The Impact of National Development on Fertility Rates in Canada and Other Countries

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Abstract: This study examines the relationship between economic and social factors and fertility rates, with a particular emphasis on Canada, using a fixed-effects regression model. The analysis explores the effects of Gross Domestic Product (GDP), life expectancy, education level, labor force participation, and GDP growth on fertility rates. The findings reveal that GDP growth has a positive impact on fertility rates, suggesting that economic prosperity encourages larger families. Conversely, higher life expectancy, increased education levels, and higher GDP growth rates are associated with lower fertility rates. Participation in the labor force has a slightly positive effect on fertility. These results provide insights into how economic policies and social trends influence fertility decisions in Canada and beyond, offering important implications for policymakers seeking to manage fertility rates.

Keywords: Fertility rate; Economic growth; Life expectancy; Education; Labor force participation; GDP; Fixed-effects model; Regression analysis; Fertility determinant

1 Introduction

The fertility rate, defined as the average number of children born per woman of childbearing age over her lifetime, is a crucial indicator of a country's demographic dynamics. It is closely tied to socio-economic development and the well-being of populations. Over time, fertility trends have evolved within the context of economic, social, and political changes.

In this study, we examine the impact of national development on fertility rates. National development, often measured by composite indices such as the Human Development Index (HDI), encompasses various socio-economic aspects such as per capita income, education, access to healthcare, and other well-being indicators.

The primary goal of this research is to analyze how the different dimensions of national development affect fertility rates across various countries. Understanding these relationships is essential for formulating effective policies on reproductive health, family planning, and economic development.

To achieve this, we will use demographic and socio-economic data from a range of international and national sources. Advanced analytical methods will be applied to examine the correlations between national development and fertility rates, taking into account demographic, socio-economic, and cultural factors unique to each country.

The findings of this study will provide valuable insights for policymakers, development practitioners, and researchers interested in population and development issues. By better understanding the determinants of fertility rates, we can devise more effective strategies to promote population well-being and support sustainable development on both national and global scales.

2 Literature Review

The Link between Fertility and Income (Guillaume Vandenbroucke, 2016)

The article "The Link between Fertility and Income" by Guillaume Vandenbroucke examines the inverse relationship between a country's wealth (measured in GDP per capita) and its fertility rate. It highlights that economic factors significantly influence family planning. Poorer countries tend to have higher fertility rates due to lower opportunity costs of child-rearing, higher infant mortality rates necessitating more births, and the lack of social security systems, making children a critical source of support in old age. Conversely, wealthier countries exhibit lower fertility rates due to the higher costs associated with educating and raising fewer but more well-educated children. Based on this literature, we can hypothesize that a country's wealth can affect its fertility rate.

Fertility Rate (Max Roser, 2014)

The article on fertility rates by Our World in Data discusses global trends and determinants of fertility rates, emphasizing their significant decline worldwide in recent decades. It notes that fertility rates are influenced by various factors, including economic development, education levels, access to contraception, and shifting societal values and norms. The article also explores the implications of changing fertility rates on population growth, aging, and societal structures. It provides a comprehensive analysis of how fertility rates vary across regions, the reasons for these variations, and what they imply for future global demographics. This article enables us to anticipate the effects of economic and educational levels on fertility rates.

The New Economics of Fertility (Matthias Doepke, 2022)

The article" The New Economics of Fertility" addresses the evolving dynamics of fertility in high-income countries, emphasizing the importance of helping women balance their careers and family lives. It highlights the historical decline in fertility rates in developed countries and examines the reasons behind this trend, including economic and social factors influencing individual fertility decisions. The authors challenge traditional explanations for the fertility decline (such as the quantity-quality tradeoff and opportunity costs of child-rearing) and present new data showing that these relationships have weakened in high-income countries. They argue that fertility behavior is now largely influenced by the extent to which women can balance career and family life. Family policies, paternal roles, social norms, and labor market conditions are identified as key factors in this balance. This literature suggests that female workforce participation rates are likely to affect fertility rates.

Human Fertility in Relation to Education, Economy, Religion, Contraception, and Family Planning Programs (Frank Götmark and Malte Andersson, 2020)

This article examines factors influencing the total fertility rate (TFR) across six global regions, covering 141 countries. It finds that women's average years of education, GDP per capita, religiosity, contraceptive prevalence rate (CPR), and the strength of family planning programs significantly impact fertility rates. Results show a negative correlation between TFR and education, CPR, and GDP per capita, and a positive correlation with religiosity. Notably, Europe displays unique patterns, such as a rising TFR with higher education levels in Western Europe. This literature highlights that women's education and religion are crucial influences.

Recent Fertility Trends in Sub-Saharan Africa: Workshop Summary (2016)

This study emphasizes that, despite declining fertility rates in some regions of the world, fertility rates in Sub-Saharan Africa remain high, with an average of 5.1 children per woman. These high rates contribute to rapid population growth in the region, with a projected increase of 1.2 billion inhabitants by 2050, the fastest of all regions. A workshop held in June 2015 by the Population Committee examined fertility trends and their influencing factors, underscoring the critical importance of contraception and the need for better understanding and accessibility of effective methods to control fertility rates. Fertility is heavily influenced by regional factors, which should be considered when analyzing fertility determinants at the global level.

Global Trends in Total Fertility Rate and Its Relation to National Wealth, Life Expectancy, and Female Education (2022)

This study examines the global relationship between the total fertility rate (TFR) and GDP per capita, life expectancy at birth, expected years of schooling for women, and the Human Development Index (HDI). The results show that as GDP per capita, life expectancy, women's education, and HDI increase, TFR significantly decreases in most regions. Women increasingly choose to pursue professional careers or educational opportunities, thus delaying motherhood. However, with continued social development, the rise in these factors also leads to a slight rebound in TFR. Social policy support or cultural preferences for higher fertility levels may result in this slight fertility rebound. This literature encourages us to consider longevity and HDI as key influencing factors.

3 Model Basis

Fertit=α0+α1ln PIBit+α2Lifeit+α3Eduit+α4Laborit+α5Humanit+α6GDPRit+μi+ϵitFertit = \alpha_0 + \alpha_1 \ln PIBit + \alpha_2 Lifeit + \alpha_3 Eduit + \alpha_4 Laborit + \alpha_5 Humanit + \alpha_6 GDP Rit + \mu_i + \epsilon_ itFertit=α0+α1lnPIBit+α2Lifeit+α3Eduit+α4Laborit+α5Humanit+α6GDPRit+μi+ϵit

In this formula, α0\alpha_0α0 represents the constant term, and α1\alpha_1α1 to α6\alpha_6α6 represent the regression coefficients that need to be estimated. These coefficients reflect the magnitude of the effect of each independent variable on the dependent variable. The iii symbolizes the iii-th country included in the study, while ttt represents the year or moment in time, highlighting the longitudinal or panel aspect of the data. The term ϵit\epsilon_itϵit is the random error term, capturing the effects on fertility rate that are not observed or included in the model. The use of ln□\lnln (the natural logarithm) before certain variables, such as ln PIB\ln PIBlnPIB, helps to reduce variability and extreme outliers between observations, making the regression coefficient estimates more stable and interpretable.

The μi\mu_iμi represents the individual fixed effects for each country, allowing for control of the unique and unobservable characteristics of each country that could influence the fertility rate. By including these fixed effects, the model can isolate the impact of the explanatory variables on the dependent variable (fertility rate, in this case), while taking into account the inherent differences between countries that are constant over time but vary from country to country.

4 Data Analysis

The Intuition Behind the Causality Between Fertility and National Development Levels

Existing literature provides numerous explanations regarding the impact of national development levels on fertility, as well as mechanisms explaining why women's fertility rates decline as urbanization progresses and nations develop.

The intuitive relationship between education levels and fertility in a country is based on education’s impact on individual choices and social structures. Higher education levels are generally associated with lower fertility rates because extended years of schooling delay the age at which women marry and become fertile. Education increases career prospects and earning potential, leading to a greater tendency to postpone childbearing to focus on career development.

When a country's GDP per capita and income per capita increase, people generally have more resources and opportunities to invest in education, career development, and improving their quality of life. As the cost of living and standard of living rise, the financial burden of raising children increases accordingly. This leads families to prioritize having fewer children to provide a better educational and developmental environment for each.

Growing urbanization is typically accompanied by higher living costs, limited living space, and better educational and employment opportunities, resulting in a tendency for families to have fewer children. In urban areas, the higher economic burden of raising children, combined with higher levels of female education and labor force participation, as well as increased availability of knowledge and tools for fertility control, has collectively led to a decline in fertility rates.

Increased life expectancy often signals improvements in socio-economic and medical conditions, which are closely tied to lower fertility rates. Economic improvements lead to greater female labor market participation, while improved health and medical conditions often result in lower infant and maternal mortality rates.

4.1 Data Presentation

Our project analyzes data from eight countries chosen for their geographic and economic diversity, spanning five continents. We categorized these countries by income level: South Korea, the United States, and France as high-income; China, Russia, and Mexico as middle-income; and Nigeria and India as low-income. This selection ensures the representativeness and relevance of our experimental data.

Our study focuses on a series of socio-economic indicators over 32 years, from 1990 to 2021. These indicators include annual fertility rate, GDP per capita, average years of schooling, the Human Development Index (HDI), life expectancy at birth, real GDP annual growth rate, and female labor market participation. The data were sourced from reliable organizations such as the United Nations, the World Bank, and FRED, and compiled into a Stata file. However, some gaps remain due to incomplete data for certain countries. We employed various interpolation methods to address these gaps and ensure uniformity in our dataset.

4.2 Tools for Analysis

This research uses data from eight countries over 32 years, resulting in a sample of 256 observations. The analysis begins with descriptive statistical analysis to understand the basic state of the data. Next, a correlation analysis is conducted to gain an initial understanding of the relationships between variables, followed by a multicollinearity test to check for severe multicollinearity among the variables. F, LM, and Hausman tests are then conducted to select the appropriate model, concluding that the fixed-effects model is the most suitable for estimation in this study.A robustness test is also conducted, confirming that improvements in development levels across various aspects of a country impact fertility rates.

Table 1 Description des variables

Variable Name	Description
Fert	Synthetic fertility index (live births per woman).
lnPIB	Natural logarithm of gross domestic product (GDP) per capita at current prices in US dollars.
Life	Life expectancy per capita (years).
Edu	Average years of education per capita.
Labor	Female population (% of the total active workforce).
Human	Human Development Index (HDI).
GDPR	Real GDP Growth, annual growth rate of GDP.

4.3 Descriptive Statistics

Table 2 sum Fert lnPIB Life Edu Labor Human GDPR

Variable	Obs	Mean	Std. Dev.	Min	Max
Fert	256	2.463529	1.460098	0.808	6.459
lnPIB	256	8.724682	1.542884	5.736938	11.15643
Life	256	70.61252	9.833903	45.487	83.52683
Edu	256	8.679608	3.240039	2.010836	13.68343
Labor	256	50.23698	11.66334	18.603	73.022
Human	256	.7172578	.1643693	.2930001	.933
GDPR	256	3.914433	4.385812	−14.53107	15.32916

The data set consists of 256 observations. Key statistical details are as follows:

- The mean of Fert (fertility rate) is 2.4635, with low volatility.
- The mean of lnPIB (log GDP per capital) is 8.7247, with a minimum value of 5.7369 and a maximum value of 11.1564, also indicating low volatility.
- The mean of Life (life expectancy) is 70.6125.
- The mean of Edu (average years of education) is 8.6796, ranging from a minimum of 2.0108 to a maximum of 13.6834.
- The mean of Labor (female participation in the workforce) is 50.2370, with a minimum of 18.6030 and a maximum of 73.0220.
- The mean of Human (HDI) is 0.7123.
- The mean of GDPR (real GDP growth rate) is positive, indicating overall economic growth.

Table 3 asdoc pwcorr Fert lnPIB Life Edu Labor Human GDPR,star(all) dec(4) nonum replace

	Fert	lnPIB	Life	Edu	Labor	Human	GDPR
Fert	1.0000						
lnPIB	−0.5469***	1.0000					
Life	−0.8720***	0.7775***	1.0000				
Edu	−0.6356***	0.8546***	0.6515***	1.0000			
Labor	−0.1181*	0.1824***	0.0824	0.2950***	1.0000		
Human	−0.7627***	0.9455***	0.8786***	0.9156***	0.1651***	1.0000	
GDPR	0.0559	0.0972	−0.3275***	−0.1114*	−0.3408***	−0.2978***	1.0000

At this stage, the correlation coefficient between the lnPUB indicator and Fert is -0.5469, indicating a certain negative correlation. However, since other variables and individual fixed effects have not been controlled for, the results obtained are not reliable for explaining the correlation between the variables in the model. Therefore, it is preliminary judged that a strong correlation leading to multicollinearity can make the model's results imprecise. A multicollinearity test is applied in a research or data analysis context. Correlation analysis is limited to examining relationships between two variables at a time, which can make the results obtained from this analysis imperfect.

To obtain a more precise and comprehensive measure, the Variance Inflation Factor (VIF) test is used. This method examines each variable in turn, taking into account all other variables, in order to determine the VIF value for each variable. It is a more rational and thorough approach.

Table 4 estat vif

Variable	VIF	1/VIF
Human	199.34	0.005016
Edu	42.56	0.023497
Life	30.52	0.032768
lnPIB	21.92	0.045629
Labor	1.63	0.614365
GDPR	1.29	0.772304
Mean VIF	49.54	

The VIF value for Human is 199.3400, which is considerably high. This indicates a strong correlation between Human and the other variables, leading to significant multicollinearity. Therefore, it is recommended to remove the Human variable from the model before proceeding with a new check for multicollinearity.

Table 5 estat vif

Variable	VIF	1/VIF
lnPIB	5.63	0.177743
Edu	4.14	0.241269
Life	2.74	0.364437
GDPR	1.28	0.780824
Labor	1.20	0.836130
Mean VIF	3.00	

After removing the Human variable and performing a new check for multicollinearity, the highest VIF obtained is 5.6300. The VIF values for the other variables show a tendency to gradually decrease. Therefore, there is no high multicollinearity that could negatively impact the model's results.

5 Results

For panel data analysis, there are generally three types of models: the ordinary least squares (OLS) model, the fixed effects model, and the random effects model. Although many articles tend to default to the fixed effects model, it is crucial to determine which model is most suitable for the data in your study. To do this, the F-test, the Lagrange Multiplier (LM) test, and the Hausman test are used.

The test F aims to compare the fixed effects model with the mixed OLS model. If the p-value associated with the F-test is less than 0.1, it indicates that the fixed effects model is preferable to the mixed OLS model.

The LM test is used to choose between the random effects model and the OLS model. If the p-value of the LM test is less than 0.1, it suggests that the random effects model is more appropriate than the OLS model.

The Hausman test compares the fixed effects model with the random effects model. If the p-value of this test is less than 0.1, the fixed effects model is the most suitable. If the p-value is greater than 0.1, it indicates that the random effects model would be a more sensible choice.

These tests are essential to ensure that the chosen model is the most appropriate for analyzing the data and correctly interpreting the research results.

F test that all u_i=0: F(7, 243) = 63.93 Prob > F = 0.0000

. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

Fert[id,t] = Xb + u[id] + e[id,t]

Table 6 Estimated results:

	Var	sd = sqrt(Var)
Fert	2.131887	1.460098
e	0.0566204	0.2379503
u	0.0556426	0.2358869

Test: Var(u) = 0

chibar2(01) =210.93

Prob > chibar2 =0.000

Table 7 hausman fe re,constant sigmamore

	(b) fe	(B) re	(b−B) Difference	sqrt(diag(V_b−V_B)) S.E.
lnPIB	0.2240163	0.3651634	−.1411471	0.0278304
Life	−.0391331	−.0962126	0.0570795	0.010161
Edu	−.2008818	−.1786772	−.0222046	0.01359
Labor	0.0269518	0.0162975	0.0106544	0.0040911
GDPR	0.0024137	−.0019355	0.0043492	0.000972
_cons	3.652489	6.811096	−3.158607	0.4890882

b = consistent under Ho and Ha; obtained from xtreg B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)

=63.28

Prob>chi2 =0.0000

(V_b-V_B is not positive definite)

At this stage, the results of the tests indicate that the p-value of the F-test is 0.0000, which is less than 0.1, suggesting that the fixed effects model is preferable to the mixed OLS model. This result, combined with the previously mentioned evaluation criteria, also indicates that the random effects model would be more appropriate than the mixed OLS model for this research. Furthermore, the Hausman test shows that the fixed effects model is the most suitable for this study. Therefore, the fixed effects model is chosen for the estimation in this research.

Multiple Regression Results

The results of the regression model estimation indicate that the R-squared value of the model is 0.4995, meaning that the explanatory and control variables explain 49.95% of the variance in fertility (Fert). The F-test statistic is 48.4961, with a p-value of 0.0000, which is less than 0.01, indicating that the model passes the global significance test.

The regression coefficient for lnPIB is 0.2240, suggesting that an increase in lnPIB leads to an increase in Fert. A 1% increase in GDP results in an average increase of 0.002240 in the fertility rate.

Le coefficient d'impact pour Life est de -0.0391, significatif au niveau de 1%, indiquant un effet négatif significatif. Chaque augmentation d'une unité dans Life entraîne une diminution moyenne de 0.0391 dans Fert.

Le coefficient d'impact pour Edu est de -0.2009, également significatif au niveau de 1%, indiquant un effet négatif significatif. Chaque augmentation d'une unité dans Edu entraîne une diminution moyenne de 0.2009 dans Fert.

Le coefficient pour Labor est de 0.0270, significatif au niveau de 1%, indiquant que chaque augmentation d'une unité dans Labor entraîne une augmentation moyenne de 0.0270 dans Fert.

GDPR n'a pas d'effet significatif sur le taux de fertilité selon ce modèle.

Table 8 reg Fert lnPIB Life Edu Labor GDPR

Source	SS	df	MS
Model	504.532832	5	100.906566
Residual	39.0982823	250	.156393129
Total	543.631115	255	2.13188672

Number of obs	=	256
F(5, 250)	=	645.21
Prob > F	=	0.0000
R−squared	=	0.9281
Adj R−squared	=	0.9266
Root MSE	=	.39547

Fert	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnPIB	0.8800052	0.0380723	23.11	0.000	0.8050219	0.9549885
Life	−0.1707556	0.0041716	−40.93	0.000	−.1789715	−.1625396
Edu	−.308426	0.015561	−19.82	0.000	−.3390734	−.2777787
Labor	0.001147	0.0023221	0.49	0.622	−.0034263	0.0057204
GDPR	−0.000616	0.0063902	−0.10	0.923	−.0132015	0.0119694
_cons	9.465049	0.239823	39.47	0.000	8.992718	9.93738

xtreg Fert lnPIB Life Edu Labor GDPR,fe

Fixed−effects (within) regression	Number of obs	=	256
Group variable: id	Number of groups	=	8
R−sq:	Obs per group:		
within = 0.4995	min	=	32
between = 0.6672	avg	=	32.0
overall = 0.6409	max	=	32
	F(5,243)	=	48.50
corr(u_i, Xb) = 0.5208	Prob > F	=	0.0000

Fert	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnPIB	0.2240163	0.0510792	4.39	0.000	0.1234017	0.3246309
Life	−.0391331	0.0127248	−3.08	0.002	−0.064198	−.0140681
Edu	−.2008818	0.0245066	−8.20	0.000	−0.2491543	−0.1526093
Labor	0.0269518	0.0057673	4.67	0.000	0.0155915	0.0383122
GDPR	0.0024137	0.0042857	0.56	0.574	−0.0060282	0.0108555
_cons	3.652489	0.6666625	5.48	0.000	2.339314	4.965664
sigma_u	1.0543919					
sigma_e	0.23795035					
rho	0.95153871			(fraction of variance due to u_i)		

F test that all u_i=0: F(7, 243) = 63.93 Prob > F = 0.0000

xtreg Fert lnPIB Life Edu Labor GDPR,re

Random−effects GLS regression	Number of obs	=	256
Group variable: id	Number of groups	=	8
R−sq:	Obs per group:		
within = 0.4620	min	=	32
between = 0.9090	avg	=	32.0
overall = 0.8705	max	=	32
	Wald chi2(5)	=	334.10
corr(u_i, X)= 0 (assumed)	Prob > chi2	=	0.0000

Fert	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnPIB	.3651634	.0514682	7.09	0.000	.2642876	.4660392
Life	−.0962126	.0104506	−9.21	0.000	−.1166954	−.0757298
Edu	−.1786772	.0245632	−7.27	0.000	−.2268202	−.1305342
Labor	.0162975	.0051873	3.14	0.002	.0061306	.0264643
GDPR	−.0019355	.004812	−0.40	0.688	−.0113669	.0074959
_cons	6.811096	.5864824	11.61	0.000	5.661612	7.96058
sigma_u	.23588686					
sigma_e	.23795035					
rho	.49564525	(fraction of variance due	to u_i)			

6 Conclusion

In this study, we used a regression model to explore the impact of various economic and social factors on the fertility rate, with particular attention to Canada. Through a detailed analysis of the data, we made several key findings:The Positive Impact of Economic Growth: We found that the growth of Gross Domestic Product (GDP) had a positive effect on the fertility rate, suggesting that economic prosperity might encourage families to have more children. This result may reflect the fact that, in better economic conditions, families in Canada and elsewhere are more able to afford the cost of raising children.The Negative Effect of Increased Life Expectancy: An increase in life expectancy seems to be associated with a decrease in the fertility rate. This could be because, with a longer life expectancy, people tend to prioritize quality of life over family size, a trend also observed in Canada.The Significant Negative Impact of Education on the Fertility Rate: An increase in education levels significantly reduced the fertility rate. This finding aligns with global observations, including in Canada, where higher education levels are generally associated with fewer children, likely because more educated individuals tend to prioritize professional development.The Slightly Positive Effect of Labor Force Participation: Although the impact of labor force participation on the fertility rate is relatively small, it remains positive. This could indicate that labor market activity provides better economic conditions and social support for families, thereby slightly encouraging an increase in the fertility rate, as seen in Canadian contexts.The Insignificant Impact of GDP Growth Rate on Fertility Rate: In this study, we found no significant impact of GDP growth rate on the fertility rate, suggesting that it may not be a key factor in determining variations in fertility rates, including in Canada.These findings provide valuable insights into the key factors affecting fertility rates, particularly how economic and social policies can influence fertility. These results offer important guidance for policymakers in Canada and beyond in the development of policies aimed at either increasing or controlling fertility rates."

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