Economics Bulletin

Volume 29, Issue 4

Looking for a J-shaped development-fertility relationship: Do advances in development really reverse fertility declines?

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Abstract

In their article published in the "Nature" journal, Myrskylä et al. (2009) claimed that in highly developed countries development-fertility relationship becomes J-shaped. This means that further advances in economic and social development can reverse declining fertility rates. The present paper employs threshold regression analysis (Hansen 2000) to examine the existence of the proposed J-shaped fertility-development curve. The findings indicate that the threshold value of human development index is 0.777. The threshold regression analysis reveals that in countries with a low human development index higher levels of HDI tend to be associated with lower fertility rates. Likewise, in countries with a high human development index, higher levels of HDI tend to be associated with lower fertility rates, albeit the relationship is weak. Thus, the findings of this study do not support the proposition that advances in development can reverse fertility decline, neither do they confirm the existence of the J-shaped development-fertility relationship.

The author is grateful to the following persons: Iwao Kato, Ho Chong Mun, and Qaiser Munir for their useful comments. My special thanks go to Iwao Kato for raising the awareness of the importance of this topic.
Citation: Fumitaka Furuoka, (2009) "Looking for a J-shaped development-fertility relationship: Do advances in development really reverse fertility declines?", *Economics Bulletin*, Vol. 29 no.4 pp. 3067-3074.
Submitted: Dec 02 2009. **Published:** December 07, 2009.

1. Introduction

On August 3, 2009, a leading science journal, *Nature*, published a thought-provoking article on the development-fertility relationship. In the article, the authors pointed out that "unprecedented increases" in social and economic development in the 20th century had been accompanied by considerable declines in population growth rates and fertility. As the researchers stated, "The negative association of fertility with economic and social development has therefore become one of the most solidly established and generally accepted empirical regularities in the social sciences" (Myrskylä *et al*. 2009).

In their study, Myrskylä *et al*. (2009) used cross sectional and longitudinal analyses of the fertility rate and the human development index (HDI) to prove that there had occurred "a fundamental change in the well-established negative relationship between fertility and development as the global population entered the twenty-first century". The main finding of the study was that in highly developed countries with a high HDI, further development halts the declining fertility rates; thus, the previously negative development-fertility relationship becomes J-shaped.

As the researchers contended, development-fertility relationship is negative when HDI levels are below the range of 0.85-0.9. However, when in recent years some countries reached very advanced levels of development with the HDI above 0.9, "the HDI-fertility relationship started to change fundamentally" (Myrskylä *et al*., 2009). This means that the HDI-fertility association reverses to a positive relationship once the HDI level becomes higher than 0.9.

The findings of the study by Myrskylä *et al*. (2009) have been widely reported by the mass media. An article that appeared in a reputable international publication, *The Economist,* boldly proclaimed that a rule of demography that people in rich countries tend to have fewer children "no longer holds true" as in two dozen of the countries with HDI above 0.9 remarkable things happened when their fertility rates began approaching to two children per woman. The significance of the discovery is that the policy makers would need to change the assumptions they hold in present when devising their models of the future (*The Economist*, August 8, 2009).

The current study aims to empirically scrutinize the proposed existence of the J-shaped relationship between fertility and development. It employs threshold regression analysis (Hansen 2000) for this purpose. In other words, this paper attempts to examine empirically whether the advances in development do in reality reverse the declining fertility rate.

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

2. Hansen's threshold regression method

Hansen (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:

$$y_i = \theta_1 x_i + e_{1i} \qquad \text{if } q_i \le \gamma \qquad (1)$$

$$y_i = \theta_2 x_i + e_{2i} \qquad \text{if } q_i > \gamma \qquad (2)$$

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

Since the threshold value is unknown *a priori* so it should be estimated in addition to the other parameters. When the threshold variable is smaller than the threshold value, the model proceeds to estimate equation 1. On the other hand, when the threshold variable is larger than the threshold value, the model estimates equation 2.

In this paper, the OLS regression without threshold can be expressed as:

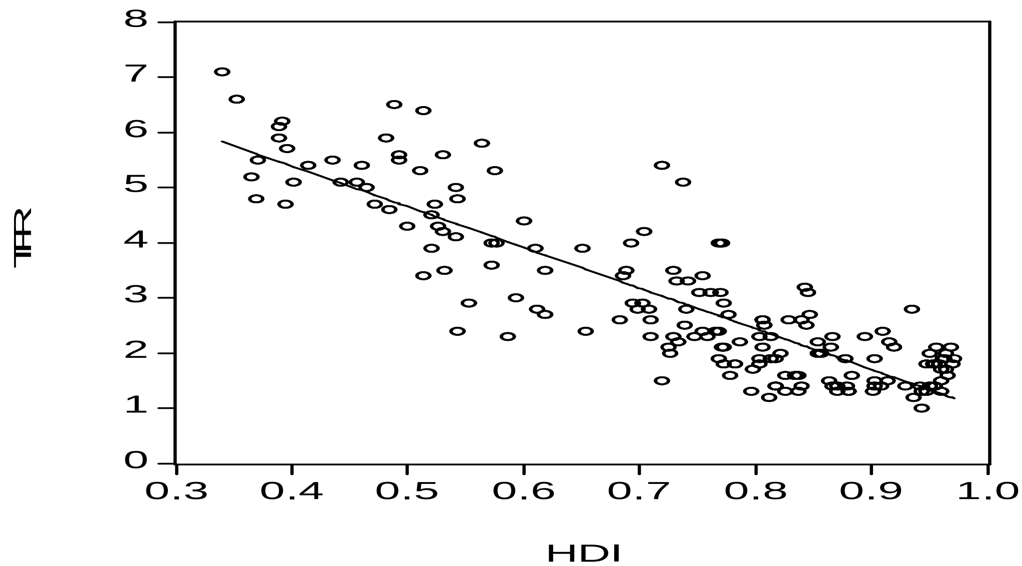
$$TFR_i = \beta_0 + \beta_1 HDI_i + \varepsilon \qquad (3)$$

where β_0 is intercept, β_1 is slope coefficient, ε is error term; TFR_i is the total fertility rate for the period 2005-2010 in country i; HDI_i is the human development index in country i in the year 2009.

All the data were obtained from the United Nations Development Program's Human Development Report 2009 (UNDP 2009).

As Figure 1 shows, there is a strong negative relationship between the total fertility rate (TFR) and the human development index (HDI) levels. This means that countries with a high human development index tend to be associated with a low fertility rate. By contrast, countries with a low human development index are associated with a high fertility rate.

Figure 1: Total fertility rate (TFR) and human development index (HDI)



Source: UNDP (2009)

The threshold regression can be expressed as:

$$TFR_i = (\beta_{10}+\beta_{11}HDI_i)d\{HDI_i<=\gamma\} + (\beta_{20}+\beta_{21}HDI_i)d\{HDI_i>\gamma\}+ \varepsilon \qquad (4)$$

where $d\{.\}$ is the indicator function; $d\{HDI_i<=\gamma\}$ equals to 1, and $d\{HDI_i>\gamma\}$ equals to 0 if HDI_i is equal to or less than the threshold value, which indicates a regression estimate of the 'first regime'. On the other hand, $d\{HDI_i<=\gamma\}$ equals to 0, and $d\{HDI_i>\gamma\}$ equals to 1 if HDI_i 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 the equation (4). The threshold effect is defined as the difference in the slope coefficients between the first and the second regimes (Hansen 1997). 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 (Hansen 1996).

The next step is to examine the threshold value. According to Hansen (1997), an appropriate estimation method for this purpose is the Least Square (LS). The LS estimation of γ is the value that minimizes the residual variance. The residual variance can be expressed as:

$$\hat{\sigma}_n{}^2(\gamma) = \frac{1}{n}\sum_{i=1}^{n}\hat{e}_i(\gamma)^2 \qquad (5)$$

where n is number of observations, and e is the residual.

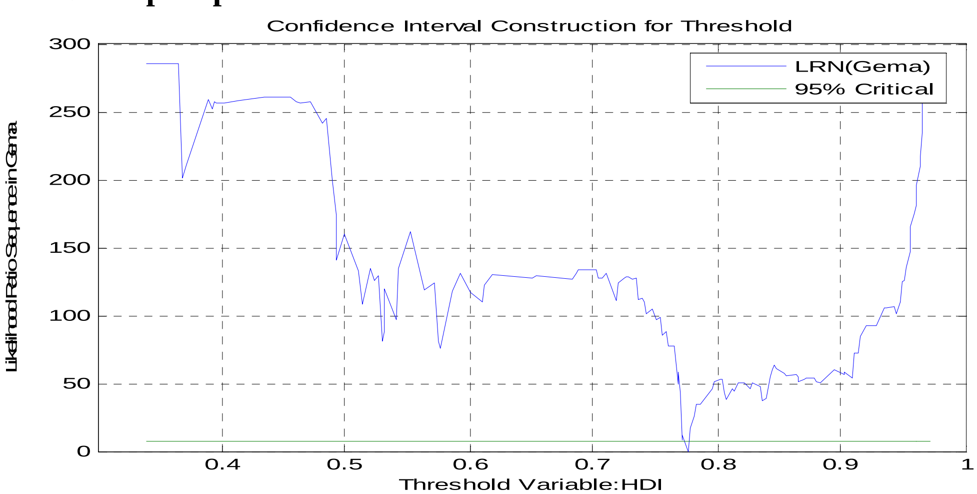
As a third step, this study proceeds to form a confidence level for γ. According to Hansen (2000), a common method to form a confidence level is through inversion of the Wald statistic. The threshold regression is an example when the Wald statistic has a poor finite sample behavior. This is because asymptotic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

3. Empirical Findings

The current study aimed to examine the existence of the J-shaped development-fertility relationship by employing a threshold regression analysis. It used the HDI as the threshold variable to split all the countries in the data into two groups. The first group includes the countries with a low human development index, i.e., the HDI level in these countries is equal to or less than the threshold value. The second group consists of the countries with a high human development index, i.e. where the HDI level is greater than the threshold value.

As the first step of the empirical analysis, this paper employed OLS analysis to examine the development-fertility relationship without the threshold. Secondly, the heteroskedasticity-consistent Lagrange multiplier (LM) test was used to examine whether there was a sample split based on the HDI level. Upon running 1000 bootstrap replications, the LM statistic was 26.95, and its p-value was 0.001. This means that the LM test strongly rejected the null hypothesis of no threshold. This finding suggests that there might be a sample split based on the HDI level.

Figure 2: Sample Split Based on HDI



Thirdly, the likelihood ration (LR) test was used to detect the threshold value and to construct the confidence interval. Figure 2 displays a graph featuring the normalized likelihood ratio (LR) as a function of the threshold in HDI level. As the figure indicates, the least square (LS) estimation of γ, which minimizes the residual variance as well as the LR statistic, was 0.777 while the confidence interval was [0.777, 0.777]. These findings indicate that the threshold estimation was precise and the confidence interval was very tight.

Table 1 reports the empirical results of the OLS estimation and threshold regression analysis of the countries with both regimes (i.e., countries with a high human development index and those with a low human development index).

Table 1: OLS without and with threshold estimation

	Without threshold estimation	**With threshold estimations**	
		Regime 1 Countries with a low human development index ($HDI \leq 0.777$)	Regime 2 Countries with a high human development index ($HDI > 0.777$)
Constant	8.333** (35.199)	8.779** (21.772)	3.346** (4.548)
HDI2007	-7.368** (-23.478)	-8.072** (-12.354)	-1.736* (-2.084)
R-squared	0.760	0.626	0.05
Adjusted R-squared	0.758	0.622	0.04
Number of observations	176	93	83

Figures in the parentheses indicate number of lag structures
** indicates significance at 1% level
* indicates significance at 5% level

The OLS estimation without the threshold value shows that there existed a strong negative relationship between fertility rate and human development index. In other words, countries with a high human development index tended to have a low fertility rate.

A more important finding as revealed by the OLS estimation with the threshold value is that in the countries with a relatively low human development index, the human development index level and the fertility rate had a strong negative or steeper sloped relationship. On the other hand, in the countries with a relatively high human development index, the human development index level and the fertility rate had a negative but weak or a flatter sloped relationship.

In short, the threshold regression analysis done in this study indicates that the threshold value of the HDI level is 0.777. A negative association between the HDI level and the fertility rate was detected in the countries with a low human development index. In the countries with a high human development index, there was a weak negative relationship between the two variables. These results do not support the existence of the J-shaped relationship between fertility and development.

4. Conclusion

This paper aimed to empirically examine the existence of a J-shaped relationship between fertility and development proposed by Myrskylä *et al*. (2009). As the researchers argued, advances in economic development can reverse the declining fertility rate. The current study employed a threshold regression analysis (Hansen 2000) to examine this proposition.

As the findings of this study reveal, in the group of countries with a relatively low human development index, higher level of HDI tended to be associated with lower fertility rates. Likewise, in the group of countries with a relatively high human development index, higher HDI level tended to be associated with lower fertility rates, albeit the relationship was weak.

As a conclusion, the findings of this study do not support the proposition that advances in development are able to reverse the declining fertility rate. In the course of the empirical analysis, no J-shaped development-fertility relationship could be established. This indicates that as far as the relationship between human fertility and economic and social development is concerned, the old assumptions the policymakers hold in present still may serve them well in the future.

References

Hansen, Bruce E. (2000) "Sampling splitting and threshold estimation" *Econometrica* **68**(3), 575-603.

Hansen, Bruce E. (1997) "Inference in TAR model" *Studies in Nonlinear Dynamics and Econometrics* **2**(1), 1-14.

Hansen, Bruce E. (1996) "Inference when a nuisance parameter is not identified under the null hypothesis" *Econometrica* **64**(2), 413-430.

Myrskylä, M., Kohler, H and Billari, F.C. (2009) "Advances in development reverse fertility rate" *Nature* **460**, (August 6, 2009), 741-743.

The Economist (2009). "A link between wealth and breeding. The best of all possible worlds?" (August 8, 2009), 64-65.

United Nations Development Program (2009) *Human Development Report 2009*, http://hdr.undp.org/en/statistics/ [accessed on November 4, 2009]