stationarity properties at the level value. When considered in this context, we observe that no series is stationary at the level value for the selected countries. This situation shows that the data must be made stationary in order for the model to be valid, and therefore stationarity must be achieved by taking the first difference in the data. Information on the level values is provided in Tables 1-4.

Table 1. Stationarity values of series for Azerbaijan

Level of Stagnation													
		Female employment		Fertility rate		Wage and salaried workers		Educational attainment, at least Bachelor's or equivalent		Educational attainment, at least completed lower secondary		Urban population growth	
		t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.
ADF testing statistics		-2.191670	0.2152	-0.737890	0.8148	-3.343826	0.0894	2.879508	1.0000	-0.192540	0.9215	-0.787376	0.8010
Test Critical Values	%1	-3.831511		-3.808546		-4.535298		-3.920350		-3.920350		-3.808546	
	%5	-3.029970		-3.020686		-3.673616		-3.065585		-3.065585		-3.020686	
	%10	-2.655194		-2.650413		-3.277364		-2.673460		-2.673460		-2.650413	
First Order Stationarity Levels													
		Female employment		Fertility rate		Wage and salaried workers		Educational attainment, at least Bachelor's or equivalent		Educational attainment, at least completed lower secondary		Urban population growth	
		t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.
ADF testing statistics		-2.889572	0.0063	-5.519023	0.0003	-3.364031	0.0260	-7.825592	0.0000	-4.089036	0.0072	-3.691417	0.0140
Test Critical Values	%1	-2.692358		-3.831511		-3.831511		-3.857386		-3.920350		-3.857386	
	%5	-1.960171		-3.029970		-3.029970		-3.040391		-3.065585		-3.040391	
	%10	-1.607051		-2.655194		-2.655194		-2.660551		-2.673460		-2.660551	

Source: Author

Table 2. Stationarity values of series for Moldova

Level of Stagnation						
	Female employment	Fertility rate	Wage and salaried workers	Educational attainment, at least	Educational attainment, at least completed	Urban population growth

Source: Author

Level of Stagnation												
	Female employment		Fertility rate		Wage and salaried workers		Educational attainment, at least Bachelor's or equivalent		Educational attainment, at least completed lower secondary		Urban population growth	
	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.
Low	-0.76	0.448	-0.90	0.370	-0.76	0.448	-0.76	0.448	-0.76	0.448	-0.76	0.448
Medium	-0.76	0.448	-0.90	0.370	-0.76	0.448	-0.76	0.448	-0.76	0.448	-0.76	0.448
High	-0.76	0.448	-0.90	0.370	-0.76	0.448	-0.76	0.448	-0.76	0.448	-0.76	0.448

ADF testing statistics		-2.491328	0.1329	-1.639971	0.4439	-2.226592	0.2036	-1.850502	0.3471	-1.194279	0.6543	-2.068358	0.2581
Test Critical Values	%1	-3.831511		-3.831511		-3.808546		-3.808546		-3.831511		-3.831511	
	%5	-3.029970		-3.029970		-3.020686		-3.020686		-3.029970		-3.029970	
	%10	-2.655194		-2.655194		-2.650413		-2.650413		-2.655194		-2.655194	
First Order Stationarity Levels													
		Female employment		Fertility rate		Wage and salaried workers		Educational attainment, at least Bachelor's or equivalent		Educational attainment, at least completed lower secondary		Urban population growth	
		t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.
ADF testing statistics		-3.646970	0.0146	-2.944619	0.0055	-3.988078	0.0281	-6.502245	0.0000	-7.408127	0.0000	-1.949288	0.0511
Test Critical Values	%1	-3.831511		-2.692358		-4.532598		-3.831511		-3.831511		-2.692358	
	%5	-3.029970		-1.960171		-3.673616		-3.029970		-3.029970		-1.960171	
	%10	-2.655194		-1.607051		-3.277364		-2.655194		-2.655194		-1.607051	

Source: Author

Table 4. Stationarity values of series for Uzbekistan

Level of Stagnation													
		Female employment		Fertility rate		Wage and salaried workers		Educational attainment, at least Bachelor's or equivalent		Educational attainment, at least completed lower secondary		Urban population growth	
		t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.
ADF testing statistics		2.212126	0.2096	1.079333	0.7015	1.826282	0.3578	0.771087	0.9905	4.224093	1.0000	1.983891	0.5744
Test	%1	3.920350		3.831511		3.808546		3.831511		3.857386		4.498307	

Critical Values	% 5	3.065585		3.029970		3.020686		3.029970		3.040391		3.658446	
	% 10	2.673460		2.655194		2.650413		2.655194		2.660551		3.268973	
First Order Stationarity Levels													
		Female employment		Fertility rate		Wage and salaried workers		Educational attainment, at least Bachelor's or equivalent		Educational attainment, at least completed lower secondary		Urban population growth	
		t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.
ADF testing statistics				3.279577	0.0316			6.166807	0.0001	5.806185	0.0010	4.045473	0.0068
Test Critical Values	% 1			3.857386				3.831511		4.571559		3.857386	
	% 5			3.040391				3.029970		3.690814		3.040391	
	% 10			2.660551				2.655194		3.286909		2.660551	
Second Order Stationarity Levels													
		Female employment		Fertility rate		Wage and salaried workers		Educational attainment, at least Bachelor's or equivalent		Educational attainment, at least completed lower secondary		Urban population growth	
		t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.	t-statistics	Sig.
ADF testing statistics		11.68460	0.0000			5.569448	0.0004	6.166807	0.0001				
Test Critical Values	% 1	4.616209				3.886751		3.831511					
	% 5	3.710482				3.052169		3.029970					
	% 10	3.297799				2.666593		2.655194					

Source: Author

After applying the necessary tests for the stationarity of the data, it was determined that the variables for the three countries were stationary at the same level. However, it was observed that for some data for Uzbekistan, a second difference had to be taken in order to make them stationary. Detailed information on the stationarity levels is again given in Tables 5, 6, 7.

Tablo 5. Johansen cointegration test for Azerbaijan

H ₀ : There is no long-term relationship between dependent and independent variables.							
H ₁ : There is a long-term relationship between dependent and independent variables.							
Hypotheses	Eigenvalue	Trace statistic	0.05 critical value	Prob**	Max-Eigen statistic	0.05 critical value	Prob**
None	0.996149	204.1372	95.75366	0.0000	105.6310	40.07757	0.0000
At most 1	0.939316	98.50619	68.81889	0.0001	53.23937	33.87687	0.0001
At most 2	0.671725	45.26682	47.85613	0.0858	21.16418	27.58434	0.2664
At most 3	0.560373	24.10264	29.79707	0.1961	15.61474	21.13162	0.2482
At most 4	0.346154	8.487897	15.49471	0.4148	8.072784	14.26460	0.3714
At most 5	0.021611	0.415113	3.841465	0.5194	0.415113	3.841465	0.5194

Source: Author

Tablo 6. Johansen cointegration test for Moldova

H ₀ : There is no long-term relationship between dependent and independent variables.							
H ₁ : There is a long-term relationship between dependent and independent variables.							
Hypotheses	Eigenvalue	Trace statistic	0.05 critical value	Prob**	Max-Eigen statistic	0.05 critical value	Prob**
None	0.986451	197.5441	95.75366	0.0000	81.72798	40.07757	0.0000
At most 1	0.964886	115.8161	69.81889	0.0000	63.63378	33.87687	0.0000
At most 2	0.680616	52.18232	47.85613	0.0186	21.68587	27.58434	0.2369
At most 3	0.580586	30.49645	29.79707	0.0415	16.50903	21.13162	0.1965
At most 4	0.484897	13.98742	15.49471	0.0833	12.60438	14.26460	0.0900
At most 5	0.070205	1.833038	3.841465	0.2936	1.383038	3.841465	0.2396

Source: Author

Tablo 7. Johansen cointegration test for Russia

H ₀ : There is no long-term relationship between dependent and independent variables.							
H ₁ : There is a long-term relationship between dependent and independent variables.							
Hypotheses	Eigenvalue	Trace statistic	0.05 critical value	Prob**	Max-Eigen statistic	0.05 critical value	Prob**
None	0.997514	267.2592	95.75366	0.0000	0.997514	267.2592	95.75366
At most 1	0.955236	153.3128	69.81889	0.0000	0.955236	153.3128	69.81889
At most 2	0.948917	94.29197	47.85613	0.0000	0.948917	94.29197	47.85613
At most 3	0.768294	37.78023	29.79707	0.0049	0.768294	37.78023	29.79707

At most 4	0.277799	9.996828	15.49471	0.281 0	0.277799	9.996828	15.49471
At most 5	0.181839	3.813237	3.841465	0.050 8	0.181839	3.813237	3.841465

Source: Author

The Johansen cointegration test was performed for countries that provided first-degree stationarity. The Johansen cointegration test is a method used to determine whether there is a long-term equilibrium relationship between time series. The test is particularly suitable for testing whether more than one variable has long-term relationships, and its results provide information about the existence of cointegration vectors.

When we evaluate the Johansen cointegration test in the context of Azerbaijan, we see that there is a cointegration test for some values and no cointegration for some values. In other words, there are cases where the hypotheses are supported and not supported. However, when a general evaluation is made, it is shown that there is at least one cointegration relationship between the time series and that there is a long-term balance relationship. The test result for Moldova shows that there is a balance relationship between the variables, but the number of these relationships is limited. It is shown that the variables examined for Russia have a certain balance relationship with each other in the long term, but this relationship is one. These results show us that the series are in a balance relationship with each other. In other words, the variables in the data are interconnected and affect each other in the long term.

Table 8. Appropriate delay length

Countries	Lag	LogL	LR	FPE	AIC	SC	HQ
Azerbaijan	0	-49.63831	NA	1.41e-05	5.856664	6.154908	5.907139
	1	31.07634	101.9553	1.58e-07	1.149854	3.237567	1.503182
	2	128.0076	61.21976*	1.30e-09*	-5.263961*	-1.386790*	-4.607790*
Moldova	0	-32.69832	NA	2.37e-06	4.073507	4.371751	4.123982
	1	66.35656	125.1220*	3.86e-09	-2.563849	-0.476141	-2.210526
	2	137.3651	44.84747	4.87e-10*	-6.248954*	-2.371783*	-5.592782*
Russia	0	17.45280	NA	1.21e-08	-1.205558	-0.907314	-1.155083
	1	89.25150	90.69310	3.47e-10	-4.973842	-2.886135	-4.620519
	2	202.3099	71.40533*	5.23e-13*	-13.08526*	-9.208086*	-12.42909*
Uzbekistan	0	40.27219	NA	1.09e-09	-3.607598	-3.309355	-3.557124
	1	140.6069	126.7386	1.56e-12	-10.37968	-8.291972	-10.02636
	2	328.7370	118.8190*	8.69e-19*	-26.39337*	-22.51620*	-25.73719*

Source: Author

In this study, methods such as Likelihood Ratio Test (LR), Posterior Error of Prediction (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SC) and Hannan-Quinn Criterion (HQ) were used to determine the appropriate lag length. As a result of the analysis, the most appropriate lag length was selected as 2. The fact that it was determined as

2 in this study means that the model made the prediction using the data of the past 2 periods and this length gave the best results according to the tests performed (Table 8).

Table 9. Results of the Granger causality test

Hypotheses	F-value	Significance value (p)	Decision at 5% significance level
Azerbaijan			
The level of female labor force is not the cause of postgraduate education	2.78717	0.0957	Fail to reject H_0
The level of postgraduate education is not the cause of female employment level			
The level of female labor force is not the cause of undergraduate education	0.85848	0.4450	Fail to reject H_0
The level of postgraduate education is not the cause of female employment level			
Fertility level is not the cause of female employment level	1.41779	0.2750	Fail to reject H_0
The level of female labor force is not the cause of fertility level	1.00042	0.3926	Fail to reject H_0
The level of female labor force is not the cause of urbanization level			
The level of urbanization is not the cause of female employment level	0.99038	0.3960	Fail to reject H_0
The level of wages is not the cause of female employment level	0.13553	0.8744	Fail to reject H_0
The level of female labor force is not the cause of wages level	2.08288	0.1627	Fail to reject H_0
Moldova			
The level of female labor force is not the cause of postgraduate education	2.541689	0.2806	Fail to reject H_0
The level of postgraduate education is not the cause of female employment level	3.431808	0.1798	Fail to reject H_0
The level of female labor force is not the cause of undergraduate education	3.566370	0.1607	Fail to reject H_0
The level of postgraduate education is not the cause of female employment level	1.160559 3	0.4381	Fail to reject H_0
Fertility level is not the cause of female employment level	4.086538	0.1296	Fail to reject H_0
The level of female labor force is not the cause of fertility level	1.662184	0.4356	Fail to reject H_0
The level of female labor force is not the cause of urbanization level	0.843988	0.6557	Fail to reject H_0
The level of urbanization is not the cause of female employment level	1.367183	0.5048	Fail to reject H_0
The level of wages is not the cause of female employment level	3.836131	0.1469	Fail to reject H_0
The level of female labor force is not the cause of wages level	0.841149	0.6567	Fail to reject H_0
Russia			

The level of female labor force is not the cause of postgraduate education	0.345508	0.8413	Fail to reject H_0
The level of postgraduate education is not the cause of female employment level	1.112314	0.5734	Fail to reject H_0
The level of female labor force is not the cause of undergraduate education	0.144281	0.9304	Fail to reject H_0
The level of postgraduate education is not the cause of female employment level	3.504830	0.1734	Fail to reject H_0
Fertility level is not the cause of female employment level	0.864222	0.6491	Fail to reject H_0
The level of female labor force is not the cause of fertility level	0.573720	0.7506	Fail to reject H_0
The level of female labor force is not the cause of urbanization level	65.01680	0.0000	Reject H_0
The level of urbanization is not the cause of female employment level	3.986772	0.1362	Fail to reject H_0
The level of wages is not the cause of female employment level	6.929815	0.0313	Reject H_0
The level of female labor force is not the cause of wages level	0.158840	0.9237	Fail to reject H_0
Uzbekistan			
The level of female labor force is not the cause of postgraduate education	0.715826	0.6991	Fail to reject H_0
The level of postgraduate education is not the cause of female employment level	6.033625	0.0490	Reject H_0
The level of female labor force is not the cause of undergraduate education	2.296137	0.3172	Fail to reject H_0
The level of postgraduate education is not the cause of female employment level	0.693855	0.7069	Fail to reject H_0
Fertility level is not the cause of female employment level	1.391752	0.4986	Fail to reject H_0
The level of female labor force is not the cause of fertility level	1.406749	0.4949	Fail to reject H_0
The level of female labor force is not the cause of urbanization level	0.452315	0.7976	Fail to reject H_0
The level of urbanization is not the cause of female employment level	1.523282	0.4669	Fail to reject H_0
The level of wages is not the cause of female employment level	10.07664	0.0065	Reject H_0
The level of female labor force is not the cause of wages level	11.48196	0.0032	Reject H_0

Source: Author

Each Granger causality test reported in Table 9 is evaluated against the following generic statistical null and alternative hypotheses:

- H_0 : The variable does not Granger-cause (does not have predictive power for) the other variable.
- H_1 : The variable Granger-causes (has predictive power for) the other variable.

In this study, the factors affecting female labor force participation in different countries were analyzed and the results obtained for each country were interpreted. The findings of the study reveal the diversity of the factors affecting female labor force participation in different countries and that they differ according to the economic, social, and cultural contexts of the countries.

Firstly, in the case of Azerbaijan and Moldova, no statistically significant Granger-causal relationships were found between FLFP and any of the tested variables (education, fertility, urbanization, and the share of wage and salaried workers) at the 5% level. This does not mean that FLFP in these two countries is unaffected by any factor; it means only that, within this specific model and sample period, none of the tested variables show detectable predictive power for FLFP, or vice versa. Other unmodeled factors, such as social norms or informal-sector dynamics, may well be relevant, but this cannot be established from the present Granger causality results, since such variables were not included in the model.

In the case of Russia, the share of wage and salaried workers was found to Granger-cause FLFP, i.e., its past values have predictive power for future FLFP; the reverse direction (FLFP Granger-causing the wage-employed share) was not statistically significant. For urbanization, the significant relationship runs in the opposite direction from what is often assumed: FLFP was found to Granger-cause urban population growth, while urbanization did not Granger-cause FLFP at the 5% level. This suggests that, in Russia, rising female labor force participation may be a leading indicator of subsequent urban population growth, rather than urbanization being a driver of women's labor force participation.

In Uzbekistan, postgraduate education attainment was found to Granger-cause FLFP, meaning its past values have predictive power for subsequent FLFP; the reverse direction was not statistically significant. This is consistent with the view that higher education is associated with greater access to skilled, better-paid employment, though the Granger result establishes a predictive association rather than a proven causal mechanism, and the I(2) issue noted above means this result should be treated with some caution. In addition, a bidirectional Granger-causal relationship was found between the share of wage and salaried workers and FLFP in Uzbekistan: each variable was found to have predictive power for the other. This bidirectional pattern is consistent with wage employment and female labor force participation reinforcing one another over time, though the specific mechanism cannot be identified from a Granger causality test alone.

As a result, the predictive relationships between the tested variables and FLFP vary considerably across the four countries. In Azerbaijan and Moldova, none of the tested variables showed a statistically significant Granger-causal relationship with FLFP, whereas in Russia and Uzbekistan specific variables did (the share of wage and salaried workers in both countries, urban population growth in Russia, and postgraduate education in Uzbekistan). These findings indicate that the relevance of the tested economic and demographic variables for FLFP is not uniform across CIS countries, and that country-specific factors outside the scope of this model likely also play a role. Policy conclusions should therefore be drawn cautiously and tailored to each country's specific empirical results rather than generalized across the region.

DISCUSSION AND CONCLUSION

This study examined the predictive (Granger-causal) relationships between selected socioeconomic factors and female labor force participation (FLFP) in the case of four CIS member countries, and confirmed that FLFP is a multidimensional and complex phenomenon. In the study, the relationships between education level, fertility rate, urbanization, and the share of wage and salaried workers on the one hand and FLFP on the other were examined, and the results were compared across the four selected countries.

The findings show that the tested variables' predictive relationships with FLFP differ considerably across countries. In Azerbaijan and Moldova, none of the tested economic and demographic variables showed a statistically significant Granger-causal relationship with FLFP; other, unmodeled factors may well be relevant, but this cannot be confirmed from the present results. In Russia, the share of wage and salaried workers was found to Granger-cause FLFP, and FLFP was in turn found to Granger-cause urban population growth, the opposite direction from the common assumption that urbanization drives female labor force participation.

The example of Uzbekistan highlights the decisive effect of women's level of education on labor force participation. It has been observed that educated women are more likely to work in higher-paying jobs and have better career opportunities. Furthermore, a bidirectional causal relationship between wage levels and female labor force participation in Uzbekistan has been found, indicating that women's labor force participation is affected not only by external economic factors, but also by social and individual factors.

This study reveals that the factors affecting female labor force participation are not limited to economic elements, but also social, cultural, and educational factors play an important role. Comparisons made between countries emphasize that specific policies and strategies should be developed to encourage female labor force participation. In particular, a more in-depth consideration of factors such as education, wage incentives and urbanization to increase female labor force participation can ensure that women take a greater part in economic life.

In conclusion, this study underscores that the relationship between socioeconomic factors and women's labor force participation is country-specific rather than uniform across the CIS region. Policymakers and future researchers should treat the predictive relationships identified here as a starting point for country-specific investigation, and should combine them with data on social, institutional, and cultural factors, which lie outside the scope of this study, before drawing firm policy conclusions.

Limitations

This study has several limitations that should be considered when interpreting its findings. First, the sample is limited to four CIS countries selected primarily on the basis of data availability; results cannot be generalized to the CIS region as a whole or to other transition economies. Second, the Granger causality test used here identifies predictive (statistical) relationships and does not establish structural or "real" causality; the direction and significance

of a Granger-causal relationship should not be read as evidence of a specific economic mechanism. Third, for Uzbekistan, some series were found to be integrated of order two, $I(2)$, rather than order one; this is a departure from the standard $I(1)$ assumption of the Johansen and Granger framework and means the Uzbekistan results should be interpreted with additional caution. Fourth, standard VAR diagnostic checks (serial correlation, stability/roots of the characteristic polynomial, and residual normality tests) were not reported in this version of the study; the validity of the Granger causality results depends on these assumptions holding, and future revisions of this paper should report them explicitly. Fifth, the empirical model does not include social, institutional, or cultural variables, or macroeconomic variables such as economic growth and unemployment discussed in the introduction; consequently, the study cannot determine whether such omitted factors explain the country differences observed. Future research with a larger country sample, richer variable sets, and formal diagnostic testing would help address these limitations.

Conflict of Interest: The author declare that they have no conflict of interest.

REFERENCES

- Abdulloev, I., Ira, N. G., & Myeong-Su, Y. (2014). Migration, education and the gender gap in labour force participation. *The European Journal of Development Research*, 26, 509–526. <https://doi.org/10.1057/ejdr.2014.27>
- Becker, G. (1964). *Human capital: A theoretical and empirical analysis, with special reference to education* (Vol. 3). University of Chicago Press.
- Besamusca, J., Tijdens, K., Keune, M., & Steinmetz, S. (2015). Working women worldwide: Age effects in female labor force participation in 117 countries. *World Development*, 74, 123–141.
- Cooray, A., Gaddis, I., & Wacker, K. M. (2012). *Globalization and female labor force participation in developing countries: An empirical (re-)assessment* (Courant Research Centre Discussion Paper No. 129). University of Göttingen.
- Croda, E., Ekaterini, K., & Ioannis, P. (2011). *Intertemporal labor force participation of married women in Germany: A panel data analysis* (Working Paper No. 17). University Ca' Foscari of Venice, Department of Economics.
- Dalkıranoglu, T. (2006). Çalışma yaşamında kadın işgücü ve cinsiyet ayrımcılığı: Konaklama işletmelerinde bir uygulama [Female labor force and gender discrimination in working life: An application in accommodation businesses] [Unpublished master's thesis]. Anadolu University.
- De la Rica, S., & Ferrero, M. D. (2003). The effect of fertility on labour force participation: The Spanish evidence. *Spanish Economic Review*, 5(2), 153–172.
- Du, C., Muhammad, K. A., Michael, Y. P. P., Sameh, E. A., Abdelmohsen, A. N., Khalid, Z., & Muhammad, M. Q. A. (2022). Women's autonomy and its impact on environmental

- sustainability agenda. *Journal of Environmental Planning and Management*, 65(10), 1893–1913. <https://doi.org/10.1080/09640568.2021.1952168>
- Esteve-Volart, B. (2004). *Gender discrimination and growth: Theory and evidence from India* (LSE STICERD Research Paper No. DEDPS42). London School of Economics.
- Gaddis, I., & Klasen, S. (2014). Economic development, structural change, and women's labor force participation: A reexamination of the feminization U hypothesis. *Journal of Population Economics*, 27, 639–681. <https://doi.org/10.1007/s00148-013-0488-2>
- Ganguli, I., Hausmann, R., & Viarengo, M. (2014). Closing the gender gap in education: What is the state of gaps in labour force participation for women, wives and mothers? *International Labour Review*, 153(2), 173–207. <https://doi.org/10.1111/j.1564-913X.2014.00007.x>
- Granger, C. W. J. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*, 37(3), 424–438.
- Huseynli, B. (2023). Causality relationship between the development of the oil and gas sector and foreign investments. *International Journal of Energy Economics and Policy*, 13(2), 404–409. <https://doi.org/10.32479/ijeep.13573>
- Karabıyık, İ. (2012). Türkiye'de çalışma hayatında kadın istihdamı [Women's employment in working life in Turkey]. *Marmara Üniversitesi İktisadi ve İdari Bilimler Dergisi*, 32(1), 231–260.
- King, E. M., & Hill, M. A. (Eds.). (1993). *Women's education in developing countries: Barriers, benefits, and policies*. The Johns Hopkins University Press.
- Kızılgöl, Ö. A. (2012). Kadınların işgücüne katılımının belirleyicileri: Ekonometrik bir analiz [Determinants of women's labor force participation: An econometric analysis]. *Doğuş Üniversitesi Dergisi*, 13(1), 88–101.
- Korkmaz, A. (2012). Türkiye'de kadının işgücüne katılımının belirleyicileri [Determinants of women's labor force participation in Turkey]. *Süleyman Demirel Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 17(2), 41–65.
- Lee, G. H. Y., & Sing, P. L. (2014). Childcare availability, fertility and female labor force participation in Japan. *Journal of the Japanese and International Economies*, 32, 71–85. <https://doi.org/10.1016/j.jjie.2014.01.002>
- Maurer-Fazio, M., Hughes, J., & Zhang, D. (2007). An ocean formed from one hundred rivers: The effects of ethnicity, gender, marriage, and location on labor force participation in urban China. *Feminist Economics*, 13(3–4), 159–187. <https://doi.org/10.1080/13545700701439424>
- Özdemir, Z., İlkay, N. Y., & Seda, B. (2012, October). Kadın istihdamı ve ekonomik kalkınma: Geçiş ekonomileri örneği. In *International Conference on Eurasian Economies* (Vol. 11, No. 13, pp. 115–122).

- Özer, M., & Biçerli, K. (2003). Türkiye'de kadın işgücünün panel veri analizi [Panel data analysis of female labor force in Türkiye]. *Anadolu Üniversitesi Sosyal Bilimler Dergisi*, 3(1), 55–85.
- Özsoy, G. C. (2012). Türkiye'de kadın işgücü, eğitim ve büyüme ilişkisinin VAR analizi [VAR analysis of the relationship between female labor force, education and growth in Türkiye]. *Finans Politik ve Ekonomik Yorumlar*, 49(568), 21–40.
- Parlaktuna, İ. (2010). Türkiye'de cinsiyete dayalı mesleki ayrımcılığın analizi [Analysis of gender-based occupational discrimination in Türkiye]. *Ege Akademik Bakış*, 10(4), 1217–1230.
- Şimşek, M. (2008). Küreselleşen dünyada kadının ekonomik konumu [Women's economic position in a globalizing world]. Ekin Basın Yayın Dağıtım.

SEÇİLMİŞ MDB ÖLKƏLƏRİNDƏ QADINLARIN İŞÇİ QÜVVƏSİNDƏ İŞTİRAKINI MÜƏYYƏN EDƏN AMİLLƏR

Nigar Hüseynli

XÜLASƏ

Bu gün qadınların işçi qüvvəsində iştirakı kişilərlə müqayisədə daha aşağı səviyyədə qalır. Bu tədqiqatda, qadınların işçi qüvvəsinin iqtisadi inkişafa təsiri, seçilmiş Müstəqil Dövlətlər Birliyinin (MDB) üzv ölkələri nəzərə alınmaqla araşdırılır. Bu tədqiqat qadınların işçi qüvvəsində iştirakına təsir edən müxtəlif amilləri araşdırır. Xüsusilə, iqtisadi artım və işsizlik kimi amillərin qadınların məşğulluğuna təsiri ədəbiyyatda geniş müzakirə olunan mövzulardan biridir. Lakin, bu tədqiqatda qadınların işçi qüvvəsində iştirakına təsir edə biləcək təhsil səviyyəsi (bakalavr və magistr), doğum səviyyəsi, şəhərləşmə səviyyəsi və əmək haqqı alan işçilərin ümumi işçi qüvvəsindəki payı kimi daha spesifik sosial-iqtisadi amillər də nəzərdən keçirilmiş və təhlil edilmişdir. Qeyd olunmalıdır ki, Qranger səbəb-nəticə testi statistik proqnozlaşdırma əlaqəsini göstərir və dəyişənlər arasında struktur mənada "real" səbəbiyyəti sübut etmir. Tədqiqat 2002-2023-cü illər arasında MDB ölkələri üzrə toplanmış məlumatlar əsasında aparılmış və empirik təhlildə Qranger səbəb-nəticə testindən istifadə edilmişdir. Nəticələr göstərir ki, bəzi amillər arasında əhəmiyyətli əlaqələr mövcuddur, digər amillər arasında isə heç bir əhəmiyyətli səbəb-nəticə əlaqəsi tapılmayıb. Bu vəziyyət qadınların işçi qüvvəsində iştirakının çoxölçülü bir fenomen olduğunu və hər bir amilin təsirinin müxtəlif yollarla baş verə biləcəyini göstərir. Bundan əlavə, nəticələr siyasət və strategiyaların hazırlanmasında diqqətli bir yanaşmanın tətbiq edilməli olduğunu vurğulayır.

Açar sözlər: *qadın işçi qüvvəsində iştirak, əmək iqtisadiyyatı, MDB ölkələri, Qranger səbəb-nəticə analizi*

ФАКТОРЫ, ОПРЕДЕЛЯЮЩИЕ УЧАСТИЕ ЖЕНСКОЙ РАБОЧЕЙ СИЛЫ В ОТДЕЛЬНЫХ СТРАНАХ СНГ

Нигар Гусейнли

РЕЗЮМЕ

Сегодня участие женщин в рабочей силе остается на более низком уровне по сравнению с мужчинами. В данном исследовании рассматривается влияние участия женщин в рабочей силе на экономическое развитие на примере отдельных стран-членов Содружества Независимых Государств (СНГ). В исследовании анализируются различные факторы, влияющие на участие женщин в рабочей силе. В частности, влияние таких факторов, как экономический рост и безработица, на занятость женщин является одной из наиболее широко обсуждаемых тем в литературе. Однако в данном исследовании также были рассмотрены и проанализированы более специфические социально-экономические факторы, такие как уровень образования (бакалавриат и магистратура), уровень рождаемости, уровень урбанизации и доля наемных работников в общей занятости, которые могут влиять на участие женщин в рабочей силе. Следует отметить, что тест причинности Грейнджера отражает статистическую прогностическую связь и не доказывает наличие структурной, «реальной» причинности между переменными. Исследование проводилось на основе данных, собранных по странам СНГ в период с 2002 по 2023 год, а для эмпирического анализа использовался тест причинности Грейнджера. Результаты показывают наличие значимых взаимосвязей между некоторыми факторами, в то время как между другими факторами значимой причинно-следственной связи обнаружено не было. Эта ситуация свидетельствует о том, что участие женщин в рабочей силе является многомерным явлением, и влияние каждого фактора может проявляться по-разному. Кроме того, результаты подчеркивают необходимость тщательного подхода при разработке политики и стратегий.

Ключевые слова: участие женщин в рабочей силе, экономика труда, страны СНГ, тест причинности Грейнджера

Received: 01.05.2026

Revised: 11.06.2026

Accepted: 30.09.2026

Published: 01.10.2026

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial License (CC BY-NC 4.0), which permits any non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.