Does economic development drive the fertility rebound in OECD countries?

Angela Luci[£], Olivier Thévenon[¥]

INED
Institut National d'Etudes Démographiques
133, Boulevard Davout
75980 Paris Cedex 20

4th draft.
Comments highly welcome.

This version: August 27, 2010

Abstract

We are concerned about the extent to which changes in fertility trends are related to ongoing economic development in OECD countries. Knowing about the inverse J-shaped relationship between the human development index (HDI) and total fertility rates that was recently found by Myrskylä, Kohler and Billari (2009), we single out the impact of economic development on fertility. We empirically test the hypothesis of a convex impact of GDP per capita on fertility, using data from the OECD area that spans the years 1960 to 2007. We test the robustness of our findings by controlling for birth postponement and for different income distribution patterns. By designating a clear turning point in the relationship between economic development and fertility, we find that economic development is likely to induce a fertility rebound, but is not sufficient to lift fertility on a significantly higher level in all OECD countries. Country-specific factors explain why countries with similar GDP per capita level achieve significantly lower or higher fertility rates than the estimated baseline, however. By decomposing GDP per capita in several variables, we identify female employment as main factor impacting fertility, behind GDP variations. The positive association between the diffusion of female employment and fertility rates suggest a key role played by the changes in norms and institutions supporting the combination between work and family that go along with the process of economic development.

Keywords: fertility rebound, economic development, female employment, gender

JEL codes: J11, O1

This article was written within the framework of the international collaborative research project "REPRO" (reproductive decision-making in a macro-micro perspective) for the European commission (http://www.oeaw.ac.at/vid/repro/). The article has benefited greatly from comments of many colleagues from the REPRO group, INED and from University Paris 1 Panthéon- Sorbonne. We also thank the participants of the European Society for Population Economics (ESPE) congress in Essen, Germany for their comments and advice. Furthermore, we thank Mikko Myrskylä and Peter McDonald for their comments made at the Population American Association meeting in Dallas as well as Hye-Won Kim, Wooseok Ok and Youngtae Cho for their discussion at the Seoul's International Conference on Population Prospects and Policy Responses. Tomas Sobotka, who provided the data on the adjusted-tempo fertility rates, Willem Adema, Jean-Bernard Chatelain and Herbert Smith are also gratefully acknowledged for valuable and careful suggestions. Only the authors are responsible for the remaining errors.

[£] angela.luci@ined.fr, [¥] olivier.thevenon@ined.fr

1. Introduction

The consequences of economic development on fertility dynamics have given rise to controversial but often negated predictions. An example of this is the pioneering thesis of Malthus, who anticipated a rapid growth in population size going hand in hand with economic development. While Malthus predicts a pro-cyclical evolution of fertility, the demographic transition theory (DTT) suggests that in countries that develop from a pre-industrial to an industrialized economic system, long-term increases in economic wealth and income per capita are combined with a transition from high to low birth and death rates (c.f. Galor and Weil, 1999; Doepke, 2009). The DTT predicts ever decreasing fertility rates with economic growth. Actually, over the recent decades in many OECD countries, a rapid decline of fertility below replacement level could have been observed that went hand in hand with economic growth. However, within the recent years, especially in highly developed countries, a reversal of fertility trends has been occurring and can be observed simultaneously with continuing economic development.

Answering the question whether further economic advancement is likely to provoke a re-increase of fertility in highly developed countries is of important political, social and economic interest. As fertility affects population growth and the age structure of the population, the evolution of fertility in the nearest future has far-reaching consequences on economic development, productivity growth and several aspects of the Welfare systems (Barro and Becker, 1989; Prskawetz and Lindh, 2006; Prskawetz *et al*., 2008). Fertility response to economic development is not of similar nature all along its path. Many factors shape the relation, above and behind the economic dimension (Lesthaeghe and Surkyn, 1988).

Yet a series of empirical studies have identified changing relationships between economic growth and fertility rates. Butz and Ward (1979), for example, find that whereas in the USA fertility trends were pro-cyclical before 1960, they turned counter-cyclical from the 1960s on until the late 1970s. Most recently, Myrskylä, Kohler and Billari (2009), find a so called "inverse J-shaped" relationship between the human development index (HDI) and total fertility rates, suggesting a fertility rebound from a certain level of human development on. However, the use of a composite measurement of human development masks the particular contributions of each of the indicator's components (GDP per capita, life expectancy and school enrolment). In addition, Myrskylä *et al.* (2009) do not provide clear empirical estimates for the exact level of HDI leading to a reversal of the fertility trend. Hence, the empirical studies do not allow concluding whether in OECD countries, further economic growth can be expected to go hand in hand with a fertility increase.

In order to find out whether *economic* development is the driving factor behind the fertility rebound observed in several highly developed OECD countries, we focus our analysis on the impact of income per capita only on fertility. Based on theoretical arguments, recent empirical findings and descriptive statistics, we set up the hypothesis of a convex impact of GDP per capita on fertility, implying an inverse J-shaped pattern of fertility along the process of economic development (i.e. a U-shaped pattern with the declining branch on the left hand side longer than the rising branch at the right hand side). We empirically test our hypothesis using data for OECD countries that spans the years 1960 to 2007. As GDP per capita captures several dimensions of economic advancement, we filter out the impact of its different components (labour productivity, average working hours, employment) on fertility, whereas we also account for their gender distribution.

The main novelty of our contribution is that we propose a one-step estimation model, which allows quantifying a clear turning point in the relationship between economic development and fertility, at which further economic advancement can be expected to lead to a rebound of fertility. Moreover, we separately identify within-country trends and between-country variations in order to capture within-country trends as precisely as possible, once controlled for cross-country differences that can shift the relations in one sense or the other. A range of econometric techniques are used to control for omitted variable bias, non-stationarity and endogeneity. Furthermore, in addition to standard periodic fertility rates, we use tempo-adjusted fertility rates in order to control for changes in the timing of births. We also test the robustness of our findings by controlling for different income distribution patterns. We find that economic development is likely to induce a fertility rebound, but is not sufficient to lift fertility on a significantly higher level in all OECD countries. By dividing GDP per capita in several components, we identify an increase in female employment as main correlate to the re-increase in fertility back to replacement level that recently took place in several OECD countries. The possibility to combine work with family formation thus emerges as a key parameter explaining variations in fertility trends.

Our interpretation of these results is the following: A qualitative change in the content of economic growth changes the nature of its influence on fertility rates. The change occurs because fertility and economic development are linked in a two-way relationship. On the one hand, changes in the population composition, which are caused by fertility variations, affect the propensity of women to work. Furthermore, the population composition affects a country's level of investments in education as well as the propagation of innovation and technologies, which shape productivity. By this means, fertility affects the long-term path of economic growth. On the other hand, economic growth affects fertility. However, if economic growth increases or decreases fertility depends on a country's development stage. Consequently, the impact of economic development on fertility can change its sign along the process of economic development. We show that in economically advanced countries, the impact of economic development on fertility has changed from negative to positive. Furthermore, we find that female employment, which is a key dimension of GDP, is a driving factor for this change, as the re-increase in fertility goes hand in hand with the development of female employment. Our finding suggests that the change in the impact of economic development on fertility reflects new patterns of fertility behaviour, in which childbearing comes along with female labour market participation.

The outline of the paper is as follows: Section II presents an overview of the existing theoretical literature on the two-sided interactions between economic development and fertility. The following empirical sections focus on the impact of economic development on fertility. In section III, we present the hitherto existing empirical findings of the impact of macroeconomic outcomes on fertility. Section IV discusses our data. Section V presents our empirical strategy and the estimation results. Finally, section VI concludes by summarising the main findings and by identifying axes of future research.

2. Economic development and fertility: the chicken or the egg?

Macroeconomic outcomes and fertility variations are highly interconnected. A general theoretical setup throwing light to this interconnection is given by Barro and Becker (1989), who, among others, put forward the co-determination of fertility and economic growth paths. Further theoretical developments have clearly extended the idea of a two-way relationship between fertility behaviour and economic advancement. However, the arguments concerning the impact of economic advancement on fertility that can be found in the literature are ambiguous. At the same time, there are numerous channels through which fertility inversely impacts economic outcomes, and theory also shows ambiguous results for this direction of effect.

The two-way relationship between population growth and economic development makes it difficult to designate a clear impact of one variable to the other. To keep track of the possible effects of economic outcomes on population growth, it is necessary to consider also the inverse effects of economic development on population growth. This applies to the empirical investigation not less than to the theoretical analysis, which is why, before presenting the theoretical literature on the impact of economic development on fertility, we first present some main arguments how fertility impacts economic outcomes.

a) *The impact of fertility on economic outcomes*

Neoclassical growth models suggest a negative impact of fertility on economic outcomes, while newer endogenous growth models rather speak in favour of a positive impact. Based on the Malthusian "population trap" argument, according to which fertility increases lead to poverty and pauperisation due to the finiteness of natural resources, Solow's (1956) "exogenous" growth model of predicts that population growth leads to a "dilution" of physical capital, under the assumption that supply of capital is fixed and returns of labour are diminishing. Intergenerational models assume that a reduction in family size increases private savings and enables households to invest more in each of their children, which makes the labour force more productive and thus enhances growth (Galor and Weil, 1996, 1999, 2000; de la Croix and Doepke, 2003; Doepke, 2004; Galor, 2005). In addition, reduced fertility enables women to participate in the labour force, which is beneficial for a country's labour force and increases investments in children and thus is positive for economic growth (Klasen, 1999; Knowles *et al*., 2002; Klasen and Lamanna, 2009; Bloom *et al*., 2009). Another stream of arguments relates to the "demographic dividend" by emphasizing that declining fertility rates imply decreasing youth dependency rates and thus a relative increase in the share of working age people in a population, which in turn increases output per capita and therewith per capita income (Bloom *et al.,* 2003; Bloom *et al*., 2010).

However, in the middle and long run, decreasing young cohorts lead to a reduction of the working age population and therewith to a reduction of a country's labour force as well as to an increase in old age dependency rates. Consequently, the long-term impact of a decrease in fertility on economic growth may be rather negative fertility (Lindh and Malmberg, 1996; Beaudry and Green, 2000; Prskawetz and Lindh, 2006). In the same line, main parts of the *endogenous growth* theory speak in favour of a positive impact of fertility on economic development. By defining human capital, innovations and technical advancement as a key element of economic growth, endogenous growth models emphasise the importance of population growth, as population growth increases number of workers available to the economy and therefore its "talent pool". Moreover, population density boosts innovations, technology transfer and knowledge exchange which stimulate productivity and thus income growth. (Arrow, 1962; Boserup, 1965, 1970; Phelps, 1966; Lucas, 1988; Simon, 1981, 1986). Following this logic, an ageing population risks decreasing labour productivity and growth by slowing down the motor for technical innovations, which are driven mainly by younger generations[1]. Furthermore, high old-age dependency ratios increase health and pension expenditures at the expense of investments in education, research and development (Blanchet, 2002).

b) The impact of economic development on fertility

In developed countries, the impact of economic development on fertility is ambiguous. The relation between the two variables can be divided in three different periods since World War II. The first period is clearly marked by a co-increase in income levels and fertility rates, reflecting pro-cyclical variations of fertility. Then, fertility rates have been shifting downward since the late 1960s or early 1970s onwards, while average income levels, as measured by GDP per capita, continued to increase (disregarding short-term fluctuations). Early observers, such as Butz and Ward (1980), have argued an emergence of contra-cyclical

[1] The empirical evidence of a declining productivity with an ageing population is limited, however. Some studies even point to a quite opposite conclusion, showing that older, more experienced workforces can increase productivity (Malmberg et al., 2008; Prskawetz et al., 2008).

fertility going hand in hand with an increase in female employment. This does not accommodate, however, with the recent reversal of fertility rates, which first has been observed in a very limited number of countries until the early 2000s, but since covers a growing number of countries. Some scholars have advocated that this fertility “rebound” reflects a transition towards new patterns of family formation in which childbirths are highly postponed compared to some decades ago. According to this argument, the upswing of fertility rates illustrates the end of the transition period during which childbirth has been postponed, whereas the total numbers of children a women has on average has not decreased (Goldstein *et al*., 2009).

The new patterns of fertility are marked by an end of postponement of childbirth, by new economic and social dimensions and by modern attitudes and norms towards the family, female education and gender roles. The contribution of economic development to this process is still unclear, however. The variations in fertility outcomes over the last three or four decades raise two main questions about their connections with economic development, beyond short term fluctuations: To which extent are fertility variations connected with the trends in economic development? Which specific dimensions of economic outcomes are responsible for the recent upswing of fertility rates?

The impact of economic growth on fertility is ambiguous in theory, as an increase in income per capita can either bring an increase in the demand of children because the explicit costs are more easily borne (“income effect”) or a decrease in the demand of children. When explaining the negative impact of income on fertility, main arguments are brought in by the so-called “new home economic theory”. Becker (1960, 1981), interprets fertility reduction as a rational behaviour of individuals by explaining that the impact of an increase in individual income on fertility is subject to a *quality-quantity* trade-off. An household income increase raises not only the indirect but also the direct costs of children, because in modern societies parents set more focus on children’s “quality” to rise the chances of their children, which induces a substitution effect against the number of children in favour of the “quality” per child (education) and the living standard of the household (Becker and Lewis, 1973; Willis, 1973; Cigno, 1991). Another argument in favor of a negative impact of economic development stresses the rise in the “opportunity costs” of children derived from the increase in women’s educational achievement and participation in the labor market. Given the increase of the earning potential associated with higher educational attainment, women are encouraged to invest more time in labor market participation than in caring for children. A consequence is that women most probably substitute work against children. The development of women’s employment then comes as one of the most prominent factors explaining fertility decrease over the recent decades (Mincer, 1963; Becker, 1965; Willis, 1973). Substitution may dominate over the income effect when household income is limited and highly dependent on women’s earnings, with a decrease in fertility as a consequence. The domination of a substitution effect is even higher when the induced increase in household income is invested in the “quality” of children rather than in their “quantity” which is likely to appear when households’ income increases (Willis, 1973; Cigno, 1991). The two arguments – the focus on child quality and an increase in the opportunity cost combined, are economic factors which strongly contributed to the sharp decrease in fertility rates observed since the early 1970s when income was constantly increasing (Hotz *et al*., 1997).

In addition, the increase in women’s education has been found to impact the timing of births but not necessarily the probability to have children. Blossfeld (1995) finds that the postponement of the first childbirth is largely (if not entirely) explained by the longer enrolment of women in the educational system, but does not always reduce the “demand” of the total number of children. Consequently, increased education and employment for women leads to a postponement of childbirth (tempo effect), but does not necessarily affect the total number of children a woman has (quantum effect) (Rindfuss *et al*., 1980; Lesthaeghe, 2001; Bongaarts, 2002). This implies that, once the process of postponement of childbirth has come to an end, total fertility rates are likely to re-increase (Goldstein, Sobotka and Jasilioniene, 2009).

However, the impact of economic development on fertility may alter over time, for two main series of arguments. First, the focus on child quality may dominate the "quantity" effect of income on fertility only up to a certain threshold of wealth, from which household can afford having additional children without any erosion in their living standard – if the lack of income was an obstacle to the completion of desired fertility. A dominating income effect may so be expected if economic development proves to increase the disposable income of households. The relative importance of this income effect is likely to be higher after a certain stage of development is attained, when family size is relatively low or when the number of hours supplied by women for paid work is already quite large (Hotz *et al*., 1997). However, positive long-term trends in economic growth do not necessarily preclude a rise of unemployment, which is known to impact negatively on fertility rates (Adsera, 2004; Sobotka *et al*., 2010).

Second, macro-level contexts shape how economic development impacts fertility behaviour (Leastheghe and Surkin, 1988; Philipov *et al*., 2009). Since they change over time, the incidence of economic development of fertility trends may also vary. Changes in norms regarding the transition to adulthood, partnership formation and parenthood, which accompany economic development, also shape the incidence this latter may have on childbearing decisions (Laesthege, 2010; Liefbroer and Merz, 2010). In some Western countries, these changes are characterised by an increasing tolerance for extramarital childbearing and for the career development of both sexes. This increasing tolerance may contribute to the fact that in some countries, women feel more encouraged to work and have children at the same time than in other countries. By providing more flexibility to childbearing decisions, increasing child care opportunities and modern norms are likely to increase the probability that economic growth has a positive impact on fertility. In contrast, the positive impact may be refrained in countries with insufficient child care services and rigid gender norms. Changing attitudes towards sexuality and the diffusion of contraception has been a key component this "postponement" process as it gives couples larger opportunities to control not only the number of children, but also the timing of births. In all, these changes reflect to some extent the fact that societies have progressively moved towards norms of family size which are less binding that those applying several decades ago. Clearly these norms do not affect directly the cost of children, but they impact the importance this cost may have on childbearing decision.

The development of female employment is also crucial in this process, since it impacts the direct and the opportunity costs of raising children. The diffusion of female employment is, furthermore, critically dependent on the process of economic development. Different phases have been broadly outlined in the literature which suggests a convex relationship between growth and female employment rates (Goldin, 1995; Mammen and Paxson, 2000; Luci, 2009). A first period of decreasing women's labour market participation can be first associated to economic development if growth is primarily driven by improvements in men's opportunities without corresponding improvements in women's career potential. Boserup (1970) argued that such a process is very likely in the early stages of industrialization and urbanization which involve a growing demand for labour mobility that weakens family networks and therefore reduces the opportunities to combine work and family. In this context, women either restrain their participation in the labour market or limit their number of children. A second period is expected to emerge, however, when development generates more opportunities for women to participate in the labour force. Policies accompanying economic development to facilitate the combination between work and family may also accelerate this process. The conflict between female employment and family formation may also be reduced in that case if sufficient support is provided to working parents. Changes in norms towards childcare and work are also expected to deeply alter the conflict between female employment and childbearing. On the one hand, childbirths can be postponed up to a period of life at which they are less damaging career opportunities of women. The diffusion of contraceptives, and the changes in the norms of childbearing age are also clearly parameters that allow household to more freely decide about the timing of births. On the other hand, changing attitudes towards female employment and the care of young children facilitate also the adaptation of childbearing behaviours. These variations of contexts, which goes along with economic development, are so very likely to increase women's the opportunities to combine work and childbearing. Simultaneous increases in female labour market participation and fertility rates can be expected in this case.

Following these arguments listed above, the influence of economic growth on fertility is likely to change over time, as long as the process of growth self-develops. In a context of low average income and high fertility, it is very likely that an increase in average income may, in a first period, impact negatively fertility when economic growth takes place in a context low average income colliding with a high value in children' human capital and the development of female employment. Economic growth induces higher productivity and so higher wages, which may first encourage households to invest more time into work and to postpone childbearing. This may however occur up to the limit from which households may use their additional resources to realize their fertility plans rather than further increasing their labour supply. A second time may appear, however, as national income continues to grow. In that stage, higher income may nonetheless help households to have children when they want, but the adaptation of norms and of institutional context that accompany economic development and the increase in female labour market participation may also facilitate the realisation of fertility plans. Childbearing may be relatively postponed in this period compared to the first one.This non-monotonic influence of economic growth may be captured by a rebound in fertility rates coming after a decrease. Said differently, the impact of an increase in GDP per capita on fertility rates may vary with the countries' development stages. One issue then is to investigate whether a change from negative to positive in the influence of economic wealth on fertility trends can be identified in order to explain the recent fertility re-increase.

A clear empirical strategy can be derived from these developments. First, we aim at empirically testing the anticipated inverse J-shaped impact of economic development, as captured by General Domestic Product per capita, on fertility. A clear distinction between within-country variation and between country differences is required to figure out how exactly the relation between the two variables evolves over time. Then, a second step consists in opening the "GDP black box" to assess which components of economic development are most related to fertility trends. Are fertility trends primarily driven by the evolution of income generated by work, the time constraints derived form working hours or the growing diffusion of female employment? Moreover, our attempt is to capture which of the GDP components have been responsible for the increase in fertility rates observed over the very recent years in many OECD countries. Changes in labour productivity, employment rates and working hours patterns as well as their gender distribution will be scrutinized to identify the main "drivers" of the fertility rebound.

3. Previous empirical findings on the impact of economic development on fertility

The existence of divergent relations between economic growth and fertility rates are also assessed on the empirical side. Butz and Ward (1979) observe that in the US fertility rates were pro-cyclical until the 1960s, but started to decline in a period of persistent economic growth from the 1960s on until the late 1970s, implying an inverse J-shaped pattern of fertility along the process of economic development. In the same line, An and Seung-Hoon (2006) find an inverted J-shaped relationship between demographic and economic growth in 25 OECD countries for the years 1960 to 2000.

The study by Butz and Ward (1979) has been challenged, however, for several reasons. While some studies like for example by Mocan (1990) still provide figures of persistent counter-cyclical fertility patterns, other studies raise objections to the empirical strategy pursued by Butz and Ward (1979) and propose different estimates that do not confirm the negative impact of real wages and income on fertility rates at higher levels of income (McDonald, 1983; Krämer and Neusser, 1984; Macunovich, 1995). Moreover, Butz and Ward's (1979) prediction of a continuous fertility decline that goes hand in hand with further economic advancement accommodates only with a limited number of countries. In many highly developed countries, a reversal of fertility trends has been occurring during the recent decade and a rebound of fertility rates back to replacement levels can be observed simultaneously with continuous economic growth and with a continuous increase in women's labour market participation. In many European countries, the negative relationship between fertility and economic advancement has weakened within the last decade even if fertility decisions still conflict with female labour supply and an expansion of family-friendly policies would be necessary to further enhance fertility and women's labour supply (Ahn and Mira, 2002; Kögel, 2004; D'Addio and Mira d'Ercole, 2005).

Most recently, Myrskylä, Kohler and Billari (2009) argue that a fundamental change has occurred during the last quarter of the last century in the relationships between fertility and human development. Based on both cross-sectional and longitudinal data covering more than 100 countries and the years 1975 to 2005, Myrskylä *et al*. (2009) estimate the impact of human development (measured by the United Nation's Human Development Index: HDI) on total fertility rates. They use a graphical analysis to identify the potential level of HDI that turns the correlation between human development and fertility from negative to positive (HDI=0,85-0,9). For the year 1975, they find a strictly negative correlation between HDI and fertility for all countries. Yet, for the year 2005, they find a negative correlation between HDI and total fertility rates only for countries with a HDI level below that minimum. For countries with a HDI level above that minimum, Myrskylä *et al*. (2009) find that the two variables are positively correlated. This suggests that in highly developed countries like the USA, Norway and Ireland, human development implies a rebound of fertility, whereas at low and medium development levels, human development continues to decrease fertility.

However, Myrskylä *et al*. (2009) do not provide an estimation of the turning point, but only a graphical analysis that suggest where the minimum is located. Based on cross sectional data, Furuoka (2009) applies an empirical test for the threshold effect of HDI on fertility. The test constructs asymptotic confidence intervals for the threshold parameter. Like Myrskylä *et al*. (2009), Furuoka (2009) splits the sample in two regimes in order to test linear correlations. Furuoka (2009) contests the study by Myrskylä *et al*. (2009) by finding that in countries with a high human development index, higher levels of HDI still tend to be, even though only weakly, associated with lower fertility rates.

Furuoka (2009) provides technical advancement by empirically testing the minimum level of HDI. However, as both Furuoka (2009) and Myrskylä *et al*. (2009) propose an empirical procedure in two steps, none of the studies offers a "one step" estimation model that avoids dividing the data set in two subsamples. Moreover, both studies use a composite measure of human development, containing GDP per capita, life expectancy and school enrolment. The combination of the three components makes it difficult to interpret the estimated coefficients for two reasons. Firstly, due to limited HDI-data availability, in both studies the analysis of the fertility rebound is focused on cross-country variations only. Secondly, it is unclear which of the HDI components initiates the fertility rebound. In addition, as life expectancy and school enrolment are correlated with GDP per capita, interpretation problems arise because of multi-collinearity.

4. Data discussion

In order to identify the driving factors of the fertility rebound, we consider it appropriate to focus the analysis on OECD countries only, as the rebound is mainly observable in highly developed countries. A closer look at the single HDI components for OECD countries shows that for this limited group of countries, the variation is the biggest for GDP per capita in comparison to those of life expectancy and school enrolment. This suggests that in OECD countries, changes of GDP per capita are more important for fertility variations than changes in life expectancy and school enrolment. We therefore suggest that in OECD countries, GDP per capita is the driving factor behind the fertility rebound. To test our hypothesis, we propose an empirical analysis that isolates the impact of GDP per capita on fertility rates in OECD countries. We use a large macroeconomic panel data set that includes observations of all 30 OECD countries and over four decades (1960-2007).

The table in appendix 1 provides an overview of all data used in this study including the control variables and the decomposition variables.

4.1. Trends in total fertility rates in OECD countries

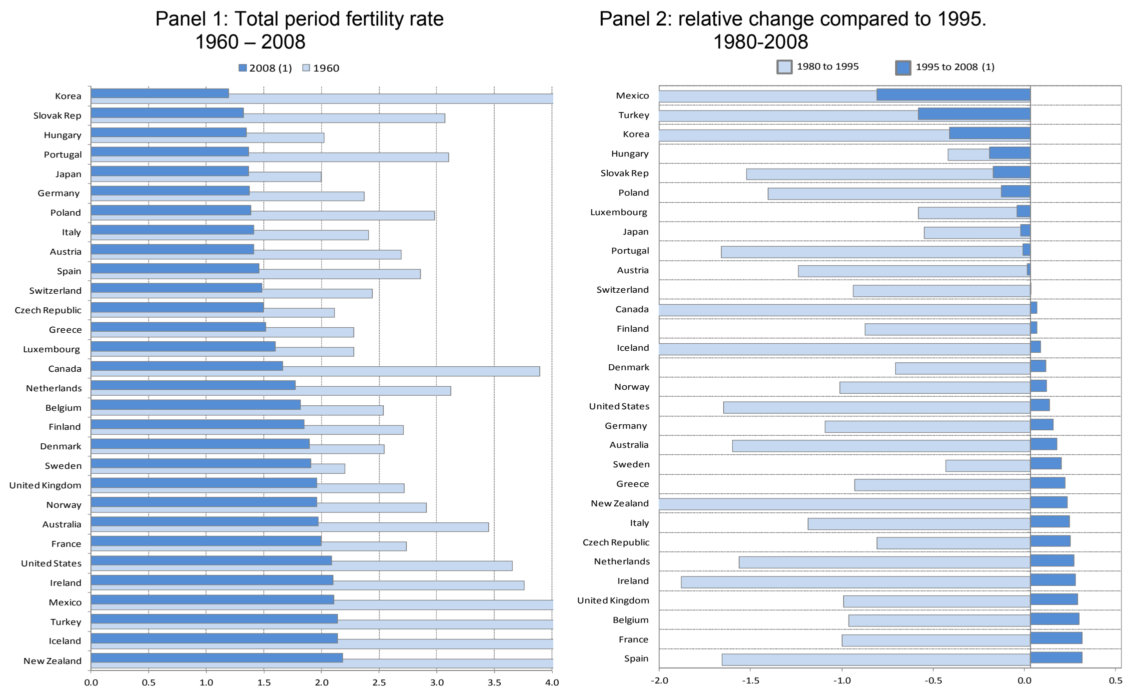
The total fertility rate (*TFR*) of a year and a country are undoubtedly the most popular indicator used to compare fertility trends between countries. This period rate corresponds to the ratio between the number of births in a given year and the average number of women of reproductive age (generally considered from age 15 to 49) and therewith represents the average number of children that would be born to a woman over her lifetime if she were to experience the exact current age-specific fertility rates through her lifetime, and if she were to survive from birth through the end of her reproductive life[2].

The *TFR* gives an accurate estimation of completed fertility level only if there is no change in the timing of births across cohorts. In the opposite case, such as when there is for example an increase in the mean age of mothers at childbirth, the number of births in a given period is reduced. Consequently, the postponement of birth at older ages reduces total fertility rates. Hence, the *TFR* is sensitive to changes in the timing of childbirth. However, if the total number of children born by women over their life course does not change, total fertility rates re-increase when postponement comes to an end at a certain age of mothers.

The dominant feature regarding fertility trends is the sharp decline of total fertility rates (*TFR*) in OECD countries over the last four decades. Looking backwards to the early 1970s, the fall appears substantial with an average *TFR* that fell from 3.23 in 1970 children per woman to 1.71 in 2008, e.g. a level well below the 2.1 threshold required to replace the population without any contribution of immigration (Figure 1 Panel 1). In 2008, only few countries have a fertility rate around or above the so-called replacement rate level (United States, Ireland, New Zealand, Iceland, and Mexico and Turkey).

[2] Total fertility rates are preferred to crude birth rates, which is the ratio between the number of births in a given year and the number of persons of a population of the same year, because this measure is influenced by the age structure of a population. The total fertility rate relates births to the age-sex group at risk of giving births (women aged 15-49 years) and therefore is a more refined measure to compare fertility across populations.

Figure 1: Fertility trends in OECD countries



Source: OECD Family database
Year 2007 for Canada, Czech Republic, Estonia and Slovenia.

The intensity of fertility decline varies across countries, however. It has been comparatively limited in countries where fertility rates still currently score above 1.8, namely in Scandinavian and English-speaking countries (except Canada) and in few Continental Europe countries (Belgium and France). Fertility rate is above the replacement level in only two of this set of countries in 2008: Iceland and Ireland. Yet fertility is also slightly above the population replacement rate in Mexico and Turkey where the decrease has been extremely steep since the early 1980s, but from a much higher initial level (*TFR* respectively around 7 and 6 in the 1960s).

A sharp decline in fertility is also observed in Korea and Japan, and in many European countries where fertility rates are currently far below 1.5 children per woman. Korea exhibits the lowest rate at around 1.2. Other “lowest-low” fertility countries, e.g. with *TFR* bellow or around 1.3 on average since 2000, include Austria, the Czech Republic, Germany, Greece, Hungary, Poland, Portugal, the Slovak Republic, Spain and Switzerland. In 2008, the lowest low-fertility countries (*TFR* below 1.4) are Poland, Germany, Japan, Portugal, Hungary, Slovak Republic and especially Korea. The very low level of fertility in these countries is of high political concern since the population will shrink rapidly if the fertility is maintained at such a level.

Despite this overall decline in fertility, many countries have recently experienced a reversal of trends, with a re-increase in fertility rates (Figure 1 Panel 2). The “rebound” has been especially high (above 0,3 children per women when TFR in 2008 is compared to the minimum achieved since 1970) in Denmark, Sweden, Czech Republic, the US, Finland, France, United Kingdom, Belgium, the Netherlands, Spain, Norway and New Zealand. The timing and pace of this change varies from country to others. Only few countries have experienced such a reversal in trends since the mid 1990s (Belgium, France, Ireland, Italy, Netherlands, Spain and the US), while a significant increase (by above 0.2 children per woman) occurred since 2000 in Sweden, Czech Republic, the UK, Greece, Spain, New

Zealand and Ireland). Nevertheless, most of OECD countries have acknowledge such an increase since 2000, though often very slight, the only exception being Germany, Korea, Mexico, Portugal, Switzerland, Turkey. Fertility rates continue to decline in this latter set of countries, but the pace of decreased slowed down. Though there is no guarantee that these trends will persist in the long-run or that they reflect more than a change in the timing of childbirths.

Alternative measurements of fertility aiming at adjusting *TFR* to filter out the impact of the changes in the timing of birth will also be used in the following analysis. While there is truly no optimal measure to capture postponement, the Bongaarts-Freeney tempo-adjusted fertility rates (*adjTFR*) have become the most common indicator (Boongaarts and Feeney, 1988; Sobotka, 2004). By weighting *TFR* by changes in women's mean age at childbirth, this adjusted measurement focuses on the quantum-component of fertility changes. Though, *adjTFR* only corresponds to a pure quantum measure of fertility under the assumption of uniform postponement of all stages, i.e. an absence of cohort effects (Kohler and Philipov, 2001). Consequently, *adjTFR* implies only an imperfect control for tempo effects. Moreover, tempo-adjusted fertility rates are only available for a subset of OECD countries. We therefore start our empirical estimations based on total fertility rates as endogenous variable and introduce *adjTFR* only in a second step.

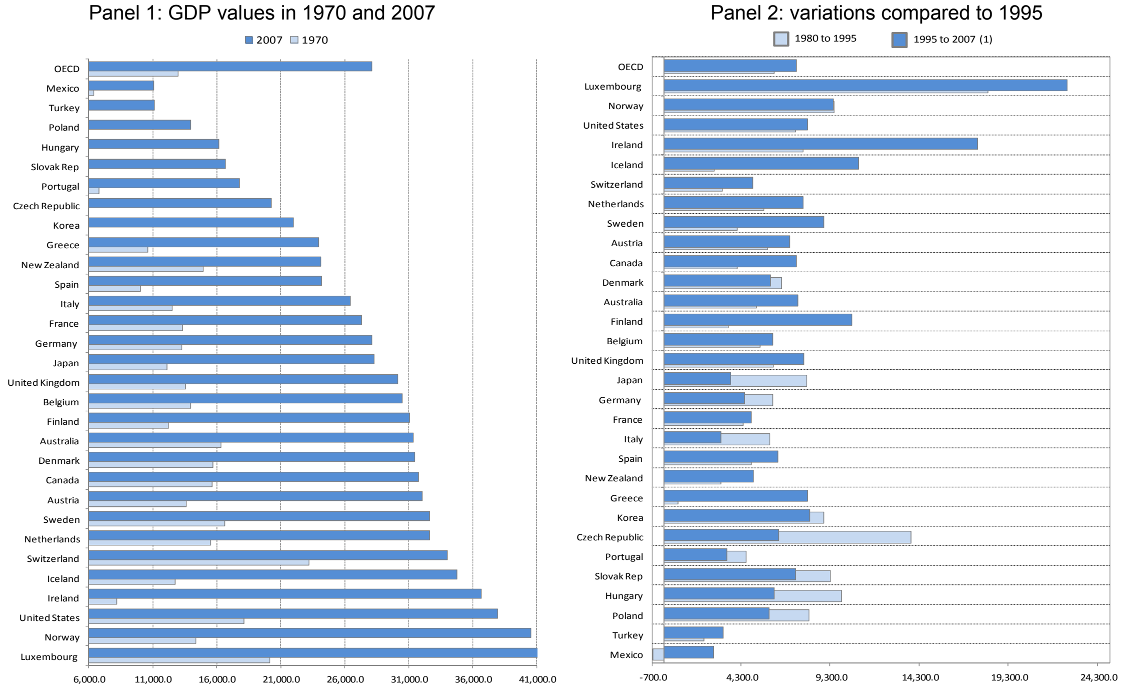
4.2. Trends in GDP per capita in OECD countries

GDP per capita is measured in purchasing power parities (PPP) and in constant 2005 US $. On average in all 30 OECD countries, GDP per capita measured in PPP increased from 11 915 US $ in 1970 to 28 134 US $ in 2007. Constant-price measures of GDP are considered here in order to filter out the increase in GDP per capita that is due to price inflation without relating to any increase in consumption basket.

In all countries, the increase is rather continuous with common breaks around 1975, 1980, 1990 and 2000 due to several economic shocks that touched all countries at the same range of time.

The highest GDP per capita level can be observed in Luxembourg for the year 2007 (65 001,25 US $ PPP; Figure 2). Luxembourg's GDP per capita level significantly overtops the GDP levels of the other observed countries since the early 1990s. Countries with high GDP levels somewhat closer to the average level are Norway, the United States and Sweden, with highest levels in the years 2000. The lowest levels of GDP per capita can be observed in Korea, Turkey and Mexico in the 1970s, followed with some distance by Poland in the 1990s and Portugal in the 1970s.

Figure 2: Trends in GDP per capita in OECD countries
US$, PPP constant prices (2005 as reference)



Source: OECD Data Base (2009)

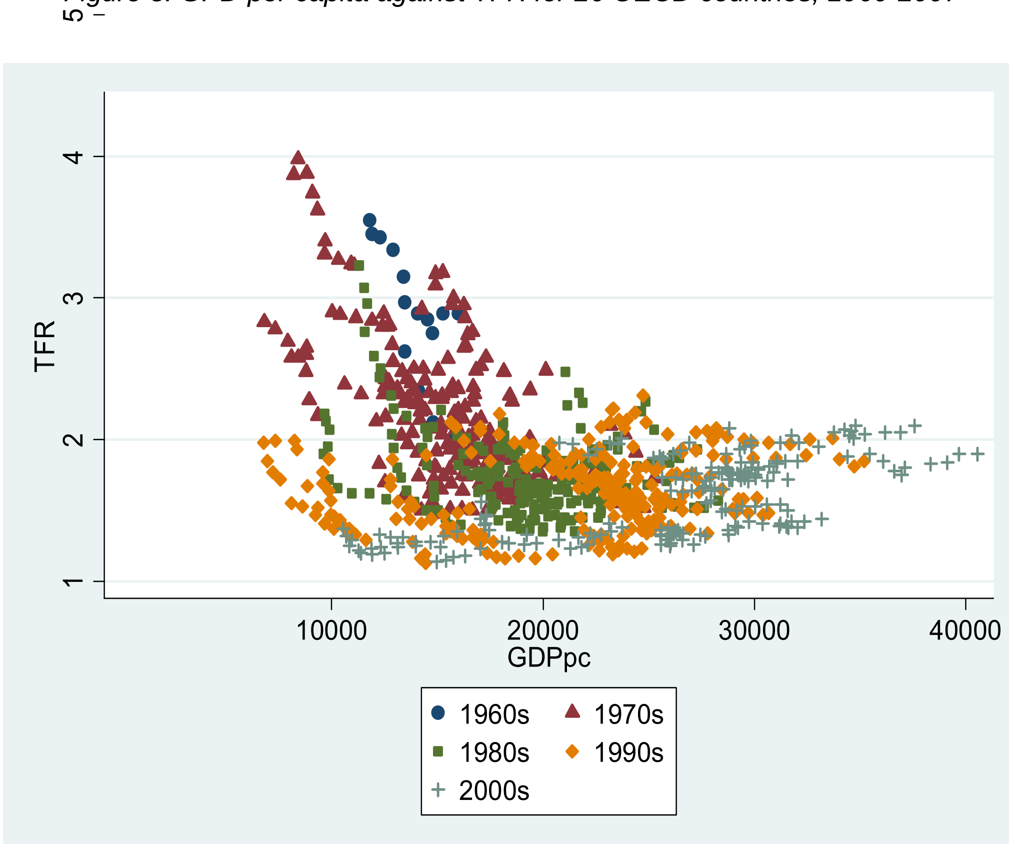
The descriptive analysis suggests that whereas until the late 1980s in all observed countries economic advancement went hand in hand with fertility decline, since the early 1990s the picture is threefold: generally speaking, countries with the lowest income levels record continuous declining fertility rates. Countries with medium income levels record stagnant fertility levels below replacement levels and countries with the highest income levels record a fertility rebound. This observation supports the hypothesis of an inverse J-shaped pattern of fertility along the process of economic development and suggests a convex impact of economic advancement on fertility.

In order to see whether the inverse J-shaped pattern can be observed graphically, we plot the observations of GDP per capita against those of total fertility (figure 3). For this data plot, we drop out some countries that risk over-accentuating the inverse J-shaped pattern. This concerns Luxembourg, which has an outstanding high level of GDP per capita among OECD countries, especially in the 2000s. This also concerns Korea, Mexico and Turkey, as these emerging countries have outstanding low levels of GDP per capita and high levels of fertility, especially in the 1960s and 1970s. However, parts of our regression analysis are based on the whole data set including emerging countries and early time periods from the 1960 on. This relatively heterogenous data allows us to capture not only effects of GDP per capita on fertility which are due to changes in the individual income (income effect, substitution effect), but also to capture development effects (reduction of fertility from very high levels of fertility on due to structural change).

Even without these countries, the data plot suggests a rather inverse J-shaped pattern of fertility along the economic development path, indicating that at low income levels, economic growth lowers fertility whereas form a certain higher level of income on, income growth increases fertility. The data plot also suggests that the negative relationship between fertility and economic development is rather dominated by observations of the 1960s, 1970s and

1980s, whereas the positive relationship is clearly dominated by observations from the 2000s.

Figure 3: GPD per capita against TFR for 26 OECD countries, 1960-2007



Source: OECD Data Base (2009)

5. Empirical analysis

Our empirical procedure aims at verifying whether in OECD countries, there is a reversal of the correlation between total fertility rates and economic advancement from a certain income level on. We address several challenges when testing an inverse J-shaped pattern between economic development and fertility. One challenge is to properly estimate the minimum level of GDP per capita and fertility by a “one step” estimation model. This procedure avoids a division of the data set and that allows at the same time an empirical estimation of the turning point in the relationship between economic development and fertility. Another challenge is to adequately control for a series of methodological problems. In comparison to hitherto existing empirical studies, we use a macroeconomic panel data set that includes a large time dimension. As the variables vary over the two dimensions of country and time, estimators are more accurate to distinguish variations between countries and over time. In addition, the time dimension of the data enables us to control for unobserved country-specific effects and to deal at best with endogeneity caused by an inverse causality between economic development and fertility. Furthermore, we distinguish between within- and between-country variations and apply various robustness controls.

Moreover, we control for birth postponement by using tempo-adjusted fertility rates besides total fertility rates as endogenous variable and by using two different measures of women’s age at childbirth as control variables. In additon, we test the robustness of our finding by controlling for different income distribution patterns as well as for education and female employment. To open up the “GDP black box”, we finally decompose GDP per capita in several variables and estimate their impacts on fertility. In order to get a deeper insight in the economic mechanisms that drive fertility, we finally decompose the GDP per capita in a number of more specific components, which are labour productivity, working hours and employment, and estimate their impact on fertility. Gender-specific variables are taken into account when available.

5.1. Econometric strategy

Based on pooled OLS, we first test a linear against an exponential and a quadratic model in order to verify whether the impact of GDP per capita on fertility is linear, convex or concave and whether there is a maximum or a minimum in the relationship. For the linear model, we use total fertility rates (*TFR*) as endogenous variable and the log of GDP per capita (*lnGDPpc*) as exogenous variable. The exponential model is tested by using the total fertility rates *(lnTFR)* as endogenous variable and GDP per capita (*GDPpc*) as exogenous variable. To test the quadratic model, we add the square of the log of GDP per capita *(lnGPDpc²)* as exogenous variable to the linear regression model in order to control for an inverse J-shaped pattern of fertility along the process of economic development.

Our estimation equation for this quadratic model is:

$$TFR_{i,t} = \beta_1 + \beta_2 * \ln GDPpc_{i,t} + \beta_3 * \ln(GDPpc_{i,t})^2 + \varepsilon_{i,t} \quad (1)$$

We use the natural logarithm of GDP per capita (*lnGDPpc*) which is standard in most macro-econometric works, as the logarithmic form reduces absolute increases in the levels of GDP per capita and therefore captures proportional rather than absolute differences in the distribution of GDP per capita levels.

As *lnGDPpc²* is a function of *lnGDPpc*, the coefficients β_2 and β_3 cannot be interpreted separately. To confirm a convex impact on economic development on fertility with a minimum point in the pattern of fertility along the process of economic development, β_3 must be significantly positive as an indicator of the curve’s convexity. Hence, a positive coefficient implies that there is a minimum in the data curve, meaning that an increase of *lnGDPpc* decreases the fertility for small levels of *lnGDPpc* and increases fertility from a higher level of *lnGDPpc* on.

After confirmation of the quadratic model against the linear and the exponential one, in a second step we test the robustness of the quadratic model. Therefore, we use more advanced estimation methods than pooled OLS, as the estimated OLS-coefficients risk being biased and inconsistent due to omitted exogenous variables, non-stationarity of the time series and endogeneity between the endogenous and the exogenous variables.

To control for possible endogeneity, we use an instrumental variables estimator (IV) that includes lagged variables of *lnGDPpc* as instruments for *lnGDPpc* and lagged variables of *lnGDPpc²* as instruments for *lnGDPpc².* Instead of simply using lagged exogenous variables directly in the estimation equation, we perform the IV-regression in two steps (Two Stage Least Squares Estimator, see appendix 2 for mathematical documentation). We use one-year lags as well as five-year lags. The use of lagged exogenous variables lessens the risk of obtaining biased and inconsistent estimators due to inverse causality between the endogenous and the exogenous variables. For example, it is not possible that *TFR* observed in 1984 impacts *lnGDPpc* in 1980. On the other hand, it is very likely that variations of fertility which lead back to changes in the economic environment appear time-lagged.

In order to account for unmeasured country-specific factors, we use a fixed effects estimation model (FE). The fixed effects model performs regression in deviations from country means. This implies an elimination of unobserved country-specific variables that are constant over time and that have an impact on fertility. One might for example think of the country's degree of national feeling that might be correlated with fertility levels as well as with a country's income level. The fixed effects estimator also captures norms and attitudes that do not necessarily change much over time but impact fertility, for example attitudes toward gender roles.

The transformation that produces observations in deviation from individual means also implies that the FE estimator focuses on within-country variation only, whereas the OLS and IV capture variations between countries and over time. To focus on between-country variation only, we also apply a between effects estimator (BE), which is based on time averages of each variable for each country. A comparison of the goodness of fit of the FE and the BE estimator tells us whether the estimated impact of economic advancement on fertility are due to within- or rather due to between-country variations.

We also compare the fixed effects model to a random effects (RE) model, which captures both within and between-country variation. The RE estimator subtracts a fraction of averages from each corresponding variable and therefore also controls for unobserved country heterogeneity. If the number of observations is large, the RE model is more efficient than the OLS and the FE model, but only under the assumption that the unobserved effects are uncorrelated with the error term. If this is the case, unobserved country specific variables that are constant over time are captured by an additional residual and the estimators are unbiased and asymptotically consistent. We use a Hausman (1978) test to chose between the FE and the RE model.

The models presented so far do not allow controlling for time specific effects and endogeneity. This is why we also use a first-differences estimator (FDE) in the next step. The differencing process eliminates unobserved variables that are constant over time and obtains stationary time series. The elimination of time trends is important as the estimation models are based on the hypothesis that the time series are stationary. Time series that are marked with a trend would lead to spurious regression and therewith to biased estimates. Graphical tests (correlogram, partial correlogram), an augmented Dickey Fuller (1979) and a Phillips Perron (1988) test for unit root in time series and a Levin, Lin and Chu (2002) test for unit root in panel data suggest the existence of an autocorrelation in some of the time series of *TFR* and *lnGDPpc* (graphs and tests not shown here). As the tests suggest that all series are difference stationary, the first-difference estimator is appropriate to control for non-stationarity.

The first difference of the natural logarithm of GDP per capita approximates the year to year relative changes of GDP per capita. Hence, the first-difference estimator estimates the impact of GDP per capita growth on fertility variations and therefore risks obtaining biased estimates due to an "underdevelopment" effect. High GDP per capita growth are likely to go hand in hand with low income levels (convergence mechanism) and therewith might be rather associated with fertility declines than with fertility increases. Thus, as the first difference estimator is not based on level variations, it does not allow clear statements about the role of economic development for the fertility rebound in highly developed countries.

Finally, we use a one step System Generalized Method of Moments estimator, which not only considers unobserved heterogeneity and non-stationarity, but at the same time also endogeneity (Box 1).

Box 1. Generalized Methods of Moments applied to the analysis of fertility trends

The GMM method goes back to Arellano and Bond (1991), who propose a difference GMM estimator that transforms the regressors by first differencing, which removes the fixed country-specific effect. Moreover, the use of lagged levels of the regressors as instruments for the first differenced-regressors controls for endogeneity. However, lagged levels of the regressors risk being poor instruments for the first differences equation. We therefore use an augmented version which implies an efficiency gain over the basic first difference GMM: a one step System GMM estimator that goes back to Arellano and Bover (1995) and Blundell and Bond (1998). The System GMM estimator combines a set of first-dirfferenced equations with equations in levels as a “system”, using different instruments for each estimated equation simultaneously. This implies the use of lagged levels of the exogenous variables as instruments for the difference equation and the use of lagged first differences of the exogenous variables as instruments for the levels equation. In addition, System GMM is a dynamic panel estimator which allows controlling for the dynamics of adjustment by including a lagged endogenous variable among the exogenous variables.

However, even though System GMM implies an efficiency gain difference GMM by using additional instruments, also the System GMM does not completely resolve the problem of weak instruments, as not only lagged levels risk being poor instruments for differences, but also differences are likely to be weak instruments for levels (Roodman, 2009; Stock and Yogo, 2002). Hence, even though the System GMM model proposes the most comprehensive control for a variety of econometric pitfalls, it does not offer a complete control for endogeity.

Moreover, the fact that the System GMM method uses more instruments than the difference GMM increases the risk that the estimation model is over-identified (Bowsher, 2002; Roodman, 2009). In order to reduce the number of instruments, we apply the System GMM estimator on edited data. We obtain quinquennial data by dividing the measured time period in five year-sections according to the following way: we use means of five years for the observations of the endogenous variable and observations of the beginning year of the respective mean for the exogenous variables for every country. This data transformation reduces the number of periods from over 40 to 10 and therefore implies a significant reduction in the number of instruments (from over 800 to around 100 depending on the number of exogenous variables). Moreover, the transformation of the data into quinquennial data allows us limiting time trends, because five year-intervals are less likely to be serially correlated than annual data. In addition, the transformed data allows intensifying the control for endogeneity: For example, if a country’s observation of *TFR* is the mean of the years 1980-1984, the corresponding observation of *lnGDPpc* is from 1980, which limits capturing impacts of fertility on GDP per capita.

However, the use of around 100 instruments still implies a significant risk of obtaining a severe overfitting bias (Bond, 2002) and reduces the power of the Sargan test to detect invalid instruments (Bowsher, 2002). In order to further reduce the number of instruments, we limit the number of lags of the instruments for the first difference and for the levels equation instead of using all available moment conditions. Moreover, we increase the length of the lag of the instruments. By doing so, we obtain a limited number of instruments that does not outnumber the degrees of freedom.

We report the number of instruments and the statistics of the Sargan test of over-identifying restrictions. The Sargan test tests the validity of the instruments and has a null hypothesis of “the instruments are exogenous as a group”. A p-value above 0.05 allows accepting this hypothesis. The Sargan difference statistics validate the extra moment restrictions imposed by the level equations in the System-GMM specification in comparison to the Difference-GMM specification.

5.2. Estimation results

a) The impact of GDP per capita on fertility

Table 1 shows the estimation results for testing a linear against an exponential and a quadratic model using pooled OLS.

Table1: Linear vs. exponential vs. quadratic model

	linear model	exponential model	quadratic model
Endogenous variable:	***TFR***	***lnTFR***	***TFR***
Type of regression:	Pooled OLS	Pooled OLS	Pooled OLS
Regressors:			
GDPpc		-0.0000166***	
		(-16.21)	
lnGDPpc	-1.013***		-15.63***
	(-24.24)		(-14.91)
lnGDPpc²			0.760***
			(13.95)
constant	11.87***	0.943***	81.92***
	(28.98)	(43.24)	(16.27)
N	1050	1050	1050
nb. of countries:	30	30	30
time period:	1960-2007	1960-2007	1960-2007
R^2:	0.359	0.200	0.460
R^2 adj.:	0.359	0.200	0.459

t statistics in parentheses, * p<0.05, ** p<0.01, *** p<0.001

When comparing the linear estimation model in the first column to the exponential model in the second column and to the quadratic model in the third column, we observe that the goodness of fit is the highest for the quadratic model. Even though the significantly negative coefficient of *lnGDPpc* in the first column suggest a dominating negative relationship between fertility and economic development, the results suggest that the impact of GDP per capita on fertility is not strictly negative and also not only exponential. In fact, the significant coefficient of *lnGDPpc²* indicates that the negative correlation between GDP per capita and fertility turns into a positive one from a certain level of economic development on, with a clear minimum point in the pattern between the two variables. In the case of an absence of that turning point, the coefficient of *lnGDPpc²* would have been insignificant. Consequently, we conclude that the quadratic model captures the variation between economic development and fertility better than the linear and the exponential one.

Table 2 compares the OLS regression results for the quadratic model to the IV, FE, BE, RE and FDE results, based on the full data set with observations of all 30 OECD countries and over four decades.

Table 2: Quadratic model, yearly observations

Endogenous variable:	total fertility rate (*TFR*)					
Type of regression:	Pooled OLS	IV (2SLS)	Fixed Effects	Between Effects	Random Effects	First Difference Estimator
Regressors:						
lnGDPpc	-15.63***	-12.36***	-16.94***	-19.14*	-16.89***	-13.75***
	(-14.91)	(-11.15)	(-20.87)	(-2.05)	(-20.86)	(-11.18)
lnGDPpc²	0.760***	0.608***	0.815***	0.960	0.813***	0.716***
	(13.95)	(10.47)	(19.45)	(1.98)	(19.45)	(11.10)
constant	81.92***	64.39***	89.54***	97.10*	89.14***	-0.0362***
	(16.27)	(12.19)	(22.76)	(2.18)	(22.72)	(-11.12)
N	1050	900	1050	1050	1050	1020
nb. of countries:	30	30	30	30	30	30
time period:	1960-2007	1960-2007	1960-2007	1960-2007	1960-2007	1960-2007
R^2:	0.460	0.35	0.542 (within)	0.327 (between)	0.4580 (overall)	0.110
R^2 adj.:	0.459	0.349	0.542	0.327		0.108
nb. of instruments:		1 (5 year-lags)				
nb. of estim. param.:	3	3	3	3	3	3
Hausman (p-value):					0.0371	
estim. minimum GDPpc $ (PPP):	29 200	26 000	32 600			
estim. minimum TFR:	1.56	1.57	1.51			

t statistics in parentheses, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

For all estimation methods except of the BE estimation, the coefficient of *lnGDPpc* is negative and the coefficient of *lnGDPpc²* is positive, which confirms a convex impact of economic development on fertility with a clear turn in the relationship between the two variables from negative to positive.

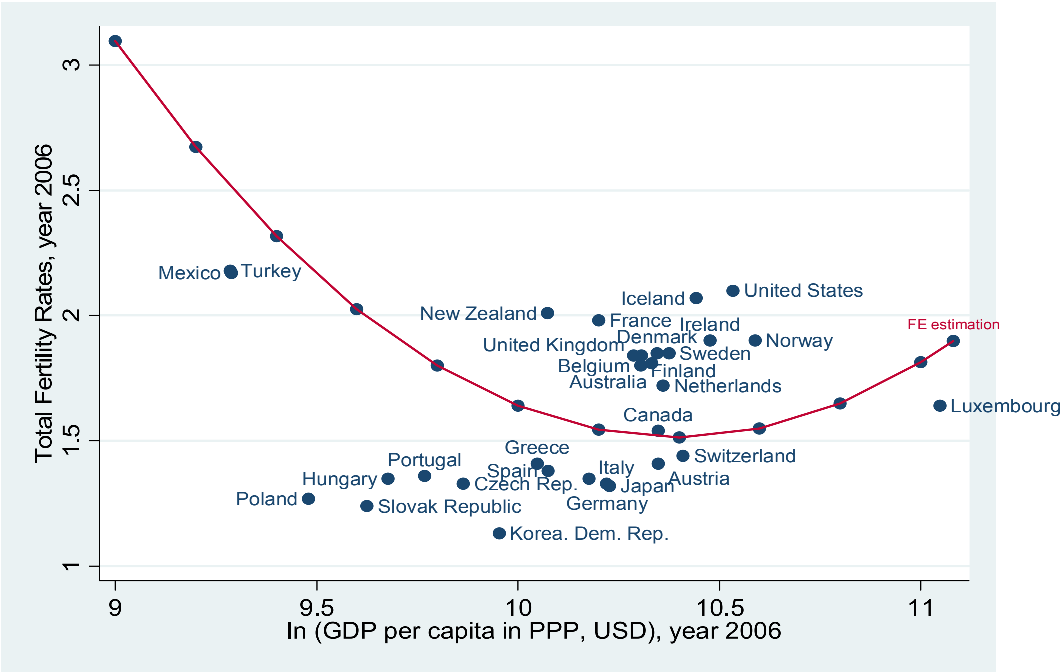
The IV-estimation results are based on five-year lags as instruments for the exogenous variables. The estimated coefficients based on one- to four-year lags do not differ much and thus are not presented in particular. The fact that the FE regression results are significant indicates that the hypothesis of a convex impact of *lnGDPpc* on *TFR* can be confirmed also for within-country variation only. This indicates that the convex impact exists not only due to cross-country variation, as suggested by Myrskylä *et al*. (2009) and Furuoka (2009), but also, and above all, due to fertility variations that appear within each of the observed countries.The goodness of fit of the within-variation is –with 54%- higher than the goodness of fit of the between-variation (33%) and the BE estimation results are hardly significant. Moreover, the goodness of fit of the within-variation is higher than the overall-variation of the OLS and RE model. The fact that the FE model is clearly superior to the BE specification indicates that the convex impact is actually dominated by within-country variation. In addition, a Hausman (1978) test comparing the fixed effects to the random effects model suggests that the difference of the estimation results of the fixed and the random effects models is systematic. This implies that the hypothesis, that the unobserved country effects are not correlated with the error term in the RE model, must be rejected. Hence, for our data the fixed effect specification is superior to a random effects specification in controlling for unobserved country-heterogeneity. The fixed effects model controls for country specific variables that do not change over time and therefore confirms that the convex impact of lnGDPpc on fertility is not driven by unobserved time-constant variables.

The last two rows of table 2 show the calculated minimum levels of GDP per capita and *TFR* based on the estimated coefficients[3]. As the FE model is proven to be the most appropriate one, fixed effect estimations are preferred to capture the critical value of GDP per capita that induces an increase in fertility. Appendix 3 shows the calculation of the minimum levels based on the estimated coefficients of the FE regression. The FE estimation results indicate that the minimum of the curve is located at an income level of 32 600 US$ (measured in PPP) and a fertility level of 1,51 children per woman. This suggests that economic development decreases fertility until a relatively high income level, but from 32 600 US$ (in PPP) on, economic growth is associated with a rebound of fertility[4].

To illustrate the pattern between *TFR* and *lnGDPpc*, we calculate the *TFR* for different income levels based on the FE regression results and present the results graphically. Figure 4 overlays our predicted path, as estimated by the FE specification, with the cross-sectional variations in countries position in 2006. We expect countries to be located close to the predicted line, in the absence of strong country-specific characteristics.

The red line in figure 4 confirms that the FE regression results imply a reversal of the relation between economic development and fertility at a fertility level of 1,51 and an income level of *lnGDPpc*=10.39, which corresponds to 32 600 US$ (in PPP). Furthermore, the line shows that the estimated pattern between *TFR* and *lnGDPpc* is actually inverse J-shaped, i.e. the declining branch on the left hand side is longer than the rising branch at the right hand side. Moreover, figure 4 compares the pattern between economic development and fertility predicted by the FE model with actual values of *TFR* and *lnGDPpc*, observed in 2006, for each of the 30 OECD countries.

Figure 4: FE estimation against actual values of TFR and lnGDPpc for 30 OECD countries (in 2006)



---

[3] As the FE estimation is superior to the BE and RE estimation, we do not calculate the minimum levels for the BE and RE estimation results. The minimum levels can also not be calculated for the FDE, as the fist-difference estimates are based on growth rates instead of levels.

[4] We test this estimated minimum by dividing our data set in two samples, one with GDP per capita levels above and the other one with GDP per capita levels below 32 600 US$ (in PPP). We find a significantly positive impact of *lnGDPpc* on *TFR* for the first and a significantly negative impact impact of *lnGDPpc* on *TFR* for the second sample (results not shown here).

Figure 4 shows that the fertility and income levels correpond quite well to the FE estimates for a couple of countries, which are Mexico, Turkey, Canada, Switzerland, Austria and Luxembourg. For Mexico and Turkey, our empirical analysis suggests that further economic growth decreases total fertility rates, whereas for Canada, Switzerland, Austria and Luxembourg, one can expect an increase in fertility coming along with a further increase in wealth.

Yet, figure 4 also sheds light on countries which significantly deviate from the expected path. Some of them like the Nordic and English-speaking countries, along with the Netherlands and Belgium, have much higher fertility levels as their income levels indicate. For some of them, especially, France and New Zealand, the TFR is much higher than its predicted value given their GDP per capita level which locate the below estimated threshold (10,39 for *lnGDPpc*) from which economic development plays as a booster of fertility. It is clear that in these countries, the fertility “rebound” took place at a time the process of economic development at which further decrease in fertility rates could be expected. By contrast, high fertility countries such as the US, Iceland, Ireland or Norway locate much clearly on the right hand-side of the predicted curve which unambiguously predict a positive influence of consumption growth on fertility.

Contrasting with this first group, the countries below the predicted line (Eastern and Southern Europe, along with Germany and Japan) have much lower fertility levels that the predicted values and the “minimum” set at 1.51. As in Japan and Germany income levels are only somewhat below 32 600 US$ (in PPP), especially for these two countries our regression results fail to explain why fertility levels stay at this low levels. Their actual level of fertility is all the more unexpected that GDP per capita is equal or higher than its value estimated for France or New Zealand.

Strikingly, the line dividing countries between the below and above the predicted fertility level meets the distinction between countries providing comparatively high to working parents with young children in the mid 2000s, as opposed to those characterised by a relatively limited assistance to families and rather low support to work and family reconciliation (c.f. Thévenon, 2010). Work and family reconciliation is achieved by different means, however, in Nordic and English-speaking countries. Publicly regulated support is relatively comprehensive in the first set of countries where generous entitlements to paid leave and early enrolment into childcare services combine together to support work and child raising in a quite continuous way. Alternatively, work and family reconciliation is facilitated by the development of part-time work combined to in-cash and in-kind support targeting primarily low income families and preschool children in the English-speaking contexts.

We now verify how our FE estimates correspond to the actual trends in fertility rates for selected OECD countries. Figure 5 compares the FE estimation results to real within-country variations in countries which are close to the estimated path: Austria, Canada and Belgium. However, in Belgium, the fertility rebound is more significant than suggested by the FE results. In Austria, like in Germany the impact of immediate further economic growth on fertility is quite inconclusive and the pattern as a whole is situated on a lower fertility level.

Figure 5: Estimated and actual trends in fertility rates
Austria, Canada and Belgium

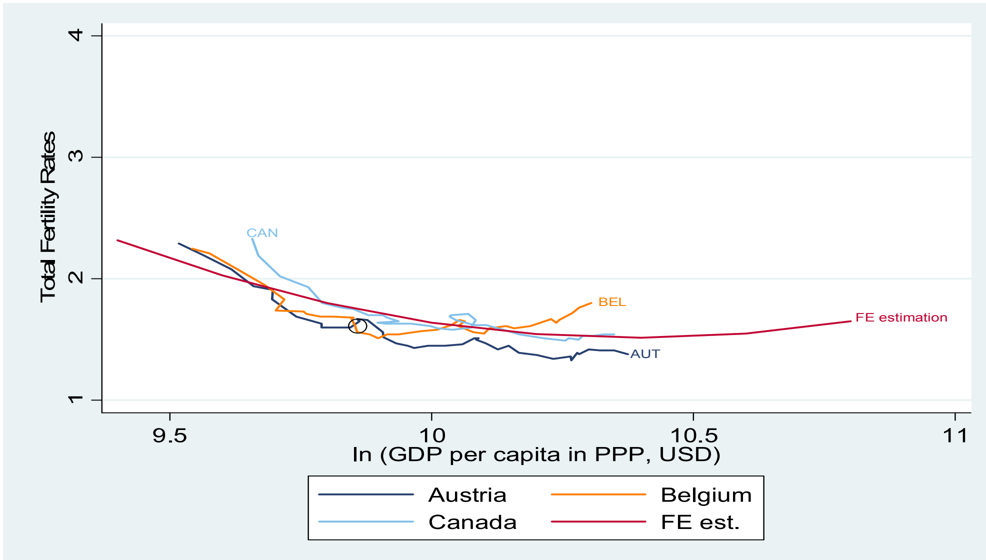
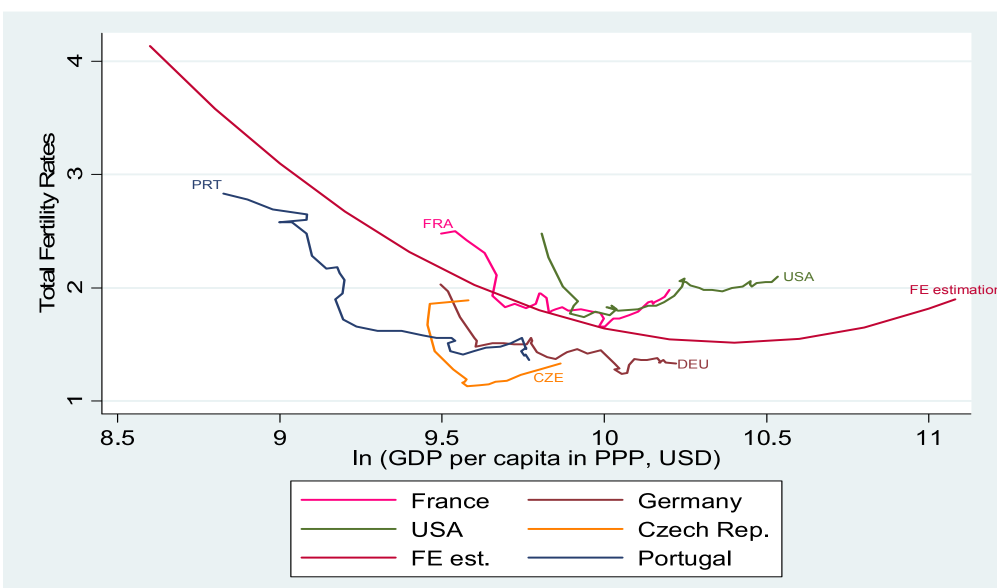


Figure 6 illustrates the cases of countries which mostly deviate from the expected path concerning the level of fertility. However, irrespective of periodical fluctuations, the pattern between fertility and income is rather J-shaped in all these countries, which confirms that economic growth decreases fertility up to a certain, relatively high level of income, and then increases it. The fertiliy rebound coming hand in hand with a certain level of economic development is particularly observable in France, the United States and the Czech Republic, whereas in Germany and Portugal, the impact of immediate further economic growth on fertility is quite inconclusive.

Figure 6: Estimated and actual trends in fertility rates
France, Germany, Portugal, the Czech Republic and the USA



As the FE model focuses on within country variation, it is not surprising that the curve based on the FE results corresponds more to variations within countries (figure 5 and 6) than to variations between countries (figure 4)[5]. However, figure 5 and 6 bring forth a common conclusion: in Eastern and Southern European countries and Germany, economic development goes hand in hand with a lower level of fertility than suggested by our empirical results, whereas in countries like France, for example, the regression analysis suggest a lower level of fertility given the country's evolution and level of GDP per capita. It is striking that in figure 6, the German pattern is almost parallel to the French one. This means that in these two countries, changes in fertility are almost identically related to changes in income. Yet, the German pattern as a whole is situated on a much lower fertility level than the French one. Moreover, recent economic growth has induced a much more significant fertility rebound in France than in Germany.

We conclude that our empirical results so far prove an inverse J-shaped pattern of fertility along the process of economic development in OECD countries. Hence, we identify economic development as a driving factor for the fertility rebound. This implies that further economic development is likely to increase fertility in many OECD countries. However, our empirical analysis does not succeed in explaining why ins some OECD countries, the inverse J-shaped pattern are situated on quite different fertility levels. Moreover, we do not know why in some countries, economic growth re-increases fertility more significantly than in other countries.

In countries like France, Belgium and New Zealand, it seems that other factors beyond economic advancement are responsible for the relatively high fertility levels and the significant fertility rebound. Moreover, in Japan, Germany, Austria and Eastern and Southern European countries, low fertility levels cannot, or not only, be explained by insufficient economic advancement. Even though our analysis suggests that also in these countries further economic growth increases fertility, it seems likely that fertility increases on a much lower level.

We now test whether the inverse J-shaped pattern of fertility along the process of economic development can also be confirmed for the System GMM estimation model. Therefore, we use quinquennial data, which includes five-year means for the observations of the endogenous variable and observations of the beginning year of the respective mean for the exogenous variables for every country. Observations from the years 1960-2007 are thus divided in ten intervals. We do not only apply System GMM but also re-estimate the OLS, IV, FE and FDE models based on quinquennial data to test the robustness of our findings.

---

[5] The line based on the results of the OLS model that captures within- and between-country variation at the same time, is, however, very similar to the line based on the FE results shown in figure 4,5 and 6.

Table 3: Quinquennial data

Endogenous variable:	total fertility rate (*TFR*)				
Type of regression:	Pooled OLS	IV (2SLS)	Fixed Effects	First Difference Estimator	System GMM
Regressors:					
lnGDPpc	-14.17***	-10.86***	-15.80***	-18.58***	-13.62***
	(-6.83)	(-5.08)	(-9.47)	(-9.88)	(-4.56)
lnGDPpc²	0.690***	0.534***	0.764***	0.982***	0.711***
	(6.39)	(4.76)	(8.86)	(9.92)	(4.62)
lagged TFR					0.537***
					(7.15)
constant	74.32***	56.81***	83.14***	-0.200***	65.81***
	(7.48)	(5.59)	(10.31)	(-7.34)	(4.54)
N	224	194	224	194	164
nb. of countries:	30	30	30	30	30
time period:	1960-2007	1960-2007	1960-2007	1960-2007	1960-2007
R^2:	0.444	0.335	0.542 (within)	0.340	
R^2 adj.:	0.439	0.328	0.468	0.333	
nb. of instruments:		1 (1 period-lag= 5 years)			16
nb. of estim. param.:	3	3	3	3	4
Sargan (p-value):					0.172
Sargan-Difference (p-value):					0.189
Instruments for first differences equation:					L5.(L.TFR L2.lnGDPpc L2.lnGDPpc²)
Instruments for levels equation:					DL4.(L.TFR L2.lnGDPpc L2.lnGDPpc²)
estim. minimum GDPpc $ (PPP):	29 000	26 200	31 000		
estim. minimum TFR:	1.57	1.59	1.45		

t statistics in parentheses, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 3 shows that all estimation models including System GMM confirm a convex impact of economic development on fertility. The significantly positive coefficient of *lnGDPpc²* of the System GMM estimation suggests that when controlling for dynamics of adjustment, for endogeneity, non-stationarity and OVB at the same time, there is still an inverse J-shaped pattern of fertility along the process of economic development. The Sargan test of over-identification restrictions suggests that all instruments are valid (exogenous) and the Sargan-Difference test validates the extra moment restrictions of the System GMM specification.

The goodness of fit is again the highest for the FE-model focussing on within-country variation. FE regression results based on quinquennial data indicate, with 31 000 US$ per capita per year (measured in PPP), a similar minimum income level than the FE results based on yearly data[6]. The minimum fertility level is, however, with 1.45, somewhat lower than the one indicated in table 2.

[6] We do not calculate the minimum levels for the System GMM estimation results, because for this estimation around 66% of the variation in total fertility rates is explained by the variation of its own past values.

b) Control for birth postponement

It is possible that in some countries, economic advancement has not yet initiated a significant rebound in fertility because in these countries, the postponement of childbearing has not yet come to an end. The postponement of births at older ages reduces the number of births in a given period and therefore reduces total fertility rates. Several studies suggest that an increase of the mean age of mothers at childbirth partially explains the decrease in fertility observed over the last decades in many OECD countries, and particularly the lowest-low fertility rates that can be observed in many Eastern European countries (Bongaarts and Feeney, 1998; Kohler, Billari and Ortega, 2002; Goldstein, Sobotka and Jasilioniene, 2009). At the same time, the total number of children born by women over their life course might not change, implying that completed cohort fertility does not decrease. In that case, once the process of postponement of childbirth has come to an end, total fertility rates are expected to re-increase. Thereafter, the "catch up" of the number of births of mothers after age 30 can partially explain the rebound of fertility in highly developed OECD countries. Bongaarts (2001, 2002) as well as Goldstein, Sobotka and Jasilioniene (2009) suggest that the declining tempo effects, which are due to an end of birth postponement, increase total fertility rates particularly in the United States, the Netherlands and Norway.

As the delay in childbirth can be a main determinant of fertility decreases and the end of birth postponement a main determinant for re-increases of fertility, we now test whether we still find an inverse J-shaped pattern between fertility and economic development when controlling for tempo effects. For this purpose, we use tempo-adjusted total fertility rates (*adjTFR*) as endogenous variable. The tempo-adjusted fertility rate intends to measure fertility levels within a given period in the absence of postponement. Taking tempo changes into account, tempo-adjusted fertility rates are usually higher than total fertility rates. Tempo-adjusted fertility rates are available for 18 OECD countries and cover the years 1961-2005.

The use of tempo-adjusted fertility rates implies a further robustness test, as the *adjTFR* is not available for the outlier countries Luxembourg, Korea, Mexico and Turkey. An inclusion of observations of Luxembourg, which has outstanding high levels of GDP per capita and at the same time relatively high fertility levels especially in the 2000s, risks over-accentuating the empirical finding that economic development increases fertility from a certain income level on. An inclusion of observations of Korea, Mexico and Turkey also risks over-accentuating the inverse J-shaped between fertility and economic development because these countries have outstanding high fertility levels and at the same time relatively low income levels, especially in the 1960s and 1970s.

Data on *adjTFR* is available as three year moving averages, which smoothes out short-term fluctuations. In order to avoid overlapping information in our data, which would cause a problem for the System GMM estimation due to its use of instruments, we do not use five-year means of *adjTFR* like we do for the *TFR*, but observations of every fifth year only like we do for *lnGDPpc.* This reduces our observed time period to the years 1965-2005.

Table 4 shows the regression results with *adjTFR* as exogenous variable, based on data with five-year observations.

Table 4: Control for birth postponement, five-year observations

Endogenous variable:	tempo-adjusted total fertility rate (*adjTFR*)				
Type of regression:	Pooled OLS	IV (2SLS)	Fixed Effects	First Difference Estimator	System GMM
Regressors:					
lnGDPpc	-4.004	-3.690	-12.94***	-10.74*	-42.97*
	(-0.94)	(-0.97)	(-3.62)	(-2.43)	(-2.01)
lnGDPpc²	0.206	0.199	0.625***	0.541*	2.165*
	(0.95)	(1.02)	(3.46)	(2.38)	(2.02)
lagged adjTFR					0.479
					(1.65)
constant	21.30	18.91	68.61***	-0.0685	213.9*
	(1.02)	(1.02)	(3.89)	(-1.62)	(2.01)
N	82	73	82	64	54
nb. of countries:	18+	18+	18+	18+	18+
time period:	1965-2005	1965-2005	1965-2005	1965-2005	1965-2005
R^2:	0.014	0.069	0.483 (within)	0.093	
R^2 adj.:	-0.011	0.042	0.325	0.063	
nb. of instruments:		1 (1 period-lag= 5 years)			7
nb. of estim. param.:	3	3	3	3	4
Sargan (p-value):					0.907
Sargan-Difference (p-value):					0.907
Instruments for first differences equation:					L6.(L2.adjTFR L.lnGDPpc L.lnGDPpc_2)
Instruments for levels equation:					DL5.(L2.adjTFR L.lnGDPpc L.lnGDPpc_2)
estim. minimum GDPpc $ (PPP):			31 300		
estim. minimum adjTFR:			1.6		

t statistics in parentheses, * p<0.05, ** p<0.01, *** p<0.001

+ OECD countries without: Australia, Belgium, Canada, France, Germany, Greece, Korea, Luxembourg, Mexico, New Zealand, Switzerland, Turkey

For all estimation methods, the coefficient of *lnGDPpc²* stays positive, though the OLS and IV results are not significant. The estimation results in table 4 confirm that fertility re-increases from a certain level of development on also when taking into account tempo effects. We conclude that changes in the timing of birth are not the driving factor behind the inverse J-shaped pattern between fertility and economic advancement, as the increase in fertility corresponds to real quantum changes. Moreover, we know now that the inverse J-shaped pattern of fertility along the process of economic development can be confirmed even when dropping countries such as Luxembourg, Korea, Mexico and Turkey that risk over-accentuating the inverse J. Once again, the goodness of the fit is by far higher for the FE – model than for the other estimation models, indicating that the J-shaped pattern is much more shaped by within country-variations than by overall- or between-country-variations.

The minimum level of tempo-adjusted fertility indicated by the FE regression is with 1.6 naturally somewhat higher than our estimated minimum level of total fertility (1.51 respectively 1.45 for the FE model in table 2 and 3), as tempo-adjusted fertility rates are usually higher than total fertility rates. However, the estimated minimum income level corresponds approximately to those indicated by the FE model in table 2 and 3.

As tempo-adjusted fertility rates are available for only 18 OECD countries and only until 2005, we apply a further control for birth postponement by keeping *TFR* as endogenous variable and by adding the mean age of mothers at childbirth (*MAB*) as well as the age of mothers at first childbirth (*MA1B*) as control variables to our regression model. These variables exist for a larger set of countries and time periods. We use the fixed effects model in order to use data with yearly observations up to 2007. The regression results, shown in table in appendix 4, confirm a significantly convex impact of *lnGDPpc* on fertility when controlling for mothers' age at childbirth and when covering observations of almost all OECD countries from 1960 to 2007. However, whether an increase in mothers' age at childbirth increases or decreases fertility depends on the age measure. Due to this ambiguous finding, we prefer using tempo-adjusted fertility rates to control for birth postponement.

c) Control for different income distribution patterns

After having tested the robustness of our findings with respect to birth postponement, we now control whether the inverse J-shaped pattern of fertility along the process of economic development can be confirmed also when controlling for different income distribution patterns. While fertility trends have proved to depend on the average increase GDP per inhabitant, it is also very likely that this impact can be altered by the fraction of the population who benefit most of this wealth increase. We therefore add, one by one, five different measures of income inequalities to our quadratic estimation equation while keeping tempo-adjusted fertility as endogenous variable. Inequality indexes are thus included to account for the evolution of inequalities at the top of income distribution (by reference to the P90/P50 inter-decile), around the median (P50/P30) or at the bottom (P50/P10). The incidence of low pay jobs is also considered. Data is available for 15 OECD countries and cover the years 1960-2007. We use the fixed effects model in order to cover observations until the year 2007. Table 5 presents the FE estimation results based on yearly observations.

Table 5: Control for income inequalities, yearly observations

Endogenous variable:	**tempo-adjusted total fertility rate (*adjTFR*)**				
Type of regression:	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects
Regressors:					
lnGDPpc	-12.39***	-12.96***	-12.25***	-15.95***	-16.28***
	(-7.89)	(-8.49)	(-7.71)	(-9.91)	(-11.68)
lnGDPpc²	0.608***	0.621***	0.605***	0.770***	0.805***
	(7.69)	(8.10)	(7.56)	(9.55)	(11.43)
p90_p10	0.129***				
	(4.86)				
p90_p50		1.109***			
		(6.29)			
p50_p10			0.307***		
			(4.20)		
p90_p30				0.732***	
				(8.51)	
low_pay_incidence					0.0495***
					(9.67)
constant	64.46***	67.28***	63.23***	82.66***	83.15***
	(8.27)	(8.88)	(8.02)	(10.31)	(12.10)
N	242	242	242	226	171
nb. of countries:	15+	15+	15+	14++	13+++
time period:	1960-2007	1960-2007	1960-2007	1960-2007	1960-2007
R^2 within:	0.315	0.356	0.298	0.468	0.594
R^2 adj.:	0.263	0.308	0.245	0.428	0.555

t statistics in parentheses, * p<0.05, ** p<0.01, *** p<0.001

+ OECD countries without: Australia, Belgium, Canada, France, Germany, Greece, Iceland, Ireland, Korea, Luxembourg, Mexico, New Zealand, Portugal, Switzerland, Turkey ,

++ OECD countries without 15 countries listed above and Spain.

+++ OECD countries without 15 countries listed above and Italy and Norway.

Table 5 shows that the fixed effects estimations confirms an inverse J-shaped pattern of tempo-adjusted fertility along the process of economic development even when controlling for income inequalities. Furthermore, for all inequality measures, the estimation results suggest that income inequalities are significantly positively correlated with fertility. As the FE model focuses on within-country variation, the estimation results imply that when inequalities increase in a country, fertility also increases. The direction of causality is not clear, however, since the FE model does not control for endogeneity. The estimated inequality coefficient is the highest for the *p90_p50* measure, which suggests that fertility and inequality increases go hand in hand especially in those countries where the upper income decile distinguishes a lot from the average income level.

However, our estimation results do not show whether there is a polarisation in fertility behaviour between upper and lower income deciles. We do not know whether it is rather the rich or the poor households that increase their number of children, or whether fertility increases are equally distributed over all income levels. More data on the micro-level is needed to answer this question. Analysing more intensively the patterns between income inequalities and fertility behaviour is certainly a fruitful way of future research. Knowing if it is the richer families that tend to increase fertility (for example because of an improved access to private services) or if it is rather the poor ones (for example because of increased teenage pregnancies) allows deriving important policy implications.

The table in appendix 5 shows some further robustness controls for the FE model based on yearly data. The impact of *lnGDPpc* on tempo-adjusted fertility stays significantly convex when controlling for different measures of education and for female employment. However, data on education is only available for a reduced time period. Only tertiary school enrolment turns out to have a significant impact on fertility. The regression results suggest that tertiary school enrolment decreases fertility.

d) Decomposition of GDP per capita

Our analysis so far confirms a convex impact of GDP per capita on fertility even when controlling for birth postponement and for different income distribution patterns. This implies that economic development is likely to induce a fertility rebound in OECD countries. However, we also found that in some OECD countries, the fertility increasing effects of economic advancement are likely to be restrained by factors that are not included in our estimation model. In order to get a deeper insight in the economic mechanisms behind fertility increase, we now decompose the GDP per capita in a number of more specific variables and estimate their impact on fertility.

First, we substitute GDP per capita by an interaction term containing three variables, which are labour productivity, average working hours per worker and the employment ratio[7].

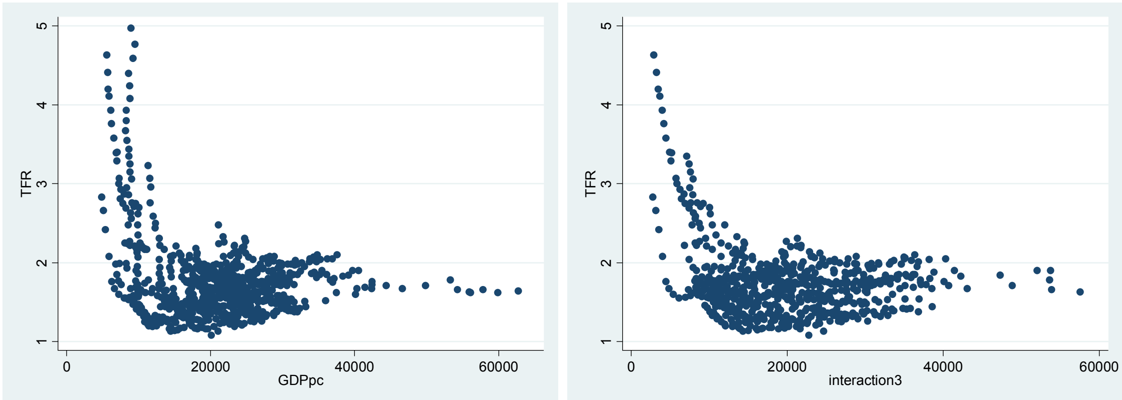
*GDPpc= labour productivity * average working hours per worker * employment ratio*

Figure 5 compares the data plot of *TFR* vs. GDP per capita against the data plot of *TFR* vs. the interaction term and illustrates that the interaction term adequately substitutes GDP per capita.

---

[7] labour productivity GDP/ sum of working hours; avrg. working hrs. per worker = sum of working hours / active population; employment ratio = active population / total population

Figure 5: Interaction term substitutes GDPpc



interaction 3= *labour productivity * average working hours per worker * employment ratio*

Now, we estimate the impacts of each of the decomposition variables on fertility. We use *adjTFR* as endogenous variables to keep the control for tempo-effects. Due to limited data availability we reduce our observed time period to the years 1980 to 2005. Including the years 1960-1980 in our estimation would seriously bias the results, as for this time period, for most of the decomposition variables data is only available for a small sub-group of countries. Moreover, the reduction of the data base allows focussing on linear impacts of the decomposition variables on fertility. In order to focus on determinants of the fertility rebound, one could think of further restraining the data base, for example to observations from the late 1990s on. However, we desist from doing so in order to keep the data set sufficiently large. When estimating linear impacts of the decomposition variables on tempo-adjusted fertility, we obtain the most robust results by limiting the observed time period to the years 1980 to 2005.

In a first step, we estimate the impact of our three decomposition variables on *adjTFR*.

$$\begin{aligned} adjTFR_{i,t} &= \beta_1 + \beta_2 * \ln(labourproductivity)_{i,t} + \\ &\beta_2 * \ln(avrg.hrs.perworker) + \beta_4 * \ln(employment\ ratio) + \varepsilon_{i,t} \end{aligned} \tag{2}$$

In a second step, we split the employment ratio into two variables, which are the employment rate (ages 25-54) and the ratio of the active population.[8] We limit the observed age group in order to better capture the impact of the employment variables on fertility. We estimate the impact of our four decomposition variables on *adjTFR* as follows:

$$\begin{aligned} &adjTFR_{i,t} = \\ &\beta_1 + \beta_2 * \ln(labourproductivity)_{i,t} + \beta_3 * \ln(avrg.hrs.perworker) \\ &+ \beta_4 * \ln(employmentrate) + \beta_5 * \ln(ratioactivepopulation) + \varepsilon_{i,t} \end{aligned} \tag{3}$$

[8]ratio active population = active population (ages 25-54)/ total population (ages 25-54)

In a third step, we use our decomposition variables disaggregated by gender and estimate our model as follows:

$$\begin{aligned} adjTFR_{i,t} &= \beta_1 + \beta_2 * \ln(labourproductivity)_{i,t} \\ &+ \beta_3 * \ln(avrg.hrs.perworker\_men) + \beta_4 * \ln(avrg.hrs.perworker\_women) \\ &+ \beta_5 * \ln(employmentrate\_men) + \beta_6 * \ln(employmentrate\_women) \\ &+ \beta_7 * \ln(ratioactivepopulation\_men) + \beta_8 * \ln(ratioactivepopulation\_women) + \varepsilon_{i,t} \end{aligned} \quad (4)$$

Table 6 presents the regression results for estimation equation (2), based on data with five-year observations from 1980 on.

Table 6: Decomposition of lnGDPpc in 3 variables, five-year observations

Endogenous variable:	**tempo-adjusted total fertility rate (*adjTFR*)**					
Type of regression:	Pooled OLS	IV (2SLS)	Fixed Effects	Between Effects	First Difference Estimator	System GMM
Regressors:						
ln(labour productivity)	-0.0166	0.00721	-0.0895	0.464	-0.0441	-0.226
	(-0.19)	(0.06)	(-1.35)	(2.01)	(-0.14)	(-1.55)
ln(avrg. hrs. per worker)	0.00449	-0.0308	0.872	1.085	-0.416	0.434
	(0.01)	(-0.08)	(1.08)	(1.61)	(-0.44)	(0.67)
ln(employment ratio)	0.624**	0.575*	-0.296	1.037*	0.172	1.541**
	(2.83)	(2.44)	(-0.82)	(2.79)	(0.46)	(3.35)
lagged adjTFR						0.557*
						(2.35)
constant	-0.499	-0.115	-3.257	-11.65	-0.0382	-7.617
	(-0.17)	(-0.03)	(-0.48)	(-1.92)	(-0.49)	(-1.28)
N	62	50	62	62	44	37
nb. of countries:	18+	18+	18+	18+	18+	18+
time period:	1980-2005	1980-2005	1980-2005	1980-2005	1980-2005	1980-2005
R^2:	0.129	0.119	0.172 (within)	0.464 (between)	0.019	
R^2 adj.:	0.084	0.061		0.349		
nb. of instruments:		1 (1 period-lag= 5 years)				13
nb. of estim. param.:	4	4	4	4	4	5
Sargan (p-value):						0.089
Sargan-Difference (p-value):						0.053
Instruments for first differences equation:						L4.(L2.adjTFR lnlabourprod lnavrghrspw lnemplrat)
Instruments for levels equation:						DL3.(L2.adjTFR lnlabourprod lnavrghrspw lnemplrat)

t statistics in parentheses, * p<0.05, ** p<0.01, *** p<0.001

+ OECD countries without: Australia, Belgium, Canada, France, Germany, Greece, Korea, Luxembourg, Mexico, New Zealand, Switzerland, Turkey

We observe that the employment ratio variable has a positive and significant coefficient for almost all estimation models, whereas the coefficients of the other exogenous variables are not robust and insignificant.

Whereas the FE model is insignificant, the BE model obtains significant results by exploiting differences between countries. As the between estimator discards the time series information in the data set, the results suggest that the positive impact of the employment ratio on fertility is driven by between country variation. This is confirmed by the fact that the goodness of fit is higher for the BE than for the FE model.

To further test whether employment is a driving factor for the fertility rebound in OECD countries, we split the employment ratio into the employment rate (ages 25-54) and the ratio of the active population. We then estimate equation (3), again based on data with five-year observations from 1980 on.

The regression results, shown in the table in appendix 6, confirm a significantly positive impact of employment on fertility for the OLS, BE and System GMM estimation. This suggests that the higher the employment rate of the population between the age 25 and 54, the higher is a country's tempo-adjusted fertility rate. Moreover, the employment rate is the most significant variable in comparison to the other variables, indicating that employment is a driving factor for the fertility rebound in OECD countries. Furthermore, the estimation results confirm that the correlation between employment and fertility is dominated by between country variations.

As the impact of the decomposition variables on fertility may differ between men and women, we now disaggregate working hours, employment rates and the ratio of the active population by gender. Table 7 shows the regression results for estimation equation (4), again based on data with five-year observations from 1980 on.

Table 7: Decomposition of lnGDPpc with gender disaggregation, five-year observations

Endogenous variable:	tempo-adjusted total fertility rate (*adjTFR*)				
Type of regression:	Pooled OLS	IV (2SLS)	Between Effects	First Difference Estimator	System GMM
Regressors:					
ln(labour productivity)	0.0465	0.354*	0.416	-0.246	0.152
	(0.31)	(2.20)	(1.40)	(-0.58)	(1.78)
ln(avrg. hrs. per worker men)	1.289*	2.412***	2.108	-1.295	0.917*
	(2.11)	(4.12)	(2.28)	(-1.03)	(2.17)
ln(avrg. hrs. per worker women)	-0.874**	-1.369*	-0.841	-0.326	-0.430*
	(-2.83)	(-2.48)	(-1.66)	(-0.26)	(-2.01)
ln(employment rate 25-54 men)	-0.357	-1.369*	-1.422	0.591	0.947
	(-0.52)	(-2.48)	(-1.36)	(0.66)	(1.63)
ln(employment rate 25-54 women)	0.601**	0.904***	1.039*	-0.552	0.377***
	(3.30)	(5.02)	(3.32)	(-1.10)	(3.58)
ln(ratio active population men)	-5.360	-3.031	-8.782	0.718	0.542
	(-1.31)	(-0.82)	(-1.12)	(0.19)	(0.22)
ln(ratio active population women)	3.797	-0.690	5.860	-0.842	-3.263
	(0.82)	(-0.16)	(0.60)	(-0.21)	(-1.20)
lagged adjTFR					0.692***
					(7.94)
constant	3.910	9.378	4.756	0.0366	1.671
	(0.58)	(1.31)	(0.36)	(0.33)	(0.41)
N	44	30	44	28	39
nb. of countries:	16⁺	16⁺	16⁺	16⁺	16⁺
time period:	1980-2005	1980-2005	1980-2005	1980-2005	1980-2005
R^2:	0.451	0.677	0.816 (between)	0.163	
R^2 adj.:	0.344	0.574	0.655		
nb. of instruments:		1 (1 period-lag= 5 years)			27
nb. of estim. param.:	8	8	8	8	9
Sargan (p-value):					0.413
Sargan-Difference (p-value):					0.140
Instruments for first differences equation:					L3.(L.adjTFR lnlabourprod lnavrghrspw_m lnavrghrspw_w lnempl_m lnempl_w lnratactpop_m lnratactpop_w)
Instruments for levels equation:					LD2.(L.adjTFR lnlabourprod lnavrghrspw_m lnavrghrspw_w lnempl_m lnempl_w lnratactpop_m lnratactpop_w)

t statistics in parentheses, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

⁺ OECD countries without: Australia, Belgium, Canada, France, Germany, Greece, Japan, Korea, Luxembourg, Mexico, New Zealand, Switzerland, Turkey , USA

Table 7 reveals that not only for the OLS, IV and System GMM estimation, but also for the between effects estimation, female employment is significantly positively correlated with tempo-adjusted fertility rates.[9] Hence, the overall-estimators and the between-estimator reveal female employment as the key dimension of GDP that goes hand in hand with a fertility rebound in highly developed countries. This suggests that the change in the impact of economic development on fertility from negative to positive in highly developed countries is driven by an increase in female labour market participation.

To date, high female employment rates (ages 25-54) over 80% along with high total fertility rates and tempo-adjusted fertility rates can especially be observed in Finland, Norway, Sweden, Denmark and Iceland. These are countries with high income levels at the

[9] To further test whether employment is a driving factor for the fertility rebound in OECD countries, we substitute labour productivity by male and female wages for all sectors (results not shown here). Even though this implies a further reduction of the number of observations, the estimation results prove the robustness of our finding, as the coefficient of female employment stays significantly positive for the OLS, IV and System GMM estimation. However, the wage coefficients are found to be insignificant.

same time. Moreover, for example France has higher female employment rates and at the same time higher fertility rates than Germany, even though Germany has somewhat higher GDP levels. Countries where fertility and female employment rates are particularly low are the Southern and Eastern European countries.

Our empirical findings accord with a series of other empirical studies, which investigate the correlation between female employment and fertility in OECD countries. Engelhardt, Kögel and Prskawetz (2004a, 2004b), for example, find for six OECD countries, that the correlation between female labour market participation and fertility is significantly negative only up to the year 1975. Kögel (2004, 2006) finds a positive association between the two variables in Western European countries from the 1980s on when focussing on cross country variation. However, the studies highlight that the association between female employment and fertility is influenced by the countries' institutional context, in particular in terms of family policies. These components are not explicitly taken into account by our study. They are only implicitly considered as governments' investments are part of GDP per capita

Our finding of a positive correlation between female employment and fertility also implies that fertility decreases when female employment decreases. This can be observed in the Eastern European, where fertility rates declined extremely along with a steep downfall of female employment in the beginning of the 1990s. Da Rocha and Fuster (2005) confirm our finding that fertility is pro cyclical by emphasising that also in Sweden, East Germany, Spain and Italy, during the 1990s both fertility and male and female employment decreased. They find that fertility and employment are positively associated in OECD countries with relatively low employment ratios.

While fertility recovery goes hand in hand with the increase in female employment rates, we find that the impact of male employment is rather insignificant, which is most likely due to the fact that the within- and between variations of male employment are rather negligible in our data base. However, estimations reveal that an increase in women's average working hours have a significantly negative impact on fertility. Thus, while the diffusion of female labour market participation is positive for fertility, working too many hours still curb fertility increase. Working more than the current average (less than 40 hours per week in our sample) is likely to alter fertility increase. By contrast, men's working hours have a significantly positive impact on fertility. These results suggest that fertility still increases in a gender-unbalanced context of division of work. The finding of a positive impact of female employment and a negative impact of female working hours on fertility suggests that reconciliation issues play an important role for women's decision to have children.

6. Conclusion

This study shows that the influence of economic development on fertility trends changed radically in the last few years over which a rebound of fertility rates has been observed. Our empirical findings support the hypothesis of a convex impact of economic advancement on fertility rates. We find an inverse J-shaped pattern of fertility along the process of economic development in OECD countries over the last decades from 1960 on, which is dominated by within-country variation. This implies that in highest developed countries, recent economic advancement goes hand in hand with a rebound in fertility. This finding is robust when controlling for endogeneity, the postponement of birth and for different income distribution patterns. Moreover, whatever the specification is, the estimated threshold from which GDP per capital can be expected to boost fertility is much higher than the actual OECD average in 2007. We so expect further economic growth to enhance fertility in a large number of OECD countries.

By designating a clear turning point in the relationship between economic development and fertility, we find that economic development is a driving factor for fertility in the majority of OECD countries and further economic development is likely to induce a fertility rebound. However, many countries do not follow the identified path. Some of them demonstrate a much lower actual fertility rate in 2006 than the one predicted from GDP trends. Eastern and Southern European countries as well as Germany, Japan and Korea are clearly in that situation. At the same time, these countries are characterised by comparatively low support to reconcile work with family formation, which seems to restrain the fertility increasing effects of economic advancement. By contrast, North European and overseas countries exhibit higher fertility rates than their expected values. These countries provide more advanced support to combine work and family, although of different nature. These differences throw light on the country-specific factors that lift fertility rates on a significantly higher level, above and beyond economic development. Changes in norms towards childbearing, in labour market contexts, and in policies supporting families or the work-life balance accompanying the process of development stand so as crucial dimensions to consider in order to better capture cross-national differences in fertility trends. Moreover, while the process of growth is expected to raise fertility from a certain stage of economic development on, the increase may be limited for most countries, unless development is accompanied by some evolution in the institutional context. Hence, economic advancement seems to be a necessary but not sufficient condition for a significant fertility rebound.

To get a deeper insight in the economic factors that “drive” fertility, we decompose the GDP per capita in a number of more specific variables and estimate their impact on fertility. Hereby, we find that fertility increases along with the diffusion of female labour market participation. One possible explanation for this finding is that in several highly developed OECD countries, economic advancement not only increases women’s labour market opportunities, but increases at the same time reconciliation possibilities for parents. Here again, the changes in labour market and institutional contexts that accompanied economic development are strong candidates for explaining this positive association between fertility and female employment trends. Patterns of development vary quite largely across OECD, however. It is clear, for example, that economic development has generated very different labour market opportunities for women and various forms of support to combine work and family in the Nordic European countries, on the one hand, and in the English-speaking countries, on the other hand, where fertility and female employment rates are though comparatively high. Further investigation on the relationships between economic growth, labour market development, policies regarding work and family reconciliation and fertility trends is now required to better understand the variety of cross-national patterns.

Finally, our estimation results suggest that economic advancement increases fertility in countries that enable female employment, but they do not allow statements concerning the role of public or private reconciliation instruments, as these are only part our GDP measures but are not modelled explicitly in this study. Therefore, further analysis is needed to test the positive association between fertility and female employment by integrating indicators of social policy and particularly of the design of reconciliation policies. An in-depth analysis of the linkages between fertility, institutional settings like norms and family policies, and women’s labour market participation seems to be a fruitful area for future research. In addition, we discover a further investigation of the patterns between income inequalities and fertility to be worthwhile.

Appendix:

<u>Appendix 1:</u> Summary statistics

variable	definition	nb. of obs.	nb. of countries	time period	mean	std. dev.	min.	max.	source
TFR	total fertility rates (average number of births per woman)	1418	30	1960-2007	2,19	0,96	1,08	7,26	OECD
adjTFR	tempo-adjusted total fertility rates, 3 year MA	519	18	1961-2006	1,97	0,32	1,34	3,43	Bongaarts & Feeney
GDPpc	gross domestic product per capita in purchasing power parities (in constant 2005 USD)	1072	30	1960-2007	19812,53	8234,63	2859,90	65001,25	OECD
lnGDPpc	natural logarithm of *GDPpc*	1072	30	1960-2007	9,80	0,46	7,96	11,08	own calculation
MAB	mean age of mothers at childbirth	1097	29	1960-2007	27,79	1,40	24,55	31,20	OECD
MA1B	age of mothers at first childbirth	702	26	1960-2007	25,79	2,09	20,70	30,70	OECD
p90_p10	the ratio of the 90th and 10th percentiles of the income distribution	433	23	1960-2007	3,35	2,10	1,75	19,33	OECD
p90_p50	the ratio of the 90th and 50th percentiles of the income distribution	433	23	1960-2007	1,82	0,20	1,27	2,35	OECD
p50_p10	the ratio of the 50th and 10th percentiles of the income distribution	441	23	1960-2007	1,80	0,89	1,30	8,70	OECD
p90_p30	the ratio of the 90th and 30th percentiles of the income distribution	366	21	1960-2007	2,24	0,41	1,41	3,79	OECD
low_pay_incidence	the share of low-wage workers among employees	309	22	1960-2007	17,36	5,66	4,60	33,88	OECD
primary school enrolment	primary school enrolment % gross (girls and boys)	632	30	1980-2003	48,57	0,51	45,41	52,60	UN
secondary school enrolment	secondary school enrolment % gross (girls and boys)	617	30	1980-2004	49,03	2,55	34,32	54,78	UN
tertiary school enrolment	tertiary school enrolment % gross (girls and boys)	605	30	1980-2005	48,70	7,15	25,54	63,66	UN
labour productivity	GDP/sum of working hours	693	30	1980-2007	26,28	12,29	2,66	78,29	OECD
avrg hrs per worker	average working hours per worker = sum of working hours/active population	711	30	1980-2007	1800,89	247,41	1334,00	2922,73	OECD
avrg hrs per worker men	average working hours per male worker = sum of working hours men/active population men	508	27	1980-2007	2198,20	160,94	1871,34	2891,76	OECD
avrg hrs per worker women	average working hours perfemale worker = sum of working hours women/active population women	508	27	1980-2007	1814,64	238,13	1244,73	2653,42	OECD
employment ratio	active population/total population	787	30	1980-2007	44,18	6,49	27,87	70,08	OECD
employment rate 25-54	number of employed persons/working age population (ages 25-54)	710	30	1980-2007	75,72	7,73	53,21	91,60	OECD

employment rate 25-54 men	number of employed men/working age population men (ages 25-54)	710	30	1980-2007	87,98	4,32	73,01	97,30	OECD
employment rate 25-54 women	number of employed women/working age population women (ages 25-54)	710	30	1980-2007	63,48	14,21	25,59	89,60	OECD
ratio active population	active population (ages 25-54)/total population (ages 25-54)	710	30	1980-2007	63,24	2,85	54,65	69,63	OECD
ratio active population men	active population men (ages 25-54)/total population men (ages 25-54)	710	30	1980-2007	63,50	2,93	54,05	70,69	OECD
ratio active population women	active population women (ages 25-54)/total population women (ages 25-54)	710	30	1980-2007	62,99	2,85	55,20	69,61	OECD

<u>Appendix 2</u>: IV-regression in two steps (Two Stage Least Squares) with one-year lags

Step 1:

Estimation of a reduced form which regresses the endogenous regressor $\ln G\hat{D}Ppc_{i,t}$ over the instrument $\ln GDPpc_{i,t-1}$:

$$\ln G\hat{D}Ppc_{i,t} = \beta_1 + \beta_2 \ln GDPpc_{i,t-1} + \varepsilon_{i,t}$$

Calculation of $\ln G\hat{D}Ppc_{i,t}$ based on the estimated coefficients in step one.

Calculation of $\ln G\hat{D}Ppc^2{}_{i,t}$ using $\ln G\hat{D}Ppc_{i,t}$.

Step 2:

Estimation of *lnTFR* based on $\ln G\hat{D}Ppc^2{}_{i,t}$ and $\ln G\hat{D}Ppc_{i,t}$:

$$\ln TFR_{i,t} = \beta_1 + \beta_2 * \ln G\hat{D}Ppc_{i,t} + \beta_3 * \ln(G\hat{D}Ppc_{i,t})^2 + \varepsilon_{i,t}$$

<u>Appendix 3</u>: Quantification of the regression results based on the estimated coefficients of the FE regression (table 2, column 3):

$$TFR_{i,t} = 89{,}54 - 16{,}94 * \ln GDPpc_{i,t} + 0{,}815 * \ln(GDPpc_{i,t})^2$$

$$\frac{\delta TFR}{\delta l \ln GDPpc} = -16{,}94 + 1{,}63 \ln GDPpc$$

$$\frac{\delta TFR}{\delta \ln GDPpc} = 0 \Leftrightarrow \ln GDPpc = 10{,}39$$

$$TFR_{i,t} = 89{,}54 - 16{,}94 * 10{,}39 + 0{,}815 * 10{,}39^2 = 1{,}51$$

→ **Minimum at *GDPpc* = 32 600 USD (PPP), *TFR* = 1,51**

Appendix 4: Further control for birth postponement, yearly observations

Endogenous variable:	total fertility rate (*TFR*)	
Type of regression:	Fixed Effects	Fixed Effects
Regressors:		
lnGDPpc	-19.42***	-15.81***
	(-18.64)	(-12.14)
lnGDPpc²	0.933***	0.779***
	(17.62)	(11.91)
MAB	0.0323*	
	(2.54)	
MA1B		-0.0580***
		(-5.59)
constant	101.6***	83.23***
	(19.54)	(12.90)
N	845	582
nb. of countries:	26+	29++
time period:	1960-2007	1960-2007
R^2 within:	0.538	0.493
R^2 adj.:	0.522	0.464

t statistics in parentheses, * p<0.05, ** p<0.01, *** p<0.001

+ OECD countries without: Canada, Korea, Mexico, Turkey

++ OECD countries without: Turkey

Appendix 5: Control for education and female employment, yearly observations

Endogenous variable:	tempo-adjusted total fertility rate (*adjTFR*)			
Type of regression:	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects
Regressors:				
lnGDPpc	-14.82***	-15.80***	-17.28***	-13.92***
	(-8.63)	(-8.77)	(-9.82)	(-8.41)
lnGDPpc²	0.725***	0.776***	0.868***	0.680***
	(8.36)	(8.51)	(9.63)	(8.05)
primary school enrolment	0.0119			
	(0.55)			
secondary school enrolment		-0.0191		
		(-1.86)		
tertiary school enrolment			-0.0202***	
			(-4.38)	
employment rate 25-54 women				-0.00130
				(-0.82)
constant	76.80***	83.07***	88.79***	73.03***
	(8.96)	(9.18)	(10.25)	(8.97)
N	286	280	282	347
nb. of countries:	18+	18+	18+	18+
time period:	1980-2003	1980-2003	1980-2003	1960-2007
R^2 within:	0.357	0.364	0.405	0.375
R^2 adj.:	0.309	0.315	0.359	0.337

t statistics in parentheses, * p<0.05, ** p<0.01, *** p<0.001

+ OECD countries without: Australia, Belgium, Canada, France, Germany, Greece, Korea, Luxembourg, Mexico, New Zealand, Switzerland, Turkey

<u>Appendix 6</u>: Decomposition of lnGDPpc in 4 variables, five-year observations

Endogenous variable:	tempo-adjusted total fertility rate (*adjTFR*)				
Type of regression:	Pooled OLS	IV (2SLS)	Between Effects	First Difference Estimator	System GMM
Regressors:					
ln(labour productivity)	-0.0309	-0.0712	0.691*	0.0296	-0.319
	(-0.30)	(-0.55)	(2.63)	(0.08)	(-1.49)
ln(avrg. hrs. per worker)	-0.0320	-0.229	1.190	-0.472	-1.561*
	(-0.09)	(-0.57)	(1.66)	(-0.51)	(-2.38)
ln(employment rate 25-54)	0.782*	0.594	1.589*	0.146	1.358***
	(2.55)	(1.93)	(2.94)	(0.28)	(4.04)
ln(ratio active population)	0.312	0.399	-2.708	0.309	-1.174
	(0.39)	(0.46)	(-1.12)	(0.55)	(-0.68)
lagged adjTFR					-0.0723
					(-0.32)
constant	-2.507	-0.458	-4.885	-0.0568	13.53
	(-0.57)	(-0.09)	(-0.42)	(-0.63)	(1.51)
N	60	47	60	42	32
nb. of countries:	18+	18+	18+	18+	18+
time period:	1980-2005	1980-2005	1980-2005	1980-2005	1980-2005
R^2:	0.134	0.122	0.534 (between)	0.022	
R^2 adj.:	0.071	0.038	0.391		
nb. of instruments:		1 (1 period-lag= 5 years)			9
nb. of estim. param.:	5	5	5	5	6
Sargan (p-value):					0.129
Sargan-Difference (p-value):					-
Instruments for first differences equation:					L4.(L2.adjTFR L.lnlabourprod L.lnavrghrspw L.lnempl L.lnratactpop)
Instruments for levels equation:					DL3.(L2.adjTFR L.lnlabourprod L.lnavrghrspw L.lnempl L.lnratactpop)

t statistics in parentheses, * p<0.05, ** p<0.01, *** p<0.001

+ OECD countries without: Australia, Belgium, Canada, France, Germany, Greece, Korea, Luxembourg, Mexico, New Zealand, Switzerland, Turkey

References:

Adsera, A., 2004, "Changing fertility rates in developed countries. The impact of labor market institutions," *Journal of Population Economics,* Springer, vol. 17(1), pages 17-43.

Ahn N., Mira P., 2002, "A note on the relationship between fertility and female employment rates in developed countries." *Journal of Population Economic* 15(4): 667-682.

An C., Seung-Hoon J., 2006, "Demographic change and economic growth: An inverted-U shape relationship." *Economic Letters* 92(3): 447--454.

Arellano M., Bond S., 1991, "Some Test of Specification for Panel Data. " *Economic Letters,* 31, 337-341.

Arellano M., Bover O., 1995, "Another look at the instrumental variable estimation of error-component models." *Journal of Econometrics* 68, 29-51.

Barro R., BeckerG.,1989, "Fertility Choice in a Model of Economic Growth," *Econometrica,* Econometric Society, vol. 57(2), pages 481-501.

Beaudry P., Green D., 2000, "Population Growth, Technological Adoption and Economic Outcomes in the Information Era." Miméo NBER.

Becker, G., 1960, "*An economic analysis of fertility."* Demographic and Economic Change in Developed Countries. NBER Conference Series 11, pp. 209-231.

Becker, G., 1965, "A theory of the allocation of time." *Economic Journal* 75:493-517.

Becker, G., 1981, "*A Treatise on the Family.",* Cambridge: Harvard University Press.

Becker G., Lewis H.G., 1973, "On the interaction between quantity and quality of children." *Journal of Political Economy* 81: S143-S162.

Blanchet, D., 2002, "Demographic trends and pensions: fiftheen years of debate."*Population and Societies* N°383.

Blossfeld, H.-P. (ed.), 1995, "*The New Role of Women: Family Formation in Modern Societies*," Boulder: Westview Press.

Bloom D., Canning D., Kink G., Finlay J. 2009. "Fertility, female labor force participation, and the demographic dividend", *Journal of Economic Growth* 14:79-101.

Bloom D.E., Canning D., Sevilla J., 2003, "*The Demographic Dividend: A New Perspective on the Economic Consequences of Population Change*," Population Matters Monograph MR-1274, RAND, Santa Monica.

Bloom D., Canning D., Fink G., Finlay J., 2010, "Fertility, the demographic dividend and economic growth", Fourth Annual Research Conference on Population, Reproductive Health, and Economic Development, Cape Town, January.

Blundell R., Bond S., 1998, "Initial conditions and Moment Restrictions in Dynamic Panel Data Models." *Journal of Econometrics*, 87, 115-143.

Bond, S., 2002, "Dynamic panel data models: A guide to micro data methods and practice", *Portuguese Economic Journal*, Vol. 1, 2002, pp. 141-162.

Bongaarts, J., 2001, "Fertility and Reproductive Preferences in Post-Transitional Societies." *Population and Development Review* 27: 260-281.

Bongaarts, J., 2002, "The End of the Fertility Transition in the Developed World." *Population and Development Review* 28 (3): 419-443.

Bongaarts J., Feeney G., 1998, "On the quantum and tempo of fertility", *Population and* Development Review 24, 271-291

Boserup, E., 1965, “The Conditions of Agricultural Progress.” Allen and Urwin.

Boserup, E., 1970, “*Women’s Role in Economic Development.”* New York: St, Martin’s.

Bowsher, C.G., 2002, “On testing overidentifying restrictions in dynamic panel data models.” *Economic Letters* Vol 77.

Butz W. P., Ward M.P., 1979, “The emergence of countercyclical U.S. fertility.” *American Economic Review* 69(3): 318-328.

Cigno, A., 1991, “*Economies of the Family,”* Clarendon Press, Oxford.

D’Addio D., Mira d’Ercole M., 2005, *“Fertility trends and the impact of policies.”* Social, Employment and Migration Working Papers, OECD, Paris.

Da Rocha J.L., Fuster L., 2006, "Why Are Fertility Rates And Female Employment Ratios Positively Correlated Across O.E.C.D. Countries?," *International Economic Review,* Department of Economics, University of Pennsylvania and Osaka University Institute of Social and Economic Research Association, vol. 47(4), pages 1187-1222, November.

Dickey D.A., Fuller W.A., 1979, “Distribution of the Estimators for Autoregressive Time Series with a Unit Root.” *Journal of the American Statistical Association*, 74, p. 427–431.

de la Croix D., Doepke M., 2003, "Inequality and Growth: Why Differential Fertility Matters," *American Economic Review*, American Economic Association, vol. 93(4), pages 1091-1113, September.

Doepke, M., 2004, “Accounting for Fertility Decline During the Transition to Growth,” *Journal of Economic Growth*, Volume 9, N°3, pp. 347-383.

Engelhardt H., Kögel T., Prskawetz A., 2004a, „Fertility and Women’s Employment Reconsidered: A Macro-Level Time Series Analysis for Developed Countries, 1960-2000.” *Population Studies* 58: 109-120.

Engelhardt H., Kögel T., Prskawetz A., 2004b, “On the Changing Correlation Between Fertility and Female Employment Over Space and Time. “ *European Journal of Population* 20: 35-62.

Furuoka, F, 2009, *“Looking for a J-shaped development-fertility relationship: Do advances in development really reverse fertility declines?”*, Economics Bulletin Volume 29, Issue 4.

Galor, O., 2005, “The demographic transition and the emergence of sustained economic growth.” *Journal of the European Economic Association*, 3(2-3), 494-504.

Galor O., Weil D.N., 1996*, “*The Gender Gap, Fertility and Growth.” *American Economic Review* 86, 374-387.

Galor O., Weil D.N., 1999, "From Malthusian Stagnation to Modern Growth," *American Economic Review*, 89, 150-154.

Galor O., Weil D.N., 2000, “Population, technology and growth. From Malthusian stagnation to the demographic transition and beyond.” *The American Economic Review*, 90(4), 806-828.

Goldin, C., 1994, *“The U-shaped female labor force function in economic development and economic history*.” nber workinpaper n°4707.

Goldstein J.R., Sobotka T., Jasilioniene A., 2009, “The end of “lowest-low fertility?”, *Population and Development Review* 35 (4): 663-699.

Hausman, J.A., 1978, “Specification tests in econometrics.” *Econometrica* 46,1251-1271.

Hotz V.-J., Kerman J.-A., Willis R.-J., 1997, "The Economics of Fertility in Developed Countries: A Survey," in Rosenzweig M., Stark O. *Handbook of Population Economics*, 1A :275-347.

Klasen, S., 1999, "*Does Gender Inequality Reduce Growth and Development?"* World Bank Policy Research Report Working Paper Nr. 7, Washington, DC: The World Bank.

Klasen S., Lamanna F.,2009, "The Impact of Gender Inequality in Education and Employment in Economic Growth: New Evidence for a Panel of Countries", *Feminist Economics*, 15: 3,91 – 132.

Knowles S., Lorgelly P.L., Owen P.D., 2002, "Are Educational Gender Gaps a Brake on Economic Development? Some Cross-Country Empirical Evidence." *Oxford Economic Papers* 54: 118-149.

Kögel, T., 2004, "Did the association between fertility and female employment within OECD countries really change its sign?" *Journal of Population Economics* 17: 45-65.

Kögel, T., 2006, "*Swedish Family Policy, Fertility and Female Wages,"* Discussion Paper Series 2006_7, Department of Economics, Loughborough University.

Kohler H.-P., Billari F.C., Ortega J.A., 2002, "The emergence of lowest-low fertility in Europe during the 1990s", *Population and Development Review* 28, 641-681.

Kohler H.P., Philipov D. 2001, "Variance effects in the Boongarts-Feeney formula", *Demography*, 38(1):1-16.

Krämer W., Neusser K., 1984, "The emergence of countercyclical US fertility: a note." *American Economic Review*, 74(1): 201-202.

Levin A., Lin S.F., Chu C.S, 2002, "Unit Root Tests in Panel Data: Asymptotic and Finite Sample Properties." Journal of Econometrics, 1-24.

Lesthaeghe R., Surkyn J. 1988. "Cultural dynamics and economic theories of fertility change" *Population and Development Review*, 14(1):1-45.

Lesthaeghe, R., 2001, *"Postponement and recuperation: Recent fertility trends and forecasts in six Western European countries,"* paper presented at the IUSSP Seminar on "International Perspectives on Low Fertility: Trends, theories, and Policies,"Tokyo, 21–23 March.

Lesthaeghe, R., 2010, "The Unfolding Story of the Second Demographic Transition." *Population and Development Review*, 36: 211–251.

Liefbroer A., and E. Merz,, 2010, Perceived norms concerning fertility-related behaviour, REPRO Working paper, http://www.oeaw.ac.at/vid/repro/assets/docs/Norms_fertility-behaviour.pdf

Lindh T., Malmberg B., 1996, "*Age Structure Effects and Growth in the OECD, 1950-90: Further Evidence*", Working Paper Series 1996:12, Uppsala University, Department of Economics.

Lucas, R., 1988, "The Mechanics of Economic Development*." Journal of Monetary Economics*, vol. 22, pp. 3-42.

Luci, A., 2009, "Female labour market participation and economic growth.", *International Journal of Innovation and Sustainable Development*, Vol. 4, nos 2/3.

Mammon K., Paxson C., 2000, "Women's work and economic development." *Journal of Economic Perspectives* 14 (4): 141–164.

Macunovich, D., 1995, "The Butz-Ward fertility model in the light of more recent data", *Journal of Human Resources*, Spring 1995, (30)2:229-255.

Malmberg B., Lindh Th., Halvarsson M. 2008. "*Productivity consequences of workforce aging: stagnation or Horndal Effect*?", in Prskawetz A., Bloom D., Lutz W. (eds), Population Aging, Human Capital, Accumulation and Productivity Growth, Supplment to Population and Development Review, 34:238-256.

McDonald, J.,1983, "The emergence of countercyclical US fertility: a reassessment of the evidence." *Journal of Macroeconomics*, 1983, vol. 5, issue 4, pages 421-436.

Mincer, J., 1963, "*Market prices, opportunity costs and income effects."* In: C.Christ et al., eds., Measurement in economics: studies in mathematical economics in honor of Yehuda Grunfeld (Standford University Press, Standford, CA).

Mocan, N., 1990, "Business cycles and fertility dynamics in the United States." *Journal of Population Economics*, 3(2).

Myrskylä M., Kohler H.P., Billari F., 2009, "Advances in development reverse fertility declines." *Nature*, 460(6), doi:10.1038/nature 08230.

Phillips, P.C.B., Perron, P., 1988, "Testing for a Unit Root in Time Series Regression" *Biometrika*, 75, 335–346.

Phelps, E.S., 1966, "Models of Technical Progress and the Golden Rule of Research." *Review of Economic Studies,* April 1966.

Philipov D., Thévenon O., Koblas J., Bernardi L., Liefbroer A., 2009, "*Reproducitve Decision-making in a Macro-micro Perspective: State of the Art."* European Demographic Research Paper 1.

Prskawetz A., Lindh T., 2006, "*The Impact of Population Ageing on Innovation and Productivity Growth in Europe",* Vienna Institute of Demography, Research Report 28.

Prskawetz A., Fent Th., Guest R. 2008*,"Workforce aging and labor productivity: the role of supply and demand for labor in the G7 countries*", in Prskawetz A., Bloom D., Lutz W. (eds), Population Aging, Human Capital, Accumulation and Productivity Growth, Supplment to Population and Development Review, 34:298-324.

Rindfuss R., Bumpass L., St. John C., 1980. "Education and fertility: implications for the roles women occupy." *American Sociological Review* 45(June):431-447.

Roodman, D., 2009, "A Note on the Theme of Too Many Instruments", *Oxford Bulletin of Economics and Statistics* Volume 71 Issue 1, Pages 135 - 158.

Simon, J.,1981, "*The Ultimate Resource."* Princeton, NJ: Princeton University Press.

Sobotka T., Skirbekk V., Philipov D., 2010. "Economic recession and fertility in the developed world. A literature review." *Vienna Institute for Demography*.

Solow, R., 1956, "A Contribution to the Theory of Economic Growth." *Quarterly Journal of Economics,* 65-94.

Stock J. H., Yogo M., 2002, "*Testing for Weak Instruments in Linear IV Regression."* NBER Working Paper No. T0284.

Thévenon O., 2010, "Work and family life reconciliation policies in OECD countries: from mixed means to balanced ends?", *Population and Development Review*, forthcoming.

Willis, R., 1973, "A new approach to the economic theory of fertility behaviour." *Journal of Political Economy* 81: S14-S64.