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Female unemployment and fertility rates in developing world: the role of economic, educational and institutional thresholds

Desempleo femenino y tasas de fertilidad en el mundo en desarrollo: el papel de los umbrales económicos, educativos e institucionales

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Abstract

This study investigates the impact of the female unemployment rate on the total fertility rate in 123 developing countries. As the nonlinearity of this impact is revealed, the dynamic panel threshold regression, which successfully deals with perceived endogeneity, is employed. The results indicate an inverse U-shaped relationship between female unemployment and fertility rates; the fertility rate achieves its peak at an unemployment rate of about 11.5 per cent before it starts to decline due to unemployment growth. This impact varies depending on the economic development: in countries with a GDP per capita below (above) $5,890, a rise in female unemployment increases (decreases) fertility rates. The analysis also finds the significant impact of educational attainment and institutional quality thresholds on this relationship. The estimation results provide recommendations for policy measures directed at facilitating fertility transitions.

Keywords: Total fertility rate, female unemployment, education attainment, institutional quality, developing economies, dynamic panel threshold regression.

Resumen

Este estudio investiga el impacto de la tasa de desempleo femenino en la tasa de fertilidad total en 123 países en desarrollo. Al revelarse la no linealidad de este impacto, se emplea la regresión de panel dinámico con umbrales, que aborda exitosamente la endogeneidad percibida. Los resultados indican una relación en forma de U invertida entre el desempleo femenino y las tasas de fertilidad; la tasa de fertilidad alcanza su pico en una tasa de desempleo de aproximadamente 11.5 por ciento antes de comenzar a disminuir debido al crecimiento del desempleo. Este impacto varía según el nivel de desarrollo económico: en países con un PIB per cápita por debajo (por encima) de $5,890, un aumento en el desempleo femenino incrementa (reduce) las tasas de fertilidad. El análisis también encuentra un impacto significativo de los umbrales de nivel educativo y calidad institucional en esta relación. Los resultados de la estimación proporcionan recomendaciones para medidas de política dirigidas a facilitar las transiciones de fertilidad.

Palabras clave: Tasa de fertilidad total, desempleo femenino, nivel educativo, calidad institucional, economías en desarrollo, regresión de panel dinámico con umbrales.

Introduction

The fertility rate is a composite phenomenon covering biological, socio-economic, and demographic aspects. From an economic point of view, children can be looked at as consumer goods that give specific fulfilment to parents, so the decision to have children is determined by factors such as family income, costs for child-rearing as well as parental desires (Firmansyah and Purnomo, 2024). In countries with greater traditional gender roles and little public support for mothers who work, the separation of work and care is strongly affected by gender (Lorenti, Nisén, Mencarini and Myrskylä, 2024). In these countries, mothers are for the most part responsible for childcare, as well as other unpaid jobs.

The fertility transition was not widespread equally throughout the less developed world. For example, Asia, Latin America, and the Caribbeans had abrupt declines, and both at present have replacement levels of fertility (Total fertility rate less than 2.1 children per woman) and are considered to have ended their fertility transitions (Bongaarts and Hodgson, 2022). In many developing countries, fertility has declined gradually in the last decades. On average, fertility rates have been lower among countries with better social environments or robust family planning programs than those lacking social surroundings or poorer programs (Jain and Ross, 2012). Fertility behavior mainly depends on the complex network of socioeconomic, behavioral and biological factors. Therefore, to investigate the impact of one particular factor it is needed to control others (Rahman, Islam and Yeasmin, 2020).

Regardless of their level of development, unemployment is an important concern in all countries (Niare and Mariko, 2023; Dunga and Maloma, 2024; Fernandez, García-Centeno, Ocaña and Sánchez, 2024). However, unemployment has more adverse socioeconomic effects in less developed countries than in advanced countries (Dunga and Maloma, 2024). A person is considered unemployed if he or she has not worked for a clearly defined time, has a wish to work and is accordingly actively searching for a job (Dunga and Maloma, 2024). Female unemployment often reflects structural inequalities in labor markets, cultural norms, and economic barriers, which, in turn, affect women's ability to participate fully in the workforce. Simultaneously, fertility decisions are closely tied to economic stability, access to resources, and social expectations, making this interplay pivotal for both economic and demographic planning.

Despite its importance, empirical studies on the nexus between female unemployment and fertility rates have yielded inconclusive results. Some studies suggest that higher female unemployment is associated with increased fertility rates, as women may choose to have more children when career prospects are limited (Adsera, 2004). Conversely, others find evidence of a negative relationship, where female unemployment delays childbearing due to economic insecurity (Matysiak and Vignoli, 2008; Currie and Schwandt, 2014; Kristensen and Lappegård, 2022;). Still, some studies highlight a non-linear relationship, indicating that cultural, institutional, and socio-economic factors mediate the impact of female unemployment on fertility rates (Goldstein, Sobotka and Jasilioniene, 2013; Berrington, Stone and Beaujouan, 2015). This ambiguity in findings underscores the need for further research, particularly in the unique socio-economic contexts of developing economies. In these countries, the urgency of examining this relationship is heightened due to the unique challenges they face, including higher economic volatility, limited social safety nets, and pronounced gender disparities. Female unemployment in developing countries is higher than male unemployment (Muñoz de Bustillo and de Pedraza, 2010; Niare and Mariko, 2023), which can exacerbate dependency ratios, hinder economic growth, and perpetuate cycles of poverty. On the other hand, elevated fertility rates in the absence of stable employment opportunities can strain public resources, reduce investments in human capital, and slow progress toward gender equality. Women often take sick leave or maternity leave, making it difficult for them to enter the labor market. Further, for example, African societies value the role of women as a wife and mothers and consider men to be the main contributors to household income. Accordingly, this kind of situation places a limit on opportunities for women for full-time employment and leaves them unprotected in periods of unemployment (Niare and Mariko, 2023).

This paper investigates the presence of a threshold effect in the impact of female unemployment rates on the total fertility rate in developing economies. This nonlinearity has important implications, as the impact of female unemployment on fertility can differ depending on its level compared to the threshold value. The analysis also includes the economic, educational, and institutional determinants of the female unemployment-fertility rate nexus, to estimate their thresholds beyond which the sign of this relationship changes. The investigation includes socioeconomic development indicators such as GDP per capita, female education, institutional quality, female labor force participation, and infant mortality rate. To this end, we employ a relatively novel dynamic panel threshold regression (DPTR) approach developed by Seo and Shin (2016) and Seo, Kim and Kim (2019). Given the possibility of reverse causality and endogeneity problems, this approach is advantageous compared to others (for instance, Hansen (1999), Kremer, Bick and Nautz (2013). The analysis also includes the panel Granger non-causality analysis using the method developed by Juodis, Karavias, and Sarafidis (2021), which examines causality while accounting for cross-sectional dependence and accommodating both homogeneity and heterogeneity.

The key contribution of this paper is to provide separate estimates and evidence of the role of female unemployment on the changes in fertility behavior in the developing world. Although previous studies have pointed to the potential importance of these factors separately on fertility, the contribution of female unemployment remains for the most part not well investigated in the countries of the developing world. In this context, such a comprehensive and holistic understanding of the determinants shaping fertility behavior is of great significance for the stakeholders and policymakers in developing countries aspiring to develop a human society characterized by inclusivity and prosperity.

The remainder of the paper is structured as follows: Section 2 reaches inside into the related literature, providing a review of relevant research works and scholarly studies. Following this, Section 3 outlines the data sources and econometric methodology explaining the used method and model for this research. Section 4 conducts an in-depth analysis of the estimated results whereas Section 5 provides a discussion of the gained results. Finally, Section 6 sums up the key findings and conclusive remarks obtained from the research.

Literature review

The theory of demographic transition refers to differences in population structure, from high birth and death rates pointing out low technological changes, education levels, and development, to low birth and death rates occurring at the same time as advancing technology, higher education levels and economic development (Amber and Chichaibelu, 2023). Also, the decline in fertility during demographic transition is of use to increase female workers as females with fewer children are more likely to participate in the labor force. Therefore, demography is related with female employment and female unemployment rates through its link with fertility rates (Amber and Chichaibelu, 2023). In general, results demonstrate that

GDP grow when fertility rates drop, and child mortality fall as GDP grows (Apire, Turyareeba, Olyanga, Katutsi, Musiita and Wamala, 2023). The life course perspective explores how the life domains of family and work interact across the lifespan (Nisén, Erlandsson and Jalovaara, 2024). Thus, differences in earnings based on childbearing likely arise from processes involving entry into parenthood as well as the birth of successive children, and also the effects of parenthood on women's employment, wages and working hours. These processes over the individual life course can be seen as embedded in a broader social context which enables and compels individuals to achieve their goals in different life domains, such as work and family. It is important to assume that the context of the welfare state influences the extent to which both processes leading to childbearing and the impacts of childbearing vary between women and men (Nisén, Erlandsson and Jalovaara, 2024).

The 'feminization U' hypothesis explains the arguments of convex impact of growth on female labor market participation in three stages (Luci, 2009). In the first stage, countries are characterized by low income standard and a vast agricultural area. In these developing countries, the participation of women in the labor market is high. Most women work on farms in home workshops. Women either work on subsistence economy or work as contributing family workers or as self-employed workers. This "at home" activity allows women to have children at the same time. In the second stage, countries go through a process of economic growth. Urbanization and industrialization led to polarization of the work activities of men and women; subsequently widen the gender gap in employment and initially reducing women's participation in the labor market, mainly due to structural changes. Thus, the reduction of the agricultural sector, as well as the increasing demand for labor mobility make it difficult for women to combine family and work. Family networks are weakening and children are becoming a barrier to women's employment, so women face labor constraints because of their childcare responsibilities. In the third stage, countries undergo further economic development and women's participation in the labor market increases and, consequently, females receive more education and training. Women's employment opportunities increase, which increases the opportunity cost of women staying at home and the fertility rate declines. Thus, the participation of women in the labor market increases in the medium and long term.

The classic microeconomic approach recognizes the extension in economic independence of women as the major cause of the fertility drop

(Barbieri, Bozzon, Scherer, Grotti and Lugo, 2015). In this regard, the decreasing number of children per woman is a result of the growing opportunity costs of child-bearing and child-rearing for females likely to take part in the labor market and try to make a balance between job and family duties. A great number of studies have highlighted the relevance of institutional factors for employment or unemployment on one side and for family formation on the other side, emphasizing also the firmly mutual fixation of the labor market and well-being state (e.g. Barbieri, Bozzon, Scherer, Grotti and Lugo, 2015). The importance of employment and fertility decisions has to be understood regarding the link between macro-level well-being support, labor market settings, and individual characteristics at a micro-level. Therefore, the weak institutional settings in providing opportunities that enable females (unemployment protective measures, active labor market policies, and welfare benefits), accompanied by a fragmented structure of the labor market, not only leads to increased levels of employment uncertainty but also raises the opportunity costs of motherhood for those women that are not regularly employed (Barbieri, Bozzon, Scherer, Grotti and Lugo, 2015). To make analysis of employment and unemployment rates of females by taking into consideration changing behavior of labor market over time and across generations the so called age–period–cohort analysis provides the required analytical mechanism (Amber and Chichaibelu, 2023). Thus, for example, younger cohorts join the labor market with lower fertility rates and higher educational completion than older cohorts do, and for that reason, they are more likely to participate. The findings suggest that as a result of behavioral change, increased female employment supply plays a substantial role in economic growth during demographic transition in the time that fertility rates decline (Alghamdi and Shaheen, 2024). Research studies point out multiple causes of declining total fertility rate in developing countries, including reduced child mortality, family planning programs, improved education and economy and female empowerment (Götmark and Wetzler, 2024; Bongaarts, and Hodgson, 2022). Using data from 136 developing countries in the period 1970–2014, Götmark and Andersson (2022), established that dropping fertility rates 1970–2000 revealed little or no association with changes in economy, with GDP or household consumption, i.e. fertility decreased despite of whether the economy grew, declined or stagnant. Therefore, the decline in fertility was closely linked to the increased use of modern contraception and was accompanied by contraceptive use and family planning programs, with advice on family size and modern contraception (Götmark and Andersson, 2022). Prior literature shows that economic uncertainty can influence the fertility desires of men and women differently within the family unit (Gatta, Mattioli, Mencarini and Vignoli, 2021). Thus, when women are primary caregivers and men the main breadwinners, the economic welfare of the household depends mostly on the achievement of the man on the labor market. Having children is considered risky since it leads to higher spending and shrinking income, at least certain time after birth. Therefore, the degree to which people are willing to have children can depend on their risk readiness (Gatta, Mattioli, Mencarini and Vignoli, 2021). In other words, the place where a person lives and his/her social environment are key drivers in fertility decision making.

Investing in human capital has a connected effect on both fertility decision-making and perception of employment unpredictability (Gatta, Mattioli, Mencarini and Vignoli, 2021). Thus, better educated individuals have a motivation to postpone childbirth to make as large as possible the prospective incomes made by investing in human capital. Commonly, the decision to have a child is made within a couple and is accordingly influenced by the labor market conditions of both partners (Barbieri, Bozzon, Scherer, Grotti and Lugo, 2015). Female education is expected to play a crucial role in mitigating the effects of employment insecurity, such that postponing first births through lower-level employment positions should be much more likely for highly educated women. For less educated women, the situation may be different, for whom insecure employment may even hasten motherhood. As noted by Barbieri, Bozzon, Scherer, Grotti and Lugo (2015), for women with very limited career chances, the role as a mother and thus the faster family formation can be tempting, and a strategy for reducing uncertainty in their lives. Furthermore, using data of Demographic and Health Surveys about 40 developing countries conducted during 2003–2010, the results of Jain and Ross (2012) found that fertility was positively related with infant mortality and negatively linked with women's education. Finally, examining the fertility transition across countries in four different income categories, Wang and Sun (2016) found that human capital is certified to be one of the most important determinants in explaining the decline in fertility rates across all income categories countries. Therefore, the significant policy implication of these findings for policymakers in lower-middle-income and low-income countries was to invest more in education, which can have a profound impact on people's perceptions of fertility, as it can help effectively reduce their fertility levels in a more humane way than can be achieved with invasive population policies (Wang and Sun, 2016).

Data and econometric methodology

Data and descriptive statistics

The current study analyses the impact of female unemployment rate (UNE) on fertility rate (FERT) in the panel of 123 low, lower, and upper-middle-income economies from 2000 to 2022. These countries are classified according to the income group classification of the World Bank, based on the level of gross national income (GNI) per capita. Countries from the specified income groups for which data were not available were excluded from the sample. The list of countries included in the analysis is provided in Table 1A in the Appendix.

The estimated econometric model includes several control variables explained in Table 1. The choice of the control variables reflects their possible impact on the dependent variable in the model. It is expected that the fertility rate is affected by the level of gross domestic product per capita (GDP), which could exhibit a positive impact (better economic conditions for childbearing) or a negative one (when higher income levels provide improved economic opportunities and enhanced access to education and family planning, all of which result in a lower fertility rate). The level of education (EDU) also reflects female awareness about the importance of childbearing, thus affecting the fertility rate. It is expected that the higher share of educated females will result in delaying marriage and childbearing, improved knowledge about contraceptive use, and a preference for smaller families, all of which lead to lower fertility rates. Infant mortality ratio (IMR) commonly exhibits a positive impact on the fertility rate, either due to the "replacement effect" (families compensate for child mortality by having more children), or due to demographic transition connected with fertility decline when child survival is more assured.

In the current study, the female labor force participation rate (LFP) is also included, as it represents the share of the female labor force (the sum of employed and unemployed females) in the female population ages 15+. The rationale for this is that the activation of females in employment or job-seeking could impact their decisions about childbearing. The expected relationship between LFP and fertility rate could be either negative (when women face challenges balancing work and childcare, leading to fewer children as more women enter the workforce), or U-shaped (fertility initially declines as women enter the labor force and subsequently increases as barriers to combining work and family life are reduced thanks to supportive social policies, workplace flexibility, and subsidized child care).

Table 1: Explanation of the variables in the model

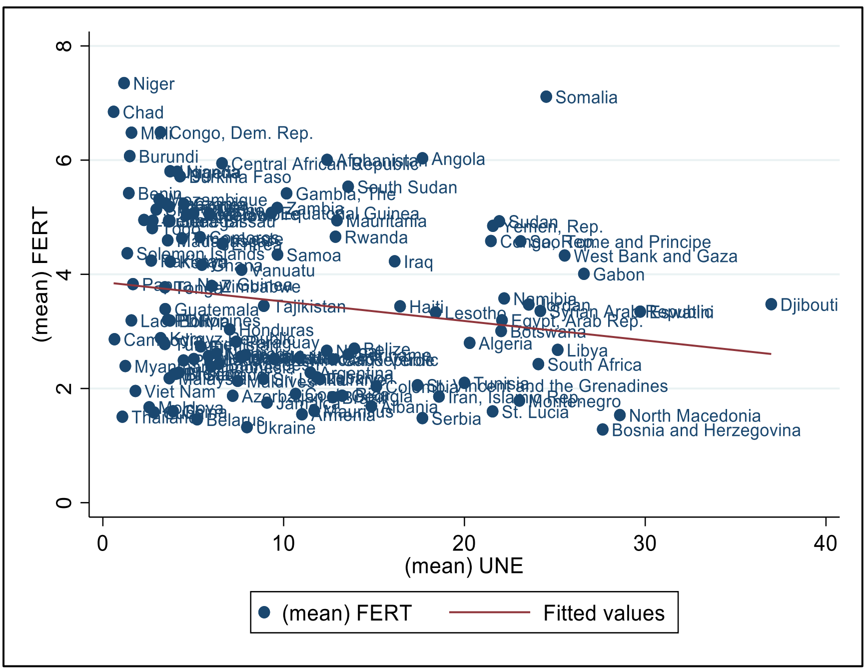
Variable	Explanation	Unit of measure	Source
FERT	Total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children following age-specific fertility rates of the specified year.	Number of children per women	World Development Indicators (WDI)
UNE	Unemployment, female; the share of the female labor force that is without work but available for and seeking employment	% of female labor force	WDI
GDP	Gross domestic product per capita converted to international dollars using purchasing power parity (PPP) rates. GDP per capita is the GDP divided by midyear population.	Log scale	WDI
EDU	Population with at least some secondary education, female (% ages 25 and older)	%	World Bank, Gender Inequality Index
IMR	Mortality rate, infant (per 1,000 live births) Infant mortality rate is the number of infants dying before reaching one year of age, per 1,000 live births in a given year.	Number (per 1,000 live births)	WDI
LFP	Labor force participation rate, female; the proportion of the female population ages 15 and older that is economically active	% of the female population ages 15+	International Labour Organization (2024)
INS	Institutional quality; equal-weight aggregation of six aggregate indicators of the governance quality	Scale −2.5 to 2.5	The Worldwide Governance Indicators (WGI)

Source: WDI, WGI, author’s compilation.

Finally, the institutional quality (INS) also represents the important factor of fertility rate dynamics. Better institutional quality is generally associated with lower fertility rates due to enhanced socio-economic development, access to healthcare and education, and increased gender equality. However, institutional quality improvements, especially in developing countries, can also increase fertility rates when they lead to improved economic stability and confidence, as well as reduced infant and child mortality. In the current study, the measure of institutional quality is calculated by equal-weight aggregation of six aggregate indicators of governance quality: Voice and Accountability; Political Stability and Absence of Violence/Terrorism; Government Effectiveness; Regulatory Quality; Rule of Law; Control of Corruption.

A scatter plot in Figure 1 visually presents the relationship between female unemployment rate and fertility. The fitted values are represented by the straight line, which is negatively sloped, indicating the reverse nexus between the mean values of these variables.

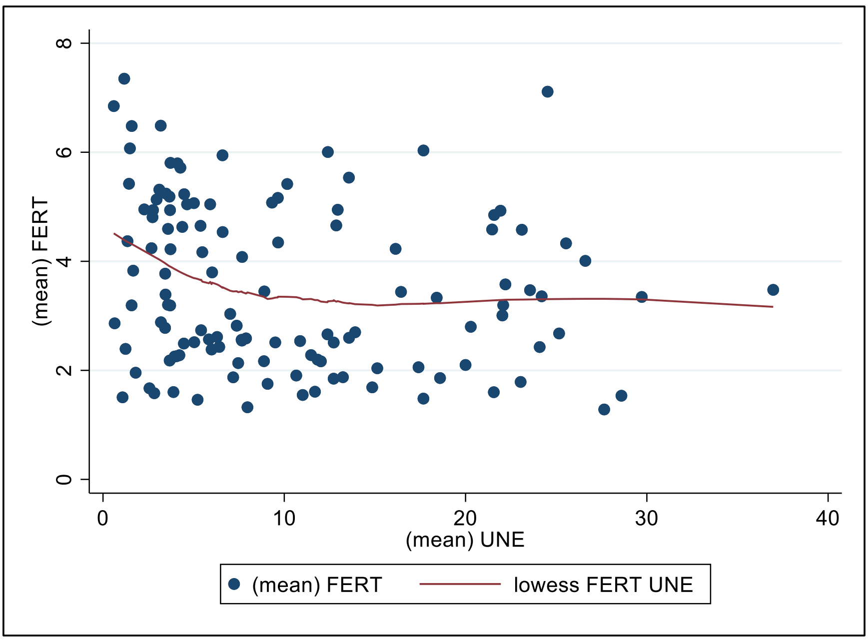
Figure 1: The scatter plot for the mean values of UNE and FERT



Source: Own calculation.

However, although the regression line indicates a negative association between the female unemployment rate and fertility, the possibility of a nonlinear relationship should be taken into account. Therefore, before econometric model estimation, it is useful to perform the preliminary analysis of the presence of nonlinearity and threshold effect. This can be done by applying the locally weighted scatterplot smoothing (LOWESS) analysis for the female unemployment rate on fertility (Figure 2). This technique doesn't make any assumption about the form of the linkage between the variables (Al Shammre, Benhamed and Jaidi, 2023). It is apparent that the relationship between debt and growth is nonlinear and that there is a threshold. Even the sign of the relationship slightly changes before and after the threshold indicating that the threshold regression technique should be employed.

Figure 2: LOWESS smoothing of UNE on FERT



Source: Own calculation.

Table 2 presents the descriptive statistics for the variables included in the model. The mean values of the variables suggest that the countries included in the analysis are characterized by relatively high fertility and female unemployment rates, as well as infant mortality rates. The institutional quality, labor force participation, and education levels are rather low. The positive skewness for fertility, unemployment, education and infant mortality rate indicates that most observations are concentrated close to the lower end. As for the kurtosis, only the unemployment rates exhibit leptokurtic distribution as some countries experience unusually high unemployment. All other variables have either platykurtic distribution (FERT, LFP, GDP and EDU) of mesokurtic distribution (INS and IMR).

Table 2: Descriptive statistics

	FERT	UNE	GDP	EDU	INS	LFP	IMR
Mean	3.517125	10.17824	8.724913	38.94401	-0.559231	49.09920	37.36440
Median	3.151000	6.864000	8.771064	32.63800	-0.542511	51.10900	30.60000
Maximum	7.732000	42.54900	10.68380	100.0000	1.100139	87.12300	138.3000
Minimum	1.078000	0.153000	6.477174	0.942000	-2.409534	4.948000	1.900000
Std. Dev.	1.556507	8.468148	0.910841	28.66717	0.598349	17.36320	25.74685
Skewness	0.536079	1.130519	-0.290338	0.584394	-0.053189	-0.340581	0.877183
Kurtosis	2.309113	3.666699	2.148711	2.167505	3.047148	2.595032	3.082590
Observations	2,829	2,829	2,829	2,829	2,829	2,829	2,829

Source: Own calculation.

Econometric model

This study investigates the impact of female unemployment rate on the fertility rate, emphasizing the presence of threshold effect and nonlinearity. To this end, we started with the following panel regression model:

$$FERT_{it} = \alpha_i + \beta_1 UNE_{it} + \beta_2 X_{it} + \theta_t + \varepsilon_{it} \quad (1)$$

Where FERT represents the total fertility rate, $_i$ denotes the country (i = 1, …, N), *t* represents the time (t = 1, …, T), α_i denotes an unobservable country-specific effect, θ_t is the time-specific effect, *X* is a vector of control variables (GDP, EDU, INS, LFP and IMR), and ε is an error term.

To capture the dynamic nature of the economic growth, i.e. the fact that the previous values of the fertility rate could be related to the current ones, the model should include the lagged values of the FERT ($FERT_{it-1}$), so we get the following model:

$$FERT_{it} = \alpha_i + \beta_0 FERT_{it-1} + \beta_1 UNE_{it} + \beta_2 X_{it} + \theta_t + \varepsilon_{it} \quad (2)$$

In order to investigate the nonlinear (threshold) effects of UNE on FERT, we implement the DPTR approach proposed by Seo and Shin (2016) and Seo, Kim and Kim (2019). This method extends the static panel threshold regression approach of Hansen (1999) and the GMM method of Kremer, Bick and Nautz (2013) by allowing for endogenous regressors and threshold variables. In other words, this approach successfully deals with potential endogeneity when there is a variable (UNE, in our study) that acts not only as a threshold variable but also as an explanatory one. Furthermore, this is empirically relevant, since the dependent variable (fertility rate) could also impact the female unemployment rate.

The model is estimated using the Generalized Method of Moments (GMM) in first differences in order to obtain consistent estimates in a dynamic panel setting. By first-differencing the equation, time-invariant country-specific effects (α_i) are eliminated:

$$\Delta FERT_{it} = \beta_0 \Delta FERT_{it-1} + \beta_1 \Delta UNE_{it} + \beta_2 \Delta X_{it}$$

$$+ \text{regime terms} + \Delta\theta_t + \Delta\varepsilon_{it}$$

However, differencing introduces correlation between the lagged dependent variable and the error term. To address this, appropriate internal instruments are used. Specifically, lagged levels of the endogenous variables (e.g., FERTit-2 and deeper lags) serve as valid instruments for the differenced regressors. This procedure ensures consistent estimation of coefficients in both regimes, as the moment conditions are constructed separately but applied within the unified DPTR framework.

In short, the empirical implementation follows these steps: 1) data are transformed using first differences to remove fixed effects; 2) endogenous variables are instrumented using appropriate lag structures; 3) the threshold parameter is estimated via grid search; 4) coefficients are estimated using GMM conditional on the identified threshold, and 5) statistical inference is conducted using bootstrap methods.

The DPTR approach addresses endogeneity not only by using lagged levels and/or lagged differences of endogenous regressors as instruments, but also by allowing the threshold variable to be endogenous and, finally, by constructing the moment conditions to ensure orthogonality between instruments and the error term, thereby mitigating simultaneity and reverse causality bias. The approach by Seo and Shin (2016) is based on the General Method of Moments (GMM) estimator and it allows specific threshold value in the regressor (UNE), thus differentiating between the lower and upper regime. It can be presented as follows:

$$FERT_{it} = (\alpha_i + \beta_0 FERT_{it-1} + \beta_1 UNE_{it} + \beta_2 X_{it})\ I(UNE_{it} \leq \gamma_1) + (\alpha_i + \delta_0 FERT_{it-1} + \delta_1 UNE_{it} + \delta_2 X_{it})\ I(UNE_{it} > \gamma_1) + \theta_t + \varepsilon_{it} \quad (3)$$

Where γ_1 denotes the threshold value (female unemployment rate) that will be estimated, *I* represents the indicator variable with the value of 1 if the condition in the parenthesis is fulfilled and 0 otherwise, whereas β and δ are the coefficients for the lower and upper regime, respectively. The threshold value (γ_1) is determined through a grid search over possible values of the threshold variable, selecting the one that minimizes the GMM objective function. To assess its statistical significance, a bootstrap procedure is applied to obtain valid confidence intervals and p-values, given the non-standard distribution of the estimator. This allows testing the null hypothesis of no threshold effect against the alternative of a nonlinear (threshold) relationship. The instrument variables include the lagged dependent variable, the exogenous variable and the other covariates. The variables are explained in Table 1.

Apart from the model in Equation (3), this study also includes several additional models, including different control variables that act as threshold variables. In that way, it is possible to investigate whether the impact of female unemployment on fertility changes when the values of certain variables are below or above the threshold variable. In particular, the analysis includes GDP per capita, education level and institutional quality as threshold variables in separate models. These variables could impact the fertility rate and influence the relationship between unemployment and fertility. The additional model estimates can provide further insights into this relationship and serve for the robustness check of the estimation results. These models are as follows:

$$FERT_{it} = (\alpha_i + \beta_0 FERT_{it-1} + \beta_1 UNE_{it} + \beta_2 Xit)\ I(GDP_{it} \leq \gamma_2) + (\alpha_i + \delta_0 FERT_{it-1} + \delta_1 UNE_{it} + \delta_2 X_{it})\ I(GDP_{it} > \gamma_2) + \theta_t + \varepsilon_{it} \quad (4)$$

$$FERT_{it} = (\alpha_i + \beta_0 FERT_{it-1} + \beta_1 UNE_{it} + \beta_2 X_{it})\ I(EDU_{it} \leq \gamma_3) + (\alpha_i + \delta_0 FERT_{it-1} + \delta_1 UNE_{it} + \delta_2 X_{it})\ I(EDU_{it} > \gamma_3) + \theta_t + \varepsilon_{it} \quad (5)$$

$$FERT_{it} = (\alpha_i + \beta_0 FERT_{it-1} + \beta_1 UNE_{it} + \beta_2 X_{it})\ I(INS_{it} \leq \gamma_4) + (\alpha_i + \delta_0 FERT_{it-1} + \delta_1 UNE_{it} + \delta_2 X_{it})\ I(INS_{it} > \gamma_4) + \theta_t + \varepsilon_{it} \quad (6)$$

Where γ_2, γ_3 and γ_4 denote the threshold values of the GDP per capita, education level and institutional quality, respectively. Other notations are the same as in Equation (3).

To address the issue of missing data while preserving a balanced panel structure, missing observations were imputed using standard interpolation techniques. Specifically, when gaps were limited and occurred within a time series, missing values were replaced using linear interpolation based on adjacent observations, ensuring consistency with the observed data trend. In cases where consecutive values were missing or interpolation was not feasible, additional robustness checks were conducted to ensure that the imputation did not bias the results. This approach allows for maintaining a balanced dataset while minimizing potential distortions associated with missing data. All estimations are implemented in Stata software (version 16.2), using suitable routines for dynamic panel GMM and threshold models.

Considering that the observed period (2000–2022) witnessed two serious global economic crises (the global financial crisis of 2007 and the economic recession due to the COVID-19 pandemic), their impact on fertility rate dynamics should also be analyzed. Accordingly, we include the dummy variable for the crisis effect (CRIS) in the vector of control variables, which takes the value of 1 for the years 2007–2010 and 2020–2022 and 0 otherwise.

Since this approach provides the estimates follow the normal distribution asymptotically, the standard Wald test for the threshold existence can be applied. We perform the non-linearity test $\sup W = \sup W_n(\gamma)$ statistics for the null hypothesis $\beta - \delta = 0$, where $W_n(\gamma)$ is the standard Wald statistic for each fixed γ.

The current study also employs causality analysis to examine the direction of causal impact between dependent and explanatory variables. We conduct the panel Granger non-causality analysis using the novel method developed by Juodis, Karavias, and Sarafidis (2021), which examines causality while accounting for cross-sectional dependence and accommodating both homogeneity and heterogeneity. This approach is also advantageous in the case of large N and relatively small T (as in our study). Thus, it is superior to alternative methods, such as Dumitrescu and Hurlin (2012), (Xiao, Karavias, Juodis, Sarafidis and Ditzen, 2023; Juodis, Karavias and Sarafidis, 2021) started from following transformed linear dynamic panel model:

$$y_{i,t} = z'_{i,t}\,\theta_i + x'_{i,t}\,b_i + \varepsilon_{i,t} \tag{7}$$

where $z_{i,t} = (1, y_{i,t-1}, \ldots, y_{i,t-p})'$, $x_{i,t} = (x_{i,t-1}, \ldots, x_{i,t-p})'$, $\theta_{i,t} = (\theta_{i,t-1}, \ldots, \theta_{i,t-p})'$ and $\beta i = (\beta_{1,I}, \ldots, \beta_{p,I})'$. In addition, $i = 1, \ldots, N$ denotes the cross-sectional unit, $t = 1, \ldots, T$ denotes the time dimension, whereas $p = 1, \ldots, P$ denotes the lag length for the heterogeneous autoregressive coefficient. The null hypothesis, $x_{i,t}$ does not Granger-cause $y_{i,t}$, the pooled least squares estimator for β can be defined as:

$$\hat{\beta} = \left(\sum_{i=1}^{N} X_i' M_{Zi} X_i\right)^{-1} \left(\sum_{i=1}^{N} X_i' M_{Zi} y_i\right) \tag{8}$$

Where $M_{zi} = I_T - Z_i (Z'_I Z_i)^{-1} Z'_I$. As the pooled least squares estimator of β suffers a Nickell bias, Juodis, Karavias and Sarafidis (2021) suggested the half-panel jackknife (HPJ) method pioneered by Dhaene and Jochmans (2015) to eliminate the bias. The bias-corrected version of the Wald test for Granger noncausality can be presented in the following form (Xiao, Karavias, Juodis, Sarafidis and Ditzen, 2023):

$$\widehat{W}_{HPJ} = NT\tilde{\beta}'\left(\hat{J}^{-1}\hat{V}\hat{J}^{-1}\right)^{-1}\tilde{\beta} \tag{9}$$

where $\hat{J} = \frac{1}{NT}\sum_{i=1}^{N} X_I' M_{Zi} X_i$ and is $\tilde{\beta}$ the HPJ estimator that removes the bias associated with the pooled estimator under homogeneity restriction.

The estimation results

Before the empirical model estimation, the Pesaran and Yamagata (2008) slope homogeneity test is performed to investigate the presence of non-linearity and threshold effect (Table 3). The results indicate that the null hypothesis of slope homogeneity should be rejected, meaning that the slope coefficients differ before and after the threshold.

Table 3: Slope homogeneity test results

	Coefficient	Probability
Delta	38.945	0.000
Adj. delta	49.918	0.000

Note: The test of Pesaran and Yamagata (2008), using xthst command in Stata
Source: Own calculation.

The stationarity of the variables is checked using the second-generation panel unit root test – CIPS (Cross-section Im-Pesaran-Shin test) (Pesaran, 2007). This test was chosen because the presence of cross-section dependence was confirmed at the 1 per cent significance level (upper part of Table 4). The lower part of Table 4 reports the results of the CD test developed by Pesaran (2021), indicating that all variables are stationary in the first differences. Therefore, further statistical inference based on the DPTR model is valid, since it is based on the first-differenced GMM estimates (Seo and Shin, 2016).

Table 4: Cross-section dependence (CD test) and stationarity tests results

	FERT	UNE	GDP	EDU	INS	LFP	IMR
Cross-section dependence test statistic	218.674[a]	23.296[a]	222.345[a]	199.122[a]	3.881[a]	8.421[a]	354.401[a]
CIPS unit root test results							
Level	-1.815	-1.357	-1.894	-1.947	-1.973	-1.156	-2.283[a]
First difference	-2.337[a]	-2.547[a]	-2.714[a]	-2.242[a]	-2.977[a]	-2.228[a]	-2.358[a]

Notes: [a], denote statistical significance at 10%.
Source: Own calculation.

The empirical estimates for the Equation (3) are presented in Table 5. Model (a) includes all control variables, whereas Model (b) excludes LFP, IMR and CRIS. The control variables which represent economic, educational and institutional settings are included in all models. Most coefficients are statistically significant at either the 1 per cent or 5 per cent levels, suggesting robust relationships between the variables across both regimes. The female unemployment rate is a threshold variable, with an estimated threshold value of 11.5 per cent in Model (a). The results indicate an inverse relationship between female unemployment and fertility only in the upper regime. In other words, a 1 percentage point decrease in the unemployment rate leads to a 0.007 units increase in fertility in countries with a female unemployment rate above the threshold value. This could indicate that high female unemployment results in a delay or reduction of childbirth due to economic constraints and financial insecurity, as confirmed, among others, by Hsu (2023). Conversely, in the lower regime, a 1 percentage point increase in the unemployment rate leads to a fertility increase of about 0.005 units. This could suggest that, when female unemployment is low, women are more likely to participate in the labor market, often delaying childbirth to focus on their career. Thus, the relationship between FERT and UNE exhibits an inverse U-shaped pattern, suggesting that the fertility rate achieves its peak at the unemployment rate of about 11.5 per cent before starts to decline due to high joblessness.

Table 5: Dynamic panel threshold regression estimates (threshold variable: UNE)

Variables	Model estimates			
	Model (a)		Model (b)	
	Lower regime (UNE £ 11.494)	Upper regime (UNE > 11.494)	Lower regime (UNE £ 11.813)	Upper regime (UNE > 11.813)
$FERT_{-1}$	0.932*** (0.008)	0.075*** (0.009)	1.017*** (0.004)	-0.077*** (0.005)
UNE	0.005*** (0.002)	-0.007*** (0.002)	0.007*** (0.001)	-0.007*** (0.001)
GDP	-0.169*** (0.010)	0.134*** (0.012)	-0.116*** (0.010)	0.131*** (0.009)
EDU	-0.002*** (0.000)	0.001*** (0.000)	-0.001*** (0.000)	0.002*** (0.000)
INS	0.038*** (0.012)	0.058*** (0.010)	0.071*** (0.009)	0.007 (0.006)
LFP	0.003*** (0.001)	-0.002** (0.001)	-	-
IMR	-0.001*** (0.000)	-0.002*** (0.000)	-	-
CRIS	-0.007*** (0.001)	0.015*** (0.001)	-	-
Constant	-	-1.374*** (0.135)	-	1.082*** (0.115)
Threshold estimate $\hat{\gamma}_1$	11.494*** (0.735)		11.813*** (0.451)	
95% Conf. Interval	[10.054, 12.935]		[10.929, 12.698]	
Number of moment conditions	609		546	546
SupWald Statistic (p-value)	273.70 (0.000)		439.53 (0.000)	

Notes: ***, ** and * denote statistical significance at 1%, 5% and 10%, respectively. Standard errors are reported in parentheses. Model (a) contains all control variables, whereas in Model (b), LFP , IMR and CRIS are excluded. The results are estimated using xthenreg command in Stata, proposed by Seo, Kim and Kim (2019).
Source: Own calculation.

When the three control variables are excluded (Model (b)), the threshold for the female unemployment rate is very similar (11.8 per cent), and the impact of UNE on FERT also shows an inverse U pattern. As the excluded control variables have statistically significant impact on the fertility rate and do not interfere with the obtained threshold value, one can conclude that the UNE-FERT relationship is robust.

As for the control variables, the GDP relationship with the fertility rate shows the opposite pattern. In a lower regime with lower female unemployment rates, the GDP per capita growth produces a decline in the fertility rate. This could be due to the transition from a low-income, agrarian-based economy to a middle-income, industrial or service-oriented economy that changes reproductive behavior. As economies industrialize, the demand for skilled labor rises. Families prioritize education and invest more in fewer children to increase their economic prospects (Doepke, Hannusch, Kindermann and Tertilt, 2022). In addition, the rising GDP per capita is often associated with higher educational attainment, particularly for women (Gadoth and Heymann, 2020).

Education (EDU) delays marriage and childbirth, reduces desired family size, and improves knowledge of and access to contraception, all of which lead to a decline in the fertility rate. In the upper regime, with high female unemployment, the GDP per capita growth improves the economic security and living standards, which supports higher fertility rates. The effect of LFP on fertility is similar to the impact of unemployment, as the changes that lead to LFP increase (rise in activation rates) are connected with the increase of female unemployment in the short run. The impact of institutional quality (INS) is constantly positive, indicating that better institutions support childbearing by addressing economic, social, and structural challenges that discourage families from having children. Finally, IMR negatively affects the fertility rate in both lower and higher unemployment regimes. That impact is more pronounced in the upper regime, suggesting that in the high unemployment environment, the fall in IMR leads to a slight increase in the fertility rate. The crisis also has an inverse effect on the fertility rate, but only in the lower female unemployment regime.

To gain a thorough understanding of the complex relationship between female unemployment and fertility, and to illustrate how unemployment influences fertility in various economic, educational, and institutional contexts, subsequent analyses estimate separate models using GDP per capita, education level, and institutional quality as threshold variables. The GDP per capita is used as a proxy for the overall level of economic development; education level serves as a proxy for human capital, and institutional quality acts as a proxy for governance and social support systems. There is a large body of empirical literature providing evidence about the significance of these factors for the fertility rate dynamics (Testa, 2014; Götmark and Andersson, 2020; Strulik, 2024).

The estimated DPTR model with GDP as a threshold variable (Table 6) indicates that female unemployment can either support or deter the fertility rate depending on the level of economic development. More precisely, if the GDP per capita is below the threshold of 8.682 (lower regime), a 1 percentage point increase in the female unemployment rate leads to a 0.010 unit increase in fertility rate. Since the GDP per capita is measured in a natural log scale, that means that the threshold at which the unemployment-fertility nexus changes is about 5.890 USD. Above this threshold, female unemployment growth appears to reduce fertility. This finding indicates that, when unemployment rises in less developed economies, women who lose their jobs or find it difficult to enter the labor market may prioritize childbearing and household responsibilities. Fertility rates may increase during this phase because the opportunity cost of having children —measured by foregone wages and career advancement— is lower. In the case of more developed economies (GDP per capita above the threshold), unemployment may reduce fertility rate as the cost of living and raising children, combined with uncertainty about future income, discourages childbearing, particularly among younger women who may delay starting families until economic conditions improve.

Table 6: Dynamic panel threshold regression estimates (threshold variable: GDP)

Variables	Model estimates			
	Model (a)		Model (b)	
	Lower regime (GDP ≤ 8.682)	Upper regime (GDP > 8.682)	Lower regime (GDP ≤ 8.630)	Upper regime (GDP > 8.630)
$FERT_{-1}$	0.997*** (0.008)	-0.041*** (0.014)	0.968*** (0.004)	0.017*** (0.005)
UNE	0.010*** (0.001)	-0.012*** (0.002)	0.001** (0.000)	-0.003*** (0.000)
GDP	-0.019 (0.020)	-0.001 (0.029)	0.004 (0.013)	-0.028 (0.017)
EDU	0.002*** (0.001)	-0.005*** (0.001)	0.004*** (0.000)	-0.005*** (0.000)
INS	-0.139*** (0.015)	0.269*** (0.015)	-0.036*** (0.004)	0.180*** (0.009)
LFP	0.002*** (0.001)	-0.001*** (0.001)	-	-
IMR	0.001 (0.000)	-0.002*** (0.001)	-	-
CRIS	-0.009*** (0.001)	0.024*** (0.002)	-	-
Constant	-	-0.763** (0.301)	-	0.574*** (0.151)
Threshold estimate $\hat{\gamma}_2$	8.682*** (0.079)		8.630*** (0.055)	
95% Conf. Interval	[8.525, 8.838]		[8.523, 8.737]	
Number of moment conditions	609		546	
SupWald Statistic (p-value)	146.35 (0.000)		125.81 (0.000)	

Notes: ***, ** and * denote statistical significance at 1%, 5% and 10%, respectively. Standard errors are reported in parentheses. Model (a) contains all control variables, whereas in Model (b), LFP, IMR and CRIS are excluded. The results are estimated using xthenreg command in Stata, proposed by Seo, Kim and Kim (2019).
Source: Own calculation.

The coefficients of the control variables are mixed, whereas the EDU and IMR have opposite pattern compared to the results in Table 5. The institutional quality negatively affects the fertility rate in less developed economies, indicating that institutions promote job creation and economic opportunities, encouraging women to enter the labor force. This often leads to delayed or reduced childbearing. Better institutions, on the other hand, could support fertility rate increases in more developed economies.

In the model with three control variables excluded (Model (b)), the threshold value is mainly unaltered and equals 8.630 (which corresponds to the antilog value of 5.592 USD). The signs of the coefficients for UNE and included control variables are the same as in Model (a) in both lower and upper regimes.

Table 7 reports estimation results for the model with educational level as a threshold variable. In the regime with a lower education level (below 66.5 per cent of the female population with at least some secondary education), the rise in female unemployment appears to increase the fertility rate. Namely, a 1 percentage point increase in female unemployment rate leads to 0.004 units increase in fertility rate in the lower education level regime (0.001 units in Model (b)), and 0.006 units decrease in fertility rate (0.004 in Model (b)) in the case when the education level is above the threshold. This result can be explained by the fact that women with low education generally have fewer career opportunities, making the opportunity cost of childbearing less significant. The increase in the educational level above the threshold corresponds with the inverse unemployment-fertility relationship: higher unemployment tends to decrease the fertility rate as educated women are likelier to delay childbearing until unemployment resolves due to career-oriented role expectations (Kreyenfeld, 2010). In the Model (b), without control variables LFP, IMR and CRIS, the threshold value is slightly higher –68.3 per cent, but relatively similar to the case when these controls are included.

Table 7: Dynamic panel threshold regression estimates (threshold variable: EDU)

Variables	Model estimates			
	Model (a)		Model (b)	
	Lower regime (EDU ≤ 66.459)	Upper regime (EDU > 66.459)	Lower regime (EDU ≤ 68.253)	Upper regime (EDU > 68.253)
$FERT_{-1}$	1.043*** (0.008)	-0.049*** (0.008)	0.976*** (0.002)	0.103*** (0.006)
UNE	0.004*** (0.000)	-0.006*** (0.001)	0.001** (0.000)	-0.004*** (0.000)
GDP	-0.049*** (0.009)	0.359*** (0.016)	0.001 (0.006)	-0.021** (0.008)
INS	-0.051*** (0.008)	-0.059*** (0.014)	0.001 (0.005)	-0.021*** (0.009)
EDU	0.002*** (0.001)	-0.005*** (0.001)	0.001 (0.000)	-0.001 (0.001)
LFP	0.002*** (0.000)	-0.009*** (0.001)	-	-
IMR	-0.003 (0.000)	0.013*** (0.001)	-	-
CRIS	-0.009*** (0.001)	0.029*** (0.002)	-	-
Constant	-	-2.781*** (0.189)	-	-0.078 (0.069)
Threshold estimate $\hat{\gamma}_3$	66.459*** (2.268)		68.253*** (2.354)	
95% Conf. Interval	[62.014, 70.906]		[63.639, 72.868]	
Number of moment conditions	609		546	
SupWald Statistic (p-value)	171.69 (0.000)		227.38 (0.000)	

Notes: ***, ** and * denote statistical significance at 1%, 5% and 10%, respectively. Standard errors are reported in parentheses. Model (a) contains all control variables, whereas in Model (b), LFP, IMR and CRIS are excluded. The results are estimated using xthenreg command in Stata, proposed by Seo, Kim and Kim (2019).
Source: Own calculation.

The institutional quality represents an additional factor of the female unemployment-fertility rate relationship. Better institutions are likely to support fertility increase despite higher unemployment (Behrman and

Gonalons-Pons, 2020; Giannantoni and Rodríguez-Pose, 2024). However, in the developing countries context, this relationship exhibits different patterns. The estimation results in Table 8 indicate that the nexus between unemployment and fertility is positive when the quality of institutions is lower. The increase in female unemployment leads to a higher fertility rate, probably because weak institutions often fail to provide adequate unemployment benefits, pensions, or social support systems; families may see children as a form of "economic insurance" to support parents in old age or contribute to household income through labor, especially in agrarian or informal economies. Weak institutions often fail to promote gender equality, leaving women with fewer opportunities for economic independence or career growth. Thus, unemployment exacerbates economic dependency on male partners, reinforcing the role of women as caregivers and increasing fertility rates. In addition, in weak institutional settings, many women participate in informal labor markets where job loss or unemployment is less formally defined or tracked. When the quality of institutions is above the threshold (that is, the value of WGI indicator above -0.613), the rise in unemployment is likely to reduce fertility rate. The same pattern is present in the Model (b), whereas the threshold value is slightly lower (-0.607).

Table 8: Dynamic panel threshold regression estimates (threshold variable: INS)

Variables	Model estimates			
	Model (a)		Model (b)	
	Lower regime (INS ≤ -0.613)	Upper regime (INS > -0.613)	Lower regime (INS ≤ -0.607)	Upper regime (INS > -0.607)
$FERT_{-1}$	1.018*** (0.006)	-0.015* (0.009)	1.026*** (0.006)	-0.088*** (0.008)
UNE	0.007*** (0.001)	-0.009*** (0.001)	0.003*** (0.001)	-0.005*** (0.001)
GDP	-0.031** (0.013)	0.068*** (0.017)	0.042*** (0.006)	-0.005 (0.010)
INS	-0.021* (0.012)	0.077*** (0.022)	-0.075*** (0.013)	0.199*** (0.013)
EDU	0.001* (0.000)	-0.001 (0.001)	0.003*** (0.000)	-0.005*** (0.000)
LFP	0.001 (0.000)	-0.004*** (0.001)	-	-
IMR	-0.001*** (0.000)	0.001* (0.000)	-	-
CRIS	-0.002 (0.002)	0.007** (0.003)	-	-
Constant	-	-0.219 (0.166)	-	0.731*** (0.112)
Threshold estimate $\hat{\gamma}_4$	-0.613*** (0.056)		-0.607*** (0.073)	
95% Conf. Interval	[-0.723, -0.503]		[-0.749, -0.465]	
Number of moment conditions	609		546	
SupWald Statistic (p-value)	226.51 (0.000)		406.68 (0.000)	

Notes: ***, ** and * denote statistical significance at 1%, 5% and 10%, respectively. Standard errors are reported in parentheses. Model (a) contains all control variables, whereas in Model (b), LFP, IMR and CRIS are excluded. The results are estimated using xthenreg command in Stata, proposed by Seo, Kim and Kim (2019).
Source: Own calculation.

To check the potential causality among the dependent, explanatory and control variables included in the analysis, the novel approach by Juodis, Karavias and Sarafidis (2021) was employed (Table 9). The results indicate that the direction of causality goes from the female unemployment rate to the fertility rate, as the null hypothesis is rejected at one per cent significance. On the other hand, all other variables exhibit bidirectional causality with the fertility rate. This indicates the presence of endogeneity in the model, which justifies the application of the DPTR model, as it is based on the first-differenced GMM estimates (Seo and Shin, 2016).

Table 9: The results of causality based on Juodis, Karavias and Sarafidis (2021) approach

Null hypothesis	Half-Panel Jackknife Wald test statistic	Results for the Half-Panel Jackknife estimator
UNE $\nrightarrow$ FERT	114.703***	-1.358**
FERT $\nrightarrow$ UNE	0.877	-0.001
GDP $\nrightarrow$ FERT	131.948***	0.059***
FERT $\nrightarrow$ GDP	6.616**	-0.016**
EDU $\nrightarrow$ FERT	22.237***	-0.001***
FERT $\nrightarrow$ EDU	13.729***	-0.001***
INS $\nrightarrow$ FERT	52.226***	-0.039***
FERT $\nrightarrow$ INS	0.703	0.002
LFP $\nrightarrow$ FERT	4.964**	-0.169**
FERT $\nrightarrow$ LFP	12.061***	0.002***
IMR $\nrightarrow$ FERT	194.993***	-0.003***
FERT $\nrightarrow$ IMR	19.287***	-0.581***

Note: symbol “$\nrightarrow$” means “does not Granger cause”. ***, ** and * denote statistical significance at 1%, 5% and 10%, respectively.
Source: Own calculation.

Discussion

This paper contributes to the literature on the relationship between female unemployment rate and fertility behaviors in 123 developing countries and the influence of the various economic and social factors as control variables. For this purpose, the study considering the macroeconomic context including the control variables moderated the relationships between our two indicators for unemployment status and fertility behavior. Importantly, the effect of the LFP was very similar to the one on the female unemployment rate but the effect of female education as well as GDP per capita did vary significantly in their signs across the regimes. Thus, in the panel of 123 developing countries included, the total fertility rate (FERT) was highly related to all of the socioeconomic indicators included in the model.

FERT was negatively linked with the female unemployment rate, LFP and education attainment in a higher female unemployment regime but it was negatively connected with GDP per capita in a lower female unemployment regime. The impact of institutional quality on fertility levels was constantly positive and the influence of the infant mortality rate on fertility was negative in both lower and higher unemployment regimes. Therefore, these multiple causes of declining total fertility rate in developing countries coincide with the research results of Götmark and Wetzler (2024) as well as Bongaarts and Hodgson (2022), since it was evidenced that higher fertility rate was in collision with higher infant mortality, lower levels of education and most often with less access to family planning services.

Our results suggest that unemployment status in females is an important dimension in addressing fertility behavior (Nisén, Erlandsson and Jalovaara, 2024). Thus, according to the results, it was determined that the female unemployment status increased the fertility level in a lower female unemployment regime but reduced when there is a higher female unemployment regime. These findings clearly indicate that high female unemployment in developing countries leads to delay or reduction of childbirth. These findings further suggest that higher female unemployment tends to postpone fertility or to keep it at a lower level as a result of economic hindering and employment insecurity. Furthermore, it can be stated that under economic conditions with lower female unemployment regimes in developing countries, there are positive effects on fertility levels by increasing their rates. In addition, these findings correspond very well with the postulates of the 'feminization U' hypothesis (Luci, 2009). All in all, in light of these results, when it comes to the developing world as highlighted in a lot of studies in literature, it was also found in the present study that the female unemployment status has positive as well as negative effects on the fertility levels and that the inverse U-shaped relationship is commonly confirmed (Gatta, Mattioli, Mencarini and Vignoli, 2021; Amber and Chichaibelu, 2023; Barbieri, Bozzon, Scherer, Grotti and Lugo, 2015).

This research analysis suggests that the economic setting of a country, measured by GDP per capita, influences fertility rates. The other factors that were controlled for female unemployment, such as female secondary education and the quality of institutions, were also constantly related to the fertility rate. The DPTR model, using GDP as a threshold variable, revealed that the impact of female unemployment on fertility depends on a country's economic development level. Specifically, when GDP per capita is below 5,890 USD (lower regime), a rise in female unemployment leads to higher fertility rates. In less developed economies, women who lose their jobs or struggle to enter the labor market may shift their focus to childbearing and household duties, as the opportunity cost —such as lost wages and career progression— is comparatively lower. In contrast, in more developed economies with GDP per capita above this threshold, higher female unemployment tends to decrease fertility rates. The combined effects of higher living and child-rearing costs, along with income uncertainty, often discourage childbearing. Younger women, in particular, may choose to postpone starting families until economic conditions improve.

In societies where less than 66.5 per cent of the female population has attained at least some secondary education, higher female unemployment tends to lead to an increase in fertility rates. Conversely, in contexts where education levels exceed this threshold, the relationship reverses: higher unemployment generally corresponds to lower fertility rates. This shift occurs because more educated women are often influenced by career-oriented expectations, leading them to postpone childbearing until their employment situation stabilizes.

The analysis also revealed that in developing countries with weaker institutional frameworks, higher female unemployment often results in increased fertility rates, likely due to the lack of adequate unemployment benefits, pensions, or social support systems. In such contexts, families may view children as a form of "economic security", contributing to household income or supporting parents in old age, particularly in agrarian or informal economies. Weak institutions also fail to advance gender equality, reinforcing women's caregiving roles and raising fertility rates. Furthermore, in these environments, many women work in informal labor markets, where unemployment is less formally defined or recorded. However, when institutional quality surpasses the threshold (evidenced by a WGI indicator above -0.613), an increase in unemployment is more likely to lead to a decline in fertility rates.

The results of the current analysis provide empirical support for the findings from earlier research studies that well-built policy and programs that strives to provide information as well as access to family planning services are related to lower fertility levels, and that these relationships are intensified in favorable social surroundings. Improvements in overall social conditions in countries, including reduced infant mortality and improved women's education, are related to the transition from higher to lower fertility; in addition, these improvements enable better conditions for the successful implementation of family planning services (Amber and

Chichaibelu, 2023). Even if improvements in education, health, and family planning programs may not be needed in every developing country to occur fertility transition, the results of this research suggest that policies aimed at advancing female education at the secondary school level, lessening infant mortality, improving the levels of income growth, and making better the availability and quality of family planning services would have jointly strengthening effects on fertility (Gatta et al. 2021). Fertility is expected to decline with improvements in social settings, better conditions of infant survival, and good institutional governance.

Conclusion

To gain a thorough understanding of the complex relationship between female unemployment and fertility, this study illustrates how female unemployment influences fertility in various economic, educational, and institutional contexts. The outcomes of this study are foreseen to contribute to evidence-based policymaking, providing insights that can serve as the guide strategies aimed at strengthening female economic empowerment and promoting gender equality in the labor market.

By incorporating a range of control variables, including economic and social factors, this paper provides new insights into the complex interactions that influence fertility patterns in low- and middle-income nations. The analysis demonstrates that the impact of female unemployment on fertility varies significantly depending on the level of economic development, as measured by GDP per capita, female education, institutional quality, and other macroeconomic variables. The study reveals that female unemployment rates have a clear association with fertility behaviors in developing countries, but the direction and strength of this relationship are contingent upon the broader economic and institutional context. In countries with a lower GDP per capita, a rise in female unemployment tends to correlate with an increase in fertility rates, and vice versa. Moreover, the study finds that higher levels of female education act as a moderator in this relationship. In countries where female secondary education attainment exceeds 66.5 per cent, the relationship between female unemployment and fertility becomes negative. Furthermore, in countries with weak institutional frameworks, characterized by limited social safety nets and inadequate labor market protections, higher female unemployment leads to an increase in fertility.

Based on the findings of this study, several policy recommendations can be made. First of all, policymakers should prioritize expanding access to secondary and higher education for women. As this study demonstrates, higher female educational attainment is closely linked to lower fertility rates, particularly in more developed contexts. Investment in female education should be seen as a long-term strategy to reduce fertility and empower women economically, socially, and politically. Second, in countries with weak institutional frameworks, improving social protection programs, such as unemployment benefits, pensions, and family allowances, can help mitigate the negative effects of female unemployment on fertility rates. Providing social safety nets can alleviate the economic uncertainty that discourages women from having children. In particular, policies aimed at providing affordable childcare, parental leave, and flexible working conditions can support women in balancing their family and career aspirations. Third, given the strong relationship between infant mortality and fertility rates, improving healthcare systems to reduce infant mortality should be a key policy priority. Fourth, policymakers should focus on fostering economic growth that creates stable, well-paying jobs for women. Creating an inclusive labor market that promotes gender equality in terms of wages, promotions, and job security will ensure that women are not forced to choose between economic survival and childbearing. Moreover, policymakers should take into account spatial disparities within countries, particularly the differences between urban and rural areas. Labor market opportunities, access to education, healthcare, and childcare services, as well as social norms, often differ substantially between these contexts, which in turn shapes women's employment and fertility decisions. Policies tailored to rural areas (such as improving access to education, infrastructure, and formal employment opportunities) can be especially important in influencing fertility behavior.

There are several limitations of current study that should be acknowledged. First, the study relies on macroeconomic data, which may obscure the nuances of individual-level decision-making processes. Future research could benefit from micro-level studies that examine the experiences of women in specific countries or regions to better understand the contextual factors influencing fertility decisions. Additionally, this study does not account for the role of cultural and religious factors in shaping fertility behaviors. In some regions, cultural norms around family size and childbearing may have a stronger influence on fertility decisions than economic variables. Future studies could explore the interaction between cultural factors and economic conditions in shaping fertility outcomes. In particular, incorporating variables related to religiosity, gender norms, and ethnic diversity could enhance the explanatory power of the model, especially in regions where reproductive decisions are strongly influenced by social and normative frameworks. Accounting for these dimensions would allow for a more comprehensive understanding of fertility behavior beyond purely economic determinants. Finally, the analysis focuses on developing countries but does not account for the potential spillover effects of international migration. In countries with high levels of migration, the influx of labor from other regions may influence fertility patterns in ways that are not captured by the current study. Future research could investigate the impact of migration on fertility rates, particularly in countries experiencing rapid urbanization or labor market transformations.

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Appendix

Table 1A: The list of countries

Low-income countries (27)			
Afghanistan	Burkina Faso	Burundi	Central African Republic
Chad	Congo, Dem. Rep.	Eritrea	Ethiopia
Gambia, The	Guinea	Guinea-Bissau	Liberia
Madagascar	Malawi	Mali	Mozambique
Niger	Rwanda	Sierra Leone	Somalia
South Sudan	Sudan	Syrian Arab Republic	Togo
Uganda	Yemen, Rep.	Zambia	
Lower-middle-income countries (49)			
Bangladesh	Benin	Bhutan	Bolivia
Cabo Verde	Cambodia	Cameroon	Comoros
Congo, Rep.	Cote d'Ivoire	Djibouti	Egypt, Arab Rep.
El Salvador	Eswatini	Ghana	Haiti
Honduras	India	Indonesia	Iran, Islamic Rep.
Kenya	Kyrgyz Republic	Lao PDR	Lesotho
Mauritania	Moldova	Mongolia	Morocco
Myanmar	Nepal	Nicaragua	Nigeria
Pakistan	Papua New Guinea	Philippines	Sao Tome and Principe
Senegal	Solomon Islands	Sri Lanka	Tajikistan
Tanzania	Timor-Leste	Tunisia	Ukraine
Uzbekistan	Vanuatu	Viet Nam	West Bank and Gaza
Zimbabwe			
Upper-middle-income countries (47)			
Albania	Algeria	Angola	Argentina
Armenia	Azerbaijan	Belarus	Belize
Bosnia and Herzegovina	Botswana	Brazil	China
Colombia	Costa Rica	Cuba	Dominican Republic
Ecuador	Equatorial Guinea	Fiji	Gabon
Georgia	Guatemala	Iraq	Jamaica
Jordan	Kazakhstan	Lebanon	Libya
Malaysia	Maldives	Mauritius	Mexico
Montenegro	Namibia	North Macedonia	Paraguay
Peru	Samoa	Serbia	South Africa
St. Lucia	St. Vincent and the Grenadines	Suriname	Thailand
Tonga	Turkey	Turkmenistan	

Source: World Bank Development indicators (https://databank.worldbank.org/source/world-development-indicators?Series=SE.XPD.CTOT.ZS)

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