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TOTAL FERTILITY RATE AND PER CAPITA INCOME: NEW EMPIRICAL FINDINGS FROM FRANCE

This study employs a threshold regression analysis (Hansen, 2000) to examine the relationship between per capita Gross Domestic Product (GDP) and total fertility rate (TFR) by choosing France as a case study. France is an exceptional European counry where the declining fertility rate was reversed and successfully recovered to 1.98. The findings indicate there is a statistically significant threshold in the fertility-development relationship and a reverse in the fertility decline. Empirical findings indicate there is a statistically significant threshold in the fertility-development relationship. A significant regime change in the fertility decline occurred in France. However, empirical results indicate that reverse in the fertility decline does not seem to occur. More precisely, the empirical findings indicate a significant negative relationship between per capita GDP and TFR when income level in the country was below the threshold value. However, this negative association between the two variables does not reverse to positive when income level exceeded the threshold value. These findings could not establish the existence of a J-shaped development-fertility relationship in France.

Keywords: *France; GDP per capita; total fertility rate; threshold regression.*

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СУМАРНИЙ КОЕФІЦІЄНТ НАРОДЖУВАНОСТІ ТА ДОХІД НА ДУШУ НАСЕЛЕННЯ: НОВІ ЕМПІРИЧНІ ДАНІ ПО ФРАНЦІЇ

У статті застосовано аналіз порогової регресії для оцінювання взаємозв'язку між ВВП на душу населення та сумарним коефіцієнтом народжуваності на прикладі Франції. Франція є винятком із загальноєвропейської тенденції, падіння народжуваності у ній було призупинено та повернено до рівня 1,98. Результати аналізу вказують на існування статистично значущого порогу для взаємозалежності народжуваність/економічний розвиток. Емпіричні результати вказують на існування суттєвого негативного зв'язку між ВВП на душу населення та коефіцієнтом народжуваності за умови, що рівень доходів у країні є нижчим певного порогу. Однак, даний негативний зв'язок двох змінних не стає позитивним після проходження даного порогу показником дохідності. Існування залежності між рівнем народжуваності у Франції та рівнем економічного розвитку у вигляді графіку J-форми не підтверджено.

Ключові слова: *Франція; ВВП на душу населення; сумарний коефіцієнт народжуваності; порогова регресія.*

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СУММАРНЫЙ КОЭФФИЦИЕНТ РОЖДАЕМОСТИ И ДОХОД НА ДУШУ НАСЕЛЕНИЯ: НОВЫЕ ЭМПИРИЧЕСКИЕ ДАННЫЕ ПО ФРАНЦИИ

В статье применен анализ пороговой регрессии для оценки взаимосвязи между ВВП на душу населения и суммарным коэффициентом рождаемости на примере Франции. Франция является исключением в общеевропейской тенденции, падение уровня рождаемости в ней было приостановлено и возвращено на уровень 1,98. Результаты

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анализа указывают на существование статистически значимого порога во взаимозависимости рождаемость/экономическое развитие. Эмпирические результаты указывают на наличие существенной негативной связи между ВВП на душу населения и коэффициентом рождаемости при условии, что уровень доходов в стране опускается ниже определенного порога. Однако, данная негативная связь двух переменных не становится позитивной после прохождения данного порога показателем доходов. Существование зависимости между уровнем рождаемости во Франции и уровнем экономического развития в виде графику J-формы не подтвердилось.

Ключевые слова: *Франция; ВВП на душу населения; суммарный коэффициент рождаемости; пороговая регрессия.*

1. Introduction. The negative association between economic development and fertility rate is an accepted historical reality in social sciences. As Myrskyla et al. (2009) argue, unparalleled leaps that occurred in the twentieth century in many countries' social and economic development were accompanied by declines in their population and fertility rates. The researchers state that this negative association between economic and social development and human fertility is one of the most tenacious "empirical regularities" in social sciences (Myrskyla et al., 2009). In a similar vein, Doepke (2004) asserts that fertility decline is a universal trend, and that every industrialized country has experienced a demographic transition from high to low fertility.

Exploring reasons for the fertility decline that various countries experience in the course of their economic development, Bryant (2007) proposes that not only socioeconomic factors but also diffusion of new ideas have caused birth rates fall. McDonald (2000) who specifically focuses on social causes of the fertility decline argues that this demographic trend is attributable to the low level of gender equality, such as the lack of support for women's employment, the absence of a proper tax system regarding women's earnings, and the gender-oriented roles within families.

Some economists attribute fertility decline to the hypothesis that there exists a trade-off relationship between the quantity and the "quality" of children. Becker, Glaeser and Murphy (1999) define the "quality" of children as a human-capital level of each child. In the course of economic development, parents tend to augment the "quality" of their children while decreasing their quantity. According to Currais (2000), the first systematic analysis of the interaction between the quantity and quality of children was done by Gary S. Becker and H. Gregg Lewis (Becker and Lewis, 1973).

According to the hypothesis on the trade-off relationship between quantity and quality of children, there is a negative correlation between the number (or quantity) of children and their "quality" as perceived by others. Parents maximize their utility subject to budget constrains. The parental utility function can be expressed as

$$Max\ U = U(n, q, y),$$

where U is parental utility function, n is number of children, q is quality of children or a human-capital level of each child, and y is consumption. The budget constrains can be expressed as:

$$I = nq\pi + y\pi_y,$$

where I is income, π is the price of nq, and π_y is the price of y. This means that an increase in quality of children or investment in children's human capital would be more costly to the parents who have more children. This is because the increase in investment will have to be applied to more "units". Furthermore, an increase in the quantity of children would be more costly to the parents if the children are of a higher "quality" because "higher quality" children cost more to the parents.

Recently, the entrenched assumptions at the core of the fertility-development discourse have been challenged. A study by Myrskyla et al. (2009) boldly proclaims a major shift in the negative relationship between fertility and development. The researchers contend that the development-fertility relationship is negative when the Human Development Index (HDI) is below the range of 0.85-0.9. However, when the HDI surpasses 0.9, as it has recently happened in some developed countries, the development-fertility association reverses to a positive one (Myrskyla et al., 2009). The significance of this finding is that a rule of demography that people in rich countries tend to have fewer children "no longer holds true", and policy makers would need to change their present assumptions when devising the future models (The Economist, 2009).

Some researchers express doubts that high levels of development are able to reverse declining fertility rates. For example, Furuoka (2009) employs a threshold regression analysis to examine the fertility-development relationship in 176 countries. He found no empirical evidence to support the proposition that advances in development could reverse declining fertility rates. The results of his cross-sectional study indicate that in countries with a low human development index, higher levels of the HDI tend to be associated with lower fertility rates. Likewise, in the countries with a high human development index, higher levels of the HDI are associated with lower fertility rates, but the relationship is weak.

Furthermore, Furuoka (2010) examines the relationship between total fertility rates and per capita GDP in the United States. He points out that there was a statistically significant threshold in the fertility-development relationship and a reverse in the fertility decline in the United States. The threshold value of real per capita GDP based on the Laspeyres index was I$22,267, while the threshold value of real capita GDP based on the Fisher index was I$21,264. This means that the decline in the fertility rate could be reversed when per capita income reached I$21,000-I$22,000. The empirical findings also indicate a significant negative relationship between per capita GDP and TFR when income level in the country was below the threshold value. This negative association between two variables reversed to a positive relationship when income level had exceeded the threshold value. The findings of this study confirm the existence of a J-shaped fertility-development relationship in the United States[2].

The present study aims to examine empirically the fertility-development relationship in France. Interestingly, while the European continent and even some developing countries have been experiencing plunging fertility rates, there had occurred a reverse in fertility decline in France. Fertility decline in European countries has been a concern and also an important research topic for demographic specialists and economists.

[2] I$ stands for "International Dollar", which is a hypothetical currency and is used in the International Monetary Fund (IMF) or Penn World Table. International dollar has a purchasing power as strong as the US dollar.

For example, Sobotka (2004) points out that, in 2002, more than a half of Europe's population lived in countries with fertility rate at or below 1.3. Kohler et al. (2002) argue that the lowest-low fertility, which is defined as a period of total fertility rate at or below 1.3, has been a constant feature of the demographic landscape in Europe in the 1990s. Among the factors that contribute to the reduced fertility rates the researchers mention increased returns to human capital and high economic uncertainty. Until the 1980s, demographic trends in France were similar to those in other developed countries; fertility rate in France kept falling and dropped below the replacement rate of 2.1. However, recently, fertility rate in France recovered to 1.98 (World Bank 2010).

It should be noted that when per capita Gross Domestic Product (GDP) in France was lower than (approximately) I$23,000, there was a strong negative relationship between total fertility rate (TFR) and per capita GDP in the country (see Figures 1 and 2).[3] While the GDP kept increasing the fertility kept declining, as was the trend in other developed countries. In 1960, the TFR in France was relatively high at around 2.80, and the country's per capita GDP amounted to approximately I$11,500. The TFR rapidly declined to 1.92 in 1975 when per capita GDP was approximately I$17,000. In 1985, TFR dropped to 1.82 (per capita GDP I$20,366). The country's fertility rate became lowest at 1.65 in the year 1993, when per capita GDP amounted to I$23,249.

Figure 1. **Total fertility rate (TFR) in France from 1960 to 2007**

Note: Data on total fertility rate were obtained from the World Bank (2010).

Remarkably, the decline in fertility rate in France seemed to stop and reverse when per capita GDP reached I$24,000. In 1994, when per capita GDP amounted to I$24,094, the country's fertility rate increased to 1.71. It climbed to 1.90 in 2004, when the country's per capita GDP was I$28,409. In 2006, with per capita GDP at I$29,237, fertility rate in France recovered and reached 1.98.

[3] The graph reports real per capita GDP based on the Laspeyres fixed-weighted index that is derived from the growth rates of consumption (C), investment (I) and government expenditure (G). Per capita GDP is codified as "RGDPL" in the Penn World Table (CICUP, 2010).

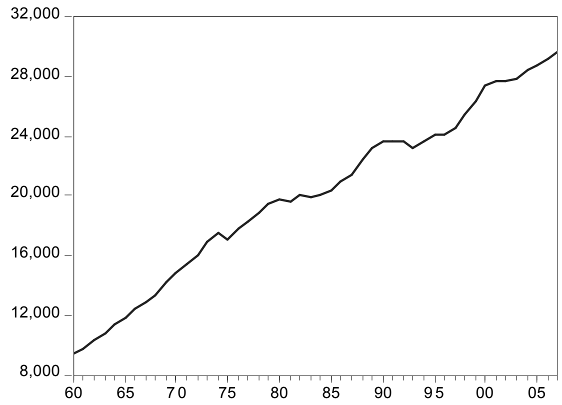

Figure 2. **Per capita gross domestic product (GDP) in France, 1960 to 2007 (International Dollars)**

Note: Data on the per capita GDP were obtained from the CICUP (2010).

To examine empirically the fertility-development relationship in France during 1960-2007, the present study employs threshold regression analysis (Hansen, 2000). There are two advantages to employing this method. Firstly, the threshold regression can be used to determine whether there was a statistically significant reverse in the decline of the fertility rate in France. Secondly, it can detect the exact threshold value or a watershed when the demographic transition from fertility decline to fertility rise had occurred.

Following this introductory section, Section 2 offers a brief explanation of Hansen's threshold regression model. Section 3 reports the empirical findings, and Section Four is the conclusion.

2. Hansen's threshold regression method. Hansen (1996, 1997, 2000) developed a new and highly functional empirical test for threshold effect that constructs asymptotic confidence intervals for the threshold parameter. According to Hansen, an exogenously given variable, which is called threshold variable, is used to split a sample into two regimes.

Hansen's threshold estimation is based on two-regime structural equations as follows:

$$y_t = \theta_1 x_t + e_{1t} \qquad \text{if } q_t \leq \gamma \qquad (1)$$

$$y_t = \theta_1 x_t + e_{1t} \qquad \text{if } q_t > \gamma \qquad (2)$$

where γ denotes the threshold value, y is the dependent variable, x is the independent variable, q is the threshold variable, θ is a slope coefficient, and e is an error term.

The threshold value is unknown apriori. Therefore, it should be estimated together with other parameters. When a threshold variable is smaller than a threshold value, the model proceeds to estimate equation 1. On the other hand, when a threshold variable is larger than a threshold value, the model estimates equation 2.

In the current study, the OLS regression without the threshold value can be expressed as:

$$TFR_t = \beta_0+\beta_1 GDP_t + \varepsilon \qquad (3)$$

where β_0 is an intercept, β_1 is a slope coefficient, ε is an error term, TFR_t is the total fertility rate in France in the year t, GDP_t is a natural log of per capita Gross Domestic Product (GDP) in France in the year t.

The data on total fertility rates were obtained from the World Bank (2010). The data on per capita GDP were obtained from CICUP (2010).

The present study uses two types of per capita *GDP*, namely, *LGDP* and *FGDP*. The *LGDP* is a real per capita *GDP* based on the Laspeyres fixed-weighted index derived from the growth rates of domestic absorption *(DA)*. The *FGDP* is a real per capita *GDP* based on the chain Fisher volume index derived from the growth rate of *DA* for each year[4].

For the purpose of the analysis, all the data were transformed into the log form.

The threshold regression can be expressed as:

$$TFR_t = (\beta_{10}+\beta_{11} GDP_t)\, d\{GDP_t \le \gamma\} + (\beta_{20}+\beta_{21} GDP_t)\, d\{GDP_t > \gamma\} + \varepsilon, \qquad (4)$$

where $d\{.\}$ is the indicator function, $d\{GDP_t \le \gamma\}$ equals to 1, and $d\{GDP_t > \gamma\}$ equals to 0 if GDP_t is equal to or less than the threshold value, which indicates a regression estimate of the first regime. On the other hand, $d\{GDP_t \le \gamma\}$ equals to 0, and $d\{GDP_t > \gamma\}$ equals to 1 if GDP_t is greater than the threshold value, which indicates a regression estimate of the second regime.

As the first step, this study examines whether there is a threshold effect in equation (4). According to Hansen (1996, 1997, 2000), the threshold effect is defined as the difference in the slope coefficients between the first and the second regimes. The null hypothesis is there is no threshold (i.e., no difference in the slope coefficients between the two regimes). The heteroskedasticity-consistent Lagrange multiplier (LM) test can be used to test this hypothesis.

As the next step, this study proceeds to examine the threshold value. Hansen (1996, 1997, 2000) suggests that an appropriate estimation method for this purpose is the Least Square (LS). Under an assumption that the residual is *iid* $N(0,\sigma^2)$, Least Square is equivalent to the Maximum Likelihood Estimation (MLE). The LS estimate of the residual variance or $\sigma_T^2(\gamma)$ can be expressed as

$$\hat{\sigma}_T^{\,2}(\gamma) = \frac{S_T(\gamma)}{T} = \frac{1}{T}\sum_{t=1960}^{2007} \hat{e}_t(\gamma)^2 \qquad (5)$$

where T is the number of observations in the time-series data, $S_T(\gamma)$ is the residual sum of squares, and e is the residual. The LS estimate of γ or γ is the value that minimizes the residual variance:

$$\hat{\gamma} = \operatorname{argmin} \hat{\sigma}_T^{\,2}(\gamma) \qquad (6)$$

where *argmin* stands for the argument of the minimum. The null hypothesis of no threshold effect is tested by the standard F-statistics. The F-statistics can be calculated as follows:

[4] In the Penn World Table, LGDP is codified as RGDPL2 and FGDP is codified as RGDPCH. For a more detailed description of the data, see CICUP (2010).

$$F_T = T\frac{S_T^0 - S_T^1(\hat{\gamma})}{S_T^1(\hat{\gamma})}, \tag{7}$$

where S_T^0 is the residual sum of squares based on equation (3), and $S_T^1(\hat{\gamma})$ is the residual sum of squares based on equation (4). If the residual is conditionally heteroskedastic, a heteroskedastic-consistent Lagrange multiplier (LM) statistic can be used to test the null hypothesis. However, the asymptotic distribution of the LM statistic is not a chi-squared distribution. The bootstrap procedure was used to approximate its asymptotic distribution and to obtain the critical values.

As the third step, this study proceedes to form a confidence level for γ. According to Hansen (1996, 1997, 2000), a common method to form a confidence level is through inversion of the Wald statistics. The threshold regression is an example when the Wald statistics has poor finite sample behaviour. This is because asymptotic sampling distribution depends on an unknown parameter. Therefore, Hansen suggested employing the likelihood ratio (LR) statistics to form the confidence level for γ. The LR statistic can be calculated as

$$LR_T(\gamma_0) = \frac{S_T(\lambda_0) - S_T(\hat{\gamma})}{S_T(\hat{\gamma})}, \tag{8}$$

where γ_0 is the actual or specific threshold value, and $\hat{\gamma}$ is an estimated threshold value. The confidence interval can be constructed as

$$\hat{\Gamma} = \{\gamma : LR_T(\gamma) \le c\}, \tag{9}$$

where $\hat{\Gamma}$ is an asymptotic C-level confidence region for γ, and c is the $100 \times C$ percentile of the asymptotic distribution of the LR statistics.

3. Empirical Findings. The current study employs a threshold regression analysis to examine the fertility-development relationship in France during 1960-2007, and uses per capita GDP as the threshold variable to split time-series data into two regimes. As the first step of the empirical analysis, this study employs OLS analysis to examine the relationship between the total fertility rates and per capita GDP without the threshold.

As Tables 1 and 2 report, the OLS estimation without the threshold value shows there existed a strong negative relationship between fertility rates and the standard of living or per capita GDP in France. In other words, as the country's economic development progressed and its people became wealthier, the total fertility rates declined.

Secondly, the heteroskedasticity-consistent Lagrange multiplier (LM) test was used to examine whether there was a sample split based on two types of per capita GDP (i.e. LGDP and FGDP). One thousand bootstrap replications were run to estimate p-values for test statistic.

Figure 3 shows that, upon running 1000 bootstrap replications, the LM statistic for LGDP was 26.68, and its p-value was 0.001. This means there could have existed a sample split based on the LGDP. In other words, according to real per capita GDP based on the Laspeyres index, there occurred a significant regime change in the fertility decline in France.

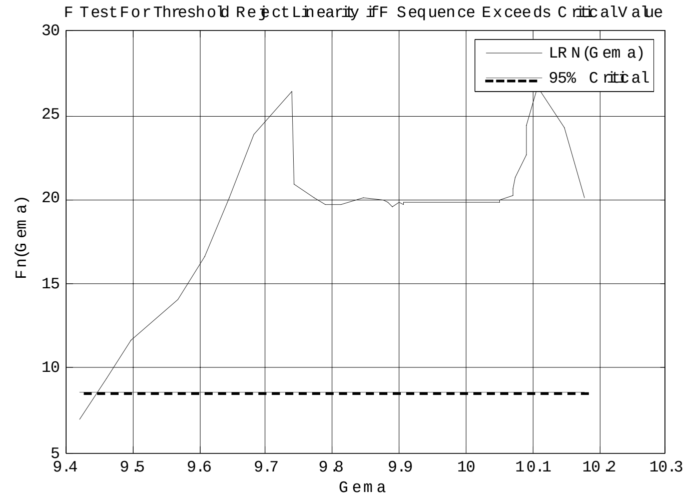

Figure 3. **Sample split based on LGDP**

As Figure 4 shows, the LM statistic for FGDP was 26.69, and its p-value was 0.001. This finding indicates there could have existed a sample split based on the FGDP. This means that the empirical findings on real per capita GDP based on the Fisher Index confirmed that there was a statistically significant regime change in the negative association between fertility and per capita income in France.

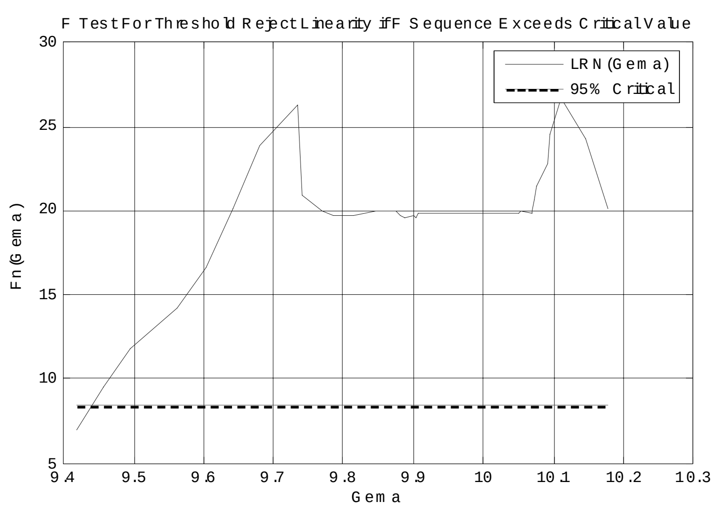

Figure 4. **Sample split based on FGDP**

Thirdly, the likelihood ratio (LR) test is used to detect the exact threshold value and to construct the confidence interval. Figure 3 is featuring the normalized likelihood ratio (LR) as a function of the threshold in the level of per capita GDP based on the Laspeyres index (LGDP). As the figure shows, the least square (LS) estimation of γ, which minimizes the residual variance as well as the LR statistic, was 9.739

while the confidence interval was [9.739, 9.739]. These findings indicate that the threshold estimation was precise and the confidence interval was tight.

Figure 4 is representing a normalized likelihood ratio (LR) as a function of the threshold in the level of per capita GDP based on the Fisher index (FGDP). As the Figure shows, the least square (LS) estimation of γ was 9.735 while the confidence interval [9.735, 9.735]. These findings indicate that the threshold estimation was precise and the confidence interval was tight.

Table 1 reports there was a significant negative relationship between income level and fertility rate in France when the natural log of real per capita GDP based on the Laspeyres index was equal to or less than 9.739. On the other hand, standard of living and fertility rate in the country had a non-significant negative relationship when the natural log of real per capita GDP was greater than the threshold value. This means that the fertility-development relationship in France does not seem to become J-shaped.

Table 1. **Empirical results without and with threshold estimation (LGDP)**

	Without threshold estimation	With threshold estimations	
		Regime 1 ($LGDP \leq 9.734$)	Regime 2 ($LGDP > 9.734$)
Constant	12.823** (14.837)	10.624** (8.128)	2.400** (2.245)
LGDP	-1.089** (-12.500)	-0.843** (-6.096)	-0.056 (-0526)
R-squared	0.722	0.755	0.008
Number of observations	48	14	34

Figures in the parentheses indicate t-statistics
** indicates significance at 1% level
* indicates significance at 5% level

As Table 2 shows, per capita GDP and fertility rate in France had a negative relationship when the natural log of real per capita GDP based on the Fisher index was equal to or less than 9.735. On the other hand, when the natural log of real capita GDP was greater than the threshold value, the relationship between per capita GDP and fertility rate became non-significant and negative. The empirical findings on per capita GDP based on the Fisher index confirmed the findings on per capita GDP based on the Laspeyres index, which does not seem to support the existence of a J-shaped fertility-development relationship in France.

Table 2. **Empirical results without and with threshold estimation (FGDP)**

	Without threshold estimation	With threshold estimations	
		Regime 1 ($FGDP \leq 9.735$)	Regime 2 ($FGDP > 9.735$)
Constant	12.782** (14.981)	10.621** (8.091)	2.430* (2.282)
FGDP	-1.085** (-12.554)	-0.843** (-6.068)	-0.059 (-0.556)
R-squared	0.774	0.754	0.009
Number of observations	48	14	34

Figures in parentheses indicate t-statistics
** indicates significance at 1% level
* indicates significance at 5% level

In short, the findings indicate there was a statistically significant threshold in the fertility-development relationship. A significant regime change in the fertility decline occurred in France. However, the empirical results indicate that reverse in the fertility decline does not seem to occur. More precisely, the empirical findings indicate a significant negative relationship between per capita GDP and TFR when income level in the country was below the threshold value. However, this negative association between two variables do not reverse to positive when income level exceeded the threshold value. These findings could not establish the existence of a J-shaped development-fertility relationship in France.

4. Conclusion. The present paper aims to empirically examine the fertility-development relationship in France, and employed a threshold regression analysis for this purpose. A justification for the choice of France as a case study is that it is the only developed country that has successfully recovered its fertility rate to the 1.98.

The empirical findings of the threshold regression analysis indicate there was a statistically significant threshold in the fertility-development relationship. A significant regime change in the fertility decline occurred in France. However, empirical results indicate that reverse in the fertility decline does not seem to occur. More precisely, the empirical findings indicate a significant negative relationship between per capita GDP and TFR when income level in the country was below the threshold value. However, this negative association between two variables do not reverse to positive when income level exceeded the threshold value. These findings could not establish the existence of a J-shaped development-fertility relationship in France.

The findings of the present study suggest that advances in a country's economic development do not seem to reverse the declining fertility rate provided that income level in a country reaches a certain threshold. However, income level or standard of living is only one of many other interrelated factors that influence fertility rate. For example, a number of other European countries and some Asian countries have high per capita income but do not experience a reverse in fertility rates. This is due to a complexity of the development-fertility relationship and the existence of other numerous factors that can affect the relationship between economic development and human fertility.

Future studies need to explore what are the other factors that could stop and reverse fertility decline. Until more research is done on the J-shaped fertility-development relationship and a better understanding of a possible reverse in the global demographic trend is achieved, old assumptions on the fertility-development relationship might as well remain a guide to decision-makers in devising future policies.

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