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RESEARCH PAPER

The Roles of Climate Change and Food Security on Fertility Rate: Evidence from MENA Countries

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Abstract

Climate change and reduced food security can have devastating effects on society and especially human health. Therefore, this paper aims to investigate the impact of climate change and food security on the fertility rate in the Middle East and North Africa (MENA) by applying the novel Method of Moments Quantile Regression (MMQR) technique over the period from 2000 to 2020. Historical temperature and precipitation are included in the study model as climatic factors, and the food production index is considered a proxy for food security. In addition, the impact of the female labor force participation rate and the female population on the fertility rate have been investigated. The results from the estimations suggest that food security, mean precipitation, and female population increase the fertility rate. The impact of mean precipitation increases with higher quantiles. In addition, mean temperature and female labor force participation rate significantly decrease the fertility rate in all quantiles. In addition to protecting women's rights to education and employment, policymakers in the region must adopt appropriate policies and laws to provide the conditions for them to have children. Also, since climate change is a severe threat to the region's countries, governments should adopt appropriate policies in the agricultural sector, such as preventing the production and export of water-intensive crops, to prevent food insecurity.

Keywords: fertility rate, food security, methods of moments quantile regression, precipitation, temperature.

JEL Classification: J13, Q54.

Introduction

In 2022, the number of people facing food insecurity increased, with more than a quarter of a billion people experiencing acute hunger (FAO, 2022). The Global Network Against Food Crises Report shows that 258 million people in 58 countries were in danger of food insecurity in 2022 (GNAFC, 2022). Unfortunately, food production is enough only for the demand of less than one-third of the population (Kinnunen et al., 2020). In the mid-1970s, the concept of food security first emerged. Based on the description provided by the Food and Agriculture Organization (FAO), food security refers to a condition when a large part of the population can access sufficient food at an affordable price at all times. Researchers examined the concept of food security and insecurity at the national and household levels (Aker and Lemtouni, 1999; Nébié et al., 2021). Limited access to appropriate foods can undermine food security and food security will be the main problem in the next decades (Tahir et al., 2023). The most significant effect of food insecurity is malnutrition, which causes serious problems for the health of different groups, especially women and children (Moafi et al., 2018). Food insecurity can also have significant effects on women's health, particularly during pregnancy, leading to considerable effects such as low birth weight, increased risk of congenital defects, and pregnancy-related mortalities (Borders et al., 2007). The relationship between fertility and food insecurity is complex. Some evidence shows that women delay their fertility when faced with food shortages (Clifford et al., 2010; Grace et al., 2017) because of their fear of hunger and the stress of financial problems leading to less sexual activity (Grace, 2017). Most studies state that fertility has a negative relationship with the economic downturn and support the idea that economic recession delays childbearing, especially of the first child (Puig-Barrachina et al., 2020).

Also, unemployment can decrease the fertility rate, for example, Adserà (2004) investigated the connection between fertility and unemployment in the OECD countries and showed that high unemployment and unstable contracts reduced fertility. Jaba et al. (2008) stated that the birth rate has been declining due to the unemployment index in Romania between 1990 and 2004. Some studies pointed out a negative relationship between unemployment and the total fertility rate (Eberstadt, 1994; Gauthier and Hatzius, 1997; Goldstein et al., 2009). Bloom and Canning (2000) argued that higher income improves accessibility to better goods and services and promotes quality health services. According to studies, the unemployment rate is a serious threat to the fertility rate (Adserà, 2004).

On the other hand, women, as half of the workforce, can contribute to economic and social development through their significantly increased participation in the development of social and economic activities (Najeeb et al., 2020). Female employment is an important factor that influences the fertility rate since women don't have enough time for children when they devote all or most of their time to labor markets. Seeking to have high incomes at the entrance into the labor market and a progressive increase in salaries, women tend to postpone motherhood. Some studies have revealed a positive relationship between food security and fertility rate, although there is some evidence to recommend that fertility does not change and might even increase when an individual or household experiences food insecurity. This conflict may be explained by environmental deterioration (Atiqul Haq, 2013), which decreases agricultural production, forcing humans to enhance crop cultivation to produce adequate food. Hence, more people must be born into the world to solve this problem. However, the rise in population is linked to greater environmental strain, making poverty and environmental deterioration into a vicious spiral (Filmer and Pritchett, 2002).

In addition, the connection between agriculture and food security is crucial for many farm households, especially in countries with low and moderate income, but it is heavily dependent on climate, and climate change influences food and nutrition security (Nicholson et al., 2021; Karimi Alavijeh et al., 2022). Climate change's severe consequences are the major threat to the whole world (Jakada and Mahmood, 2023). Over the previous 100 years, the average temperature has risen by roughly 0.15 to 0.2 degrees Celsius and is predicted to have risen by 0.3 to 4.8 degrees Celsius globally by the end of this century. Precipitation patterns have also changed globally, exhibiting both positive and negative tendencies (Chen et al., 2021; Alola and Kirikkaleli, 2021).

Climate change causes a reduction in agricultural production, resulting in food insecurity through abnormal precipitation and temperature changes (Nawrotzki et al., 2016; Paglialunga et al., 2022). Global climate change has significant effects on human populations and is likely to be accompanied by an increase in hunger and malnutrition (Randell et al., 2022). Temperature and precipitation anomalies are a severe problem for biodiversity and will affect the distribution of natural population change and species (Eissler et al., 2019; Kan et al., 2023). Climate change scenarios can benefit from understanding the long-term effects of climate change on people. Demographers and epidemiologists believe that climate change has strong effects on mortality, human migration, health, and fertility rate (De Waal et al., 2006; Bakhtsiyarava et al., 2018; Casey et al., 2019; Gray and Sellers, 2019; Mendola and Ha, 2022). Climate can have various effects on fertility over the short and long term. Research conducted in 18 sub-Saharan African nations has clearly highlighted the short- and long-term consequences of climatic fluctuation on fertility. It was discovered that whereas precipitation has differing impacts on fertility over the long and short terms, the temperature rise has negative effects on fertility both ways (Chen et al., 2021).

Some investigations showed a substantial connection between climate change and reproductive goals. Women want to reduce their fertility in unfavorable environmental conditions, especially in hot periods, while their reaction to precipitation differs in the short and long-term. Also, researchers demonstrated a reduction in the birth rate in high temperatures, while precipitation anomalies have the opposite associations with such outcomes (Bakhtsiyarava et al., 2018). Research has also revealed that high temperatures increase the risk of interpersonal and domestic violence, subsequently affecting reproductive outcomes (Bohra-Mishra et al., 2014; Sanz-Barbero et al., 2018). Climate change may alter inter-spousal conflict and possibly diminish fertility desires if it raises physiological stress or lowers income. Based on research conducted in Ethiopia, regions with low levels of precipitation had greater rates of child mortality than those with high levels. Aside from that, peasant women were less likely to give birth in very high temperatures (Sellers and Gray, 2019). Another study in Mexico found that fertility increased in arid climates more than in wetland communities after precipitation, demonstrating that precipitation, particularly for dry terrain societies, contributes significantly to fertility timing (Simon, 2017). Climate change's consequences might indirectly affect fertility. For instance, research that looked at the consequences of hunger and drought in sub-Saharan Africa revealed the presence of low fertility rates there (Winkler-Dworak, 2004). Also, Owoo et al. (2015) found that women had greater fertility choices when they lived in areas with higher mortality shocks. Most scientists agree on carbon emissions as the most important reason for global warming (Koengkan et al., 2022; Sohail et al., 2023) and the positive relationship between temperature and CO_2 emissions (Lee and Cheong, 2018). There is a broad consensus that CO_2 emissions increase climate change, and global warming is a consequence of increased greenhouse gas emissions, particularly carbon emissions (Dehdar et al., 2022), which can affect health seriously by disrupting the food system through changing food prices and shortages in the supply chain. In addition, climate change can affect health by decreasing air and water quality (Jegasothy et al., 2021). The effects of global warming on weather events and the loss of habitat threaten food security (Xie et al., 2015). High temperatures and changes in precipitation patterns are the most common consequences of climate change, which reduce agricultural production, putting a large number of people at risk, increasing food insecurity (El Bilali et al., 2020), and subsequently affecting marital relationships and conflict during the hunger season (Grace et al., 2017). The potential cost of having a child may increase, potentially encouraging women to reduce fertility in response (Eissler et al., 2019).

Food security is the greatest concern in certain regions of the world, especially in the Middle East and North African nations. UN agencies estimated that more than 55 million people were malnourished before Covid-19 in the MENA region, which has a population of 456.7 million people. Food insecurity has become more common in this region due to the pandemic, long-term conflicts, and other factors (Belhaj and Soliman, 2021). Despite their impressive gas and oil exports, which contributed to around 4% of the global crude oil and 31% of the global liquefied natural gas in 2017, these nations still depend on food imports, putting their food security at risk. In addition, with an average annual regional rainfall of 1200 m3 per capita (compared to a global average of around 7000), the MENA region is one of the driest places worldwide. The temperature in the MENA region is also really high, and climate shifts are anticipated to worsen in the ensuing decades. The mean temperature increase per decade is known as the highest global temperature level in the countries of the Middle East and North Africa (Dogar and Sato, 2018). Additionally, the MENA region's unemployment rate has been around 5% higher than the worldwide rate (Constantinidou et al., 2020; Zolfaghari and Jariani, 2021). CO_2 emissions in the MENA region were estimated to be more than 2 million metric tons, accounting for more than 6% of worldwide emissions (Shahbaz et al., 2019), necessitating closer attention given some concerns about food security and environmental circumstances in the MENA countries.

According to the explanations mentioned above, the target of this paper is to discover the impacts of climate change and food security on the fertility rate using the novel econometric method - Method of Moments Quantile Regression (MMQR) for the MENA region. Based on the previous arguments, this research contributes to the literature in three ways. The first contribution is considering climatic factors and food security as less considered factors in determining the female fertility rate for a period of 21 years (2000-2020). Second, to our knowledge, this is the first paper to use MMQR to appraise the impact of climate change and food security on the fertility rate in MENA countries. Third, this approach gives a perfect picture of the conditional distribution compared to traditional panel approaches such as fixed effects ordinary least squares (FE-OLS). In fact, this method provides a nonlinear relation between variables through various quantiles distributions. This study also aligns with the United Nations

Sustainable Development Goals, namely Zero Hunger and Good Health and Well-being (Goals 2 and 3), which can help policymakers achieve the targets.

The remaining structure of this research is as follows: Section 2, the research methodology, includes the case study, the data used, and the econometric methods. Section 3 is devoted to model estimation and experimental results of the study. Finally, the conclusion and policy implications are presented in Section 4.

Theoretical Literature

Many factors, including economic, environmental, biological, and social aspects, can impact fertility in any country. However, the potential effects of climate change and food security on human fertility have not been extensively studied by researchers. Conducting a thorough analysis of existing research can help identify the critical elements associated with fertility changes in such contexts. A worrying picture of food insecurity is painted by recent statistics, which show a notable rise in the number of acutely hungry people (FAO, 2022). According to some research, during times of food shortage, women may modify their short-term reproductive goals, including the timing of childbirth and desired family size. This implies that women's reproductive decisions are significantly influenced by food availability, as they weigh the difficulties of raising more children in settings with inadequate resources. Researchers emphasize how critical it is to consider food insecurity in larger contexts related to family planning and reproductive health (DiClemente et al., 2021; Szabo, 2016; Patel and Surkan, 2016).

Female labor is another factor in the fertility rate function. In modern society, low fertility has been a topic of discussion, especially as many countries struggle with growing economic uncertainties. In this setting, research has turned its attention to the association between female labor and fertility. To understand the dynamics at work between these two crucial factors, more research is necessary as the results obtained thus far have been erratic and ambiguous (Kristensen and Lappegård, 2022). Numerous studies have consistently found that increasing employment rates may align with decreasing fertility rates because the growing number of women entering the workforce and their desire for greater wages frequently result in less time available for childcare (Bearak et al., 2021; Kato, 2020; Busetta et al., 2019; Schmitt, 2012). On the other hand, some studies show that increasing employment rates may lead to an increasing fertility rate because having a secure job and earning income has become essential for having children (Fernández et al., 2020; Autor et al., 2019; Cazzola et al., 2016; Jaba et al., 2016; Shastri, 2015).

Another factor affecting the fertility rate is climate change. High temperatures and precipitation patterns are two of the most impactful extreme climate events, affecting human life and population dynamics on a global scale (Ebi et al., 2021). Changes in temperature and precipitation patterns brought on by climate change can have an impact on population dynamics since they can affect fertility behavior (Grace, 2017). Due to the potential influence of climate change on rising temperatures, food scarcity may arise, leading to diminished health and lower fertility rates (Cho, 2020; Eissler et al., 2019; Sellers and Gray, 2019; Barreca et al., 2018). Not only can temperature changes affect fertility, but precipitation patterns also do. Contrary to the adverse effects of temperature-related events on fertility rates, precipitation events, such as heavy rainfall and flooding, have often been associated with increased fertility rates. Increased agricultural productivity in areas where rainfall is a scarce resource, which improves food security and nutritional status, could be one explanation for this phenomenon (Ahmed, 2022; Chen et al., 2021; Carrico and Donato, 2019).

Finally, the relationship between the female population and fertility rate has been very important among researchers. The rate of fertility is one element influencing population changes (Fathi, 2009). Some studies indicate that there is a direct and proportional relationship between the number of women and the fertility rate. This suggests that the overall fertility rate would increase concurrently with an increase in the female population within a community. Since each woman has the potential to influence the fertility rate, a larger female population would logically lead to more births and, consequently, a higher fertility rate (Zhu et al., 2022; Huang et al., 2019; Ouedraogo et al., 2018; Baliamoune-Lutz, 2016).

Methods and Materials

Case Study

The MENA nations include the Middle East and North Africa, which are important oil-producing regions. As a result, variations in oil prices throughout the world significantly impact the economies of these nations. The area runs from Iran, the Middle East's easternmost nation, to Morocco in northwestern Africa. Around 6% of the world's population is located in the Middle East and North Africa. Ethiopia and Sudan are occasionally included in the MENA region, which normally includes 22 nations (Figure 1). The MENA region has a hot, dry climate, and in recent years, its average rate of surface temperature increase per decade has been among the highest ever recorded worldwide (Dogar and Sato, 2018; Zittis et al., 2019; Constantinidou et al., 2020).

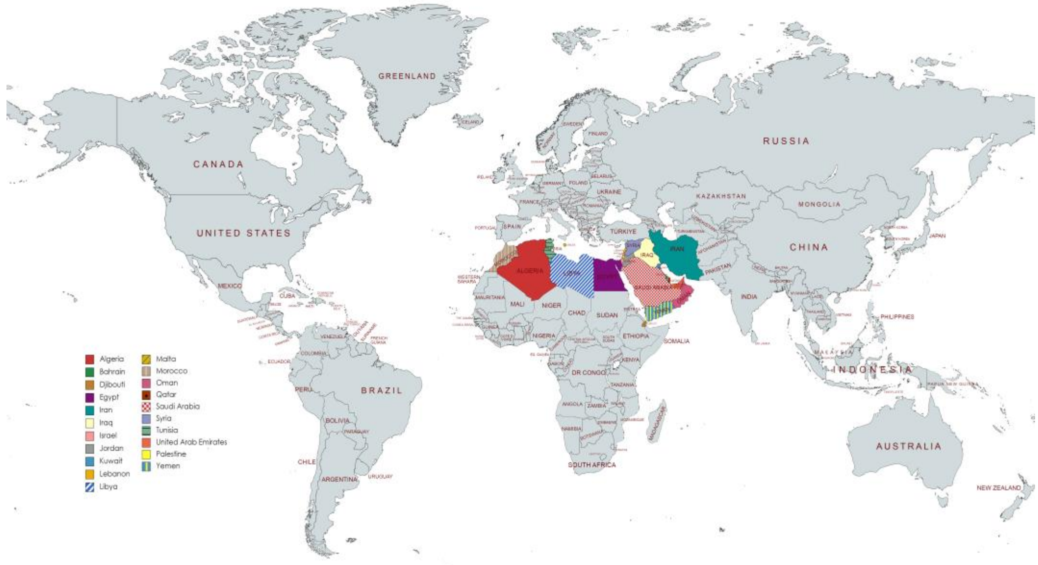

Figure 1. MENA Countries
Source: www.mapchart.net.

Figure 1 indicates the 22 countries of the MENA region.

Methods of Moments Quantile Regression

Koenker and Bassett (1978) initially described the quantile regression approach. Concerning specific exogenous variable values, this method calculates the response variables' conditional median or the number of quantiles. Additionally, this method provides a systematic way to examine how each determinant impacts the dependent variable across its conditional distribution in the panel of nations. The current investigation uses the Method of Moments Quantile Regression (MMQR) with fixed effects, which was developed by Machado and Silva (2019). As shown below, the MMQR equation is:

$$Y_{it} = \alpha_i + X'_{it}\lambda + (\delta_i + Z'_{it}\Phi) + U_{it} \tag{1}$$

where:

- $\alpha, \lambda, \delta,$ and Φ are unidentified variables that need to be assessed.
- A known differentiable transformation of one of the components of X is represented by the k-vector Z.
- $P\{\delta_i + Z'_{it}\Phi > 0\} = 1$ is the known function
- The unobserved random variable U_{it} has been normalized to comply with the moment criteria which has two conditions:

$E(U) = 0 \qquad E(|U|) = 1$

- X'_{it} and U_{it} are independent.

Thus Equation 1 indicates the following:

$$Q_Y(\Psi|X_{it}) = \big(\alpha_i + \delta_i q(\Psi)\big) + \acute{X}_{it}\lambda + \acute{Z}_{it}\Phi q(\Psi) \quad (2)$$

In Equation 2, $\alpha_i + \delta_i q(\Psi) \equiv \alpha_i(\Psi)$ is the impact of distribution at quantile Ψ. MMQR of Equation 2 is done by calculating two fixed effects regressions and using a univariate quantile.

Model and Variables

The present paper examines the effect of food security and climate change on the fertility rate in 14 MENA countries (Iran, Iraq, Saudi Arabia, Kuwait, Qatar, United Arab Emirates, Algeria, Bahrain, Egypt, Israel, Oman, Tunisia, Morocco, Yemen) using MMQR. In this research, average temperature and average precipitation are considered indicators of climate change (Brown and Lall, 2006). Thus, according to previous studies (Casey et al., 2019; Lal et al., 2021; Chen et al., 2021) and theoretical foundations, the model specified in this research is:

$$FR_{it} = f(FS_{it}, FL_{it}, TEM_{it}, PR_{it}, POPF_{it}) \quad (3)$$

In Equation 3, FR, FS, FL, TEM, PR, and POPF represent fertility rate, food security, female labor, temperature, precipitation, and female population, respectively. The number of countries is displayed by i (from 1 to 14) and t indicates the time period. Therefore, Equation 4 is as follows:

$$FR_{it} = \alpha_i + \beta_1 FS_{it} + \beta_2 FL_{it} + \beta_3 TEM_{it} + \beta_4 PR_{it} + \beta_5 POPF_{it} + \xi_t , \quad (4)$$

According to Equation 3, α_i represents the constant term. β_1, β_2, β_3, β_4 and β_5 define the long-run elasticities. ξ_t denotes the error terms. Table 1 provides the introduction of variables in Equation 3.

Table 1. Introduction of Variables

Variable	Abbreviation	Definition	Source	Supporting reference
Fertility rate	FR	Fertility rate, total (births per woman)	WDI	Alola et al. (2019)
Food security	FS	Food production index	WDI	Anser et al. (2020)
Female labor	FL	Labor force participation rate, female (% of female population ages 15+)	WDI	Kato (2020)
Temperature	TEM	Average air temperature (°C)	CCKP	Chen et al. (2021)
Precipitation	PR	Average precipitation (mm)	CCKP	Chandio et al. (2020)
Female population	POPF	Population, female (% of total population)	WDI	Lal et al. (2021)

Source: Research finding.

Note: (1) The estimation period is limited to 2000-2020 due to the unavailability of data in some countries after this period. (2) All variables are logarithmic. (3) WDI and CCKP stand for World Development Indicators, and World Bank Group, Climate Change Knowledge Portal, respectively.

Figures 2 and 3 display changes in the fertility rate and food security for the selected MENA countries during the years 2000–2020. The findings of Figure 2 show the female fertility rate. Yemen had the highest fertility rate of 6.31 births per woman in 2000, while the United Arab Emirates had the lowest fertility rate of 1.41 births per woman in 2020. According to Figure 2, Yemen and Iraq have the highest fertility rates from 2000 to 2020. During the period under review, the fertility rate decreased in all countries except Iran, Algeria, Egypt, Israel, and Tunisia. The results of Figure 3 show food security in the selected MENA countries. We used the food production index as an indicator of food security. The United Arab Emirates and Algeria had the highest and the lowest food production indices with 182.39, and 41.5 in 2000.

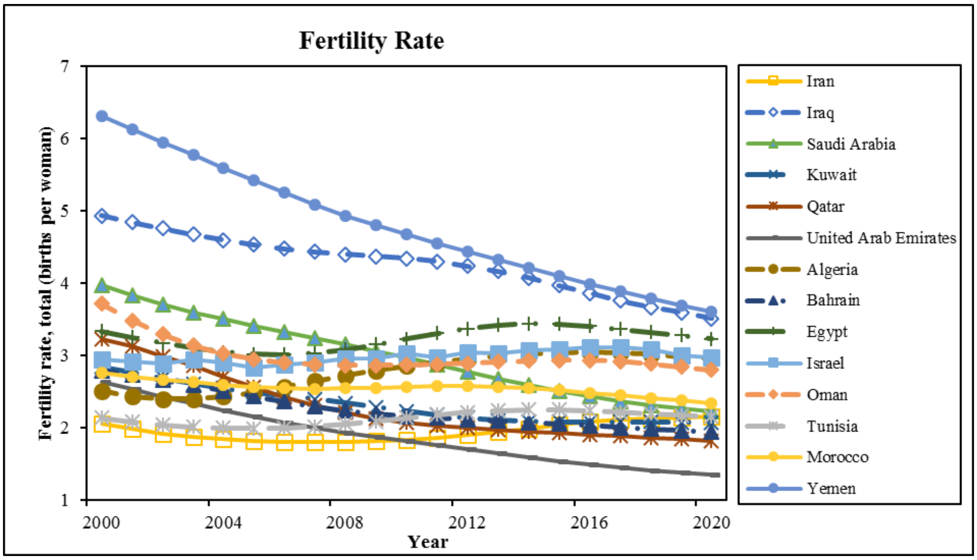

Figure 2. Fertility rate, total (births per woman).
Source: WDI, 2020.

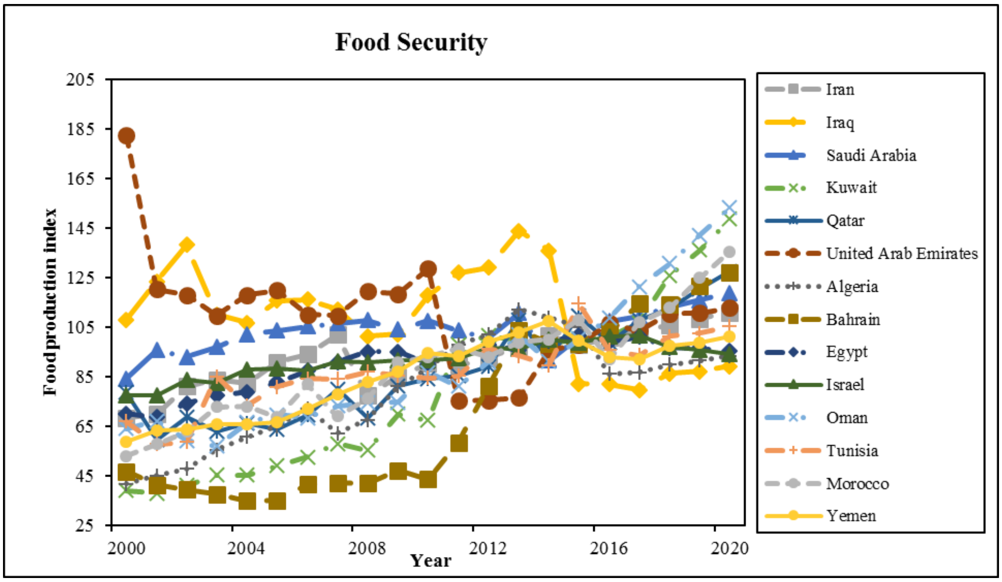

Figure 3. Food Security
Source: WDI, 2020.

Result and Discussion

Description of Variables

In this subsection, variables descriptive statistics are provided (Table 2). The outcomes indicate the minimum and maximum fertility rate from 0.131 to 0.800

for all MENA countries. FS and FR have the largest and smallest mean between the variables, respectively. The mean value of food security is 1.939 with a standard deviation of 0.125. Also, all of the variables follow the left-skewed distribution except FR. The statistic of the Jarque-Bera test for all variables is less than the 1% and 5% significance. So, the null hypothesis data is rejected and all variables have an asymmetric distribution. This output confirms the use of the MMQR method (Sun et al. 2022). In addition, the investigation of the normality can be shown graphically by the plotting of histograms. Therefore, the absence of normality is also obvious in Figure 4.

Table 2. A Summary of Descriptive Statistics

Variables	FR	FS	FL	TEM	PR	POPF
Mean	0.430	1.939	1.401	1.372	1.897	1.636
Std.dev.	0.126	0.125	0.245	0.063	0.313	0.090
Skewness	0.460	-0.975	-0.279	-0.444	-0.232	-1.508
Kurtosis	3.066	3.998	2.396	2.077	2.145	4.302
Minimum	0.131	1.541	0.778	1.245	1.091	1.367
Median	0.422	1.968	1.388	1.372	1.845	1.693
Maximum	0.800	2.261	1.777	1.467	2.547	1.705
Jarque-Bera	10.436***	58.847***	8.275**	20.097***	11.596***	132.330***

Source: Research finding.

Note: ***significance at the 1% level, **significance at the 5% level.

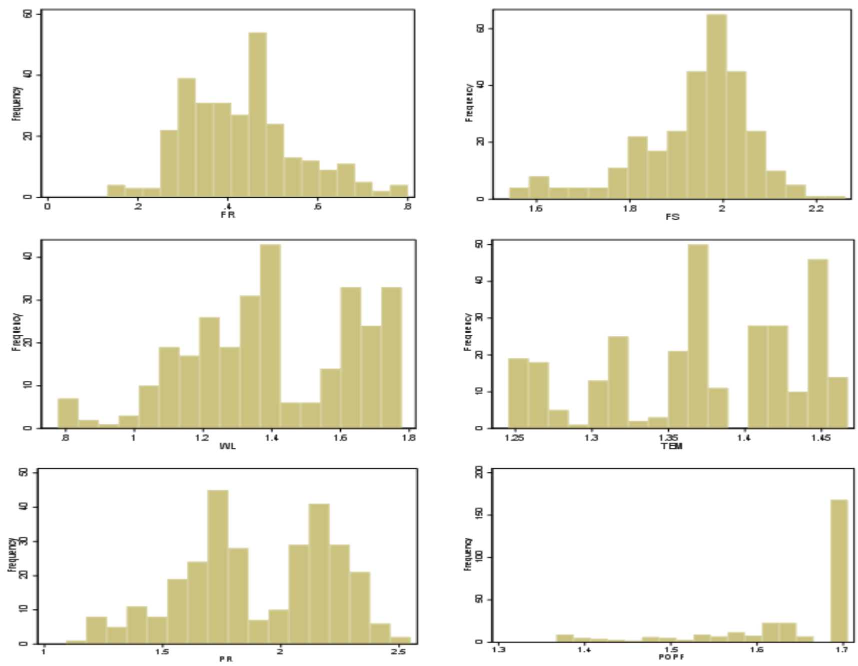

Figure 4. Histogram of Data
Source: Research finding.

Correlations, VIF Statistics and Hausman Tests

Table 3 displays the correlations among the variables in this study. Food security, precipitation, and female population show a positive correlation with fertility rate, while female labor and temperature indicate a negative correlation. All the correlation matrix coefficients are less than 0.8 in absolute value, which indicates that there is no multicollinearity. Therefore, the findings of the regression will be reliable. Furthermore, the mean VIF is less than 6 (2.20 < 6). Thus, there is no severe multicollinearity problem (Koengkan et al. 2023).

Table 3. Correlation Matrix and VIF

Variables	FR	FS	FL	TEM	PR	POPF	VIF	1/VIF
FR	1.000						-	-
FS	0.352***	1.000					3.26	0.307
FL	-0.524***	-0.129**	1.000				3.04	0.328
TEM	-0.288***	-0.105*	0.354***	1.000			2.01	0.497
PR	0.778***	0.067	-0.201***	-0.714***	1.000		1.59	0.627
POPF	0.451***	-0.061	-0.568***	-0.719***	0.514***	1.000	1.10	0.910
Mean VIF	-	-	-	-	-	-	2.20	-

Source: Research finding.

Note: ***significance at the 1% level, **significance at the 5% level, *significance at the 10% level.

To investigate whether the panel data model has random effects or fixed effects, the Hausman test is used. Table 4 indicates the findings of the Hausman test. The results show that the null hypothesis is rejected and there are fixed effects in the research model. This outcome is consistent with the requirements of the MMQR approach, which requires fixed effects.

Table 4. The Result of Hausman Test

chi2(5) = 17.10 ***

Source: Research finding.

Note: ***significance at the 1% level.

Unit Root and Cointegration Tests

Before starting the analysis, it is necessary to perform the panel unit root test because non-stationary data can cause unreliable results (Cheng et al., 2021). Therefore, three types of panel unit root tests have been conducted to investigate the stationarity of the six variables in the research model. These tests include the Fisher–ADF unit root test (Maddala and Wu, 1999), Fisher–PP unit root test (Choi, 2001), and Im-Pesaran-Shin unit root test (IPS test) (Im et al., 2003). Table 5 displays the findings of the unit root tests. It can be observed that the level series of PR and TEM are stationary; therefore, their first-order difference series are also stationary. The other variables are static after first differencing at the 1% significance level.

Due to the existence of variables with different orders of integration, it is necessary to investigate the cointegration relationship between the variables. In this study, Kao's (1999) residual cointegration test has been used in the panel data as a pre-test to avoid spurious regression. The result of Kao's (1999) cointegration test is shown in the last line of Table 5. The statistic value is significant at the 5% level. In other words, the variables are cointegrated, and there is a long-run relationship between the variables.

Table 5. Results of Panel Unit Root Tests and Co-Integration Test of Variables

	Series	Fisher ADF		Fisher PP		IPS	
		Constant	TC	Constant	TC	Constant	TC
Levels	FR	719.57***	152.158***	84.957***	25.705	-14.424***	-15.269***
	FS	32.033	30.934	32.676	59.000***	0.482	-0.204
	FL	24.973	13.996	20.882	7.997	0.903	3.337
	TEM	50.331***	64.928***	119.521***	127.971***	-2.923***	-4.378***
	PR	73.276***	53.106***	153.769***	123.796***	-4.534***	-2.631***
	POPF	206.383***	201.427**	35.760	8.481	-1.323*	-1.260*
First difference	FR	98.715***	94.662***	45.552***	52.815***	-6.431***	-6.519***
	FS	115.086***	96.840***	272.740***	190.541***	-7.904***	-6.860***
	FL	49.105***	49.142***	91.749***	79.733***	-2.475***	-2.392***
	TEM	155.811***	108.847***	373.924***	264.661***	-10.803***	-7.929***
	PR	169.810***	135.192***	507.127***	273.425***	-11.713***	-9.886***
	POPF	187.672***	220.291***	47.833***	50.231***	-12.624***	-22.738***
Kao Residual Co-integration Test: -1.892** (0.029)							

Source: Research finding.
Note: (1) ***significance at the 1% level, **significance at the 5% level, *significance at the 10% level.
(2) TC shows trend and constant.

Table 6. MMQR Results and OLS Fixed Effects

	Quantiles					
Variable	**10th**	**25th**	**50th**	**75th**	**90th**	**OLS fixed**
FS	0.202**	0.216***	0.243***	0.261***	0.274***	0.240***
FL	-0.194***	-0.181***	-0.157***	-0.141***	-0.129***	-0.159***
TEM	-1.439***	-1.450**	-1.469***	-1.482***	-1.492***	-1.467***
PR	0.020	0.038	0.072***	0.095***	0.112***	0.069***
POPF	1.276***	0.794***	1.022***	1.006***	0.937***	1.018***
Observations	294	294	294	294	294	294
Post-estimation test for the panel quantile model						
F/Wald test	Chi2(5) = 94.90***		Chi2(5) = 327.96***		Chi2(5) = 107.82***	

Source: Research finding.
Note: (1) ***significance at the 1% level, **significance at the 5% level.

Table 7. Robust Check: Excluding FL

	Quantiles					
Variable	**10th**	**25th**	**50th**	**75th**	**90th**	**OLS fixed**
FS	0.230**	0.270***	0.313***	0.354***	0.381***	0.312***
FL	-	-	-	-	-	-
TEM	-0.903***	-1.213***	-1.546***	-1.867***	-2.076***	-1.537***
PR	-0.056	-0.001	0.057***	0.114***	0.152***	0.056**
POPF	1.257***	1.293***	1.331***	1.368***	1.392***	1.330***
Observations	294	294	294	294	294	294
Post-estimation test for the panel quantile model						
F/Wald test	Chi2(4) = 56.69***		Chi2(4) = 229.62***	Chi2(4) = 90.71***		

Source: Research finding.

Note: (1) ***significance at the 1% level, **significance at the 5% level.

MMQR Results

As described in Section 2-2, MMQR is applied to examine the effect of food security, temperature and precipitation on women's fertility rate. The research model has been estimated at different quantiles (0.1, 0.25, 0.5, 0.75, and 0.9), the results of which are represented in Table 6. Table 6 also reports the outcomes of OLS fixed-effects regression estimation to facilitate comparative analysis. Besides, Figure 5 provides a graphical representation of the results, showing positive associations of fertility rate with food security, precipitation, and female population and negative effects of women's labor and temperature on fertility rate. As Table 6 shows, the relationship between food security (FS) and women's fertility rate (FR) is positive and significant across all quantiles. The magnitude of the coefficient in each quantile is similar to that of the OLS fixed-effects regression (Salehnia et al., 2020). For example, in the 0.10 quantile, the fertility rate increases by 0.20% for a 1% increase in food security. The findings of OLS fixed-effects regression also corroborate a significant and positive relationship between food security and fertility rate. In this study, food production index is regarded as an indicator of food security. Therefore, increasing food production increases food security, improves women's reproductive health, and reduces infant mortality. The result of this research is in line with Chen et al. (2021), who indicated that the relationship between crop production and total fertility rate was directly positive in Bangladesh.

Female labor force participation rate (FL) is found to influence the fertility rate negatively and significantly in both the quantile regression and the OLS fixed-effects regression. According to the results of the OLS fixed-effects regression model, the fertility rate decreases by 0.15% if FL increases by 1%. Thus, increased female labor force participation rate has led to lower fertility rates in the 14 selected countries in the Middle East and North Africa. In other words, when women are in the labor market and want to earn more income, they do not have enough time to take care of children and thus postpone their pregnancy. This finding is consistent with the study of Fernández et al. (2020), and Lal et al. (2021). However, this finding contradicts the study of Kato (2020), who reported that an increase in the total fertility rate corresponds with an elevated level of female labor participation. The MMQR and OLS fixed-effects regression results confirm the negative and statistically significant impact of temperature (TEM) on women's fertility rate in all quantiles. The OLS fixed-effects regression results show that the fertility rate will decrease by 1.46% with a 1% increase in temperature. Table 6 also displays an increase in the impact of TEM on fertility rate with increasing quantiles. Rising temperatures further reduce fertility rates in countries with lower fertility rates more than in those with higher fertility rates. It is noteworthy that MENA countries are less developed, and the economies of developing countries are dependent on agriculture. In this region, 70 percent of the agricultural sector is rain-fed and extremely exposed to climate change (Waha et al., 2017). Therefore, climate change and rising temperatures will lead to a decrease in agricultural products, consequently resulting in food insecurity, reduced health, and lower fertility rates. This result is in line with the findings of Eissler et al., (2019) for sub-Saharan African countries.

According to the findings of the OLS fixed-effects regression, the impact of mean precipitation (PR) on fertility rate was positive and significant, while the results of MMQR indicate that this impact is not significant in all quantiles, with positive and significant impacts of PR on the fertility rate only in the 0.5, 0.75, and 0.9 quantiles. The impact of mean precipitation increases along the quantiles, and a coefficient increase can be observed for the 0.9 quantile. The MENA region is highly exposed to climate change conditions, which have been shown to affect human health (McMichael et al., 2006). Most of the land in the MENA region receives less than 300 mm of annual rainfall, and considering that the lower limit for rain-fed agriculture is between 200-300 mm of annual rainfall, MENA countries are vulnerable to precipitation and related implications for food security (Waha et al., 2017). Access to food is one of the important links between climate change and human health (Myers and Patz, 2009); thus, higher precipitation increases agricultural yields and food security, health, and fertility. A study by Chen et al. (2021) displayed similar findings.

Finally, according to the results, the impact of female population (POPF) on fertility rate is positive and significant in all quantiles. The results of OLS fixed-effects demonstrate that the fertility rate rises by 1.01% with a 1% increase in the female population. Assuming all women are born fertile, get married in the future, and have children, a higher female population in the country means more reproduction (Lal et al., 2021). Given that women's rights have not been realized in the countries of the MENA region, and there are no equal conditions for education and employment in these countries (Klasen and Lamanna, 2009; Baliamoune-Lutz, 2016), a positive relationship may be found with women's fertility. Hence, the increase in the female population becomes an effective factor in fertility.

Also, the findings of the post-estimation test at the end of Table 6 indicate that the model estimator selected in the current research is appropriate for this analysis.

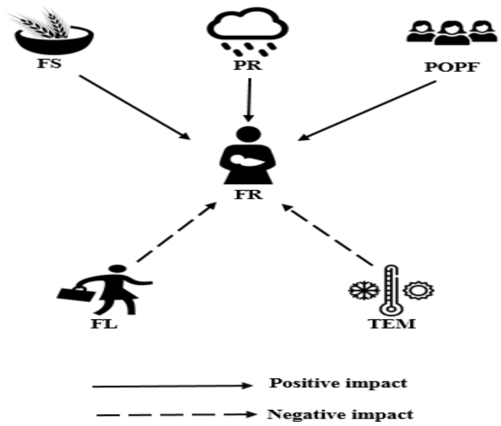

Figure 5 Graphical image of estimation results.
Source: Research finding.

Robustness Check

This sub-section considers an alternative model to verify the stability and robustness of the results (Zhu et al., 2016; Cheng et al., 2018; Cheng et al., 2021). FL is excluded in one additional robustness check (Table 7). As shown, the estimation results of the robustness checks are almost consistent with the findings in Table 6. Consequently, the robustness of the findings reported in the present study is confirmed.

Conclusion and Policy Implication

This study investigated the effect of food security and climate change on the fertility rate in 14 MENA countries during the years 2000-2020, utilizing MMQR. Mean temperature and mean precipitation have been regarded as indicators of climate change, and the food production index represents food security. Also, the female labor force participation rate and the female population have been introduced as control variables.

According to the empirical results obtained through the MMQR method, the impact of food security on the fertility rate is positive and significant in all quantiles. On the other hand, the impact of the female labor force participation rate on the fertility rate is negative and significant in all quantiles. In addition, the relationship between temperature and fertility rate is significant and negative in all quantiles. In contrast, the effect of precipitation on the fertility rate increases with increasing quantiles. Finally, the female population increases the fertility rate in all quantiles.

Based on the results, policymakers should be aware that maintaining food security contributes to the health of people in the community by increasing female fertility and reducing infant mortality rates. Therefore, it is suggested that governments support advanced agricultural methods to deal with the impacts of climate change on agriculture in MENA countries. For example, farmers can apply novel irrigation methods and low-carbon emission farming systems to achieve more effective and higher quality crop production, which is possible with government support and the payment of subsidies to farmers. Also, according to findings, assuming that all women in the MENA region have reproductive capacity and there are no infertile women, increasing the female population means increasing the fertility rate. It should be noted that most women in the Middle East and North Africa are deprived of their rights to education and employment. Also, the age of marriage for girls in this region is lower than in developed countries, indicating that an increased population of women can have a positive effect on their fertility rate. Therefore, policymakers in these societies should provide the conditions for women to have children while also supporting their rights in education and employment by adopting appropriate policies and laws.

Like other studies, this study has limitations. The first limitation is that this research considers 14 countries in the MENA region, while considering more countries can lead to a wider understanding of the research topic. Also, based on the literature, this study has only chosen food security, female labor force participation rate, temperature, precipitation, and female population as factors affecting the fertility rate, which will inevitably lead to the omission of other relevant factors. To overcome the limitations, future studies can replicate this research for other groups of countries such as ASEAN, D-8, and OECD countries. Besides, other scholars can extend this paper by adding other variables such as CO2 emissions, education level of women, inflation, government size, family welfare, etc., and obtain valuable results.

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