Australian National University

Crawford School of Public Policy

CAMA

Centre for Applied Macroeconomic Analysis

Determinants of fertility in the long run

CAMA Working Paper 70/2016
December 2016

Jong-Wha Lee
Korea University and
Centre for Applied Macroeconomic Analysis, ANU

Abstract

This study investigates the determinants of fertility in the long run, using a newly constructed panel data set consisting of fertility rates, measured as crude birth rates, infant mortality rates, per-capita income, and the educational attainment of men and women for 43 countries from 1890 to 2010 at five-year intervals. The regression results show the significant effects of per-capita income, infant mortality, educational attainment, and political development on fertility rates. A woman's educational attainment at the primary and secondary levels has a pronounced negative effect on fertility rates. On the contrary, an increase in a woman's tertiary educational attainment, with the level of a man's remaining constant, tends to raise fertility rates, indicating that highly educated women can have a better environment for childbearing and childrearing in a society with greater gender equality. The presented research thus identifies the important role of human capital accumulation, especially attained by women, in demographic transition through fertility decisions for over a century of human history.

Keywords

Economic Development, Education, Female Education, Fertility, Gender Inequality

JEL Classification

125, J13

Address for correspondence:

(E) cama.admin@anu.edu.au

ISSN 2206-0332

DETERMINANTS OF FERTILITY IN THE LONG RUN*

Jong-Wha Lee#

Korea University and

Centre for Applied Macroeconomic Analysis, Australian National University

November 2016

Abstract

This study investigates the determinants of fertility in the long run, using a newly constructed panel data set consisting of fertility rates, measured as crude birth rates, infant mortality rates, per-capita income, and the educational attainment of men and women for 43 countries from 1890 to 2010 at five-year intervals. The regression results show the significant effects of per-capita income, infant mortality, educational attainment, and political development on fertility rates. A woman's educational attainment at the primary and secondary levels has a pronounced negative effect on fertility rates. On the contrary, an increase in a woman's tertiary educational attainment, with the level of a man's remaining constant, tends to raise fertility rates, indicating that highly educated women can have a better environment for childbearing and childrearing in a society with greater gender equality. The presented research thus identifies the important role of human capital accumulation, especially attained by women, in demographic transition through fertility decisions for over a century of human history.

Keywords: Economic Development; Education; Female Education; Fertility; Gender Inequality

JEL classification: 125; J13

* The author would like to thank Robert Barro and the seminar participants at Nanyang Technological University for their helpful discussions and comments. I also thank Hanol Lee for research assistance.
# Economics Department, Korea University, 145 Anam-ro, Seongbuk-gu, Seoul 02841. Tel.: +82-2-32901600, Fax: +82-2-923-4661, E-mail: jongwha@korea.ac.kr

1. Introduction

Since the Industrial Revolution in the middle of the 18th century, the growth rates of per-capita income in Western Europe have increased markedly. This unprecedented income growth has been associated with a rapid demographic transition. Crude birth rates and fertility rates increased in most Western European countries until the second half of the 19th century (Galor 2005).[1] A dramatic acceleration in the pace of income and population growth then followed in other regions as industrialization spread globally.

Since the late 19th century, fertility rates have rapidly declined. In the post-Malthusian era, economic growth was associated with the acceleration of human capital accumulation. There was strong growth in average educational attainment worldwide for men in the first stage and then for women throughout the 20th century. Human capital accumulation thus contributed to the rapid decline in fertility rates. The rise in average education level, especially that of women, raised the opportunity costs of childbearing and thereby lowered fertility (Becker 1960; Becker and Lewis 1973). Moreover, technological progress increased demand for human capital and led parents to have fewer but better educated children (Galor and Weil 2000).

This study investigates empirically the determinants of fertility rates across countries and over time. Many studies have analyzed the determinants of fertility rates by estimating the relationship between fertility rates and socioeconomic factors. This study goes beyond previous works as it examines the determinants of fertility rates for a long-term period (over 120 years) by using a newly constructed panel data set consisting of fertility rates, infant mortality rates, per-capita income, and male and female educational attainment for 43 countries from 1890 to 2010.

---

[1] Galor (2005) describes three distinct regimes that have characterized the process of economic development over the long-run period of human history: the Malthusian Epoch, the Post-Malthusian Regime, and the Sustained Growth Regime.

Only a few studies, including Herzer et al. (2012), Murtin (2013), and Barro and Lee (2015), have empirically analyzed the determinants of fertility by using long-term cross-country data. Yet, these studies do not use comprehensive data on historical fertility rates and infant mortality rates. To bridge this gap in the literature, by using a variety of sources, this study compiles data for historical crude birth rates and infant mortality rates for a group of 43 countries since 1890 at five-year intervals. In the sample, 21 countries have complete data throughout the sample period from the 1890s and all the other countries have continuous data between 1930 and 2010.[2]

Among the potential determinants of fertility, this study highlights human capital for men and women at different education levels (primary, secondary, and tertiary) and its effect on fertility decisions for a large number of countries in the long run. For this, it uses the recent data set on educational attainment constructed by Lee and Lee (2016), disaggregated by gender and education level from 1870 to 2010.

The remainder of this paper is organized as follows. Section 2 reviews the theories and empirical evidence of the determination of fertility rates. Section 3 describes the data and empirical methodology adopted for the analysis and presents the empirical findings with their interpretations. Finally, Section 4 concludes.

2. Theories and Empirical Evidence of Fertility Determination

According to existing theories, the effect of income on fertility rates is predicted to be mixed. As suggested by Malthusian theory, demand for children increases with income level given the argument that higher income makes raising children more affordable to parents and society. By

[2] There are exceptions that have missing observations, mostly during the World War II period. See footnote 6 and Appendix 1.

considering children to be "durable consumer goods," most modern theories of demographic transition and economic growth predict that income has a positive effect on demand for children ("income effect"). However, raising children is costly not only in terms of monetary inputs, but also in terms of time inputs. The opportunity cost of parents' time is most crucial for raising children. As the relative price of children increases with economic development, demand for children among parents falls ("substitution effect"). If the negative substitution effect dominates the positive income effect, economic development is associated with decreasing fertility (and increasing otherwise). That is, the net effect of income on demand for children is negative since the cost of nurturing and educating each child becomes more expensive as income rises.

Families face the trade-off between having more children and having fewer, but better educated, children (Becker 1960; Becker and Lewis 1973; Becker and Barro 1988). Becker (1960) argues that as income increases, demand for both the quantity and the quality of children increases, whereas the income elasticity of quality outweighs the income elasticity of quantity.

Evidence on the relationship between income and fertility is also mixed. Earlier studies find that family size is negatively correlated with income. In the United States, for example, Becker (1960) observes that most data support this negative relationship. Becker et al. (2010) find a negative relation between enrolment rates in primary schools and fertility rates in Prussian counties in the late 19^{th} century, supporting the trade-off between the quantity and quality of children. By contrast, other studies find a positive empirical relationship between household income and fertility (e.g., Heckman and Walker 1990; Schultz 1997). Lindo (2010) finds that a large, permanent, and negative income shock due to the husband's job displacement has a negative impact on fertility. Murphy (2015) finds that income is positively correlated with fertility rates during the demographic transition in France, after controlling for education and mortality rates.

Theoretical models also suggest a negative relationship between women's relative wage rate and fertility. Because women are usually expected to spend more time on childrearing than men, a rise in women's relative wage leads to a much higher increase in the opportunity cost of women's time than that in average household income. In this context, higher female educational attainment, which contributes to reducing the relative gender wage gap and raising the opportunity cost of women, can reduce fertility. Galor and Weil (1996) suggest that economic development is associated with a reduction in the comparative advantage of men in production, thus increasing the opportunity cost of childrearing for women.

Better educated women are more likely to be aware of birth control methods and may also have greater bargaining power, thereby making their husbands consent to use contraceptives. An additional effect may come from the fact that teenage girls have a lower probability of getting pregnant than if they are not in school. However, the postponement of childbearing away from school years may have a negligible effect on total fertility over the lifetime of women.

On the contrary, more education for women can increase the educational attainment and income of their partners through assortative mating (Behrman and Rosenzweig 2002). A higher permanent income can make parents increase fertility if the income effect dominates the substitution effect. Highly educated women can substitute a significant part of their own parenting time with other people's time by purchasing market services to raise children and run their households, thereby enabling them to have more children (Hazan and Zoabi 2015).

Most of the empirical literature strongly supports the negative effect of a woman's education and relative wage on fertility. Schultz (1985) shows that the ratio of women's to men's wages contributed to the fertility decline across Sweden between 1860 and 1910. Ainsworth et al. (1996)

find that the primary and secondary education of girls has a negative relation with fertility and a positive relation with contraception use in 14 Sub-Saharan African countries. A study of Nigeria shows that primary educated girls tend to have fewer children (Osili and Long 2008). Murphy (2015) also finds that women's educational attainment had an adverse effect on fertility rates during the demographic transition in France. Amin and Behrman (2014) show that more educated women tend to have fewer children, using twin data in the United States.

However, other studies show more nuanced results. For instance, Barro and Lee (1994) find that the relation between fertility and female schooling is negative for low values of schooling, while the relation becomes positive for higher values, using panel data on sample countries. Shang and Weinberg (2013) show that highly educated women in the United States have tended to have more children, especially in older age, since the 1990s, controlling for other factors. Hazan and Zoabi (2015) find that the cross-sectional relationship between women's education and fertility in the United States between 2001 and 2011 is U-shaped and that the change in the relative cost of childcare accounts for much of the U-shaped pattern. McCrary and Royer (2011) compare mothers born just before and after the school entry date in the United States and conclude that female education has an insignificant effect on fertility.

There is a negative association between mortality and fertility when parents target an ideal family size (Kalemli-Ozcan 2003; Soares 2005). A higher infant mortality rate raises the number of births required to achieve a given number of survivors. Eckstein et al. (1999) find that the fall in child mortality has been the primary cause of the reduction in fertility in Sweden since the mid-19th century. Angeles (2010) shows that mortality changes have accounted for a major part of the fertility reductions in a number of countries since 1960.

Some studies consider the effect of the political and social environment on fertility decisions

(Przeworski 2000). For example, Beer (2009) finds that compared with autocracy, democracy is more likely to support gender equality and therefore promote labor participation among women. In turn, higher labor participation and wage rates for women are expected to lower fertility in countries with a high degree of democracy. Further, a society that is democratic and has lower corruption is more likely to provide resources for reproductive health and family planning.

The empirical literature on the determinants of fertility rates provides diverse findings depending on population size in different regions and time periods as well as empirical strategies. Hence, exploring the average relationship between per-capita income, infant mortality rates, educational attainment, and fertility rates across countries and in the long run is an interesting issue. However, few studies assess the determinants of fertility by using long-term cross-country data, notably because of data limitations. The longitudinal study by Herzer et al. (2012), using panel cointegration techniques and panel data on 20 countries spanning from 1900 to 1999, finds that mortality reduction and income growth contribute to the fertility decline. Murtin (2013) investigates the determinants of the demographic transition in the 20th century and finds primary schooling among the adult population to be most significant determinant of fertility rates. He uses an unbalanced sample of 70 countries, but only 16 advanced economies have complete data since 1870. Barro and Lee (2015) also attempt to explore the determinants of fertility, using unbalanced panel data on 40 countries since 1875, and find negative effects of female education on fertility, especially for countries with lower educational attainment. However, data for only 17 countries of the sample are available from 1945.

3. Estimation of Fertility Rates

A. Data and Estimation Method

The basic empirical model is represented by

$$Fert_{i,t} = \alpha + \beta_1 \log y_{i,t} + \beta_2 \log y_{i,t}^2 + \gamma Mort_{i,t} + \phi Demo_{i,t} + \delta Educ_{i,t} + \varepsilon_{i,t} \quad (1)$$

where $Fert_{\mathrm{it}}$ is the fertility rate measured as the logarithm of the crude birth rate of country i in period t,[3] y_{it} is the country's per-worker GDP at the beginning of the period, $\mathrm{Mort}_{\mathrm{it}}$ is the infant mortality rate, $Educ_{\mathrm{it}}$ denotes the average years of schooling among the total, male, and female populations aged 15–64, and $Democ_{\mathrm{it}}$ is a democracy indicator as a measure of political development. For the education variable, we also use educational attainment disaggregated by gender and education level: primary, secondary, and tertiary. The specification includes period dummies to control for common shocks to (common trends in) fertility rates in all countries.

Our regression of specification (1) applies to a panel set of cross-country data for 43 countries over 24 five-year periods from 1890 to 2010, corresponding to the periods: 1890–1894, 1895–1899. . ., 2000–2004, 2005–2009. Thus, the panel data set considers information that varies across time and country.

One concern in the empirical specification is that any effect from the explanatory variables may reflect reverse causation to them from fertility. For example, the relationship between contemporaneous fertility and infant mortality could be interpreted as fertility influencing infant mortality. This problem can be addressed by adopting the instrumental variable (IV) estimation technique. Note that this reverse causality may not be a serious concern for the education variables because average years of schooling for the adult population would be unaffected by contemporary fertility or educational investment decisions.

Omitted variable bias is the other concern. If we do not control for all the important factors explaining fertility rates, the estimates of the explanatory variables could be biased. For example,

3 Historical data are scarce for total fertility rates compared with crude birth rates.

religious and cultural factors, which are omitted from the specification because accurate measures are lacking, can affect not only fertility but also female educational attainment. This problem can be avoided by employing country fixed effects. If we assume that an omitted variable varies by country but is constant over time, the inclusion of a country fixed-effects term would eliminate this source of endogeneity bias.

To reduce bias sourced from reverse causality and omitted variables, this study thus employs the IV panel estimation with country fixed effects. The IV technique controls for the possible simultaneity problem when the explanatory variables are endogenously determined. Instruments are mostly lagged values of the independent variables.[4] As previously mentioned, the fixed-effects estimation technique is adopted under the assumption that unobserved country characteristics that influence fertility rates and are also correlated with explanatory variables are invariant over time.

Historical per-capita GDP data are sourced from Maddison (2010). I use Barro and Ursúa's (2012) macroeconomic data set to fill in missing observations.[5] Data on crude birth rates are compiled from three major sources: Reher (2004), the Committee for International Cooperation in National Research in Demography (1975), and the World Bank's World Development Indicators (WDI) (World Bank 2013). Additionally, I compile data prior to 1950 from the League of Nations (various years), World Heritage Encyclopedia (2016), and various national statistical publications. Data from United Nations (2015) are also used to fill in missing observations for

[4] Although the use of lagged values as instruments can address the problem of endogeneity to some extent, it is not satisfactory if there is strong serial correlation in the explanatory variables. However, it is practically difficult to construct an array of fully convincing exogenous instruments in this panel structure.

[5] The five countries are Egypt, Greece, Mexico, New Zealand, and Venezuela. Barro and Ursúa (2012) construct per-capita GDP data that cover 42 countries and are available from at least 1913 and in many cases from 1870 or earlier (www.rbarro.com/data-sets). By using the Barro and Ursúa per-capita GDP data as the main source along with the Maddison data in the regressions, the main results remain the same.

the period after 1960.

The historical data on infant mortality rates are compiled from Abouharb and Kimball (2007), Birn (2005), the Committee for International Cooperation in National Research in Demography (1975), Valaoras (1960), and national statistical publications. Additionally, I update the data on infant mortality rates by using the World Bank's WDI.

To construct per-worker GDP, I use data on population structure by age from Mitchell (2003a, 2003b, 2003c), United Nations (1955), and League of Nations (various years) for the period prior to 1950. Data from United Nations (2015) are used to construct the working age population from 1950.

Average years of school attainment for the overall population, women, and men are sourced from Lee and Lee (2016), who present a data set on educational attainment, disaggregated by education level (primary, secondary, and tertiary) and gender, for 111 nations and former colonies at five-year intervals from 1870 to 1945. By combining the historical estimates with the information from Barro and Lee (2013), they construct a complete time series of educational attainment up to 2010.

The measure of democracy is the Polity indicator, which is constructed as democracy less autocracy (converted from a -10 to +10 scale to a 0–1 scale, with 1 representing the highest level of democracy) (Polity IV Project 2016).

The full sample is composed of 43 countries that have historical data on per-capita GDP, fertility, mortality, educational attainment, and democracy since 1890. All sample countries have continuous data on per-capita GDP, fertility, mortality, and educational attainment from 1930 and

21 countries have complete data throughout the sample period, starting from the 1890s.[6] Appendix 1 lists the 43 countries.

Since the late 19th century, there has been a sharp decline in fertility rates globally along with remarkable growth in per-capita income and average educational attainment as well as a narrowing of the gender gap in average educational attainment. Figure 1 shows that crude birth rates have declined steadily in selected countries in Western Europe as well as in other regions since 1890. The figures in Appendix 2 present the changes in fertility rates for individual countries, most of which show a similar trend. In some countries, fertility rates declined during the Second World War and recovered quickly thereafter. The fall in fertility rates is also associated with the decrease in mortality rates (Figure 2).

<INSERT FIGURES 1 & 2 HERE>

Economic, social, and political developments led to a rapid expansion of educational attainment for the overall population in the late 19th century and the 20th century (Figure 3). Primary education began to spread globally in the first half of the 20th century, and secondary and tertiary education expanded in the latter half of that century (Barro and Lee 2015). Moreover, the acceleration in human capital accumulation occurred along with a narrowing of the gender gap in educational attainment worldwide in the 20th century (Figure 4).

<INSERT FIGURES 3 & 4 HERE>

During the modern economic growth era, unprecedented income growth was also associated with political developments. There was a broad tendency toward improvement in democracy

[6] The observations of per-capita GDP are missing in Poland and Romania during the Second World War period. Crude birth rates are not available for China for 1935‑1944 and Venezuela for 1895–1904. The democracy variables are missing for earlier years in a number of Asian countries: China (1937–1945), India (–1949), Korea (1911–1947), Taiwan (–1949), and Sri Lanka (–1947). The sample includes interpolated data on crude birth rates for Greece (1915–1919, 1920–1924) and infant mortality rates for Greece (1915–1919, 1920–1924) and Taiwan (1945‑1949).

globally in the 1990s, despite some deterioration during the World Wars. For many developing countries, political rights began to improve only from the 1980s (Figure 5).

<INSERT FIGURE 5 HERE>

Figure 6 examines whether the panel data confirm the theoretical predictions. Figure 6a shows that fertility, measured as the log of crude birth rates, is negatively related to per-capita income. Figure 6b indicates a strong positive relationship between infant mortality and fertility. Figure 6c demonstrates that fertility is negatively related to educational attainment. Figures 6d and 6e demonstrate that fertility decreases with both male and female education. Owing to the high correlation between average years of schooling for men and for women, the relationships in Figure 6d and 6e look similar. Finally, Figure 6f shows that fertility is negatively related to level of democracy, although the relationship is weak. By using Figure 6, it is thus hard to prove the causal relationships between these explanatory variables and fertility. To assess which variables are important factors for fertility changes, regression analysis is therefore conducted.

<INSERT FIGURE 6 HERE>

B. Regression Results

Table 1 presents the regression results in which the dependent variable is fertility, measured as the log of crude birth rates in period t, averaged over 1890–1894,…, 2005–2009. In 1890–1894, the mean of the dependent variable was 3.5, corresponding to a crude birth rate of 33.2; in 2005–2009, the mean was 2.6, or a crude birth rate of 13.5. The regressions are applied to an unbalanced panel of 43 countries over the 24 five-year periods from 1890 to 2010. I adopt a fixed-effects IV estimation technique to control for the unobserved country-specific factors.

<INSERT TABLE 1 HERE>

Column 1 in Table 1 includes the log of real per-capita GDP, its square term, total years of school attainment for the total population aged 15–64, and the infant mortality rate, as the independent variables. The results show a nonlinear effect of per-capita income on fertility. The coefficients of per-worker GDP and its square term are negative and positive, respectively. This configuration of coefficients indicates an initial decline and a subsequent rise in fertility with income, when the other variables are controlled for: the linear term of -0.606 (s.e. = 0.130) and squared term of 0.0349 (s.e. = 0.0072) imply that for low-income countries that operate in the range below a breakpoint of per-capita GDP of $4,637 per year (in 2005 U.S. dollars), an increase in income lowers fertility, for the given values of the other explanatory variables including education and infant mortality rates. In total, 23% of countries included in the regressions were in this range.

The negative impact of income on fertility rates implies that parents substitute quality of children for quantity with rising income. The substitution effect from the increased value of parents' time surpasses the income effect. However, it seems that the substitution effect dominates only in low-income countries, for the same levels of educational attainment. This regression result may indicate that the positive income effect eventually exceeds the negative substitution effect.[7] The positive income–fertility relationship may also reflect the greater availability of affordable childcare and high-fertile immigrants in high-income countries.

The results show a positive effect of infant mortality on fertility. The estimated coefficient of infant mortality is positive and statistically significant. This positive relationship suggests that parents need a small number of births to achieve the targeted number of children surviving into

[7] Murtin (2013) adds a cubic term of log per-worker income and finds that its estimated coefficient is positive, implying that the positive effect of income on fertility is accelerating in higher-income countries. However, its estimated coefficient is statistically insignificant in the sample of the balanced panel of 16 countries. In our analyses, the estimated coefficients of the cubic term appear negative and often statistically insignificant.

adulthood.

Further, there is a strong negative effect of overall schooling on fertility. The estimated coefficient is negative and statistically significant, -0.0422 (0.0087). The higher education level is, for the given income and infant mortality, the lower is the fertility rate.

Column 2 adds level of democracy as an independent variable into the specification. There is strong evidence of a negative effect of democracy on fertility. This evidence seems to support that more democratic environments tend to reduce fertility by providing lower gender imbalance and higher female labor force participation. Although the magnitude becomes smaller, the estimates of other explanatory variables are the same.

Columns 3 and 4 add primary, secondary, and tertiary education separately. The estimated coefficients of the primary and secondary schooling variables are negative and statistically significant: -0.064 (0.010) and -0.033 (0.014). By contrast, the tertiary education term is positive and statistically insignificant: 0.0029 (0.055). Hence, the negative effect of schooling on fertility occurs mostly through educational attainment at the primary and secondary levels. Column 4 also shows the significant negative effect of democracy on fertility.

In Columns 5–8 of Table 1, the schooling variables for men and women are entered separately, with level of democracy controlled for. Column 5 includes average years of schooling for men and women. The estimated coefficient of the average years of schooling of women, -0.0571 (0.0143), is negative and statistically significant, whereas that of men, 0.0152 (0.0141), is statistically insignificant. Hence, female education alone has a strong negative effect on fertility rates.

The negative effect of female education on fertility must reflect the rising opportunity cost of time for women. Women who obtain more education are more likely to have knowledge of birth control and greater intrahousehold bargaining power. On the contrary, the positive, although statistically insignificant, effect of male schooling on fertility may suggest that the substitution effect on fertility from a higher value of a man's time is negligible because men, especially in developing countries, tend to spend a small proportion of their time on childrearing.

Column 6 includes the primary, secondary, and tertiary schooling of women and the average schooling years of men. The estimated coefficients of female educational attainment at the primary and secondary levels are negative and statistically significant. On the contrary, those of female educational attainment at the tertiary level are positive and statistically insignificant. These results indicate that the negative effect of female education on fertility is more pronounced at the primary and secondary levels. The positive relation between a woman's tertiary education and fertility may support the argument that higher household income (which is not captured by average per-capita income) helps tertiary-educated women buy childcare services in the market. The effect of the average schooling years of men on fertility remains statistically insignificant, for the given female education and income.

Column 7 includes the primary, secondary, and tertiary schooling of men and the average schooling years of women. The estimated coefficient of women's average years of schooling is negative and statistically significant. The estimated coefficients of male primary and secondary education are positive, while that of male tertiary education is negative; however, all the estimated coefficients are statistically insignificant.

Column 8 includes primary, secondary, and tertiary education for women and men.[8] When all six female and male educational attainment variables enter together, the estimated coefficients of female primary and secondary education are negative and statistically significant, while those

[8] There is a high correlation between male and female education at each education level. For example, the correlation between male and female tertiary educational attainment is 0.97.

of male primary and secondary education are positive and statistically insignificant. Hence, the educational attainment of women at the primary and secondary levels has a strong negative effect on fertility rates. Interestingly, in this specification, the estimated coefficient of female tertiary education is positive and statistically significant, while that of male tertiary education is negative and statistically significant. Thus, given the same level of male educational attainment, an increase in a woman's attainment at the tertiary level raises fertility rates. The estimated coefficients of female and male tertiary education are of a similar magnitude with the opposite signs: 0.243 (0.106) and -0.252 (0.104), respectively. Hence, an increase in both male and female tertiary education by an equal amount does not have a significant effect on fertility, while an increase in the ratio of female-to-male tertiary education leads to higher fertility. This finding may suggest that a society with greater gender equality in educational attainment at the tertiary level provides a better environment for childbearing and childrearing.

4. Concluding Remarks

This study assesses what determines fertility rates in the long run, using a newly constructed panel data set consisting of fertility rates, measured in crude birth rates, infant mortality rates, per-capita income, and male and female educational attainment for 43 countries from 1890 to 2010 at five-year intervals.

Since the late 19th century, fertility rates have declined rapidly along with significant mortality decline, strong income growth, and the acceleration of human capital accumulation. Unprecedented income growth has also been associated with global progress in spreading democracy, although democracy deteriorated in many countries during some periods.

The empirical analysis confirms the causal relationships between economic, social, and political developments and fertility rates. The panel regression results show that per-capita income, infant mortality, educational attainment, and political development have significant effects on fertility rates. There is also strong evidence of the negative effect of female educational attainment at the primary and secondary levels on fertility rates.

The interactions among income, human capital accumulation, and fertility rates have played an important role in many countries' industrialization and demographic transitions. Our research identifies the important role of human capital accumulation, especially attained by women, in demographic transition through fertility decisions for over a century of human history.

Many governments have pursued policy measures to improve female education and reduce gender inequality in education. These policies contribute to improving the quality of labor as well as social welfare, thereby promoting economic growth. However, there is concern that some policies may lower fertility rates, thus reducing long-term growth potential. Against this background, this study shows that an increase in the ratio of a woman's education at the tertiary level relative to a man's raises fertility rates, rather than reducing them. This finding suggests that in a society with greater gender equality, highly educated women can have a better environment for childbearing and childrearing.

Owing to the limited availability of the historical data set used in this study, it is unable to assess the impact of government policies and social environments on fertility rates and the exact mechanism through which economic, social, and political developments affect fertility rates. A more accurate assessment would require long-run micro-level data and better quality measures of economic, social, and political developments.

References

Abouharb, M. R., & Kimball, A. L. (2007). A new dataset on infant mortality rates, 1816–2002. Journal of Peace Research, 44(6), 743–754.

Ainsworth, M., Beegle, K., & Nyamete, A. (1996). The impact of women's schooling on fertility and contraceptive use: A study of fourteen sub-Saharan African countries. The World Bank Economic Review, 10(1), 85–122.

Amin, V., & Behrman, J. R. (2014). Do more-schooled women have fewer children and delay childbearing? Evidence from a sample of U.S. twins. Journal of Population Economics, 27, 1–31.

Angeles, L. (2010). Demographic transitions: Analyzing the effects of mortality on fertility. Journal of Population Economics, 23, 99–120.

Barro, R. J., & Lee, J. W. (2013). A new data set of educational attainment in the world, 1950-2010. Journal of Development Economics, 104, 184–198.

Barro, R. J., Lee, J. W. (2015). Education matters: Global schooling gains from the 19th to 21st century. New York: Oxf. Univ. Press.

Barro, R. J., & Lee, J. W. (1994). Sources of economic growth. Carnegie Rochester Conference Series on Public Policy, 40, 1–46.

Barro, R. J., & Ursúa, J. F. (2012). Rare macroeconomic disasters. Annual Review of Economics, 4(1), 83–109.

Becker, G. S. (1960). An economic analysis of fertility. In National Bureau of Economic Research, Demographic and economic change in developed countries (pp. 209–231). Princeton: Princeton University Press.

Becker, G. S., & Lewis, H. G. (1973). On the interaction between the quantity and quality of children. Journal of Political Economy, 81(2), 279–288.

Becker, G. S., & Barro, R. J. (1988). A reformulation of the theory of fertility. The Quarterly Journal of Economics, 103(1), 1–25.

Becker, S. O., Cinnirella, F., & Woessmann, L. (2010). The trade-off between fertility and education: Evidence from before the demographic transition. Journal of Economic Growth, 15(3), 177–204.

Beer, C. (2009). Democracy and gender equality. Studies in Comparative International Development, 44(3), 212–227.

Behrman, J. R., & Rosenzweig, M. R. (2002). Does increasing women's schooling raise the schooling of the next generation? American Economic Review, 92(1), 323–334.

Birn, A. E. (2005). Uruguay on the world stage: How child health became an international priority. American Journal of Public Health, 95(9), 1506–1517.

Committee for International Cooperation in National Research in Demography. (1975). 1974 Country Monographs. http://www.cicred.org/Eng/Publications/content/3MonographNational/Index.html (accessed June 27, 2016).

Eckstein, Z., Mira, P., & Wolpin, K. I. (1999). A quantitative analysis of Swedish fertility dynamics: 1751–1990. Review of Economic Dynamics, 2(1), 137–165.

Galor, O. (2005). The transition from stagnation to growth: Unified growth theory. Handbook of Economic Growth, 1, 171–293.

Galor, O., & Weil, D. N. (1996). The gender gap, fertility, and growth. American Economic Review, 86(3), 374–387.

Galor, O., & Weil, D. N. (2000). Population, technology, and growth: From the Malthusian regime to the demographic transition and beyond. American Economic Review, 90(4), 806–828.

Hazan, M., & Zoabi, H. (2015). Do highly educated women choose smaller families? The Economic Journal, 125(587), 1191–1226.

Heckman, J. J., & Walker, J. R. (1990). The relationship between wages and income and the timing and spacing of births: Evidence from Swedish longitudinal data. Econometrica, 58(6), 1411–1441.

Herzer, D., Strulik, H., & Vollmer, S. (2012). The long-run determinants of fertility: One century of demographic change 1900–1999. Journal of Economic Growth, 17(4), 357–385.

Kalemli-Ozcan, S. (2003). A stochastic model of mortality, fertility, and human capital investment. Journal of Development Economics, 70(1), 103–118.

Lee J.-W., & Lee, H. (2016). Human capital in the long run, Journal of Development Economics, 122, 147–169.

League of Nations (various years). Statistical Yearbook of the League of Nations. Geneva.

Lindo, J. M. (2010). Are children really inferior goods? Journal of Human Resources, 45(2), 301–327.

Maddison, A. (2010). Historical statistics of the world economy: 1-2008 AD. http://www.ggdc.net/maddison/oriindex.htm (accessed July 1, 2013).

McCrary, J., & Royer, H. (2011). The effect of female education on fertility and infant health: Evidence from school entry policies using exact date of birth. The American economic review, 101(1), 158-195.

Mitchell, B. R. (2003a). International historical statistics: Africa, Asia and Oceania 1750–2000, 4th ed. London, UK: Palgrave Macmillan.

Mitchell, B. R. (2003b). International historical statistics: The Americas 1750–2000, 5th ed. London, UK: Palgrave Macmillan.

Mitchell, B. R. (2003c). International historical statistics: Europe 1750–2000, 5th ed. London, UK: Palgrave Macmillan.

Murphy, T. E. (2015). Old habits die hard (sometimes). Journal of Economic Growth, 20(2), 177–222.

Murtin, F. (2013). Long-term determinants of the demographic transition, 1870–2000. Review of Economics and Statistics, 95(2), 617–631.

Osili, U. O., & Long, B. T. (2008). Does female schooling reduce fertility? Evidence from Nigeria. Journal of Development Economics, 87(1), 57–75.

Polity IV Project (2016). Political Regime Characteristics and Transitions, 1800–2015. http://www.systemicpeace.org/inscrdata.html.

Przeworski, A. (2000). Democracy and development: Political institutions and well-being in the world, 1950–1990 (Vol. 3). Cambridge: Cambridge University Press.

Reher, D. S. (2004). The demographic transition revisited as a global process. Population, Space and Place, 10(1), 19–41.

Schultz, T. P. (1985). Changing world prices, women's wages, and the fertility transition: Sweden, 1860–1910. The Journal of Political Economy, 93(6), 1126–1154.

Schultz, T. P. 1997. Demand for children in low income countries. Handbook of Population and Family Economics, 1(1), 349–430.

Shang, Q., & Weinberg, B. A. (2013). Opting for families: Recent trends in the fertility of highly educated women. Journal of Population Economics, 26(1), 5–32.

Soares, R.R. (2005). Mortality reductions, educational attainment, and fertility choice. American Economic Review, 95(3), 580–601.

United Nations (1955). Demographic yearbook. New York: United Nations.

United Nations (2015). World Population Prospects: The 2015 Revision. https://esa.un.org/unpd/wpp/ (accessed June 27, 2016).

Valaoras, V. G. (1960). A reconstruction of the demographic history of modern Greece. The Milbank Memorial Fund Quarterly, 38(2), 115–139.

World Bank (2013). World Development Indicators 2013. Washington, DC: World Bank.

World Heritage Encyclopedia (2016). http://www.worldheritage.org/ (accessed June 27, 2016).

Table 1 Cross-country Panel Regressions for Fertility, 1890–2010

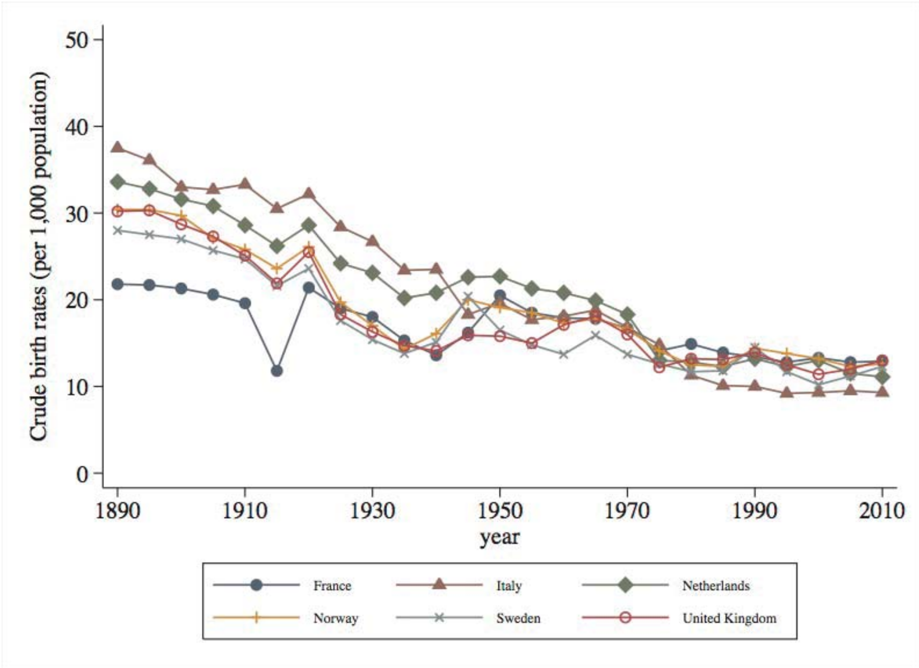
	(1)	(2)	(3)	(4)
Log(initial per-worker GDP)	-0.606***	-0.629***	-0.321*	-0.519***
	(0.130)	(0.133)	(0.172)	(0.179)
Log(initial per-worker GDP) squared	0.0349***	0.0381***	0.0183*	0.0317***
	(0.00724)	(0.00741)	(0.00977)	(0.0103)
Log(Infant mortality rate)	0.279***	0.293***	0.285***	0.298***
	(0.0234)	(0.0253)	(0.0242)	(0.0262)
Democracy indicator		-0.129***		-0.121***
		(0.0332)		(0.0360)
Total school years, 15–64 aged	-0.0482***	-0.0422***		
	(0.00820)	(0.00874)		
Total primary school years, 15–64 aged			-0.0641***	-0.0487***
			(0.0102)	(0.0109)
Total secondary school years, 15–64 aged			-0.0326**	-0.0334**
			(0.0138)	(0.0142)
Total tertiary school years, 15–64 aged			0.0293	-0.0228
			(0.0551)	(0.0584)
No. of obs.	901	857	901	857

Notes: The regressions are applied to an unbalanced panel consisting of data from 43 countries over the 24 five-year periods from 1890 to 2010. A fixed-effects IV estimation technique is employed to control for the unobserved country-specific factors. The dependent variable is the log of total fertility rates averaged over 1890–1894, 1895–1990. . ., 2005–2009. Per-worker GDP is for 1890, 1895, . . ., 2005. The values for 1889, 1894, . . ., 2004 are used as instruments. Other regressors are averages over periods, with lagged values used as instruments. Period dummies are included. Standard errors are in parentheses. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

	(5)	(6)	(7)	(8)
Log(initial per-worker GDP)	-0.573***	-0.394**	-0.563***	-0.346*
	(0.134)	(0.188)	(0.166)	(0.190)
Log(initial per-worker GDP) squared	0.0350***	0.0245**	0.0345***	0.0218**
	(0.00744)	(0.0108)	(0.00953)	(0.0110)
Log(Infant mortality rate)	0.282***	0.280***	0.286***	0.276***
	(0.0254)	(0.0264)	(0.0264)	(0.0267)
Democracy indicator	-0.123***	-0.108***	-0.124***	-0.108***
	(0.0330)	(0.0360)	(0.0352)	(0.0359)
Female school years, 15–64 aged	-0.0571***		-0.0558***	
	(0.0143)		(0.0146)	
Male school years, 15–64 aged	0.0152	0.0162		
	(0.0141)	(0.0144)		
Female primary school years, 15–64 aged		-0.0662***		-0.0780***
		(0.0156)		(0.0219)
Female secondary school years, 15–64 aged		-0.0572***		-0.0668**
		(0.0199)		(0.0340)
Female tertiary school years, 15–64 aged		0.0193		0.243**
		(0.0559)		(0.106)
Male primary school years, 15–64 aged			0.0126	0.0273
			(0.0160)	(0.0202)
Male secondary school years, 15–64 aged			0.0196	0.0377
			(0.0165)	(0.0326)
Male tertiary school years, 15–64 aged			-0.00220	-0.252**
			(0.0581)	(0.104)
No. of obs.	857	857	857	857

Figure 1 Change in Crude Birth Rates, Selected Economies, 1890–2010

a. France, Italy, the Netherlands, Norway, Sweden, and the United Kingdom



b. Argentina, Australia, Egypt, India, Japan, and the United States

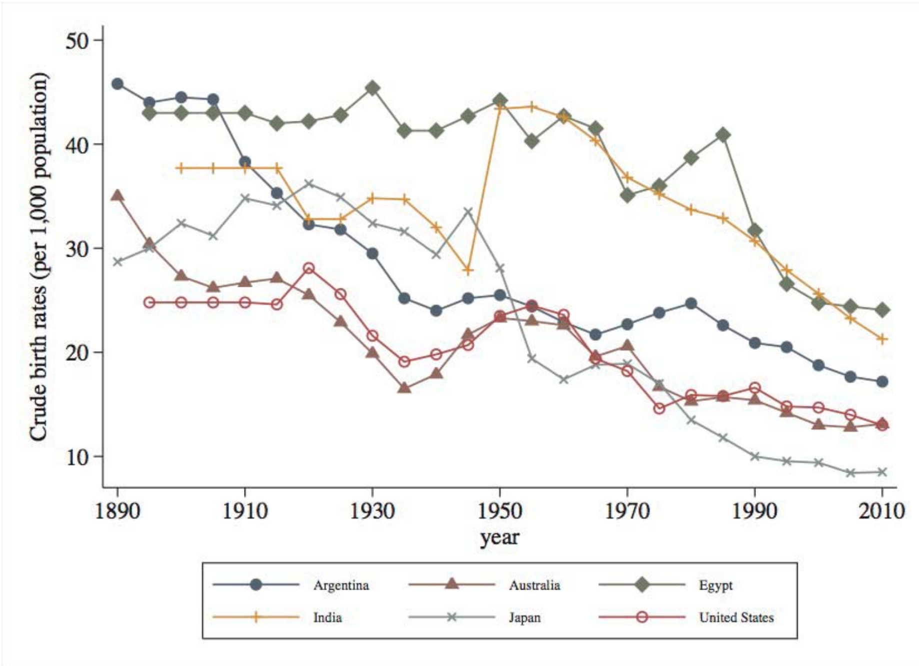
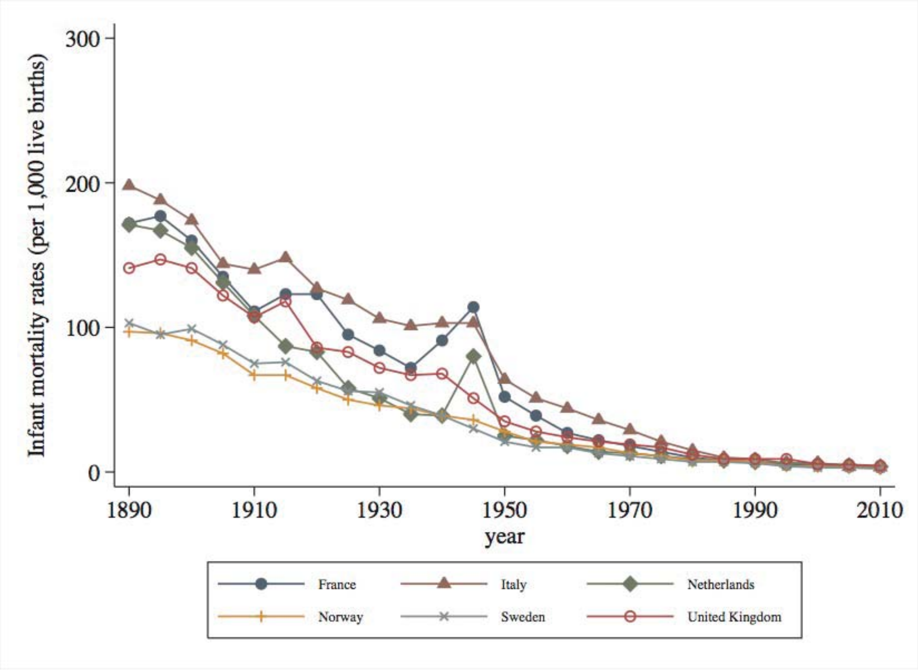


Figure 2 Changes in Infant Mortality Rates, Selected Economies, 1890–2010

a. France, Italy, the Netherlands, Norway, Sweden, and the United Kingdom



b. Argentina, Australia, Egypt, India, Japan, and the United States

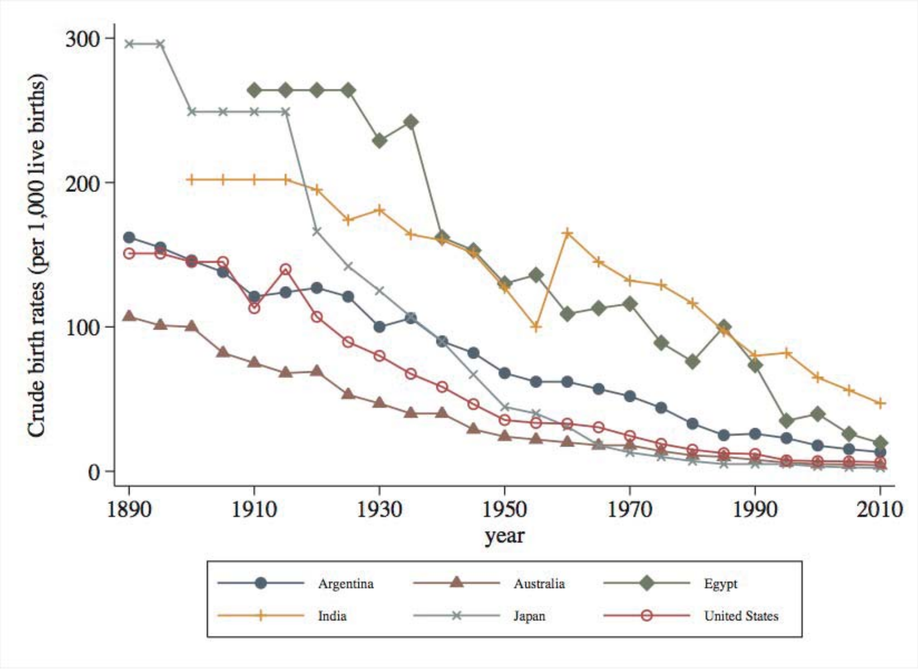
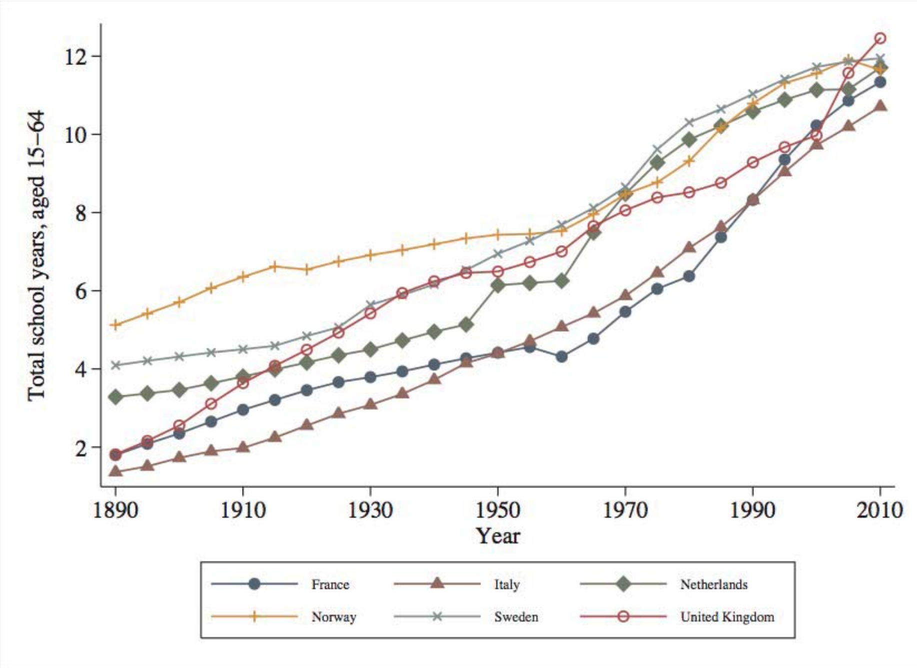


Figure 3 Trends in Educational Attainment for the Population Aged 15–64, Selected Economies, 1890–2010

a. France, Italy, the Netherlands, Norway, Sweden, and the United Kingdom



b. Argentina, Australia, Egypt, India, Japan, and the United States

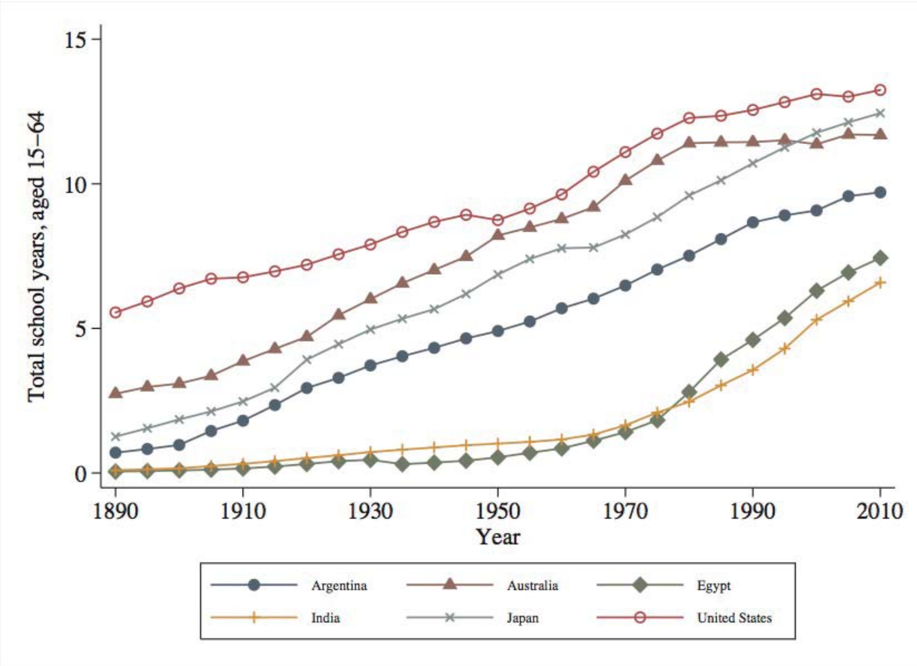
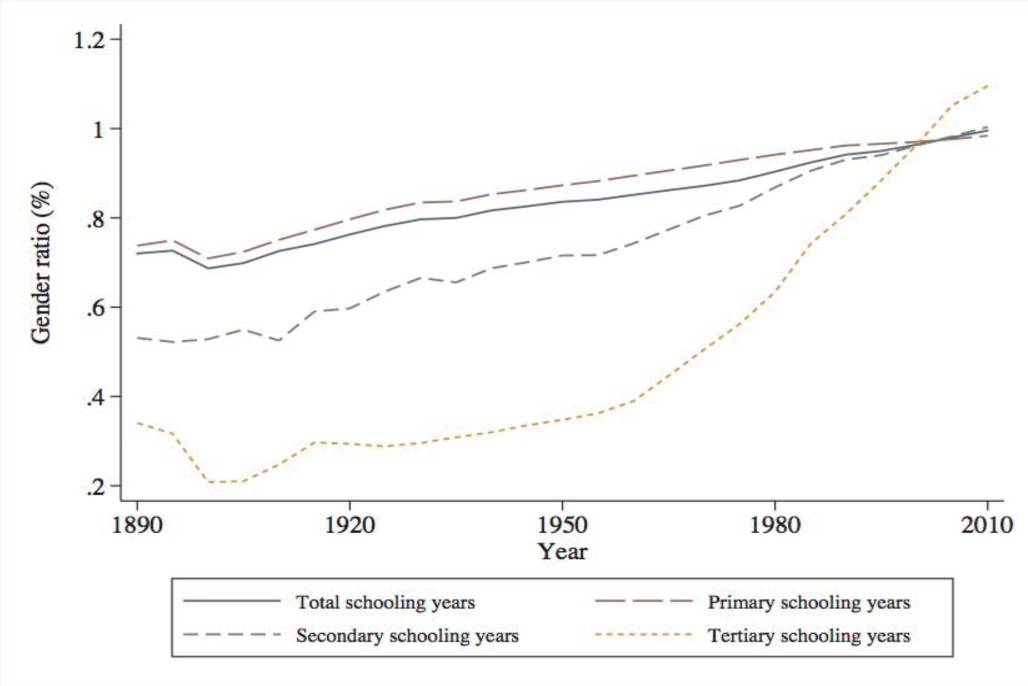
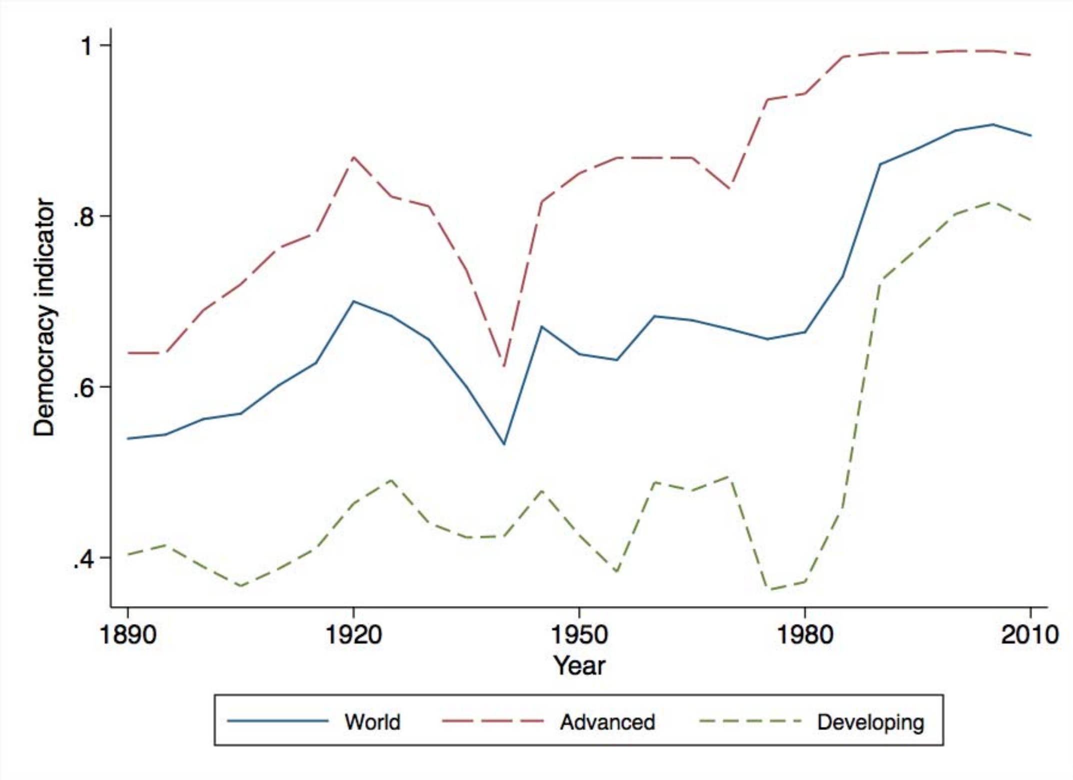


Figure 4 Trends in Gender Ratios in Educational Attainment Worldwide, 1890–2010



Note: The figures are the simple averages of the ratios between average years of schooling for women and those for men by education level among the sample of 43 countries that have at least one observation over the whole period at five-year intervals.

Figure 5. Evolution of Democracy, 1890–2010.

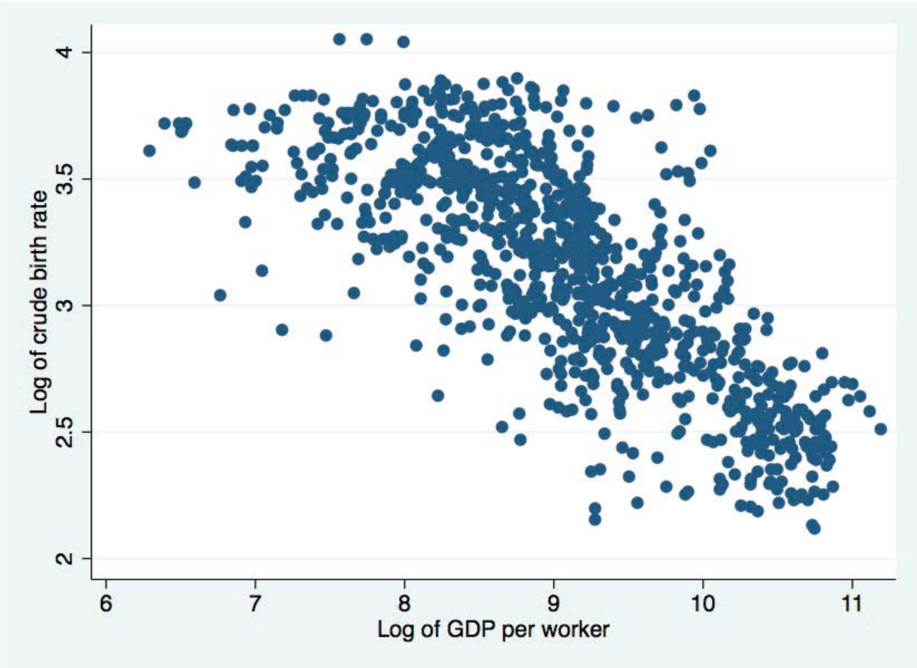


Source: Polity IV project (www.systemicpeace.org).

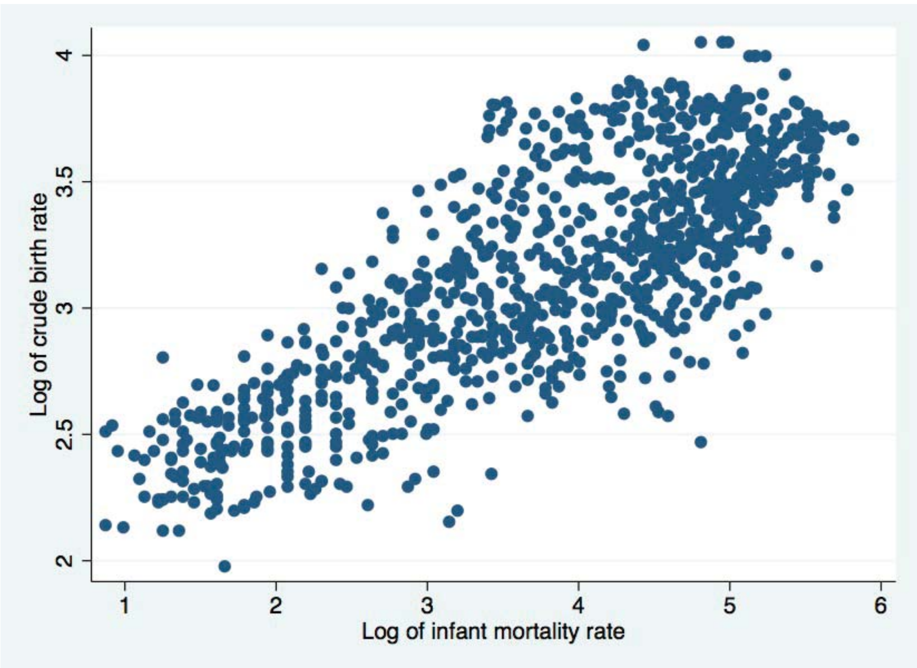
Notes: The figures are the simple averages of the democracy index (on a 0–1 scale, with 1 representing the highest level of democracy) among the sample of 43 countries that have at least one observation over the whole period at five-year intervals. The group of "advanced countries" includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

Figure 6. Relationships of Log Crude Birth Rates with Income, Infant Mortality, Educational Attainment, and Democracy, 1890–2010

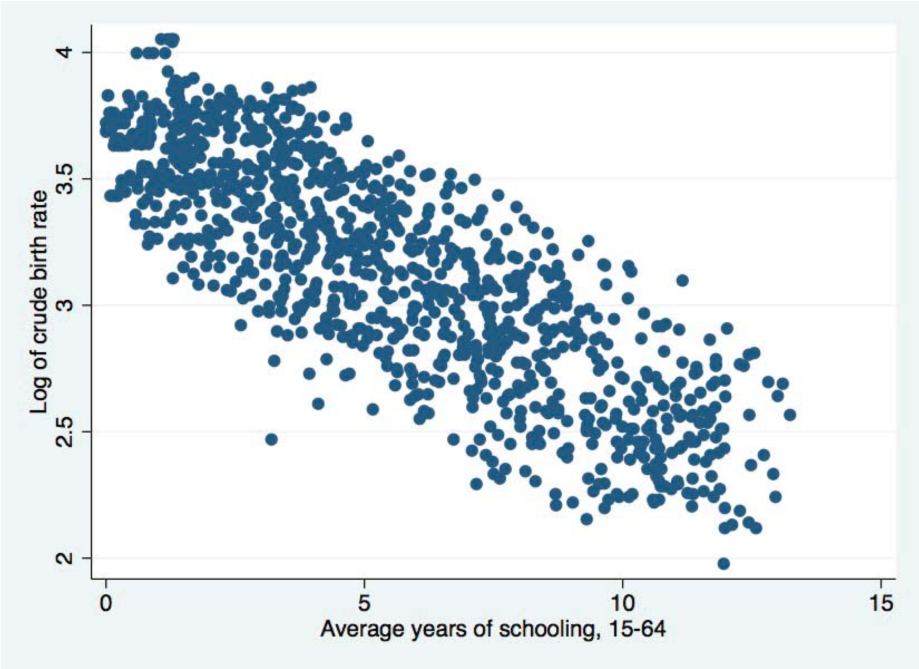
a. Per-worker GDP



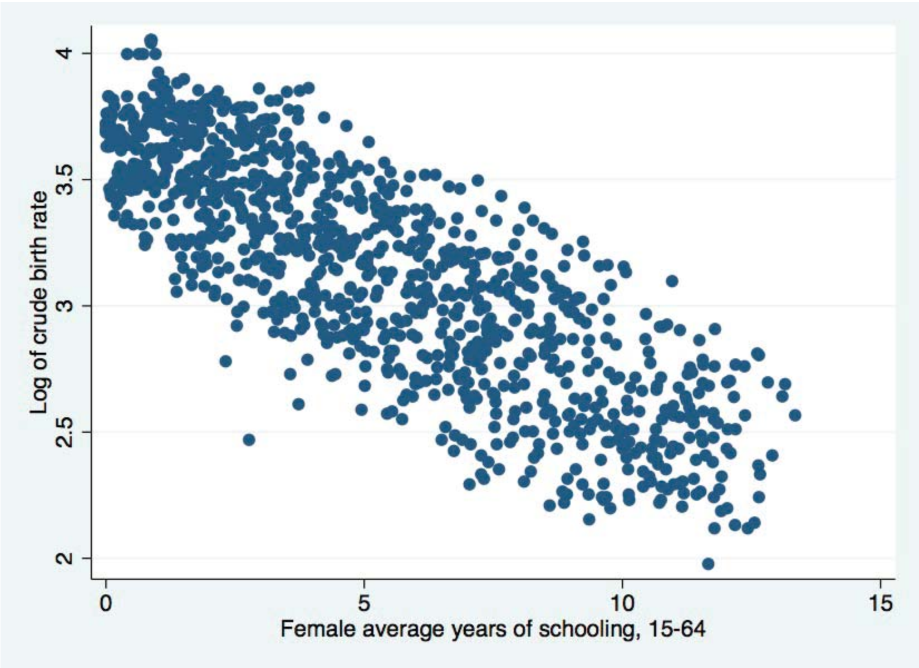
b. Infant Mortality Rate



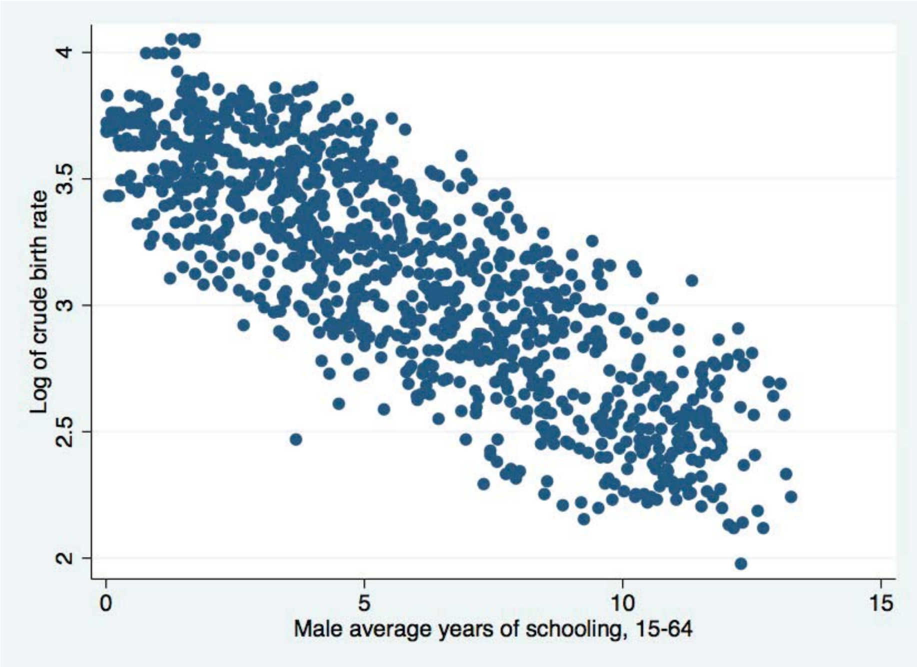
c. Average Years of Schooling



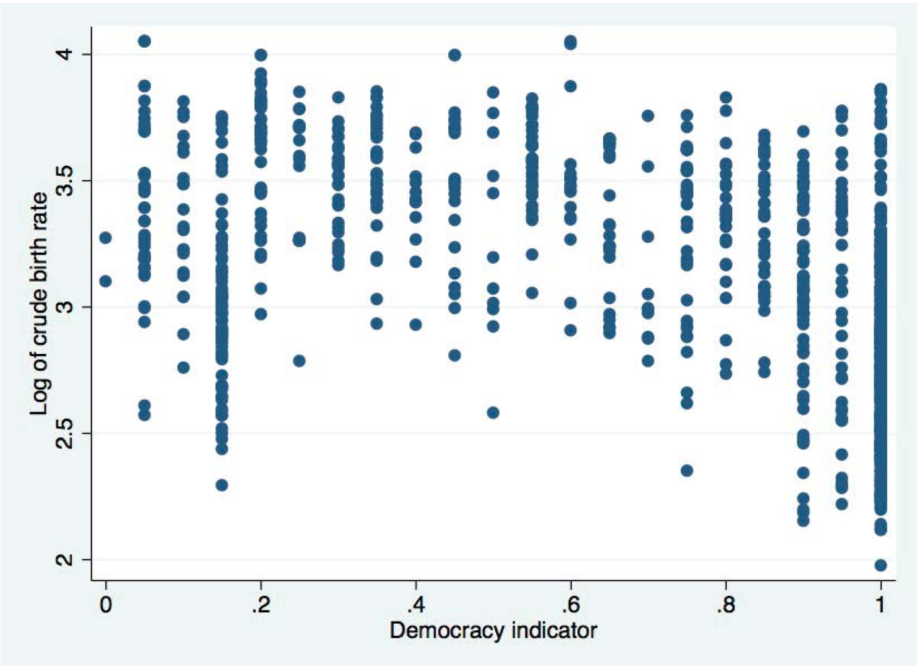
d. Female Average Years of Schooling



e. Male Average Years of Schooling



f. Democracy

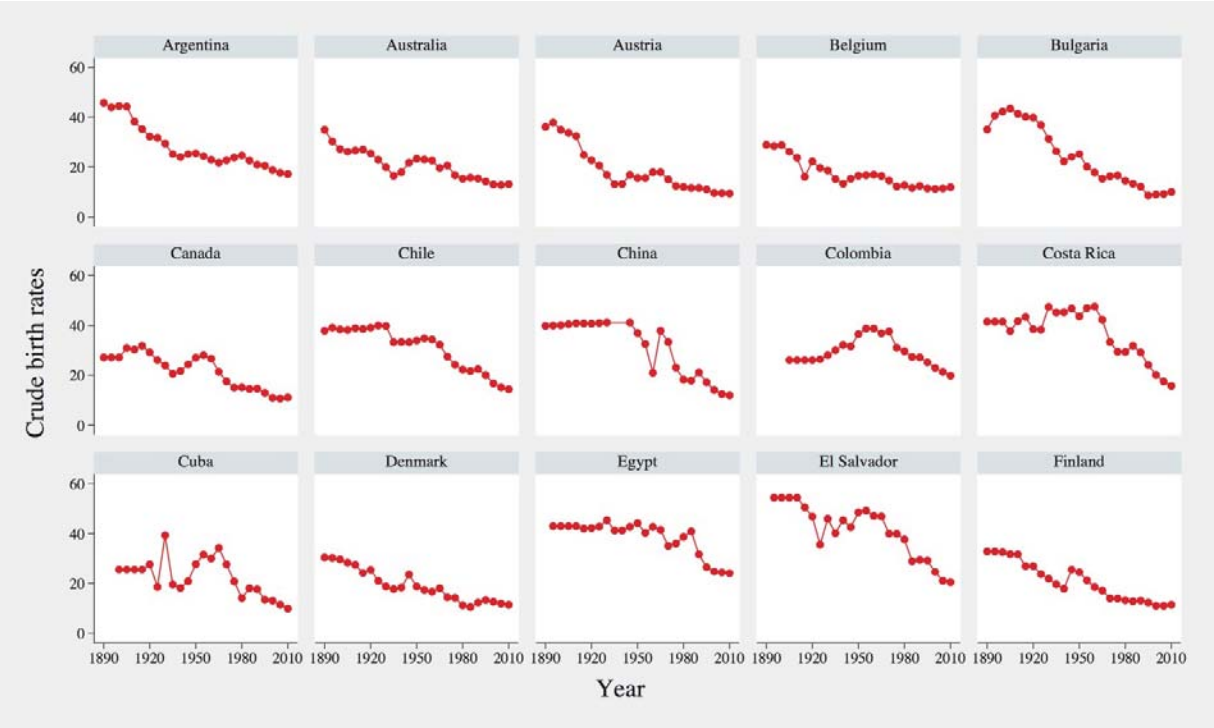


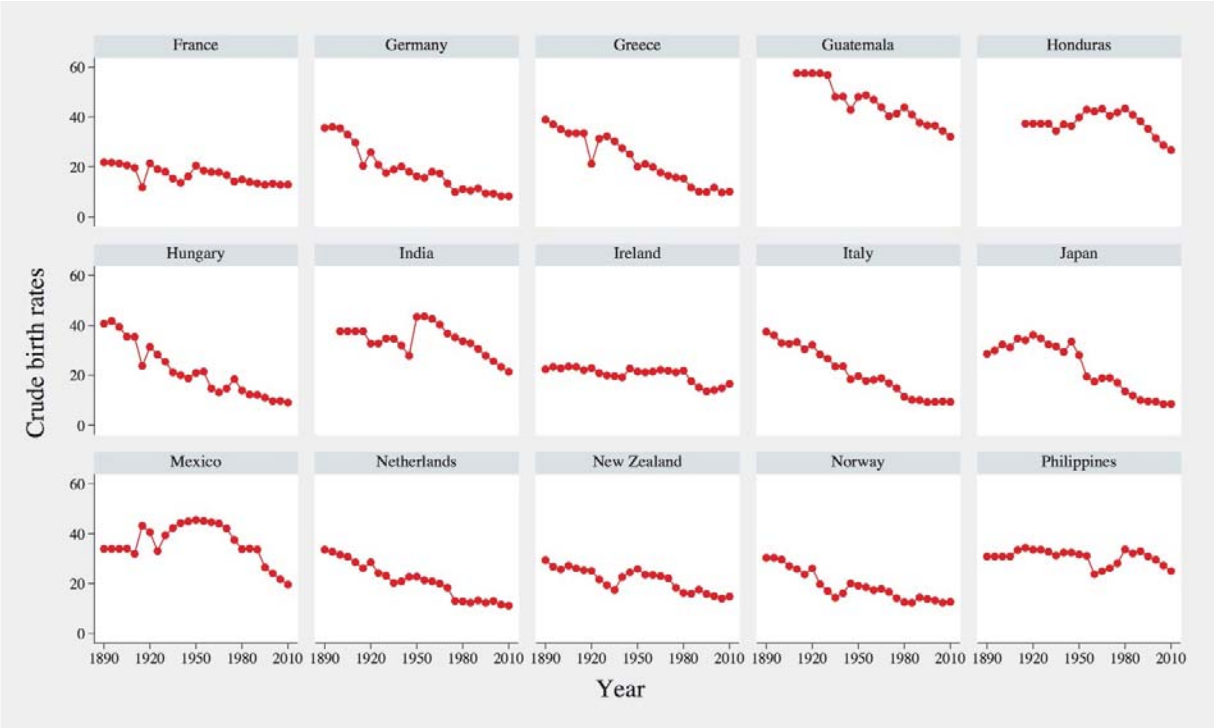
Appendix 1. Sample of the 43 Economies used for the Regressions

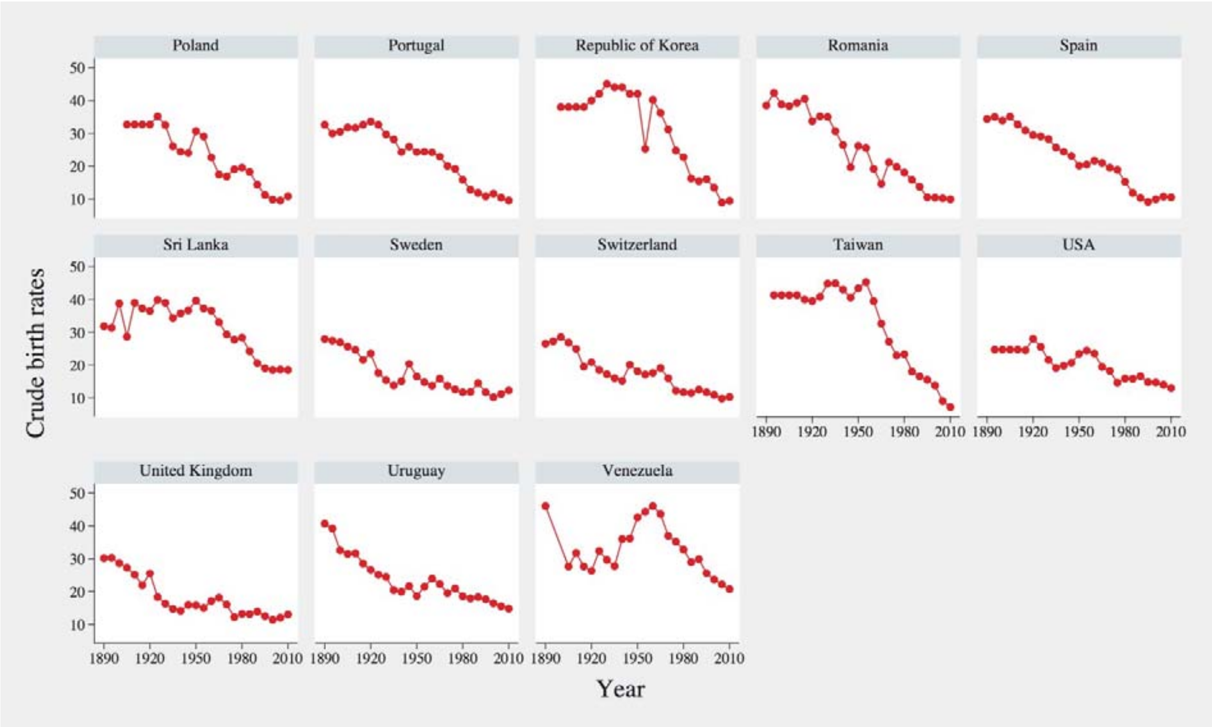
Country	Data Available Since	Country	Data Available Since
Argentina	1890–1894	Ireland	1925–1929
Australia	1890–1894	Italy	1890–1894
Austria	1890–1894	Japan	1890–1894
Belgium	1890–1894	Mexico	1900–1904
Bulgaria	1925–1929	Netherlands	1890–1894
Canada	1900–1904	New Zealand	1890–1894
Chile	1890–1894	Norway	1890–1894
China[a]	1925–1929	Philippines	1905–1909[a]
Colombia	1920–1924	Poland[b]	1930–1934
Costa Rica	1925–1929	Portugal	1900–1904
Cuba	1930–1934	Republic of Korea	1925–1929
Denmark	1890–1894	Romania[b]	1930–1934
Egypt	1925–1929	Spain	1890–1894
El Salvador	1925–1929	Sri Lanka	1900–1904
Finland	1890–1894	Sweden	1890–1894
France	1890–1894	Switzerland	1890–1894
Germany	1890–1894	Taiwan	1905–1909
Greece	1890–1894	United Kingdom	1890–1894
Guatemala	1925–1929	United States	1905–1909
Honduras	1930–1934	Uruguay	1895–1899
Hungary	1925–1929	Venezuela[c]	1890–1894
India	1910–1914		

Notes: *a* The sample does not include the period of 1935–1944 because crude birth rates are not available.
b The sample does not include the periods of the World War II (1940–1944, 1945–1949) because per-capita GDP data are not available.
c The sample does not include the period of 1895–1904 because crude birth rates are not available.

Appendix 2: Trends of Crude Birth Rates for Individual Countries, 1890–2010







Poland
Portugal
Republic of Korea
Romania
Spain
Sri Lanka
Sweden
Switzerland
Taiwan
USA
United Kingdom
Uruguay
Venezuela
Crude birth rates
Year
50
40
30
20
10
1890
1920
1950
1980
2010