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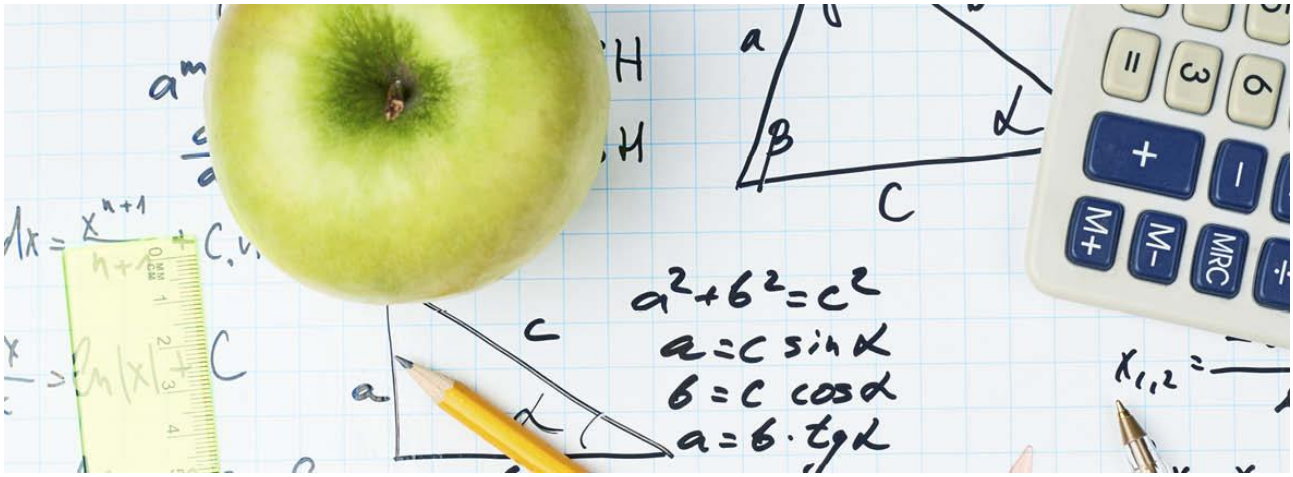


# Small-Area Variation of Fertility Rates

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# Small-Area Variation of Fertility Rates

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**Abstract**

Alike most of the Western world, the Danish fertility rate declined throughout the 20th century simultaneous to economic growth. This development, which conflicts with economic intuition, has been denoted the fertility paradox, and several studies have been devoted to resolve it. The present study analyzes the geographic variation across Danish municipalities in the fertility rate during the years 1982 to 2004. Several factors commonly believed to explain the variation in the fertility rate is found to be exerted to considerable regional variation. A model linking the fertility rate to several economic determinants is established and further modified to capture geographic small-area variation. Specifically, a positive correlation between regional levels of income and fertility is found, which contradicts the fertility paradox. Thus, the necessity of separating small-area and dynamic variation, aiming at obtain a proper interpretation of the link between fertility and its determinants, is demonstrated.

**Keywords:** Spatial econometrics, Demography, Fertility, Regional population variation

**JEL classifications:** C21, N3, J13, R23

## 1. Introduction

During the 20th century, the fertility rates in Western European countries have shown varying patterns during. Generally, the tendency is declining as concluded from the Princeton European Fertility Project by Coale and Watkins (1986). However, the general tendency covers considerable national and regional variation. This is demonstrated for the case of Denmark by Figure 1, which shows the development in the average of the fertility rates for 270 Danish municipalities from 1982 to 2004, including bands defined by plus/minus two standard deviations. Apparently, the average municipal fertility rate increases until the mid 1990'es, followed by a decline until 2000, where after it increases again. On the other hand, taking the bands in consideration, the rate is close to stable during the period.

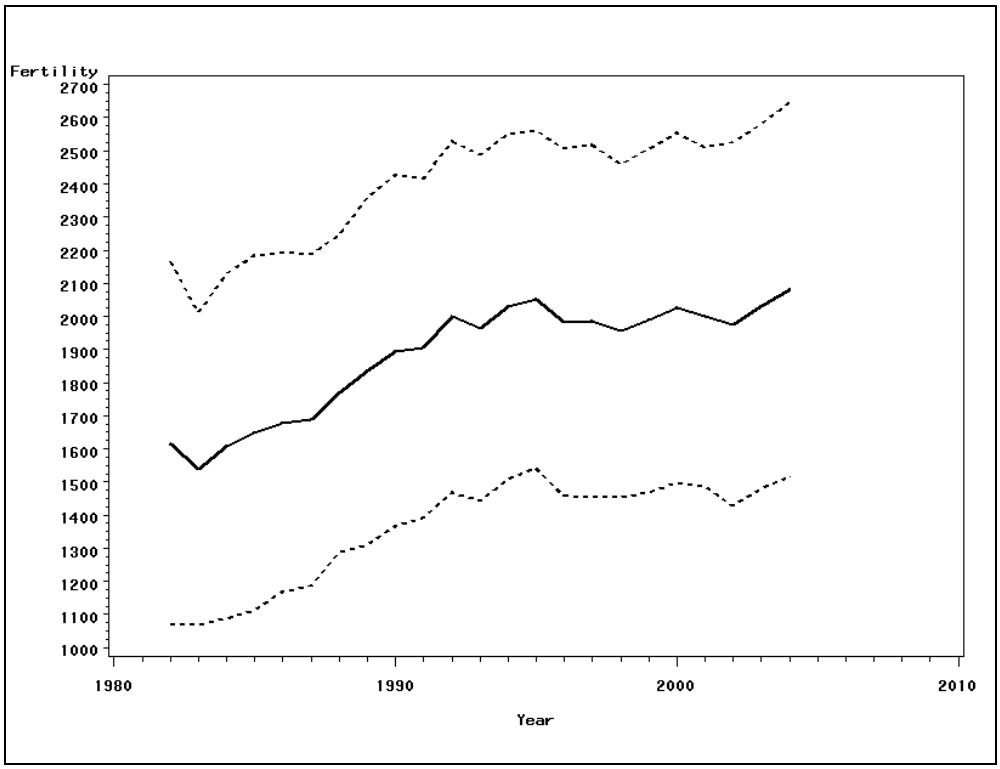


**Figure 1.** Average municipal fertility with upper/lower bands (defined by +/- 2 standard deviations)

Figure 2 shows the distribution of fertility across municipalities in 1982, 1993 and 2004, together with the changes in fertility between these years. Throughout, fertility appears to move from peripheral and countryside to central and city areas.


**Figure 2.** Fertility rate and change by municipalities

The purpose of the present study is to establish a model to explain the variation in fertility rates by variation in economic determinants. In particular, focus will be on the fertility paradox, i.e., whether there is a positive or negative relationship between income and fertility. Section 2 provides a review of economic theory, while Section 3 presents the methodology applied, including methods to adjust for geographical variation and spill over. Upon presentation of the data in Section 4, results of the analysis are presented in Section 5, followed by concluding remarks to round off in Section 6.

## 2. Determinants and geography of fertility

From an economic perspective, households are assumed to be rational units acting optimally in any given situation in order to maximize the utility of the household. Children are assumed to provide a

utility to the household which is compared to that of other material and non-material goods, including education, professional career etc. Thus, economic analyses predominantly focused on the number of children in the household (Ermisch 1991; Tasirin 1993; Hotz et al. 1997) or the timing and spacing of children during the woman's life cycle (Heckman and Willis 1976; Wolpin 1984; Moffit 1984; Cigno and Ermisch 1989; Tasiran 1993; James 1996).

Early studies (Leibenstein 1957; Becker 1960, 1965; Mincher 1963; Wilkinson 1973) stressed that the female wage rate is negatively correlated to the household's number of children, while the male wage rate is positively related. The argument is that the male is the primary income earner of the family, while the female has the main responsibility for the children. Therefore, the higher the female income, the more expensive it is to stay out of work. Empirical evidence is provided by several authors (Winegarden 1984; Lee and Gan 1989; Wang and Famoye 1997).

Given that the negative relationship between income and fertility to some extent conflicts with economic theory and intuition, it has been denoted the fertility paradox or the demographic-economic paradox (McFalls 1987; Weil 2004).

However, the support for a negative relationship has become weaker in most countries over recent decades and even turned into an expectation of a positive relationship (Siegel 2012). Denmark, alike other Nordic countries, is one example where the fertility and the female labour participation rate increased simultaneously until the early 1990'es. One reason is the build up of public welfare systems, including children day-care and financing of maternal leave. Moreover, the norm of most young people – male as well as female – has long been education first; next ensure position on labour market, and finally having children (Sundström and Stafford 1992; Hoem 1993; Hoem and Hoem 1996; Andersson 1999).

On the other hand, while good economic conditions may be expected to correlate positively to fertility, the time spent for education delays the time until birth of first children and thus reduces fertility (Gustafsson et al. 2001; Löfström and Westerberg 2002; Cigno and Ermish 1989). It is therefore expected that the fertility rate will be higher in municipalities with a high rate of uneducated people.

Taking further the arguments that income may potentially increase fertility, it seems reasonable that unemployment reduces fertility.

Demography and family formation is another important set of factors behind fertility. It is expected that municipalities with many divorced individuals possesses lower fertility rates, and, correspondingly, that municipalities with many married people has high fertility rates (Alesina and Giuliano 2007). Ethnic minorities are known to establish more traditional family patterns, where the female takes care of the children and where the number of children is higher. Thus, a positive relationship between the number of persons from ethnic minorities and the fertility rate is expected (Lievesley 2010).

Geography and surroundings are known to be considerably connected with the variation of fertility rates, and spatial panel data methods have been applied (Galloway, Hammel and Lee 1994; Brown and Guinnane 2002; Guinnane 2011; Goldstein and Klüsener 2014). Housing units are more expensive in cities than in rural areas, so that families with children are motivated to move away from city areas, i.e., the degree of urbanisation is expected to be negatively related to fertility (Martine et al. 2013). Further, the service offered by the municipality, relative to the payment for this service via taxes, is an important factor which attracts families with children and thus increases fertility (Löfström 2000).

A final important matter is related to the small-area geographical dispersion of fertility. Specifically, if the number of families with children is large in a municipality, then – everything else kept equal – a spatial spill over of families with children to neighbourhood municipalities may be expected. In other words, the fertility in a municipality is expected to be positively related to the average fertility in the municipalities surrounding it (Sandberg and Westerberg 2005). A look at Figure 2 illustrates that such a spatial spill over is present. Such a spatial spillover will be denoted an endogenous spillover, in order to distinct it from exogenous spatial spill over, caused by the explanatory factors (Anselin 1988). The latter notion refers to the phenomenon that the impact of these factors may go across the municipal border lines. For example, if a municipality offers a good service to child families, then the fertility will be relatively high. But what if the average level of service in the neighbourhood municipalities is high? Then these municipalities will be more attractive for families with children than the municipality considered, so that – everything else kept equal – the fertility will be lower in the municipality considered. Such exogenous spatial spill over effects may be of a contra-signed nature as illustrated by the example, but they may also be of the same sign as their non-spatial counterparts. As an example, income increases fertility. Likewise,

high average income in neighbourhood municipalities will spill over to the municipality in the form of family movements, whereby fertility is increased.

### 3. Methodology

The point of departure is a linear regression model defined for the *N*=270 municipalities in a single year by

(1) $$y_t = X_t\beta + \upsilon_t, \quad \upsilon_t \sim N(0, \sigma^2 I)$$

where $X_t$ is an *N* by *K* dimensional matrix of the *K* explanatory variables, $y_t$ an *N* dimensional vector of the fertility rates in the municipalities, and $\beta$ a *K* dimensional coefficient vector measuring the effects of the explanatory variables on fertility. The term $\upsilon_t$ is a residual term, which represents the fertility rates when controlled for the explanatory factors of $X_t$ and may be denoted the residual fertility.

As discussed above, spatial spill over patterns across the municipalities have to be taken into account. Operationally, endogenous spatial spillover is controlled for by adding the average of $y_t$ in the neighbourhood municipalities (denoted by $y_t^W$) as an explanatory variable in (1) to obtain the *spatially autoregressive* (SAR) specification (Anselin, 1988)

(2) $$y_t = y_t^W\lambda + X_t\beta + \upsilon_t,$$

where $\lambda$ is a parameter specifying the magnitude of spill-over, formally restricted to the interval between (-1) and (+1), but for most practical purposes restricted to be positive. Likewise, exogenous spatial spillover is controlled for by adding the averages of $X_t$ in the neighbourhood municipalities (denoted $X_t^W$) as explanatory variables in (1) to obtained the *spatially distributed lag* (SDL) specification (Florax, 1992)

(3) $$y_t = X_t\beta + X_t^W\delta + \upsilon_t,$$

while both types of spillover are controlled for simultaneously by simply involving both $y_t^W$ and $X_t^W$ to obtain a combined SAR-SDL specification.

One further methodological problem needs attention. While pooled data for *T* years are applied, the residual fertilities across years for any municipality are correlated. Also, the variance of the residual fertility within each year may potentially vary across years. Thus, between any two years, the covariance of the residual fertility reads as

(4) $$E(\upsilon_t'\upsilon_s) = \sigma_{ts}^2 \quad t,s = 1,..,T .$$

To obtain efficient estimates of $\beta$, we apply Feasible Generalised Least Squares (F-GLS) estimation as suggested by Zellner (1962) to obtain Seemingly Unrelated Regression (SUR) estimates for $\beta$.

Finally, to provide devices for comparison of alternative models, some quantities are applied. One is a pseudo-R-square ( $R^2$ ), calculated as the square of the correlation between $y$ and its predicted values. This measure is readily calculated for the SUR and the SUR-SDL models, but it is not defined for the SUR-SAR specification. A second device applied is the familiar Akaike Information Criterion (AIC) calculated as (-2LogL + 2*K*). Finally, nested models are tested against each other using Likelihood Ratio (LR) test, calculated as twice the difference between the values of the log likelihoods of the two models.

**4. Data**

The data to be applied are defined in Table 1, which further shows the means by year of the variables. Data were obtained for 270 Danish municipalities annually from 1994-2003.

**Table 1.** Data applied for the study

| Variable | Definition |
|---|---|
| Fertility | Summaric fertility rate per 10,000 females[1] |
| No education | % population without further education[2] |
| Tax-Service | Ratio of municipal service to tax collected, annual country average = 100[2] |
| Urbanisation | % population living in urban area[2] |
| Unemployment | % population without employment[2] |
| Foreigners | Number of inhabitants from countries outside EU, North America and Canada per 1,000 inhabitants[2] |
| Married | % population who are married[2] |
| Divorced | % population who are divorced[2] |
| Tax base | Income deductible for municipal and county taxation per inhabitant[2] |

Source: [1] Statistics Denmark (www.dst.dk) and [2] the Key Figure Base (www.im.dk)

## 5. Results

Table 2 shows the spatially unadjusted model and the model adjusted for spatial spill over, applying the SAR-SDL framework as described above.

**Table 2.** Unadjusted and spatially adjusted models of fertility

| | Unadjusted model | Spatially adjusted model | |
|---|---|---|---|
| | | Direct effect | Effect of spatial lag |
| Constant | 1428.12***<br>(226.74) | 2466.51***<br>(380.07) | |
| Time trend | -55.92***<br>(9.06) | -49.94***<br>(10.94) | |
| Time trend squared | 4.74***<br>(0.67) | 4.24***<br>(0.76) | |
| No education | 6.50***<br>(1.52) | 8.24***<br>(1.63) | -4.73*<br>(2.62) |
| Tax-Service | 0.98<br>(1.12) | 3.08***<br>(1.11) | -5.80***<br>(2.05) |
| Urbanisation | -3.52***<br>(0.58) | -3.53***<br>(0.57) | 0.76<br>(1.00) |
| Unemployment | -11.38***<br>(4.19) | -4.46<br>(5.95) | -2.89<br>(7.72) |
| Foreigners | 1.80***<br>(0.49) | 1.20**<br>(0.50) | -0.47<br>(0.86) |
| Married | 17.35***<br>(2.74) | 23.78***<br>(3.19) | -22.04***<br>(4.45) |
| Divorced | -49.95***<br>(5.49) | -26.71***<br>(8.56) | -37.29***<br>(10.80) |
| Tax base | 1.81***<br>(0.57) | -0.21<br>(0.69) | 2.21**<br>(1.06) |
| Spatial lag of fertility | | | 0.06***<br>(0.01) |
| LogL | -15783.73 | -15748.22 | |
| AIC | 31701.46 | 31646.44 | |

Apart from the explanatory variables, their spatial counterparts and the spatial lag of fertility rates, a time trend and the square of the time trend is added to capture the U shaped development of the fertility rates across years.

Inspection of the spatially unadjusted model generally confirms the initial expectations regarding effects of determinants. The U shaped development of the fertility rates across years is confirmed by the significantly positive second order term of the time trend. Percentage without education is positively related to fertility, i.e., a negative relationship between education and fertility is proved. The service-to-tax rate exerts a positive impact, confirming that municipalities offering a good service attract families with children and thus experience a higher fertility. It is, however, noticed that the effect is not significant. Municipalities with a high degree of urbanisation experience a lower fertility as expected. Unemployment exerts the expected negative impact on fertility. High proportions of foreigners lead to high fertility rates. Marriage is positively related to fertility, and divorce negatively, as expected. Finally, the fertility paradox is questioned, as income is positively related to fertility.

By comparing the unadjusted model to the spatially adjusted, however, the importance of adjusting for spatial spill over becomes evident. For the latter, it is especially noticed that the positive effect of the service-to-tax rate turns out to be highly significant. Moreover, the spatial lag of the service-to-tax rate comes out with a negative effect. I.e., if the service level is high in a municipality, then the fertility rate will be increased. But if the average service level in the surrounding municipalities is high, then the fertility rate will be reduced. An alike contra-signed pattern is found for proportion of uneducated: The direct effect is positive as expected. But if the proportion of uneducated in the surrounding municipalities is high, then a negative effect on fertility occurs. If lack of education is a large-area phenomenon characterising an entire region of municipalities, then this region will be an economically peripheral region, which is not attractive for families with children, i.e., the fertility rate will fall. An alike contra-signed tendency is present for percentage of married, but for other reasons: If this percentage is high in the surrounding municipalities, then these municipalities are potentially attractive for married couples, whereby – everything else kept equal – such couples will move away from the municipality considered so that a drop in fertility is caused. Opposed to married, it is seen that the direct as well as the spatial effect of percentage of divorced are negative.

An important observation regarding the effect of income is called for. It is seen that the direct effect of income is not significantly different from zero, while the positive effect of income is rather caused by the income level in the surrounding region of municipalities. Thus, the positive effect of income is super-regional, rather than restricted to the local municipality. Specifically, this illustrates that the negative relationship as suggested by the fertility paradox is merely a dynamic and transitional feature, while the small-area effect of income reflects traditional economic theory by being positive.

Moreover, it is noticed that the direct effects of percentage of foreigners and urbanisation are as expected, while - not especially surprising - the spatial effects for these are not significantly different from zero. Finally, a positive spill over from the average of fertility rates in surrounding municipalities is found as expected.

A few comments to the quantities for comparison of models remain. The LR test for the spatially unadjusted SUR versus a simple linear specification rejects the latter in favour of the former. Further, the LR test for the spatially adjusted model versus the spatially unadjusted strongly supports the spatially adjusted model. Put together, these quantities strongly support the necessity of controlling carefully for the spatial nature of the data as well as for the repetition of observations across time.

## 6. Conclusions

Alike most of the Western world, the Danish fertility rate declined throughout the 20$^{th}$ century simultaneous to economic growth. This development, which conflicts with economic intuition, has been denoted the fertility paradox, and several studies have been devoted to resolve it. The present study analyzes the geographic variation across Danish municipalities in the fertility rate during the years 1982 to 2004. Several factors commonly believed to explain the variation in the fertility rate is found to be exerted to considerable regional variation. A model linking the fertility rate to several economic determinants is established and further modified to capture geographic small-area variation. A positive small-area correlation between regional levels of income and fertility is found, which contradicts the fertility paradox. Thus, the necessity of separating small-area and dynamic variation, aiming at obtain a proper interpretation of the link between fertility and its determinants, is demonstrated.

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