# DEVELOPMENT AND FERTILITY IN BRAZIL: FERTILITY REVERSION FOR MORE DEVELOPED MUNICIPALITIES?

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During the last century, several countries observed a rapid increase in economic development with simultaneous decline in fertility and population growth rates. Using a threshold regression analysis as proposed by Hansen (2000), this article investigates the negative association between economic development and fertility for Brazilian municipalities using 2000 census and human development data. Results show no evidence to support the existence of an inverse J-shaped development-fertility as found by Furuoka (2010) to the United States, in opposite to the results suggested by Myrskylä *et al* (2009). Moreover, we found four different regimes, all statistically significant, and there is evidence that the intensity of the relation in the third regime is weaker than others as is found by Furuoka (2009).

**Keywords**: fertility; endogenous sample split; Brazil.

## DESENVOLVIMENTO E FECUNDIDADE NO BRASIL: REVERSÃO DA FECUNDIDADE PARA MUNICÍPIOS MAIS DESENVOLVIDOS?

Durante o último século, vários países observaram um aumento rápido no desenvolvimento econômico com declínio simultâneo das taxas de crescimento da fertilidade e da população. Usando uma análise de regressão limiar como proposto por Hansen (2000), este artigo investiga a associação negativa entre o desenvolvimento econômico e fertilidade para os municípios brasileiros, utilizando dados do Censo de 2000 e de desenvolvimento humano. Os resultados não mostram nenhuma evidência para apoiar a existência de uma relação inversa em forma de J desenvolvimento fertilidade como encontrado por Furuoka (2010) para os Estados Unidos, ao contrário dos resultados sugeridos pelo Myrskylä *et al.* (2009). Além disso, foram observados quatro regimes diferentes, todos estatisticamente significativos, e há evidências de que a intensidade da relação no terceiro regime é mais fraca do que os outros como é encontrada por Furuoka (2009).

**Palavras-chave**: fecundidade; divisão endógena da amostra; Brasil.

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## DESARROLLO Y FECUNDIDAD EN BRASIL: REVERSIÓN DE LA FECUNDIDAD EN LOS MUNICIPIOS MÁS DESARROLLADOS?

Durante el siglo pasado, varios países se observó un aumento rápido en el desarrollo económico con la disminución simultánea de las tasas de fecundidad y el crecimiento de la población. Utilizando un análisis de regresión del umbral propuesto por Hansen (2000), este artículo investiga la asociación negativa entre el desarrollo económico y la fertilidad de los municipios brasileños con censos de 2000 y los datos de desarrollo humano. Los resultados muestran ninguna evidencia que apoye la existencia de una relación inversa entre el desarrollo en forma de J de la fertilidad que se encuentran por Furuoka (2010) a los Estados Unidos, de manera opuesta a los resultados sugeridos por Myrskylä et al (2009). Además, se encontraron cuatro regímenes diferentes, todos estadísticamente significativos, y no hay evidencia de que la intensidad de la relación en el tercer régimen es más débil que los demás como se han encontrado los Furuoka (2009).

**Palavras clave**: fecundidade; division endogeno de la amuestra; Brasil.

## LE DÉVELOPPEMENT ET LA FÉCONDITÉ AU BRÉSIL: LA FERTILITÉ RÉVERSION POUR LES MUNICIPALITÉS PLUS DÉVELOPPÉS?

Au cours du siècle dernier, plusieurs pays ont observé une vite augmentation dans le développement économique avec une baisse simultanée des taux de fécondité et la croissance de la population. En utilisant une analyse de régression proposé par Hansen (2000), cet article explore l'association négative entre le développement économique et de la fertilité pour les municipalités brésiliennes utilisant le recensement de 2000 et des données de développement humain. Les résultats ne montrent aucune preuve pour étayer l'existence d'une relation inverse en forme de J-développement de fécondité trouvée par Furuoka (2010) aux États-Unis, en face des résultats suggérés par Myrskylä et al (2009). En plus, nous avons trouvé quatre régimes différents, tous statistiquement significatifs, et il est prouvé que l'intensité de la relation dans le troisième régime est plus faible que les autres comme on trouve par Furuoka (2009).

**Mots-clés**: fertilité; division endogène de l'échantillonnage; Brésil.

**JEL**: J10, J13, O10.

## 1 INTRODUCTION

During the last century, several countries observed a rapid economic development with simultaneous decline in fertility and population growth rates. This implies that there exists a negative association between economic development and fertility rate.[1] In addition, Doepke (2004) considers fertility decline a universal trend, fact related to the demographic transition and economic development.

However, in a recent and provoking paper, Myrskylä *et al.* (2009), suggest that the previously negative development–fertility association has actually become an inverse J-shaped. That is, Human Development Index (HDI) being positively associated with fertility in more developed economies. The analysis proposed by Myrskylä et al (2009) was divided in two parts. The first part focuses on cross-

1. See, for example, Bryant (2007), Lee (2003), Balter (2006) and Bongaarts (1996).

sectional estimates of the relation between development and fertility for countries of all levels of development (107 countries in 1975 and 140 in 2005). This first look indicates the J-shaped relation. In the second part, they analyzed 25 more developed economies that have reached HDI of .90 in 2005. Longitudinal analysis for more developed countries, as they entered HDI above 0.86, suggests that increases in development level increases fertility. They argued that this reversal in fertility decline is a result of continued economic and social development.

The results presented in Myrskylä *et al.* (2009) were criticized because the split of the sample in low and high human development countries is done on an *ad hoc* basis. Furuoka (2009), using endogenous split sample methodology proposed by Hansen (2000), finds results that do not support Myrskylä et al (2009) conclusions. Furuoka (2009) argues that the relationship remains statistically negative (but weaker) for developed countries. Furuoka (2010) finds empirical evidence suggesting a significant negative relationship between per capita GDP and the Total Fertility Rate (TFR) when income level in the country was below the threshold value. The author argues that this negative association between the two variables reversed to a positive relationship when income level had exceeded the threshold value. The results confirm the existence of an inverse J-shaped fertility-development relationship in the United States.

In this paper, we follow the same methodology to investigate whether there are different regimes for the relationship between development and fertility in the case of Brazilian municipalities. Brazil is an interesting case to study the relationship between economic development and fertility decline because of large differences among the municipalities. Recent research (Potter et al, 2002; Potter et al, 2010: Muniz, 2010) showed how variations in economic measures affect fertility change and its pace of decline. However, these papers do not investigate whether more developed regions have different regimes of the relationship during the rapid fertility transition observed in Brazil.

The paper is organized as follows. Section 2 outlines a discussion about the evolution and the determinants of Brazilian fertility. Section 3 briefly presents aspects of threshold regression analysis. Section 4 outlines a preliminary analysis of fertility-development relationship for Brazilian municipalities. Section 5 reports tests and threshold effects estimations. Section 6 concludes.

## 2 FERTILITY IN BRAZIL: EVOLUTION AND DETERMINANTS

### 2.1 The rapid fertility decline

Over the last 40 years, Brazil has experienced a rapid decline of its fertility rates (Martine,1996; Carvalho, 1997/1998). The Total Fertility Rate (TFR) declined from 6.2 in 1940 to 1.86 in 2010, which implies a rate of decline of 2.47% per year.

The decline of fertility reflects in impressive decline in the population growth rates, from 2.8% in the 1960's to 1.5% per year in the 1990's.

TABLE 1
**Total fertility rates – Brazil and Regions (1940-2010)**

| Regions | Total Fertility Rates | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1940 | 1950 | 1960 | 1970 | 1980 | 1991 | 2000 | 2010 |
| Brazil | 6.2 | 6.2 | 6.3 | 5.8 | 4.4 | 2.9 | 2.3 | 1.86 |
| North | 7.2 | 8.0 | 8.6 | 8.2 | 6.4 | 4.2 | 3.2 | 2.42 |
| Northeast | 7.2 | 7.5 | 7.4 | 7.5 | 6.2 | 3.7 | 2.6 | 2.01 |
| Southeast | 5.7 | 5.5 | 6.3 | 4.6 | 3.5 | 2.4 | 2.1 | 1.66 |
| South | 5.7 | 5.7 | 5.9 | 5.4 | 3.6 | 2.5 | 2.2 | 1.75 |
| Mid-West | 6.4 | 6.9 | 6.7 | 6.4 | 4.5 | 2.7 | 2.2 | 1.88 |

Source: IBGE, Brazilian Censuses, 1940-2010.

Table 1 presents the TFR's for Brazil and regions from 1940 to 2010. All the regions in the country observed rapid decline in their fertility rates over this period. The data show that a faster decline was observed in the more developed parts of the country (southern regions). The Northeast, the poorest and less developed region, observed a slower decline in the early decades, but since 1980 its rates of decline are accelerating and the observed TFR shows some signs of convergence with the lowest ones observed in the country (Potter et al, 2010).

The process of fertility decline in Brazil is one of the most impressive in the world, and it becomes more interesting when one considers that there was not an aggressive family planning program as observed in other countries (Alves, 2006; Caetano, 2004; Martine, 1996). In comparison with countries that had similar patterns of fertility decline over recent decades, Brazil is slower than China, Hong Kong, Iran and Thailand, Costa Rica and South Korea, but much faster than Mexico, India and Bangladesh – despite the fact that all these countries had a family planning program, but Brazil.

Carvalho (1997/1998) suggested that the decline in fertility does not follow any theoretical model. Its decline started during the economic boom (1970's) and continued during the times of severe economic recession (1980); there was a slightly increase in the educational levels (the average years of schooling went from 3.2 in 1976 to 5.3 in 1996) but the quality and the regional distribution of this spread cannot easily be linked to the decline of fertility.

Also, Carvalho and Brito (2005) showed that several factors are related to the observed changes in the pattern of fertility in Brazil and included contraceptive use, increase in educational levels, institutional and cultural changes, among others.

### 2.2 What explains fertility decline in Brazil?

There is a wide body of literature discussing the determinants of fertility decline in Brazil (for example see Merrick & Berquo, 1983; Martine, 1996; Carvalho, 1997/1998 and Carvalho & Brito, 2005). One of the important factor to the decline of fertility in Brazil according to several studies is the increasing and widespread use of contraceptive methods in the country. Data from the Demographic and Health Surveys showed that over 66% of women were using any method in 1986 and over 80% in 2006. A large part of women were using female sterilization which is an irreversible method therefore having major impacts on the fertility levels.

TABLE 2
**Percentage of married (formal and informal) women using contraceptive methods – Brazil (1986-2006)**

| Methods | 1986 | 1996 | 2006 |
|---|---|---|---|
| Any Method | 66.2 | 76.7 | 80.6 |
| Modern Methods | 56.5 | 70.3 | 77.1 |
| Sterelization | 26.8 | 40.1 | 29.1 |
| Vasectomy | 0.8 | 2.6 | 5.1 |
| Oral Contraceptive | 25.7 | 22 | 28.7 |
| DIU | 1.0 | 1.1 | 1.9 |
| Male condom | 1.7 | 4.4 | 12.2 |
| Tradicional | 9 | 6.1 | 3.2 |
| Other | 1.2 | 0.4 | 0.4 |

Source: Demographic and Health Survey, 1986-1996; PNDS, 2006 and Amorim and Bonifácio (2010).

Table 2 shows the use of contraception among married women, formal and informal, in Brazil between 1986 and 2006. The increase in the use of methods over the period is observed in both developed and less developed areas of the country. The most striking factor, as already indicated, is that the government did not have a direct policy towards the use of contraception in the country. Carvalho (1997/1998) and Martine (1996) showed that the federal government maintained a neutral policy regarding family planning, when the only clear position was to support the decision made by the couples. In 2006, 80.6% of women in Brazil used some sort of contraceptive method, of those 29% use the pill and 29% were sterilized (Berquó et. al, 2008).

In a provoking paper, Vilmar Faria presented an original explanation behind Brazil's rapid fertility decline, and this has been influential in the ongoing debate on this topic since its publication. Faria (1997/1998) argues that the rapid and persistent decline of fertility in Brazil is a direct and indirect effect of the institutional changes carried out by the federal government over the last decades. The author suggests that although the government did not an explicit family planning program, the transformations in the institutional, educational and structural spheres have significant indirect impacts on the fertility decisions of families all over the country.

Faria (1997/1998) suggested that four (4) major changes in the Brazilian social structure lead to the decline in fertility. The first one is the *credit policies* which allow the participation of a major part of the population in the market economy, had effect of increasing the consumption of durable goods (consumer goods) and changed the costs and preferences faced by the families. In addition to that, universalization of mass communication helped to spread fertility decision behavior from the more developed areas of the country to the less developed. Also, improvements in the health care system and universalization of the social security program reduce the importance of the family to take care of the elderly increasing the importance of the state as an important safety net In addition to that, Martine (1996) suggested that the rapid process of urbanization, and its relation to modernization, acted together with the increasing school enrollment and the empowerment of women leading to a fast fertility decline.

Recent research has shown the importance of considering regional variables in explaining fertility decline in Brazil. Muniz (2010) discussed the importance of fertility behavior in neighboring municipalities in explaining fertility trends in Brazil. The author argued that spatial distribution of fertility levels has a strong relation to local fertility rates and, also, a multiplier effect. Potter et al (2002) and Potter *et al.* (2010) find strong relationship between fertility decline and changes in social and economic conditions across regions in Brazil. Potter et al (2002) argued that fertility has changed through the spread of new ideas and social interaction, which is closely related to the process of development. The authors also show that in the urban areas changes in fertility are related to a wide spectrum of socioeconomic variables, whereas in rural areas improvements in female education played a very important role. Potter et al (2010) showed that the pace of fertility decline is directly related to improvements in economic and social measures contrary to the idea that once fertility has started to decline its changes are independent from social and economic changes. More specifically, they find that changes started in some parts of the south and southeast regions before the 1960 and in the northeast only in the 1970s. An important finding is that early transition regions observed a much slower decline than later ones. Finally, recent studies have shown still important differences across educational and income groups, with more educated women presenting much lower fertility than less educated ones (Rios-Neto, 2005; Berquo & Cavenaghi, 2006; Alves & Cavenaghi, 2009).

## 3 THRESHOLD REGRESSION ANALYSIS

Hansen (2000) presents an econometric methodology – asymptotic confidence intervals to the threshold parameter – that separates, in an endogenous way, one sample in two (or more) regimes. Hansen, in a paper published in Econometrica, shows that one exogenous variable, called threshold variable, can be used to split a sample, for example, in two different regimes as suggests by Furuoka (2009).[2] Two regimes endogenous threshold effect estimation can be represented by the equations as follows:

$$y_i = \theta_1 x_i + e_{1i} \quad \text{if} \quad q_i \le \gamma \tag{1}$$

$$y_i = \theta_2 x_i + e_{2i} \quad \text{if} \quad q_i > \gamma \tag{2}$$

where $\gamma$ is the threshold value, $y$ a dependent variable, $x$ an independent variable, $q$ a threshold variable, $\theta$ is the angular coefficient of $x$, and $e$ is the stochastic term. The threshold value is a priori unknown, what implies that it must be estimated as the other parameters. If the threshold variable is lower than the threshold value, equation 1 represents the more adequate model. If the threshold variable is greater than the threshold value, equation 2 became the correct specification.

Furuoka (2009) employs the following specification for OLS regression without threshold effect:

$$FER_i = \beta_0 + \beta_1 HDI_i + \varepsilon_i \tag{3}$$

where $\beta_0$ is the intercept term, $\beta_1$ the angular coefficient, $\varepsilon_i$ the error term; $FER_i$ the total fertility rate of municipality $i$ (average number of children a woman would bear if she survived through the end of the reproductive age span and experienced at each age a particular set of age-specific fertility rates, in the case, 2000 municipality $i$ age-specific rates); $HDI_i$ the human development index of municipality $i$. The dataset used by the author were obtained from the *Human Development Indicators* (PNUD, 2003).

The threshold regression can be specified as:

$$FER_i = (\beta_{10} + \beta_{11} HDI_i)\, d\{HDI_i \le \gamma\} + (\beta_{20} + \beta_{21} HDI_i)\, d\{HDI_i > \gamma\} + \varepsilon_i \tag{4}$$

d{.} is an indicator function; when $d\{HDI_i \le \gamma\}$ equals to 1 and $d\{HDI_i > \gamma\}$ equals to 0, if HDI is equal to or less than the threshold value. This situation indicates "first regime" regression. The "second regime" regression would be used for the cases when $d\{HDI_i \le \gamma\}$ equals to 0 and $d\{HDI_i > \gamma\}$ equals to 1, if HDI is greater than the threshold value.

2. In this paper we test the existence of more than two regimes.

In this case, it is necessary to analyze statistically the existence of the threshold effect (one or more) as suggested by equation (4). Following Hansen (1997), the threshold effect captures differences among the first and second regimes coefficients. A heteroskedascity-consistent Lagrange Multiplier (LM) test can be used to test the null hypothesis whether the coefficients are the same and there's no threshold effect (Hansen, 1996). Hansen (1996; 2000) suggests employing a Sup F statistic (Andrews e Ploeberger, 1994). We use a bootstrap proceeding (1000 replications) to obtain the critical values since the test do not presents standard asymptotic distribution. Here, this test is performed until no other sample partition is statistically significant at 10% level.

In sequence, the threshold value is estimated as Hansen (1997). We estimated it using an OLS estimator as γ is the value that minimizes the residual variance:

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

where n is the number of observations and ê the estimated error term.

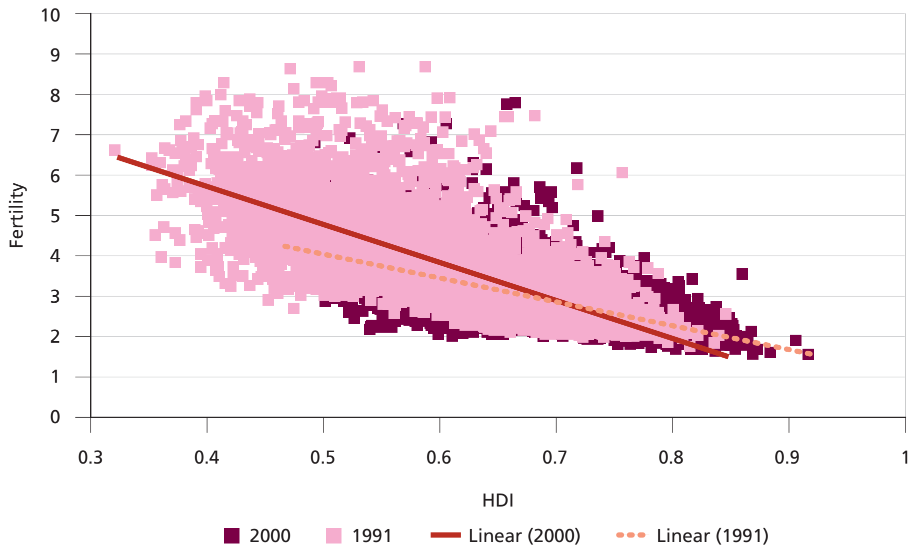
Finally, it is necessary to define confidence levels to γ. Hansen (2000) suggests to use the Likelihood Ratio (LR) statistic. Data used in the paper are collected from Atlas do Desenvolvimento Humano no Brasil (PNUD, 2003) to the 5507 Brazilian municipalities.

## 4 FERTILITY AND DEVELOPMENT: A PRELIMINARY ANALYSIS

Graph 1 shows the strong negative relationship between the Total Fertility Rate (TFR) and the HDI of Brazilian municipalities in 1991. This relationship appears to be negative but less intense in 2000. Anyway, this means that for both years, municipalities with the highest human development have low fertility and the highest fertility rates are observed in municipalities with lower human development, on average. There are some criticisms to the use of period TFR to analyze the changes in fertility. In an important paper, Bogaarts and Feeney (1998) developed an estimate of fertility adjusted by tempo and quantum effects. Their argument is that period rates are affected by the timing of fertility behavior. That is, period fertility estimates might be lower than they actually are, because women are postponing their fertility. In the case of Brazil, we do not expect this to have much effect, because the age profile of fertility in Brazil, both in 1991 and 2000, did not show signs of childbearing postponement. Moreover, we do not have enough information to apply Bongaarts and Feeney method to our data. Myrskylä et al (2009) tested their results, for 41 countries, adjusting for tempo-quantum effects and obtained similar results.

GRAPH 1

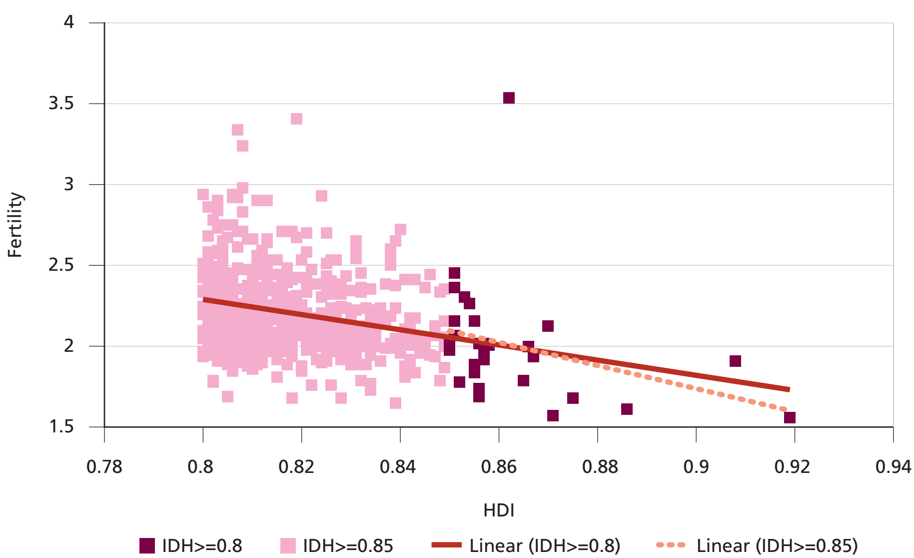
**Brazilian municipalities: fertility X HDI (1991 and 2000)**




Source: Atlas do Desenvolvimento Humano (PNUD, 2003).

GRAPH 2

**Brazilian municipalities: fertility X HDI (2000)**




Source: Atlas do Desenvolvimento Humano (PNUD, 2003).

Graph 2 shows that the negative relationship between Total Fertility Rate (TFR) and HDI for the year 2000 can also be observed for the municipalities with the highest human development (HDI above 0.80 and 0.85). That is, this initial view (from an exogenous criterion for split the sample) suggests that the relationship does not revert to the municipalities of greater human development in Brazil, contrary to what was observed for countries by Myrskylä *et al*. (2009). The results presented in Myrskylä *et al.* (2009) are criticized because the split of the sample in low and high human development countries is done on an *ad hoc* basis.

Furuoka (2009), using the methodology proposed by Hansen (2000) finds results that do not support Myrskylä *et al.* (2009) conclusions. Furuoka (2009) argues that the relationship remains statistically negative (but weaker) for developed countries. However, Furuoka (2010) finds evidence to support the existence of an inverse J-shaped development-fertility to the United States. The same methodology is used in this paper to test if there are statistically different regimes for the relationship between development and fertility in the case of Brazilian municipalities.

## 5 RESULTS: TESTS AND THRESHOLD EFFECT REGRESSIONS

Table 3 presents regimes threshold results obtained from Hansen (2000) methodology. First round of threshold model selection, after 1,000 replications, achieve p-value equal zero to LM test. This suggests a first split existence of the total sample based on HDI (null hypothesis rejection of no threshold existence).

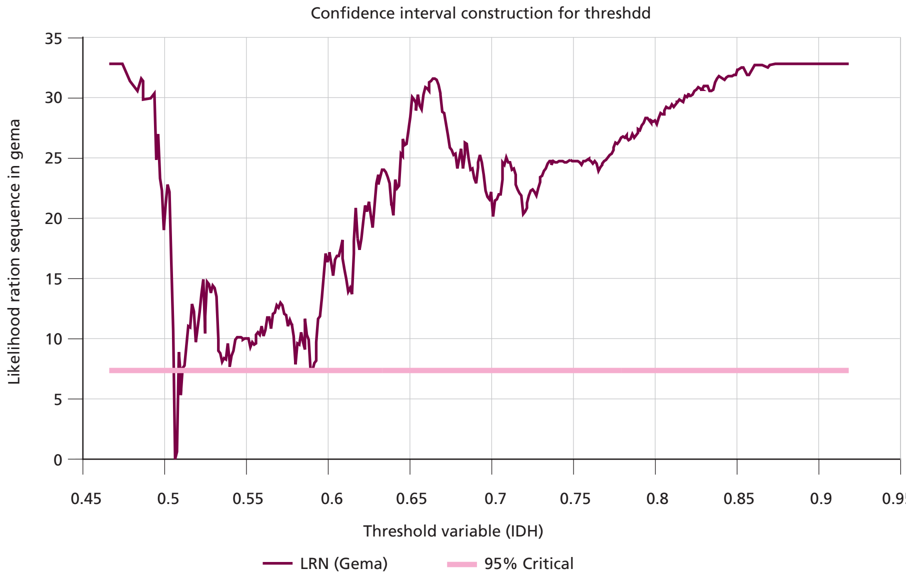
TABLE 3
**Four regimes threshold effect estimation**

| | | |
|---|---|---|
| Regime 1 | HDI £ 0.507 | 30 municipalities |
| Regime 2 | 0.507 < HDI £ 0.641 | 1,575 municipalities |
| Regime 3 | 0.641 < HDI £ 0.702 | 957 municipalities |
| Regime 4 | HDI > 0.702 | 2,945 municipalities |

See the text.

Threshold value estimated by OLS that minimizes residual variance and LR statistics is 0.507 (Figure 1) with asymptotic confidence of 95% between [0.507000;0.591000]. This value splits the sample in two groups: one with 30 municipalities with the lowest human developed municipalities and a larger group of all 5,477 municipalities.

FIGURE 1
**Threshold variable confidence interval**




Second round selection,[3] is based on 5,477 municipalities with HDI value above 0.507. P-value equals zero to LM test what suggests a second split existence of this sample based on HDI. Threshold value estimated by OLS that minimizes residual variance and LR statistics is 0.702 (Figure 2) with asymptotic confidence of 95% between [0.536000;0.729000]. This value splits the sample in two groups: one with 2532 (0.507 < HDI £ 0.702) municipalities and another with 2,945 municipalities (HDI > 0.702).

Third round selection is based on 2,532 municipalities. P-value equals zero to LM test what suggests a new split existence in this sample based on HDI. Threshold value estimated by OLS that minimizes residual variance and LR statistics is 0.641 (Figure 3) with asymptotic confidence of 95% between [0.533000;0.662000]. This value splits the sample in two groups: one with 1,575 municipalities (0.507 < HDI £ 0.641) and another with 957 municipalities (0.641 < HDI £ 0.702).

3. Furuoka (2009) do not report second (or more) rounds selection of threshold models. This means that a more adequate statistical confirmation is not done what implies that the doubt about Myrskylä *et al.* (2009) results still remain.

FIGURE 2
**Threshold variable confidence interval**

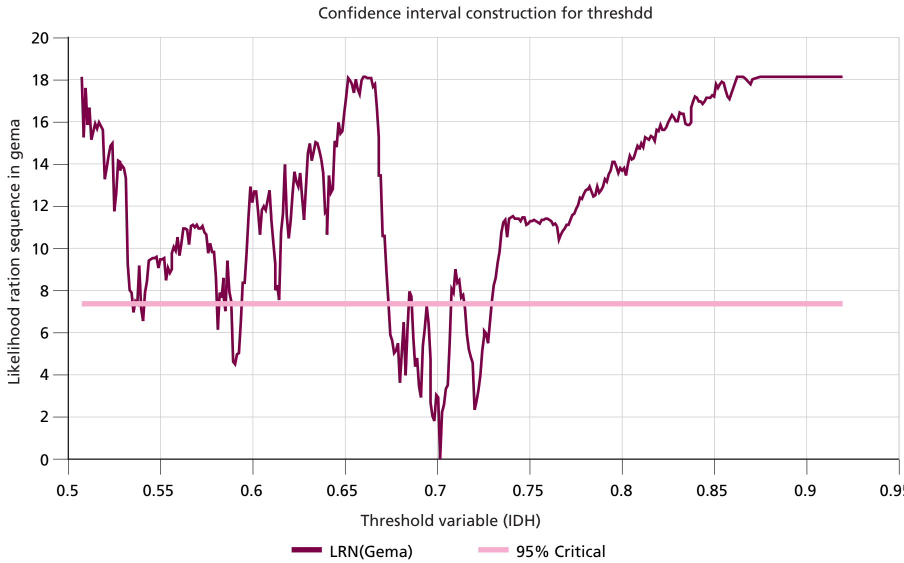
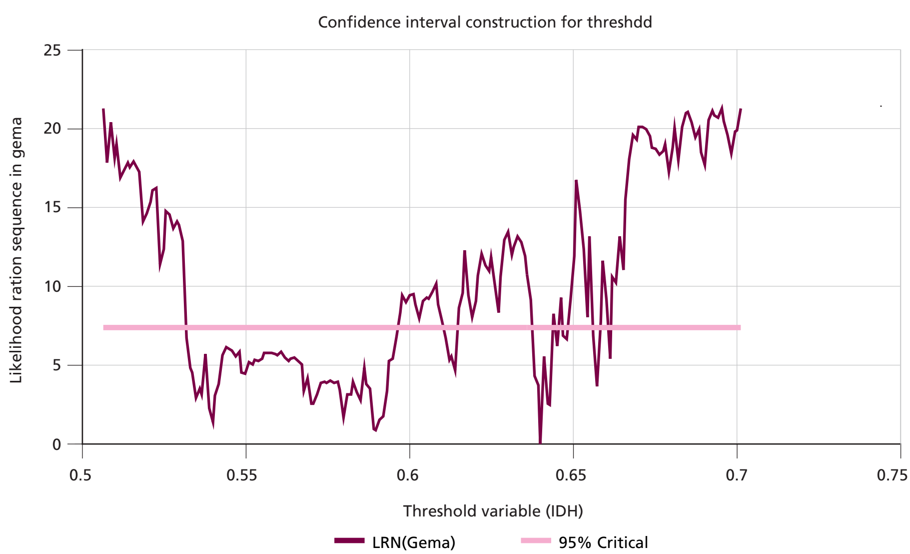



FIGURE 3
**Threshold variable confidence interval**



Additional splits of subsamples of 30; 1,575; 957 and 2,945 municipalities were tested (HDI £ 0.507; 0.507 < HDI £ 0.641; 0.641 < HDI £ 0.702; HDI > 0.702) but LM test did not reject the null hypothesis of no threshold existence in each case.

Table 4 presents estimated coefficients and their standard errors (in parentheses) to the relation between fertility and HDI to all Brazilian municipalities and to different subsamples (regimes) previously defined.

TABLE 4
**OLS Estimations with and without threshold effect**

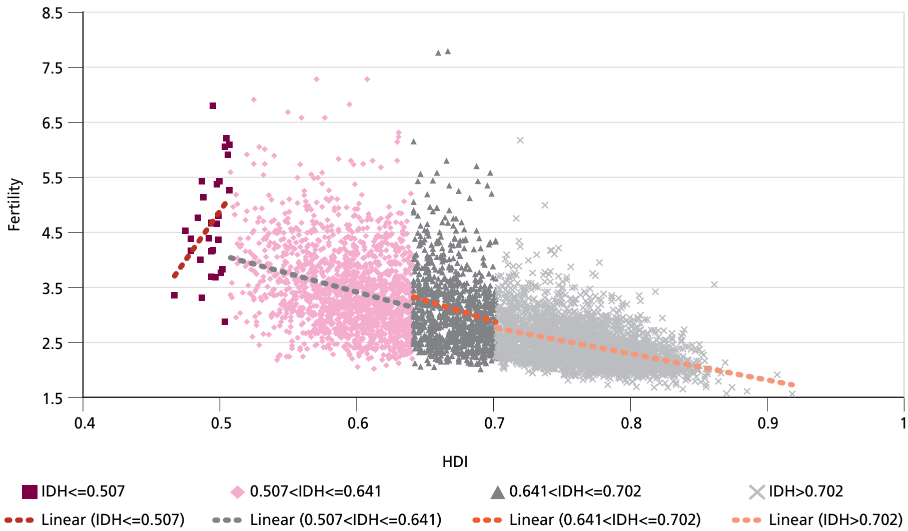
| | Without Threshold Effect Estimation | Threshold Effect Estimations | | | |
|---|---|---|---|---|---|
| | | Regime 1 Municipalities HDI ≤ 0.507 | Regime 2 Municipalities 0.507 < HDI ≤ 0.641 | Regime 3 Municipalities 0.641 < HDI ≤ 0.702 | Regime 4 Municipalities HDI > 0.702 |
| Constant | 6.995* (0.074) | -12.856*** (6.669) | 7.458* (0.364) | 8.223* (0.821) | 6.107* (0.141) |
| HDI | -5.907* (0.099) | 35.467** (13.662) | -6.738* (0.609) | -7.630* (1.214) | -4.763* (0.181) |
| $R^2$ | 0.438 | 0.137 | 0.079 | 0.037 | 0.191 |
| N.obs. | 5507 | 30 | 1575 | 957 | 2945 |

Figures in the parentheses indicate t-statistics.
* indicates significance at 1% level.
** indicates significance at 5% level.
*** indicates significance at 10% level.

Ordinary Least Squares regression to the full sample of Brazilian municipalities reveals the well known negative relationship between fertility and human development (at 1% confidence level). In other words, low fertility rates are statistically related to high human development. Notwithstanding, association intensity is weaker than what was observed by Furuoka (2009).

Interesting issues as revealed by OLS threshold estimations (Graph 3). To the first identified regime (30 municipalities), the fertility-development association is positive and significant at 5% level. That is, we observed that for municipalities in the lower bottom of economic development, higher levels of economic development tend to be associated with highest fertility rates. This result may be related to the characteristics of these municipalities: small populations, predominantly rural and located in the northern region. However, for municipalities with a high human development index, higher levels of HDI are associated with lower fertility rates, although the relationship is weaker. The other three regimes cases, traditional negative relationship is observed (at 1% confidence level in all cases). Worth noting that third regime intensity is weaker than the other three, as it was observed by Furuoka (2009). Moreover, as Furuoka (2010) concluded for the USA, there is no evidence to support the existence of an inverse J-shaped development-fertility to the Brazilian municipalities.

GRAPH 3
**Brazilian municipalities: fertility X HDI (2000)**




Source: Atlas do Desenvolvimento Humano (PNUD, 2003) and estimations.

## 6 CONCLUSIONS

During the last century, several countries observed a rapid increase in economic development with simultaneous decline in fertility and population growth rates. In a recent paper, Myrskylä *et al.* (2009), suggest that the previously negative development–fertility association has actually become an inverse J-shaped, that is, Human Development Index (HDI) being positively associated with fertility among highly developed countries. Our results indicate a clearly negative correlation between fertility and development. We are not able to determine whether economic development causes fertility decline.

Using a threshold regression analysis as proposed by Hansen (2000), this article investigates this negative association between economic development and fertility rate in the Brazilian Municipalities with recent database. This study shows that the influence o economic development on fertility, in Brazil, has the same direction as predicted by the literature. Our empirical findings support the hypothesis that higher human development (and economic development) is related to lower fertility levels. Out results show no evidence to support the existence of an inverse J-shaped development-fertility as found by Furuoka (2010) to the United States, in opposite to the results suggested by Myrskylä et all. (2009). Moreover, we found four regimes statistically significant and there is evidence that the intensity of the third regime is lesser than others as is found by Furuoka (2009).

Our results also contribute to the debate about the future trends of fertility in Brazil. Our findings indicate that as municipalities develop one should find further decline in total fertility rates. The results also raise some questions about how public policies might affect future behavior of fertility in Brazil. In general, lower fertility rates are associated to higher female labor force participation rates, thus as female labor force increases one can expected further declines in fertility in Brazil. The reversion of low fertility rates will demand proper policies especially direct to childcare and more flexible work relations. On one side, lower fertility rates might be associated with higher investments in human capital of children what can lead to positive impacts to societies and economy (Lee & Mason, 2010). On the other side, Brazil is facing a rapid process of population aging, as fertility continues to decline (and declines for all regions) the process could gain a faster pace impacting even more the future trends of population size and population age structure in Brazil. The possible impacts of population aging are well-known and discussed elsewhere (Wong and Carvalho, 2006; Rios-Neto, 2005).

Our study, however, is limited since we concentrate on 2000 data. Further studies are necessary to test the hypothesis of an inverse J-shaped relation between fertility and development. It is important to test the hypothesis with the 2010 census once the data are available to compare to our results. Further studies, should use other measures of economic development (Luci and Thvenon, 2010) such as female labor force participation, female empowerment and other gender specific measures, to test the linkages between fertility variation and institutional and social norms in Brazil. Special attention should be given to changes in female labor force participation and female status in society (Brewster and Rindfuss, 2000), since a large body of research has found for some European countries a positive relation between fertility levels and female labor force participation (Billari and Kohler, 2004).

### 6.1 Acknowledgments

We are grateful to two anonymous reviewers for many constructive suggestions for improving the manuscript. Bernardo L Queiroz acknowledges financial support from FAPEMIG (Programa Pesquisador Mineiro). The opinions, comments and analysis expressed in this document are those of the authors.

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