“Backslanted X” Fertility Dynamics and Macroeconomics

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Abstract

A large number of pairs of countries exhibit a dynamic pattern in which: (i) Fertility in both countries declines across time; (ii) Initially one country has higher fertility and lower per-capita income compared to the other; (iii) In time, as per-capita income converges, fertility rates in the poorer country become lower than in the richer one.

This paper provides statistics on the prevalence of such dynamics and a theoretical model in which these dynamics emerge endogenously. Assuming that countries differ in the degree of utility substitution between consumption and rearing children is sufficient to generate all three components of these dynamics.

Key words: Fertility, Human Capital, Economic Growth.

J. E. L. Classification: J11, J13, O40.

1. Introduction

In 1965 the output per capita ratio between Spain and the UK was 0.463. By the year 2000 this ratio rose to 0.807. A switch of the "Fertility Dominance" between these two countries accompanied this convergence: The World Bank data show that until 1984 the total fertility rate (TFR) in Spain was higher than in the UK, but since then the TFR in the UK exceeds that of Spain. Since fertility in both countries has been mostly decreasing since the 1960s – the resulting dynamics display the following "Backslanted X" shape.

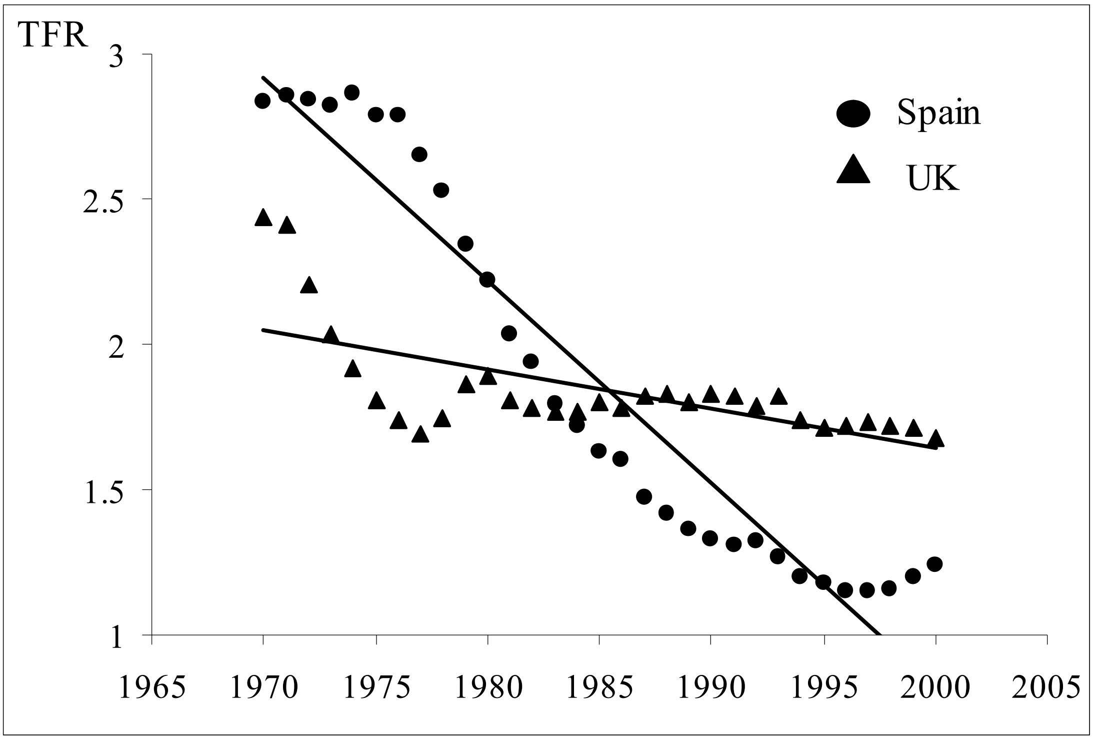

Figure 1: Total Fertility Rates (TFR) in Spain and the UK. Source: World Bank data.

More World Bank data, analyzed in detail in section 2 of this paper, show that such a joint output and fertility dynamics can be found among a substantial number of pairs of countries. In this paper I show how a single factor can be responsible for the three different components of these "Backslanted X" fertility dynamics in which: Fertility in both countries A and B declines across time; initially A has a higher fertility and lower output per capita than B; later, fertility in A becomes lower in B as output converges. Specifically, this factor is that the individuals in A have a stronger preference for consumption, rather than for rearing and educating children, compared to their counterparts in B.

Although the endogenous growth literature offers many articles trying to account for the observed fertility dynamics, the "Backslanted X" fertility dynamics has not been noticed by this literature yet.[1,2] The utter majority of the growth literature theoretical articles predict a negative link across time between fertility rates and per-capita output.[3] Therefore, these articles can account for the "Backslanted X" fertility dynamics only if they assume, as done in the current paper, cross country differences in model parameters, rather than in initial conditions.

In the theoretical model developed in this paper the co-existence of endogenous consumption, investment and fertility severely limits the ability to analyze in detail the transition towards the steady state, which is an essential part of the Backslanted X dynamics.[4] Thus, several simplifying assumptions are taken in the current model, making the accumulation of human capital the sole source of growth. This growth process is gradual since acquiring education is assumed costly, where the

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[1]For theoretical articles that study the dynamics of fertility treating it as an endogenous variable and analyzing its dynamics within a dynamic macroeconomic framework see for example Becker, Murphy and Tamura (1990), Galor and Weil (1996, 2000), Galor and Moav (2002) and Moav (2004).

[2] Several studies have come near the "Backslanted X" fertility dynamics when dealing with the reversal of the relationship between fertility and female labor participation among OECD countries. This relation was negative until the beginning of the 1980s but has turned positive since. See for example Del Boca (2002), Adserà (2004) and Apps and Rees (2004). Some of these studies merely document this reversal and others also provide explanations for the recent positive link, but none of them tries to explain the transition from the previous negative link to the current positive one.

[3] Several article, e.g., Galor and Weil (2000) do find that that income effects may generate a positive link between per-capita output and fertility. This positive relation, however, is limited to the early stages of growth and, therefore, is not relevant to the current paper.

[4] See for example Barro and Becker (1989) who study the large country case, unlike the simpler case analyzed here, and restrict themselves therefore to an analysis of the dynamics around the steady state.

total cost of education increases with the amount of education acquired. Following Galor and Weil (1996) I assume that the cost of rearing children is increasing in the parent's income. This assumption makes the fertility rates decline as the economies grow. It is also assumed that individuals derive utility from consumption, from the number of children they have and from the future welfare of these children, which depends on their education. Assuming the individuals in countries A and B differ, ceteris paribus, in the degree of the substitution in utility between current family consumption and offspring future welfare, generates the dynamics described above.

Its weaker preference for consumption implies that country B has a stronger preference for investing in children education, which makes it grow faster than A. Therefore, in the initial stages of growth the individuals in the richer economy B choose to have fewer children, compared to country A individuals. Later in time, as incomes in country A gradually catch up with those in B, the effect that the income differences exert on fertility decrease. At this stage the dominant effect on the fertility ranking is the country A individuals' stronger preference for consumption.

Since the paper focuses on the fertility dynamics of the last few decades, the relevant growth in education for most OECD and middle income countries is the growth in secondary and tertiary education. Table 1 shows the large increase in secondary schooling enrolment during the few past decades. As the table shows, even in 1970 secondary schooling enrolment still did not exceed seventy percent in developed countries such as the UK, France or Norway. The relevant education costs in this case are the secondary and tertiary schooling tuition and forgone labor earnings of young individuals in the secondary education ages and above.[5]

[5] Note however that International Labor Organization data show non-negligible rates of child labor (out of the entire population aged 10-14) in 1960 even in countries like Austria (7%), Spain (7.7%), Italy (10.9%), Greece (15.1%) and Portugal (22%).

Section 2 shows some statistics on the prevalence of the Backslanted x fertility dynamics. In section 3 a dynamic macroeconomic model is presented and its equilibrium and dynamics are analyzed. To deliver the argument of this paper in the most efficient way I use a version of the Hazan and Berdugo (2002) model. Unlike Hazan and Berdugo (2002), the current paper is not aiming at generating multiple steady state equilibria and therefore certain simplifications were inserted here into their model. In section 4 the model's implications for the dynamics of cross-country fertility differences is analyzed and Section 5 offers some concluding remarks.

2. Statistics on the Dynamics of Cross-Country Fertility Differences

In order to learn about the prevalence of this type of fertility dynamics some data were collected for the fifty countries with the highest per-capita gdp in 1975 among the countries for which the World Bank provides fertility and output data for both 1975 and 2000. Countries with population less than 100,000 were taken out of the sample. In all of the countries in the sample, except for the USA, fertility, measured by the Total Fertility Rate (TFR) has decreased over that period.

Table 2 shows a mobility matrix for the rankings of the TFR between 1975 and 2000. As the table shows, only two countries, Germany and Austria, were among the ten countries with the lowest fertility both in 1975 and in 2000. A great deal of mobility is expressed by the fact that the cells along the main diagonal of this matrix contain less than five countries and none of them is the largest in its row, with the exception of the lowest row. Of particular interest might be two large jumps from the first tenth (ranks 1-10): One to the third tenth (ranks 21-30) by Luxemburg and another to the fourth tenth (ranks 31-40) by the USA. Also note the large jump from the third tenth to the first tenth made by four countries: Hong-Kong, Spain, Hungary and Greece. The relatively large number of seven countries in the bottom tenth in both periods is due to the fact that this is the last row of this matrix and not an indication of decreasing mobility along the ranking.

Not limiting the sample to countries for which the World Bank offers GDP data for 1975 would allow into the sample the transition economies in Central and Eastern Europe. However, the World Bank provides 1975 TFR data for these countries and using this data here would strengthen substantially the already large mobility in the matrix. In fact, the entire lowest fertility tenth in the year 2000 would consist of eight such countries (together with Italy and Hong Kong) while in 1975 none of them enters that tenth.

To show how unique is this mobility in the fertility ranking Tables 3, 4 and 5 show similar matrices for the mobility in the rankings of per-capita output (measured by constant 1995 US $), Female Labor force participation (as a percentage of the 15-64 female age group), and schooling (measured by net enrollment in secondary schooling), respectively. In almost all of these fifty countries these three variables have increased between 1975 and 2000.

Table 6 presents the results of an ols regression, based on this sample, which shows that the TFR in the year 2000 is negatively correlated with per-capita GDP in 2000, but also positively correlated with per-capita GDP in 1975. Both signs are highly significant. While the negative sign of per-capita GDP in 2000 is consistent with the standard results of most models of fertility and growth, the positive sign of per-capita GDP in 1975 implies a large prevalence of the “Backslanted X” fertility dynamics. Specifically, this negative sign implies that being a “slow grower” (as Spain is with respect to the UK, for example) is associated with lower fertility.

There are 1225 different pairs of countries in this sample. In each pair denote the countries by A and B, where A is the country with the higher 2000 per-capita GDP in that pair. Let τ denote the year in which A's per-capita GDP has been the closest to B's 2000 per-capita GDP among the years 1960-2000. For 803 of the 1225 possible pairs A's TFR in year τ is larger than B's TFR in 2000. Such a magnitude can imply that neutralizing the wealth effect reveals that the richer countries have a stronger preference for having children. However, such a magnitude can also imply that there is a time trend, independent of output dynamics, of lowered fertility.

3. The Model

Consider a small, open, overlapping-generations economy that operates in a perfectly competitive world and faces a given world interest rate. Time is infinite and discrete.

3.1 Production

In every period the economy produces a single good that can be used for either consumption or investment. Two factors of production exist in the economy: physical capital and efficiency units of labor. The production function satisfies the neo-classical assumptions and given by:

$$(1) \qquad Q_t = F(K_t, L_t) = L_t f(k_t),$$

where K_t and L_t are the period t amounts of physical capital and labor efficiency units in the economy, respectively, $k_t \equiv K_t/L_t$ and $f(k_t) \equiv F(k_t, 1)$. Given these assumptions the firms' inverse demand for capital is the function:

(2) $$\bar{r} = f'(k_t),$$

where $\bar{r}$ is the world interest rate. From (2) it follows that:

(3) $$k_t = f'^{-1}(\bar{r}) = \bar{k}.$$

Since $F(K_t, L_t)$ satisfies the neo-classical assumptions it also holds that the return to one efficiency unit of labor satisfies:

(4) $$w_t = f(\bar{k}) - f'(\bar{k})\bar{k} \equiv w.$$

3.2 Individuals

In each period t a generation of individuals is born and lives for three periods. Each individual has a single parent. Individuals within a generation are identical in their preferences. A generation born at a certain period t–1 is denoted "generation t". In eac period each individual is endowed with a single time unit

In their first life period (t–1), the members of generation t are children. The parent of each child allocates a fraction denoted by τ_{t-1} of the child's time to schooling. Each schooling unit costs h output units.[6]

[6] As was discussed in the introduction, an important part of the schooling costs spring from secondary schooling tuition, which is government financed in most countries during the past few decades, and the forgone earnings of uneducated young individuals. Thus, not assuming that the cost of a unit of education increases with the growth in incomes [as done for example by Dahan and Tsidon (1998), or by Maoz and Moav (1999)] is merely a weak simplification. A version of the current paper where the price of education is an increasing concave function of adults' income yields the same qualitative results and available from author.

In their second life period (t), the members of generation t are adults. They work, have children and save. Each such individual divides this time unit between rearing children and working. The amount of efficiency units each of them has is denoted e_t and is an increasing function of the amount of schooling this individual has received as a child. Specifically:

$$e_t = 1 + b\tau_{t-1}, \tag{5}$$

where $b > 0$. Thus if a member of generation t allocates her entire period t time to working she will earn the amount I_t, given by:

$$I_t = e_t w = (1 + b\tau_{t-1})w. \tag{6}$$

In their final life period (t + 1), the members of generation t consume their savings.

Individuals derive utility from consumption, from the number of children they have and from the potential future income of their children (namely I_{t+1}). The preferences of each member of generation t are given by:

$$U_t = \alpha\ln(C_{t+1}) + \beta\ln(n_t) + \gamma\ln(I_{t+1}), \tag{7}$$

where n_t denotes the number of children each member of generation t has. Rearing children cost the fraction z of each adult's time. Thus, each member of generation t works in period t for $1 - zn_t$ time units, implying that n_t must be constrained to being less than $1/z$. The resulting constraint on the consumption of a generation t individual whose potential income is I_t is:

(8) $$C_{t+1} = (1+\bar{r})S_{t+1} = (1+\bar{r})[(1-zn_t)I_t - n_t\tau_t h].$$

Note that the term in the square brackets is the income this generation t individual acquires in period t: its first term is the income this individual receives from her work while the second term is the cost of acquiring τ_t time units of schooling for n_t children.

3.3 Optimization

Each member of generation t decides how many children (n_t) to have and how much schooling (τ_t) to give to each of these children so as to maximize the utility function given in (7), given her potential income, I_t, and subject to (5), (6), (8), $0 \le n_t < 1/z$ and $0 \le \tau_t \le 1$. In order to avoid some undesired solutions to the optimization problem several assumptions shall be now taken.

Assumption 1: $\beta > \gamma$. This assumption is required to make the offspring's amount of education, τ_t, an increasing function of the parental income, I_t.

Assumption 2: $z > \frac{\beta h}{\gamma b w} \equiv z^*$. By making the time cost attached to the quantity of children, z, sufficiently large, this assumption ensures that the quality of children would be sufficiently large too. Specifically, it ensures that $\tau_t > 0$ at each period even if the parent has the lowest possible potential income. Although this assumption and its consequences are not important to the objective of this paper it simplifies the analysis significantly.

<u>Assumption 3:</u> $z < \frac{(\beta-\gamma)b+\beta}{\gamma bw}h \equiv z^{**}$. Note that $z^{**} > z^{*}$ since $\beta > \gamma$. Making the cost on the quantity of children sufficiently small eliminates the case where although the parental income is the lowest possible, $I_t = w$, parents choose the maximal amount of schooling for their children, $\tau_t = 1$.

Given these assumptions, the optimal solution for τ_t and n_t is:

(9) $$\tau_t = \begin{cases} \frac{z\gamma bI_t - \beta h}{(\beta-\gamma)bh} & \text{if } I_t < \frac{(\beta-\gamma)b+\beta}{z\gamma b}h \equiv I^* \\ 1 & \text{otherwise} \end{cases}$$

(10) $$n_t = \begin{cases} \frac{\beta-\gamma}{\alpha+\beta}\cdot\frac{bI_t}{bzI_t - h} & \text{if } I_t < I^* \\ \frac{\beta}{\alpha+\beta}\cdot\frac{I_t}{zI_t + h} & \text{otherwise} \end{cases}$$

Assumption 1, together with $I_t > w$ and Assumption 2 ensure that τ_t and n_t are strictly positive. Also note that τ_t is increasing in I_t and that n_t is decreasing in I_t.[7] Assumption 3 ensures that $I^* > w$, implying that the economy can indeed be in the range $I_t < I^*$. Showing that $n_t < 1/z$ holds when $I_t > I^*$ is trivial. To see that $n_t < 1/z$ holds also when $I_t < I^*$ note that:

(11) $$I_t > w > \frac{\beta h}{\gamma\beta z} \equiv I^{**},$$

where the second inequality follows from Assumption 1. This leads to:

(12) $$n_t < \frac{(\beta-\gamma)bI^{**}}{(\alpha+\beta)(bzI^{**}-h)} = \frac{\beta}{(\alpha+\beta)}\frac{1}{z} < \frac{1}{z},$$

where the left inequality follows from n_t being decreasing in I_t and from $I_t > I^{**}$.

3.4 Dynamics

Applying (6) in (9) and simplifying, yields the following dynamical system:

(13) $$\tau_t = \begin{cases} \frac{z}{z^*}\cdot\frac{\beta}{\beta-\gamma}\tau_{t-1} + \frac{z-z^*}{z^{**}-z^*} & \text{if } \tau_{t-1} < \frac{z^{**}-z}{zb} \equiv \tau^* \\ 1 & \text{otherwise} \end{cases}$$

Note that in the range $0 < \tau_{t-1} < \tau^*$ the slope of this dynamical function exceeds unity since $z > z^*$ and $\beta > \gamma$. The intercept of this dynamical function is between zero and unity due to $z^* < z < z^{**}$. In addition, note that $\tau^* < 1$, due to $z^* < z < z^{**}$. The economic meaning of these results follows directly from the economic meaning of assumption 1 to 3 discussed in section 3.3. In addition, it follows from these results that the dynamical system has a unique and stable steady state equilibrium at $\tau = 1$. Figure 2 shows this system.

The value of n in this steady state equilibrium, denoted $\bar{n}$, is given by the lower row of (10).

[7] Note that τ_t is independent of α. This is not an important result but merely a by-product of the simplifying assumptions of a log-linear utility function and a time cost that is linear in n_t.

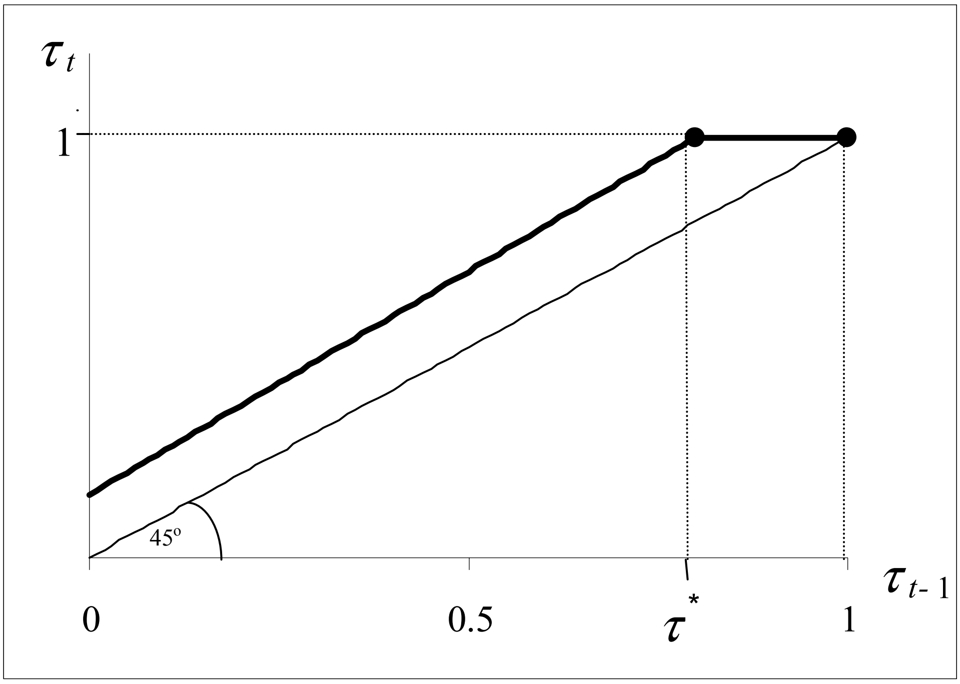

Figure 2: The dynamical system.

4. Fertility Dominance

Let n_t^i and n_t^j denote the period t fertility rates in countries i and j, respectively. Country i has "Fertility Dominance" over country j in period t if $n_t^i > n_t^j$. The following analysis shows how the fertility dominance can shift from country A to B as country A's income per-capita approaches that of B. To make the analysis more efficient I assume that in both countries $\alpha + \beta + \gamma = 1$. I also assume that $\tau_0 = 0$ in both economies. A slower growth of A with respect to B shall be achieved by assuming that $\alpha^A > \alpha^B$ which implies that the individuals in A have a stronger taste for consumption compared to those in B. It is assumed that β is identical in both countries. This implies that $\gamma^A < \gamma^B$, which joins the differences in α in making B grow faster than A.

Since $\tau_0^A = \tau_0^B = 0$, τ_1^A and τ_1^B are both below unity, as was shown in sub-section 3.4. It follows from (9) that in that range τ_t is increasing in γ. Thus, $\tau_1^B > \tau_1^A$ because $\gamma^A < \gamma^B$. In periods later than $t = 1$ the schooling and income differences in favor of country B widen because in those periods the income effect is added to the preferences effect on schooling. This is captured by the result that the slope of the dynamical function exceeds unity and limited to the stage where $\tau_{t-1} < \tau^*$.

To study the dynamics of fertility during the stage where $\tau_{t-1} < \tau^*$ it is useful to present the formula for n_t in the upper raw of (10) as the multiplication of two factors. The first one, the fraction in the left side, shall be referred to as the "preferences factor", since it merely depends on the parameters of the utility function, and since these parameters do not appear in the second factor, the fraction in the right side. This second factor shall be therefore referred to as the "constraints factor". The preferences factor is positive since $\beta > \gamma$ and also increasing in α, as follows from standard differentiation bearing in mind that $d\gamma/d\alpha = -1$. The constraints factor is positive and decreasing in I_t. Therefore, $n_t^A > n_t^B$ already in period 1, since $\alpha^A > \alpha^B$ and despite the assumption that the parental incomes are the same in these economies in that period. In later periods the fertility gap, $n_t^A - n_t^B$, increases as the effect of the increasing income gap on the constraints factor is added to the preferences effect.

At a certain period country B reaches its steady state equilibrium while country A is still growing. At this stage, the income gap, and therefore the fertility gap too, narrows. Eventually country A too approaches its steady state equilibrium. At this final stage schooling is at its maximal level, $\tau = 1$, in both countries and incomes are therefore identical too. Thus the fertility difference in the steady state depends only on the relative magnitude of β, with respect to α. Country A has therefore a lower value of β, relative to its α, and therefore lower steady state fertility. This can be seen by noticing from the lower raw in (10) that the level of steady state fertility, $\bar{n}$, is decreasing in α.

5. Concluding Remarks

In this paper I have shown that if the individuals in country A have a stronger preference for consumption over rearing children, compared to the individuals in country B, then the following dynamics might arise: A's growth of output per capita would be slower than B's; Initially, the fertility rates in A would be higher than in B; Later, as the output gap narrows, the fertility rate in A is lower than the fertility rate in B. Thus, based on this analysis, it is possible that the same reason for third world countries to have higher fertility today is the same one that would make them have lower fertility than the currently already developed economies, once a sufficient level of income convergence would be reached .

The difference between countries in individual utility parameters is taken in this paper as given. The important task of accounting for such differences, for example – by presenting them as norms and convention that rose endogenously in the past and persist onwards to the time of the fertility dynamics upon which the paper focuses, is beyond the scope of this paper.

For generating growth speed differences between economies I have assumed that individuals derive utility not merely from consumption and child quantity, but also from child quality, and that investment in child quality is the source of growth in these economies. Thus, the stronger taste for consumption in A made its growth slower, compared to B. An alternative mechanism that generates such output and fertility dynamics can be based on having investment in physical capital or in research and development as the source of growth. In such a model, assuming that the individuals in A have a stronger preference for present over future consumption, compared to individuals in B, would generate similar qualitative dynamics. Such modeling, however, would severely limit the ability to go beyond a steady state analysis and efficiently analyze the dynamic path towards the steady state, as the phenomena this paper addresses requires.

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	1970	2000
Argentina	34	79
Austria	69	88
Brazil	17	69
Chile	28	75
Finland	71	95
France	66	92
Japan	86	100
Korea Rep.	38	91
Luxembourg	45	80
Mexico	17	58
Netherlands	69	90
New Zealand	76	92
Norway	65	95
Portugal	30	85
Spain	40	93
United Kingdom	67	95

Table 1: Secondary schooling gross enrolment rates (%) in 1970 and 2000 in selected countries.

1975 \ 2000	1-10	11-20	21-30	31-40	41-50
1-10	2	6	1	1	0
11-20	3	3	4	0	0
21-30	4	1	3	2	0
31-40	1	0	2	4	3
41-50	0	0	0	3	7

Table 2: Total Fertility rate (TFR) ranking mobility between 1975 and 2000 for the fifty countries with the highest per-capita GDP among the countries for which the World Bank provides fertility and output data for both 1975 and 2000.

1975 \ 2000	1-10	11-20	21-30	31-40	41-50
1-10	7	1	1	1	0
11-20	3	6	1	0	0
21-30	0	3	4	2	1
31-40	0	0	3	5	2
41-50	0	0	0	2	8

Table 3: Per-capita GDP (in constant 1995 US$) ranking mobility between 1975 and 2000 for the fifty countries with the highest per-capita GDP among the countries for which the World Bank provides fertility and output data for both 1975 and 2000.

1975 \ 2000	1-10	11-20	21-30	31-40	41-50
1-10	6	4	0	0	0
11-20	3	4	3	0	0
21-30	1	2	6	1	0
31-40	0	0	1	8	1
41-50	0	0	0	1	9

Table 4: Female labor force participation (as a percentage of the female age 15-64 population) ranking mobility between 1975 and 2000 for the fifty countries with the highest per-capita GDP among the countries for which the World Bank provides fertility and output data for both 1975 and 2000.

1970s \ 1990s	1-10	11-20	21-30	31-40	41-50
1-10	7	2	1	0	0
11-20	3	5	2	0	0
21-30	1	2	5	1	1
31-40	0	1	1	7	1
41-50	0	0	1	2	7

Table 5: Gross enrollment in secondary schooling ranking mobility between the 1970s and the 1990s for the fifty countries with the highest per-capita GDP among the countries for which the World Bank provides fertility and output data for both 1975 and 2000. For the 1970s the average of the World Bank data for the years 1970 until 1980 was taken for each country. For the 1990s the average of the World Bank data for the years 1997 until 2002 was taken for each country.

	Coefficient	**P-Value**
$\mathbf{Y_{2000}}$	-0.35	0.0001
$\mathbf{Y_{1975}}$	0.22	0.0169
Oil	0.35	0.0084
b = 50	$R^2 = 0.55$	Adjusted $R^2 = 0.53$

Table 6: An ols regression results where TFR in the year 2000 is the dependant variable and the independent variables are the natural logarithm of per-capita GDP in the years 2000 and 1975. Oil is a dummy variable for the five Persian-gulf countries in the sample. The sample contains fifty countries with the highest per-capita GDP among the countries for which the World Bank provides fertility and output data for both 1975 and 2000.