ECONOMIC DISRUPTION, MALTHUSIAN FERTILITY, AND ECONOMIC GROWTH

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Abstract

The transition to market-oriented economies in Central and Eastern Europe and the former Soviet Union in the 1990s, like the Great Depression in the 1930s, generated sharp declines in real incomes and fertility rates. This is contrary to the robust negative relationship between income and fertility that has been extensively documented in the economic literature. This paper presents a general equilibrium growth model with physical and human capital accumulation and endogenous fertility to explain the positive relationship between fertility and income and the implications for long-run economic development. The model predicts that: i) the steeper the decline in labor income, the deeper is the fertility reduction; *ii)* the distribution of income affects growth by its impact on fertility; and *iii*) the perceived level of subsistence consumption plays an important role in determining the economy's growth path. Empirical tests provide strong support for the predictions of the formal model.

Keywords: Growth, Fertility, Human Capital, Subsistence Consumption, Transition.

JEL Classification: **J13** Fertility**; O40** Economic Growth; **J24** Human Capital.

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1 Introduction

The link between birth rates and economic growth has intrigued economists since the beginning of systematic economic analysis. Malthus suggested that fertility rises when incomes increase and vice versa, influencing the predictions of nineteenth-century economists. Nevertheless, during the past 150 years fertility fell rather than rose as income grew. Empirical evidence on the inverse relationship between fertility and the level or growth of income per capita has been extensively documented in the literature (e.g., Tamura, 1988; Barro, 1991). Most of the recent literature on fertility and economic growth has focused on modelin the transition *from* the "Malthusian" stage - featuring positive relationship between population growth and level of income per capita - *to* "modern" growth - characterized by a reversal in the relationship between income and fertility rates (e.g., Becker et al., 1990; Kremer, 1993; Galor and Weil, 1996; Dahan and Tsiddon, 1998).

In Eastern and Central Europe and the former Soviet Union, however, "Malthusian" effects have reemerged following the fall of communism. Indeed, the transition of communist countries to market-oriented economies in the 1990s, like the Great Depression in the 1930s, generated sharp declines in real incomes and fertility rates. This paper reconciles the existing models in the literature on economic growth with the positive relationship between income and fertility observed in the former communist countries. In addition to an explanation for the dramatic fall in fertility that has occurred since the beginning of the transition, this paper sheds some new light on the mechanisms linking income inequality and birth rates, as well as on the effect of the perceived subsistence level of consumption on economic growth.

Some scholars have suggested that the fall in fertility in transition countries may not be related to the economic and social difficulties experienced during the transition. According to their views, a large part of the recent decrease in fertility is the result of a shift toward Western models of reproductive behavior (Conrad, et al., 1996), demographics and attitudes toward family and work (Maxwell, 1998), or the removal of pronatalist politics of the 1980s (Zakharov and Ivanova, 1996). However, these explanations have little support in the data, as shown by the more rapid than average decline in fertility rates among older women especially in the former Soviet Union, by the frequent increases in the share of first births in the total and by the results of recent surveys on factors influencing the decisions of women on childbearing. For instance, in a 1999 survey in Russia, 97 percent of the women interviewed cited lack of money as a major barrier to having another child, 15 percent said inadequate housing was the main cause, while 8 percent cited the confidence in regaining their jobs after childbirth (*The New York Times*, 2000).[1] As in Cornia and Paniccia (1996), this paper demonstrates that the fertility reduction in the transition countries is the result of worsening economic conditions, growing poverty and income inequality, and inadequate policy action.

This paper presents an equilibrium model in which individuals consume, save and make fertility choices, in the tradition of Becker (1960), Razin and Ben-Zion (1975), and Becker and Barro (1988).[2] To derive nonergodic behavior from an otherwise standard model of economic growth, a subsistence level of consumption is introduced. The model is thus closely related to the work by Azariadis (1996) and

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[1] For additional surveys with similar findings, see Haub (1994).

[2] Note, however, that my model is not based on the assumption that parents are altruistic toward their children. The incorporation of altruism would complicate but not affect the essence of the analysis (see Zak, 2000).

Jones (2000). My work, however, extends their studies in two primary ways. First, following Zak (2000), I consider the determination of human capital accumulation which depends on both inheritable factors and parental nurture given to children. Second, I derive rather than assume a structural break that produces a nonergodic demographic transition, i.e., a state in which fertility declines as incomes decrease.

The model predicts that countries with steeper decline in per capita income will have deeper fertility reduction. This result is quite intuitive. If incomes fall sufficiently relative to subsistence levels of consumption, the willingness to have children falls. This occurs because the utility function is such that the income effect on fertility dominates the substitution effect when incomes fall below a certain threshold.[3] If this hypothesis is verified, one solution to the current fertility crisis in the transition countries would be stronger and sustained income growth, which in turn would influence positively expectations about future economic outcomes and fertility decisions. Fertility, on the other hand, also affects growth: when the number of children per family is large, per child parental nurturing is low, diluting the transmission of human capital and slowing output growth; alternatively, when family size is small, the rate of human capital transmission is high, producing highly productive workers and accelerating output growth.

Changes in income inequality have long been recognized as important correlates of economic growth.[4] This paper explores an unexamined relationship between income inequality and fertility choices in times of economic depression. The distribution of income is shown to affect aggregate number of births, with greater inequality decreasing the fertility rates when income falls below a certain threshold.[5] The policy implication of this prediction is straightforward: broad equitable economic development will stabilize and possible reverse the recent trends in fertility in the transition countries.

Analyzing the dynamics of the model reveals novel implications regarding the effect of individual views about the subsistence level of consumption on the growth path of economy. What is considered to be a minimum income "needed to make ends meet" influences fertility choices and accumulation of human capital, and, therefore, affects the long-run growth. Specifically, for countries with low initial levels of physical or human capital, a higher perceived subsistence consumption level raises the potential for economic development. If, as suggested by Milanovic and Jovanovic (1999), the subjective subsistence level of consumption is positively related to the economic well-being, this would imply the need for more aggressive initiatives to support employment, income transfer programs, enhanced tax collection and control of inflation.

The above hypotheses are tested making use of cross-section data on changes in relevant variables during the transition and fixed-effects regressions for 24 transition countries from 1979 to 1998. This includes six areas (Central Europe, the Balkans, the Baltic states, the Slavic states of the former Soviet Union, the Transcaucasian states, and Central Asia) showing considerable intercountry and

[3] Jones (2000) calls this the subsistence effect.

[4] For a thorough discussion of the relationship between income inequality and economic growth, see Galor and Zeira (1993), McGregor (1995), Owen and Weil (1997), Barro (2000).

[5] This stands in contrast to the finding of Zak (2000), who shows that increasing inequality raises the aggregate number of births. However, he only examines the modern state in which fertility strictly declines in income.

interregional variation, thus allowing the risk for spurious or weak inference to be minimized.

The rest of this paper is organized as follows. Section 2 briefly reviews the remarkable decline in birth rates and real incomes in the former communist countries during the period of transition. In Section 3, I formalize the assumptions about the determinants of fertility and human capital, and incorporate them into an overlapping generations model. Section 4 derives implications from the model, while Section 5 investigates the dynamics of a special case of the model in which agents within a generation are identical. Section 6 empirically tests the implications of the model for fertility choices. Section 7 concludes by discussing the implications of the results for policy-setting and directions for future research.

2 The Post-Communist Great Depression and the Drastic Demographic Adjustment

Although experiences varied from country to country, the transition generally featured a sharp fall in output and real incomes, associated in many countries with a rise in unemployment and inflation. In a number of countries these developments have caused widespread poverty and the break-up of the comprehensive, equitable and relatively generous safety net developed by the former regimes. It is, therefore, not surprising that the transition has profoundly affected, in many different ways, the lives and behavior of the hundreds of millions of people. One of the ways people reacted to the palpable worsening of material circumstances resulted in an abrupt and precipitous drop in fertility, unprecedented for an industrialized society during peacetime.

Table 1 illustrates the change in fertility that has occurred since the beginning of the transition. The total fertility rate (the number of births per woman) and crude birth rate (the number of births per 1,000 people) decreased sharply in all countries expect Bosnia and Herzegovina and Croatia, which have registered only moderate decreases in fertility.[6] The average crude birth rate declined from 19.05 to 12.36, or by roughly 35 percent. Central Europe and the Balkans have registered relatively moderate declines in fertility; their crude birth rates decreased, on average, by 28 and 24 percent, respectively. The decline was greater in Central Asia, even greater in the Slavic states, Moldova and the Baltics, and the greatest in the Transcaucasian states (46 percent). The dispersal of fertility rates among transition economies also declined, indicating decreasing differences among countries.

Table 1. Total Fertility Rate (TFR) and Crude Birth Rate (CBR)

Country	TFR		CBR		% change in	
	1989/90	1997/8	1989/90	1997/8	TFR	CBR

[6] Bosnia and Herzegovina and Croatia were involved in the bloodiest of all conflicts since the beginning of the transition. For Bosnia and Herzegovina the nature of the data is incomplete, while the fertility rates in Croatia recovered after the initial drastic decline.

Central Europe	*1.88*	*1.30*	*13.34*	*9.68*	*-30.85*	*-27.44*
Czech Republic	1.89	1.16	12.70	8.80	-38.62	-30.71
Hungary	1.84	1.33	12.10	9.70	-27.72	-19.83
Poland	2.08	1.40	14.90	10.30	-32.69	-30.87
Slovak Republic	2.09	1.38	15.20	10.70	-33.97	-29.61
Slovenia	1.52	1.23	11.80	8.90	-19.08	-24.58
Balkans	*2.09*	*1.63*	*16.19*	*12.32*	*-22.01*	*-23.90*
Albania	3.03	2.46	24.90	18.32	-18.81	-26.43
Bosnia and Herzegovina	1.70	1.60	14.20	13.04	-5.88	-8.17
Bulgaria	1.90	1.09	12.60	7.70	-42.63	-38.89
Croatia	1.63	1.45	11.80	10.50	-11.04	-11.02
Macedonia	2.09	1.75	18.80	14.80	-16.27	-21.28
Romania	2.20	1.32	16.10	10.60	-40.00	-34.16
Yugoslavia	2.08	1.74	14.90	11.30	-16.35	-24.16
Baltic states	*2.09*	*1.22*	*15.13*	*8.73*	*-41.63*	*-42.30*
Estonia	2.21	1.21	15.50	8.50	-45.25	-45.16
Latvia	2.05	1.09	14.60	7.60	-46.83	-47.95
Lithuania	2.00	1.36	15.30	10.10	-32.00	-33.99
Slavic states and Moldova	*2.13*	*1.34*	*15.45*	*8.95*	*-37.09*	*-42.07*
Belarus	2.03	1.23	15.00	8.80	-39.41	-41.33
Moldova	2.50	1.60	18.90	9.70	-36.00	-48.68
The Russian Federation	2.01	1.23	14.60	8.60	-38.81	-41.10
Ukraine	1.99	1.30	13.30	8.70	-34.67	-34.59
Transcaucasian states	*2.54*	*1.53*	*22.10*	*11.90*	*-39.76*	*-46.15*
Armenia	2.62	1.30	22.90	10.50	-50.38	-54.15
Azerbaijan	2.80	2.00	26.40	16.40	-28.57	-37.88
Georgia	2.21	1.29	17.00	8.80	-41.63	-48.24
Central Asia	*4.10*	*2.79*	*32.16*	*20.28*	*-31.95*	*-36.94*
Kazakhstan	2.82	2.00	23.00	14.30	-29.08	-37.83
Kyrgyz Republic	3.88	2.79	30.40	22.00	-28.09	-27.63
Tajikistan	5.23	3.40	38.80	21.40	-34.99	-44.85
Turkmenistan	4.40	2.92	34.90	20.30	-33.64	-41.83
Uzbekistan	4.18	2.82	33.70	23.40	-32.54	-30.56
All transition countries	*2.48*	*1.61*	*19.05*	*12.36*	*-32.26*	*-35.12*
EU countries	*1.64*	*1.54*	*12.43*	*11.14*	*-6.10*	*-10.38*

Source: World Development Indicators 2000.

The contrast with the EU countries puts the matter within a broader European contest. One should keep in mind that during the 1990s the main features of political, economic and social conditions in the EU countries have been relative political stability and economic prosperity, while those in the transition countries political turbulence and economic decline. As shown in Table 1, the decline in fertility in the transition countries was, on average, three to four times as fast as the decline recorded in the EU countries during the same period.[7] While the pre-transition average fertility in every group of transition countries was higher than the EU average, eight years later fertility in all the groups (with the exception of the Central Asian republics, which had traditionally higher fertility rates) was at about the same level as or at lower level than the EU average fertility.

Before the transition the vast majority of the transition countries had fertility rates of around two children per woman or higher. In the remaining countries the rates were just below two children per woman, but never below 1.6. The rates of the twenty-seven transition countries were all within a relatively wide band, 1.63-5.23.

[7] The steepest reductions in fertility rates observed in the EU countries in the 1970s and 1980s approached but never got as close as matching or exceeded those by a number of the countries in transition. For an extensive discussion of fertility declines in the transition countries compared to those in the EU states in the 1970s and 1980s, see Macura (1996).

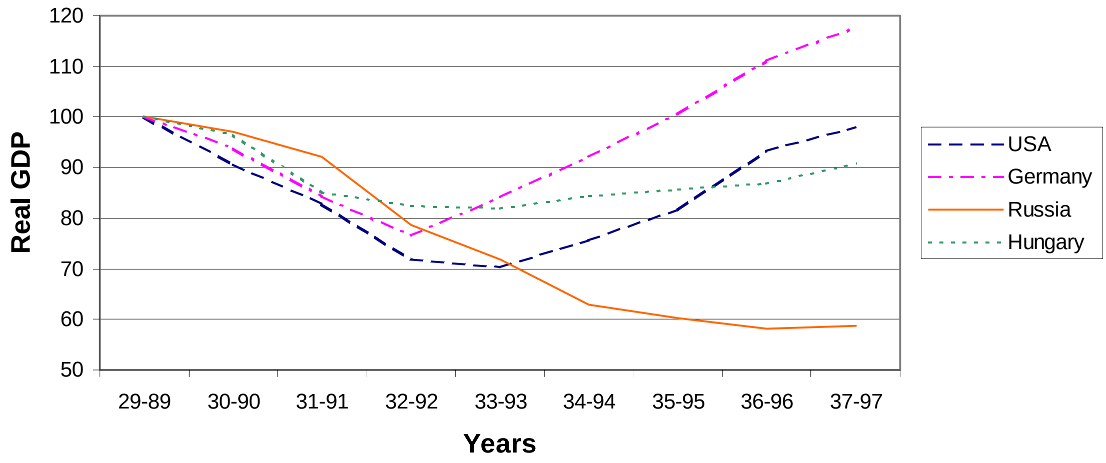
Among the EU countries, around the same time (1989/90), only two countries – Ireland and Sweden – had total fertility rates higher than two. The remaining countries had total fertility rates below this level, with the lowest rates observed in Italy and Spain, at below 1.4. The rates of the EU countries fell in the range 1.28-2.13.

In 1997/98, the fertility levels of the transition countries presented an entirely new situation, which was now a par with that of the EU countries. Most of the transition countries – with the exception of Central Asia, Azerbaijan and Albania – had total fertility rates below two. The rates for the twenty-seven transition countries were scattered over a narrower range, between 1.09 and 3.4. Among the western countries, in 1997/98, there was not a single one that had a total fertility rate higher than two. The lowest rates were again recorded in the south – Italy (1.22) and Spain (1.15). The range was also narrower than in 1989/90: 1.15-1.93. This suggests that the differences in terms of the level and the spread in overall fertility, which had existed in the beginning of the 1990s between the present-day transition countries and the EU countries, by and large disappeared by the late 1990s. In fact, the low fertility levels observed in 1997/98 in some transition countries (for example, Bulgaria and Latvia) are without precedent in post-Second World War Europe.

As noted by Milanovic (1998), the depth of the post-Communist depression is best assessed by comparing it to the 1929-33 Great Depression. Figure 1 shows the GDP for Russia and Hungary during 1989-97, using 1989 as a base year, and the GDP for the United States and Germany during 1929-37, using 1929 as a base year. The decline was initially steeper in Hungary, Germany and the USA than in Russia. However, while the other three countries emerged from the depression, Russia experienced the deepest and longest-lasting depression. Russia's GDP continued to plunge throughout the whole period, and in 1997 was 42 percent below its 1989 level. The depression in Hungary, though deeper than that in Russia during the first two years, was not as severe. The Hungarian trough, reached in 1993, was approximately 18 percent below the 1989 level. Since 1993, Hungary grew consistently and, by 1997, the Hungarian GDP was approximately 9 percent below its base level.

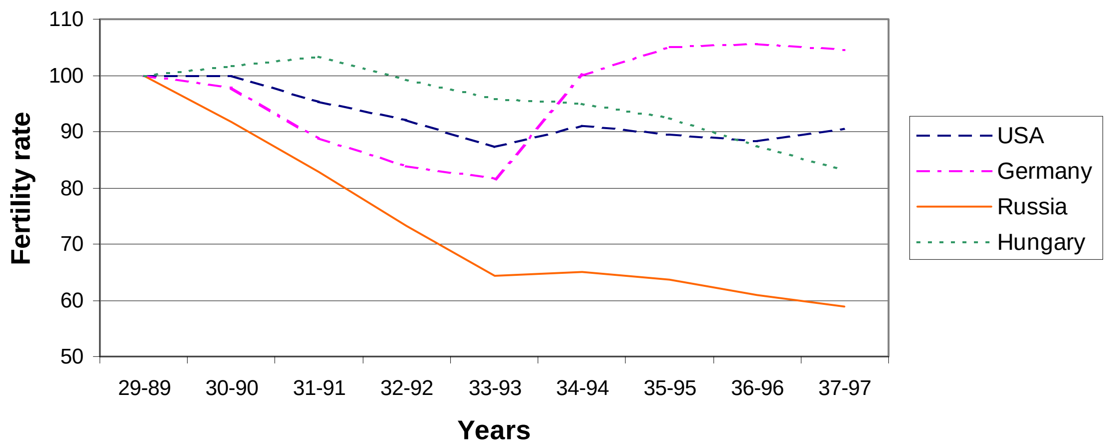
The effects of the Great Depression and the post-Communist transition on the fertility choices were also similar. As shown in Figure 2, each of the four countries experienced a decline in the birth rates. For Germany and the United States, the lowest fertility rates were reached in 1933. However, births increased in the following years and in Germany, by 1934, fertility exceeded its 1929 level. Out of the four countries, Russia experienced the most severe fertility reduction that almost matched the decline path of its GDP. In 1997 the fertility rate in Russia was approximately 41 percent below its base level, while in Hungary the births declined by roughly 17 percent.

Figure 1. Real GDP in the USA and Germany (1929-37); and in Russia and Hungary (1989-97)



Note: 1929 = 100 for the USA and Germany; 1989 = 100 for Russia and Hungary.
Source: For the USA and Germany: Liesner (1989, Table US.2 and Table G.2). For Russia and Hungary: World Development Indicators, GDP at market prices (constant 1995 US$).

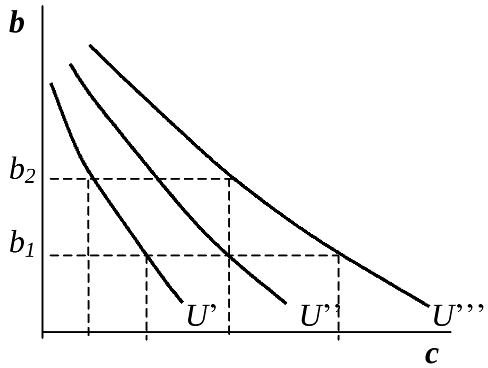
Figure 2. Fertility Rate in the USA and Germany (1929-37); and in Russia and Hungary (1989-97)



Note: 1929 = 100 for the USA and Germany; 1989 = 100 for Russia and Hungary.
Source: For the USA: Statistical Abstract of the United States (1944-45). For Germany: Mitchell (1992). For Russia and Hungary: World Development Indicators, Fertility rate, crude (per 1,000 people).

Other countries that struggled through the Great Depression in the 1930s or that have undergone transition to market economy in the 1990s experienced similar problems. While the data may be subject to measurement error, there can be little doubt that radical changes in income produce different effects on fertility than gradual changes. Unfavorable shocks seemingly jar an economy into the "Malthusian" state where fertility and income both decline. The key assumption incorporated in this paper is that simultaneous fall in income and fertility occurs when the fertility choices are sensitive to changes in income at or near subsistence level of consumption. In other words, if income falls sufficiently relative to the subsistence level of consumption, the income effect dominates the substitution effect and the willingness of agents to have children falls. This is shown in the indifference diagram of Figure 3 where, the household becomes less willing to trade consumption for children as it becomes poorer within a critical range.[8] In particular, when income is sufficiently low relative to the subsistence level of consumption, a household at the *U'* utility curve is less willing to give up consumption in order to increase the births from b_1 to b_2 than is the wealthier household at the *U'''* utility curve.

Figure 3. Indifference Curve Map at Subsistence Consumption



Note: **b** = births, **c** = consumption.

Both the Great Depression and the transition of the former communist countries featured increased macroeconomic volatility and a threat of falling into poverty for many individuals, including those that were traditionally securely in the middle class. For instance, in Russia in 1990s, downward mobility into poverty was the norm rather than the exception for large number of people, and poverty increased at an unprecedented rate.[9] Another part of the same story was the sharply increasing income inequality.[10] While mainly focusing on the links between fertility and income, the analysis that follows will also explore the effects of poverty and income inequality on fertility choices and prospects for economic growth.

3 The Model

The model represents a modified version of a standard overlapping generations model in which generations consist of heterogeneous, three-period lived agents. Individuals are identified by $i \in \Re^+$ and vary by their level of human capital

[8] For a formal presentation of the critical range of labor income, see equation (11).
[9] Milanovic and Jovanovic (1999) show that in Russia from 1993-96 the percentage of the population that was subjectively poor was extremely high: 60-90 percent. Even according to the “objective” criterion of the official poverty line, the percentage of the poor ranged between 25 and 60 percent.
[10] For empirical evidence of increased income inequality during the post-communist transition, see Kakwani (1996) and Milanovic (1998).

and perceived subsistence level of consumption. The first period of life is childhood, the second is young adulthood, and the third is old age in which agents are retired. Since parents choose a child's consumption, no utility flows from consuming goods in childhood. In the second period of life, agents supply labor inelastically to firms and save for old age. Reproduction is limited to the second period of life and, for simplicity, children are produced by parthenogenesis (asexual reproduction).[11] I also abstract from the spacing of children by assuming that parents have all of their children at the beginning of adulthood. In old age, agents are retired and consume from the principal and interest on their savings Ra^i, where $R \equiv 1 + r - \delta$ is one plus the net interest rate, i.e., one plus the gross interest rate r less the depreciation rate on capital $\delta \in [0,1]$. Agents die at the end of the third period of their lives.

3.1 The Consumer's Problem

It is convenient to specify the model in units per effective worker so that human capital enters the model in a tractable way. Agents use current labor income wh^i (the economy-wide average wage w times type i's human capital h^i) to fund consumption c_1^i, to raise children at cost e^i per child, and to save a^i for old age. Preferences are defined over youthful consumption c_1^i, old-age consumption c_2^i, and the number of children b^i. When utility is logarithmic, the lifetime utility maximization problem for agent i born at time t - 1 is

$$\max_{c_1^i, c_2^i, b^i} (1-\beta)\ln\left(c_{1,t}^i - x_{1,t}^i\right) + \beta \ln\left(c_{2,t+1}^i - x_{2,t+1}^i\right) + \gamma \ln\left(b_t^i\right) \tag{1}$$

subject to

$$c_{1,t}^i = w_t h_t^i - e_t^i b_t^i - a_{t+1}^i$$
$$c_{2,t+1}^i = R_{t+1} a_{t+1}^i$$
$$c_{1,t}^i \geq x_{1,t}^i$$
$$c_{2,t+1}^i \geq x_{2,t+1}^i$$
$$b_t^i \geq \bar{b}$$

where $\beta \in (0,1)$ is the patience parameter, $\gamma > 0$ is the preference for children, R_{t+1} is one plus the net interest rate, and $\left(x_{1,t}^i, x_{2,t+1}^i\right)$ are the perceived subsistence consumption levels in youth and old age. The budget constraints in (1) relate to consumption during the two periods of adulthood. $\bar{b} > 0$ is the minimum number of children per adult.[12]

The production and rearing of children are time intensive (Birdsall, 1988). In addition, the theory suggests that higher stocks of capital and technology reduce fertility by increasing wages and thus the cost of the time spent on child care (Schultz, 1981; Becker et al., 1990). I shall therefore assume that higher wages induce a substitution effect away from fertility by raising the cost of children nonlinearly. As a result, the cost of children is parameterized as a convex function of labor income,

[11] This permits avoiding the issue of marriage matching.

[12] The assumption $b_t^i \geq \bar{b} > 0$ is necessary for well-defined asymptotic behavior of the system, but is not crucial to the analysis.

$e_t^i = D\left(w_t h_t^i\right)^{\rho}$, where $0 < D < 1 / \left\{\left(w_t h_t^i\right)^{\rho-1} b_t^{i*}\right\}$ is a scale parameter and ρ > 1 is the constant elasticity of the cost of children with respect to the labor income.[13]

Setting aside integer constraints associated with the choice of family size and ignoring altogether complications like infant mortality, twins, and the like, the optimal choices made by a type *i* agent at time *t* for savings and the number of children are

$$a_{t+1}^{i*} = \frac{\beta}{1+\gamma}\left(w_t h_t^i - x_{1,t}^i\right) + \frac{1-\beta+\gamma}{1+\gamma} x_{2,t+1}^i / R_{t+1} \tag{2}$$

$$b_t^{i*} = \max\left\{\frac{\gamma}{1+\gamma} \frac{w_t h_t^i - x_{1,t}^i - x_{2,t+1}^i / R_{t+1}}{D\left(w_t h_t^i\right)^{\rho}}, \bar{b}\right\} \tag{3}$$

subject to the restriction $w_t h_t^i > x_{1,t}^i + x_{2,t+1}^i / R_{t+1}$.

Optimal savings, (2), is increasing in income, decreasing in the preference for children, γ, and increasing in the patience parameter, β. As expected, optimal savings is negatively related to the current perceived subsistence consumption, $x_{1,t}^i$, and positively related to the discounted value of the next-period perceived level of subsistence consumption, $x_{2,t+1}^i / R_{t+1}$. The optimal number of children, (3), increases as the preference for children rises and falls as the perceived subsistence consumption levels increase. The relationship between the optimal number of children and labor income is considered in Section 4.

3.2 Human Capital

Human capital in this model is determined by inheritable factors and family size.[14] Thus, this is a model of nature and nurture, for both are required to develop productive members of society. A child's human capital is, on average, increasing in parent's human capital and decreasing in the number of children in the family. The later obtains since the number of children in a family affects the parental nurturing per child. As family size increases, each child's educational attainment falls (Behrman and Taubman, 1989), as do grades in school (Downey, 1995). Therefore, human capital of each child h_{t+1}^i in a family where parental human capital is h_t^i and the number of children is b_t^i is given by

$$h_{t+1}^i = \frac{\varpi\, h_i^t}{\left(b_t^i\right)^{\theta}} \tag{4}$$

with ϖ > 0 being the inherited portion of human capital and θ > 0 denoting the dilution effect on parental nurturing from having more than one child.[15] This equation

[13] The assumption on the upper limit on the scale parameter, *D*, keeps the cost of children, *e*, from growing without bound as labor income increases, and has no substantive effect on the model.
[14] This specification abstracts from the effect of formal education on human capital, since Behrman and Taubman (1989) show that 81% of educational attainment is attributable to one's genetic endowment.
[15] The "production function" for human capital in (4) is similar to that used by Lucas (1988) when each family has a single child.

implies that the human capital of a single child is more likely to exceed her parent's human capital. On the other hand, if a child is born into a household in which the number of children is high and thus parental "tutoring" per child is low, she may have less human capital than her parent. Therefore, parental nurturing and fertility rates have a fundamental impact on the dynamics of the distribution of human capital.

3.3 The Firms and Equilibrium

I close the model by specifying the problem faced by firms and then defining a competitive equilibrium. In every period the economy produces a single homogenous good, using physical capital and efficiency units of labor in the production process. Assume that there are many firms operating in a competitive environment and that agents of all human capital types are necessary to produce output. Let K_t be the aggregate physical capital, μ be an appropriately defined measure over working agents, $\int_0^\infty d\mu_t \equiv N_t$, and $H_t \equiv \int_0^\infty h_t^i d\mu_t$ denote the aggregate human capital, i.e., the quantity of efficiency units of labor employed in production at time *t*.

The profit maximization problem for a representative firm at time *t* is

$$\max_{K,H} Y_t - r_t K_t - w_t H_t \tag{5}$$

where r_t is the cost of financing capital investments and w_t is the wage rate per efficiency unit of labor at time *t*. Let the production function be Cobb-Douglas

$$Y_t = K_t^\alpha H_t^{1-\alpha} \tag{6}$$

for $\alpha \in (0, 1)$. Solving for the firm's profit maximizing condition using (5) and (6), the labor income paid to type *i* agent is the marginal product of type *i* labor, [16]

$$w_t h_t^i = (1-\alpha) K_t^\alpha H_t^{-\alpha} h_t^i \tag{7}$$

and the rate of return on capital is its the marginal product,

$$r_t = \alpha K_t^{\alpha-1} H_t^{1-\alpha} \tag{8}$$

There are three markets in this model: goods, labor (all types), and capital. The labor market clears for agents with human capital h_t^i for some value of w_t by the concavity of the production function. The capital market clears when, for some value of R_{t+1}, [17]

$$K_{t+1} = \int_0^\infty a_{t+1}^{i*} d\mu_t \tag{9}$$

[16] Note that (6) and (7) indicate that the aggregate wages paid to labor are a fixed proportion of output, $w_t H_t = (1-\alpha) Y_t$.

[17] The goods market clears by Walras' Law.

where a^{i*} is given by (2).The working population at time t+1 equals aggregate births B_t at time t,

$$N_{t+1} = B_t \equiv \int_0^\infty b_t^{i*} d\mu_t \tag{10}$$

where b^{i*} is given by (3).

A *competitive equilibrium* for the model above is a set of prices $\{w_t, R_{t+1}\}_{t=0}^{\infty}$, such that given:

(i) initial conditions for the distribution of physical capital, $\int_0^\infty a_0^i d\mu = K_0 > 0$, and the distribution of human capital, $\int_0^\infty h_0^\infty d\mu = H_0 > 0$;

(ii) law of motion for human capital (4) and physical capital (9);

(iii) description of the evolution of the subsistence consumption levels $(x_{1,t}, x_{2,t+1})$;

consumers maximize lifetime utility by solving (1), firms maximize profits by solving (5), and prices clear all markets.

4 Implications of the Model

The model shows that the distribution of human capital and the level of physical capital jointly determine output. Fertility choices, on the other hand, depend on the preference for children, the perceived subsistence level of consumption and labor income. In particular, the optimal number of children given in equation (3), is a continuous function of labor income that follows the pattern depicted in Figure 4.[18] Births increase in labor income at low levels of income (below $\overline{wh^i}$), then decrease at an increasing rate at medium levels of income (between $\overline{wh^i}$ and $\overline{\overline{wh^i}}$), and finally decrease at a decreasing rate at high levels of income (above $\overline{\overline{wh^i}}$).[19]

Lemma 1 derives the threshold for a positive relationship between fertility and income.

Lemma 1 *The optimal number of children is increasing in labor income if*

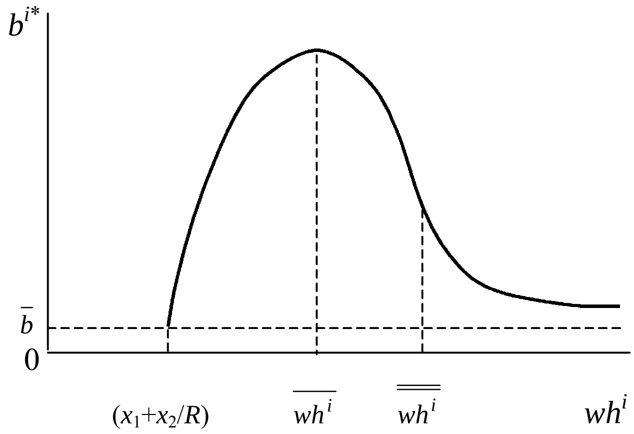
$$w_t h_t^i < \overline{w_t h_t^i} \equiv \frac{\rho}{\rho - 1}\left(x_{1,t}^i + x_{2,t+1}^i / R_{t+1}\right) \tag{11}$$

[18] Kremer (1993) assumes an almost identical pattern for population growth versus income. Jones (2000) uses the same pattern to characterize the relationship between fertility and productivity.

[19] $\overline{\overline{wh^i}} \equiv \frac{\rho+1}{\rho-1}\left(x_1^i + x_2^i / R\right)$.

Lemma 1 demonstrates if labor income declines sufficiently relative to the current and discounted future subsistence level of consumption, children become less affordable and births decrease. This income effect works in the opposite direction of the substitution effect that generates increases in fertility. Indeed, when consumption drops to near subsistence levels, the income effect dominates the substitution effect, reducing the birth rates.

Figure 4. Fertility Versus Income



Note that since ρ > 1, the "Malthusian" threshold $\overline{w_t h_t^i}$ is above the sum of the perceived subsistence consumption levels. Once income declines below $\overline{w_t h_t^i}$, the deeper the fall in income, the steeper is the fertility reduction. Furthermore, the threshold $\overline{w_t h_t^i}$ is declining in the elasticity of the cost of children with respect to labor income, ρ.[20] For example, in countries with pro-natal policies ρ might be lower and thus $\overline{w_t h_t^i}$ higher. In this case, a smaller decline in income would induce a fertility reduction. One characteristic of the former communist countries was a generally pro-children stance as reflected in relatively cheap and good facilities for childcare, free health care and education, and a heavy emphasis on family allowances.[21] Therefore, the elasticity of cost of children with respect to labor income, ρ, was presumably relatively low. This means that the threshold $\overline{w_t h_t^i}$ was relatively high, and a less drastic decline in income was sufficient to generate a rapid reduction in aggregate birth rates.

Lemma 2 shows the threshold for human capital decumulation.[22]

Lemma 2 *If the human capital of agent i is sufficiently low relative to physical capital per worker,*

$$h_t^i < \psi(k_t) \quad (12)$$

---

[20] Note that ρ is constant from individual's point of view, but it could vary across countries.
[21] See, for instance, Milanovic (1998).
[22] Proofs are contained in the Appendix.

where $\psi(k_t)$ denotes a differentiable and invertible function and $\psi'(k_t) < 0$, then the human capital of agent i's children is less than that of agent i.

This result obtains since incomes affect family size decisions. As in Galor and Tsiddon (1997), parents with high levels of human capital, and therefore high incomes and fewer siblings, are unlikely to have children whose human capital is less than their own. On the other hand, parents who have low human capital, earn low wages, and have more offspring may produce children who have less human capital than their own, leading to an intergenerational poverty trap. This cycle can be broken by sufficient growth in the physical capital per worker. Indeed, Lemma 2 demonstrates that the threshold for human capital decumulation falls as physical capital per worker increases. If the economy is growing, in the long run most of the parents will have fewer children and invest substantial nurturing in each child, leading to human capital accumulation.[23]

The model also permits a characterization of the relationship between the number of births and the shape of the distribution of labor income. Theorem 1 demonstrates that, for an economy with a significant fraction of the population with income below the "Malthusian" threshold $\overline{wh^i}$, inequality has a negative impact on fertility. To derive this result, I use the notion of mean preserving spread (Rothschild and Stiglitz, 1970) in which one distribution is constructed from another by moving mass from the middle of the distribution to the tails, keeping the mean constant and increasing the variance.[24]

Theorem 1 *If there is a significant mass of agents whose labor income is below $\overline{wh^i}$, a simple mean preserving spread of the distribution of labor income decreases the aggregate number of births.*

The intuition for this result is straightforward: during economic depressions, as poverty goes up, the proportion of agents with income below the "Malthusian" threshold increases, children become less affordable and aggregate births decrease. In other words, since higher income variance and increased downward income mobility into poverty mean that providing for the subsistence consumption level is more at risk, the result is an unwillingness of people to have children. This theorem does not depend on the minimum number of births being $\bar{b}$, but follows simply from the sensitivity of fertility to income at low-income levels.

5 The Dynamics of Fertility and Growth

In order to examine the dynamics of the model, I begin by characterizing the special case where all agents within a generation have the mean level of human capital, h_t. Assume also perceived subsistence levels of consumption

[23] Relaxing the assumption of many growth models that human capital always accumulates, allows for significant flexibility of the model as shown by the dynamic analysis in Section 5.

[24] The assumption of constant mean is not crucial to the analysis. Removing it and assuming a decreasing mean (since labor income decreases during economic depressions) can even strengthen the result.

$\left(x^i_{1,t}, x^i_{2,t+1}\right) = \left(x_{1,t}, 0\right)$. In words, young agents have constant and identical perceptions about the minimum acceptable income to make ends meet and the level of subsistence consumption for the old generation is equated to zero.[25] The dynamics of the model in per worker terms are given by

$$k_{t+1} = \frac{\beta}{(1+\gamma)} \frac{(1-\alpha)k_t^{\alpha} h_t^{(1-\alpha)} - x_{1,t}}{b_t^*} \tag{13}$$

$$h_{t+1} = \frac{\varpi\, h_t}{\left(b_t^*\right)^{\theta}} \tag{14}$$

where b_t^* is given by (3) when human capital is at its mean, h_t. Since, as shown in Figure 4, with sufficient income growth the birth rate reaches its minimum value, $b_t^* = \bar{b}$, after which human capital grows at a constant rate, there is a difference between the transitional dynamics and the dynamics on the balanced growth path.

5.1 Transitional Dynamics

In the transitional dynamics, population growth is nonconstant, i.e. $b_t^* > \bar{b}$. As a result, the transitional dynamics, in per worker terms, are

$$k_{t+1} = Ak_t^{\rho\alpha} h_t^{\rho(1-\alpha)} \tag{15}$$

$$h_{t+1} = Bk_t^{\rho\alpha\theta} h_t^{1+\rho\theta(1-\alpha)} \left[(1-\alpha)k_t^{\alpha} h_t^{1-\alpha} - x_1\right]^{-\theta} \tag{16}$$

where $A \equiv \beta D(1-\alpha)^{\rho} \gamma^{-1}$ and $B \equiv \left[\varpi^{1/\theta} D(1-\alpha)^{\rho} (1+\gamma)\gamma^{-1}\right]^{\theta}$. The model admits a trivial steady state ($k_t = h_t = 0,\ \forall\, t$) and an interior steady state $\left(\bar{k}, \bar{h}\right)$ given by the solution of

$$B^{1/\theta} A^{-1} \bar{k} - (1-\alpha) A^{-1/\rho} \bar{k}^{1/\rho} + x_1 = 0 \tag{17}$$

$$\bar{h}^{\rho(1-\alpha)} = A^{-1} \bar{k}^{1-\rho\alpha} \tag{18}$$

The dynamics of the system of equations (15) and (16) are robust to variations in parameter values as the next result shows.

[25] The subsistence consumption for the old generation is equated to zero for the sake of simplicity and getting an analytical solution to the model. This assumption also permits, as Theorem 5 demonstrates, focusing on the effect of the perceived subsistence consumption level by the young generation on the growth path of an economy.

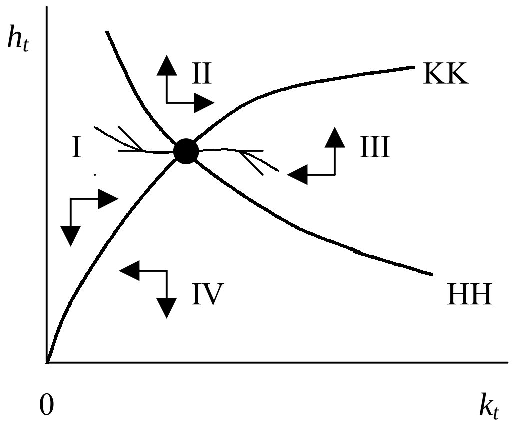
Theorem 2 *For all admissible parameter values, the steady state given by the solution of (17) and (18) is locally saddle-point stable.*

Figure 5 depicts the phase portraits of the dynamics for all admissible parameter values. The phase portraits in the figure are partitioned by the curves where physical capital is constant, denoted by KK, and where average human capital is constant, HH. The interior steady state has, as Theorem 2 demonstrates, a saddle path leading to it. Thus, for a given value of initial physical capital k_0 in a neighborhood of the steady state, there is a unique value of initial human capital h_0 that puts the dynamics on the saddle path leading to the interior steady state $(\bar{k}, \bar{h})$.

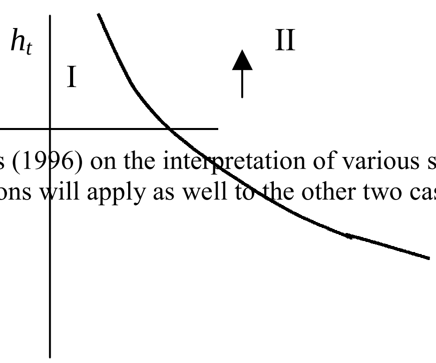
For initial values of k_0 and h_0 in region IV, the phase arrows in Figure 5 suggest that there are dynamic pressures that lead the economy towards the origin. If the economy starts in region I, with high human relative to physical capital, human capital decumulates over time (as Lemma 2 proves) until the KK curve is crossed and the trajectory enters region IV. As a result, the origin is a poverty trap in this model, while the interior steady state is a "middle-income trap."[26] For initial conditions in region II, there are pressures for growth in both k and h. If the economy starts in region III, with low human relative to physical capital, human capital accumulates over time until the trajectory crossed the KK curve and enters region II.

Figure 5 provides thorough illustration of the dynamics for all admissible parameter values. Note, however, that the share of capital α is typically measured as being near 1/3 (e.g., Stokey and Rebelo, 1995; Christiano, 1988). In this case, diagrams (5b) and (5c) would be of interest only if the cost of children increased at or faster than the cube of labor income. Since this is not plausible, I concentrate on $\rho < 1/\alpha$, i.e., $\rho < \approx 3$ in the analysis that follows.[27]

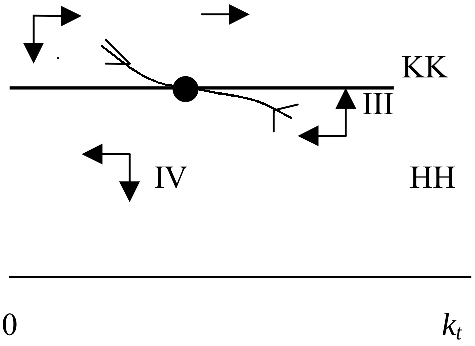
Figure 5. The dynamics. (a) $\rho < 1/\alpha$ (b) $\rho = 1/\alpha$ (c) $\rho > 1/\alpha$



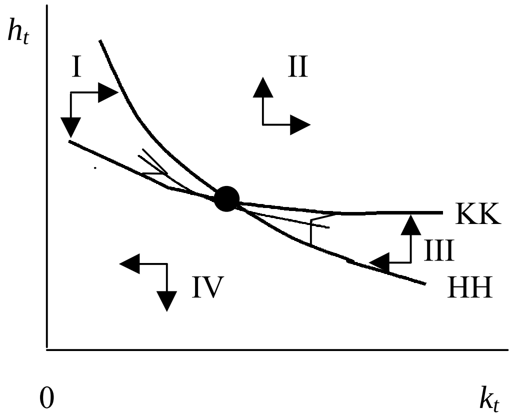
(a)



[26] See Azariadis (1996) on the interpretation of various steady states as poverty traps.
[27] The conclusions will apply as well to the other two cases.



(b)



(c)

5.2 Balanced Growth Path

In this section I characterize the balanced growth dynamics and then combine the transitional and balanced growth dynamics into a complete depiction of the model's evolution. Since balanced growth requires that all per capita variables grow at constant rates, this does not obtain for the growth in human capital until $b_t^* = \bar{b}$.

On a balanced growth path (BGP), the equilibrium dynamics are given by

$$k_{t+1} = \frac{\beta}{(1+\gamma)} \frac{(1-\alpha)k_t^{\alpha} h_t^{(1-\alpha)} - x_{1,t}}{\bar{b}} \qquad (19)$$

$$h_{t+1} = \frac{\varpi h_t}{\bar{b}^{\theta}} \qquad (20)$$

As in Lucas (1988), all per capita variables grow at an identical rate, i.e., at the rate of growth in human capital.

Theorem 3 *On balanced growth path, output, physical capital, and human capital all grow at rate* $\varpi / \bar{b}^{\theta}$.

Theorem 4 *The balanced growth path is attracting.*

Figure 6a presents the transitional dynamics and balanced growth dynamics in the same phase portrait, where, by Theorem 4, the BGP is attracting and lies in region II. In fact, for initial conditions in regions II and III the economy is attracted to the BGP. This holds "generally" because the region of attraction to the sustained growth path is quite difficult to determine. In addition, there are a set of initial conditions in region III that place the dynamics on the one-dimensional manifold leading to the interior steady state and, therefore, for these initial conditions balanced growth does not obtain.

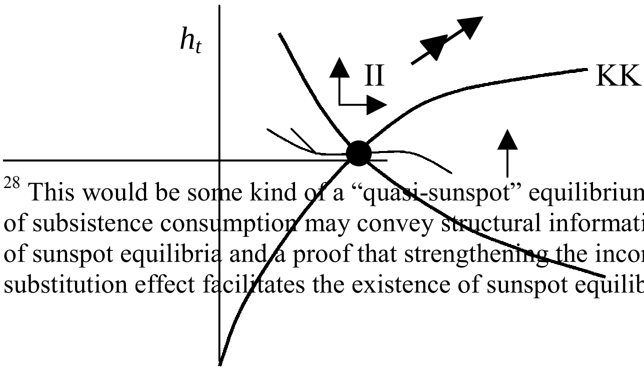
More broadly, Figure 6a suggests that the HH curve acts as a boundary leading the dynamics for most initial conditions to the right of the HH curve toward the BGP. Rather interestingly, as follows from (16), changes in the perceived subsistence level of consumption, x_1, shift the HH curve and, therefore, the lower bound for the BGP. This is shown by the next result and graphically presented in Figure 6b.

Theorem 5 *Increases in the perceived subsistence consumption, x_1, shift inward the HH curve along which the average human capital is constant. Decreases in x_1 shift outward the HH curve.*

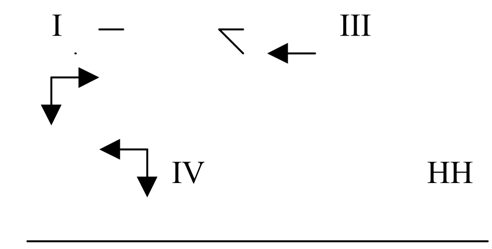
Theorem 5 shows that the question of what the population views as a minimum acceptable income affects economic development. Specifically, an increase in the perceived subsistence level of consumption shifts the HH curve inward, reducing the area of poverty trap and increasing the region of sustained growth in the phase portrait. This effect is shown in Figure 6b. At the original level of subsistence consumption, initial conditions in regions II' and III' cause the economy to be mired in a poverty trap. After the increase in the perceived subsistence consumption, however, for initial conditions in regions II' and III' the economy is generally attracted to the sustained growth path.

In other words, if all individuals believe that the subsistence level of consumption is relatively high, the potential for long-run growth will be higher.[28] This might seem counterintuitive since a higher subsistence consumption level would imply a higher proportion of people who feel poor. The mechanism through which the higher subsistence consumption positively influences growth is the fertility reduction. As (3) shows, the optimal number of children decreases in the perceived level of subsistence consumption. The law of motion for human capital defined in (4) shows that agents that have fewer children transmit more human capital on average intergenerationally. Therefore, the potential of reaching the sustained growth path increases.

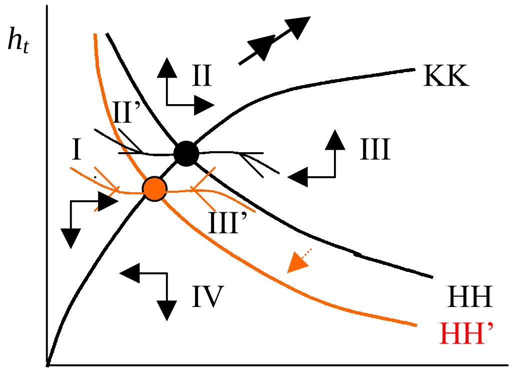
Figure 6. Transitional and Balance Growth Path Dynamics



[28] This would be some kind of a "quasi-sunspot" equilibrium, since the believes about the higher level of subsistence consumption may convey structural information. See Azariadis (1986)for an explanation of sunspot equilibria and a proof that strengthening the income effect of wage change relative to the substitution effect facilitates the existence of sunspot equilibria.



(a)



(b) Increase in the perceived subsistence consumption

5.3 Dynamics with Endogenous Subsistence Consumption

This subsection briefly examines a version of the model with an endogenous level of subsistence consumption in order to determine the robustness of the results. The dynamics of the model presented above assumed constant subsistence consumption levels. This assumption is consistent with the notion that there is some objective poverty line that does not evolve over time. However, Milanovic and Jovanovic (1999) find that the realization of seemingly ever worsening conditions leads the public to scale down its expectations of what the minimum acceptable income is. In fact, they show that the decline in the subjective poverty line coincides approximately with the decrease in real income. Taking this into account and following Azariadis (1996), suppose the perceived subsistence levels of consumption are $\left(x_{1,t}^{i}, x_{2,t+1}^{i}\right) = \left(\bar{x} k_t^{\alpha} h_t^{1-\alpha}, 0\right)$, where $\bar{x}$ is a share-of-GNP parameter. Under this assumption, the dynamics of the model in per worker terms are given by

$$k_{t+1} = A k_t^{\rho\alpha} h_t^{\rho(1-\alpha)} \quad (21)$$

$$h_{t+1} = C k_t^{\alpha\theta} h_t^{1+\theta(1-\alpha)(\rho-1)} \quad (22)$$

where $A \equiv \beta D(1-\alpha)^{\rho}\gamma^{-1}$ and $C \equiv \left[\varpi^{1/\theta} D(1-\alpha)^{\rho}(1+\gamma)(1-\alpha-\bar{x})^{-1}\gamma^{-1}\right]^{\theta}$, subject to the parameter restriction $(1-\alpha) > \bar{x}$. The model admits a trivial steady state ($k_t = h_t = 0$, $\forall$ t) and a unique interior steady state $(\bar{k}, \bar{h})$ given by

$$\bar{k} = AC^{-\rho/[\theta(\rho-1)]} \tag{23}$$

$$\bar{h} = \left[A^{\alpha} C^{(1-\rho\alpha)/[\theta(\rho-1)]}\right]^{-1/(1-\alpha)} \tag{24}$$

Theorem 6 *The interior steady state given by (23) and (24) is locally saddle-point stable.*

Overall, the transitional and balanced growth dynamics for this version of the model match those for the model with exogenous subsistence consumption given in Subsections 5.1 and 5.2. Figures 5 and 6 can be also used for an illustration of the dynamics in this version of the model. Note that specifying the level of subsistence consumption as a fraction of GNP does not eliminate the poverty trap. The BGP in this version of the model is attracting and once a country is on the BGP, endogenous variables grow at the rates of human capital transmission $\varpi / \bar{b}^{\theta}$.

Theorem 7 *Increases in the fraction of subsistence consumption in GNP, $\bar{x}$, shift inward the HH curve along which the average human capital is constant. Decreases in $\bar{x}$ shift outward the HH curve.*

Theorem 7 shows that increasing the fraction of subsistence consumption in GNP reduces the area of poverty trap while increasing the region of sustained growth, and is, therefore, good for the long-run development of the economy. The mechanism is again the fertility reduction and increased human capital transmission. Figure 6a, which presents graphically the results of Theorem 5, can be also used as a graphical presentation of Theorem 7.

6 Empirical Evidence

The empirical analysis will center on the model's implications for births, b_t^*. The main prediction for aggregate number of births is that, in times of economic depression, declining labor income causes fertility reduction. In other words, while fertility and income declined in all transition economies, deeper reduction in fertility should be expected in countries with deeper fall in real GDP per capita. In addition, increasing income inequality contributes to further decline in fertility. These predictions are tested using a cross-section regression analysis of the percentage changes in fertility, labor income, and inequality. The data span from 1987-89 through 1998 for a sample of twenty-two countries in Eastern and Central Europe and the former Soviet Union.

Recently, measurements of the key variables considered in this analysis have been significantly refined for the post communist countries, which has allowed for a better assessment of the evidence. A commonly used measure for fertility is the crude birth rate, defined as the number of children born per thousand of the population.

Labor income, by equation (7), depends on physical and human capital per worker. However, because of well-known measurement problems, physical capital per worker is proxied by real GDP per capita. This preserves the model's structure, since the production function (6) shows that physical capital and output are directly proportional to each other. Human capital is proxied by secondary school enrollment, since it is generally considered that secondary education aims at laying the foundations for lifelong learning and human capital development. The source of the data for birth rates, real GDP per capita and secondary school enrollment is the World Bank.

The difficulties in accurately measuring income inequality are well known. A major improvement took place only recently with the release of the Deininger-Squire data on Gini coefficients and income shares. The percentage increase in income inequality used in this analysis is calculated using the data on Gini coefficients provided by Deiniger and Squire (1996) and Milanovic (1988).

Another dramatic change that occurred in the transition economies since they abandoned Communism was political liberalization. To control for this effect, the percentage change in the Freedom House (inverted) index of civil and political freedom is included in the regression analysis.[29]

Table 2 presents the results of two specifications of the fertility equation. In the first one, the percentage decline in fertility is regressed on the percentage decline in real GDP per capita and secondary school enrollment and the percentage increase in income inequality. The second regression augments the model by adding a dummy variable for the countries at war during the transition period[30] and controlling for increased democracy.

The regression analysis confirms that declines in fertility were deeper in countries with deeper falls in real GDP per capita. In the both regressions the coefficient on the decline in real GDP per capita is significant and carries the expected positive sign. In the first regression, the decrease in secondary school enrollment enters with a positive, but insignificant coefficient. However, once the effects of war and increased democracy have been controlled for, the coefficient on secondary school enrollment becomes significant. The war dummy variable is positive and significant, indicating that fertility declined more in countries at war.

In neither of the two formulations, is the Gini variable significant nor does it have the predicted sign. This should be unsurprising, however, given the noisiness of the data and the small number of data points. While recent research has addressed some of the methodological problems related to the measurement of inequality, more work is needed to improve the available databases in order to allow for better comparability across countries.

Lastly, the increase in democracy enters with a positive, but insignificant sign. A reason for the failure to find a significant effect of democracy on fertility could be the relatively short democratic experience of transition economies. Muller (1988), for instance, in a sample of 50 countries finds that at least 20 years of democratic experience are required for a significant reduction in income inequality to occur.

[29] The Freedom House index measures political rights and civil liberties on a one-to-seven scale, with one representing the highest degree of freedom and seven the lowest. The index is inverted so that its higher values show greater democracies and civil liberties.

[30] The war dummy variable is created based on data provided by Milanovic (1998), p. 4.

Similarly, in order for democracy to "work" on fertility decisions, a sufficiently long period of democracy might be needed.[31]

Table 2. Cross-Country Analysis of Fertility: Transition Countries

	% decline in fertility	
% decline in GDP per capita	0.382** (0.093)	0.268* (0.111)
% decline in secondary school enrollment	0.183 (0.097)	0.246* (0.089)
% increase in Gini coefficients	-0.105 (0.089)	-0.124 (0.063)
War dummy		0.122* (0.048)
% increase in democracy		0.001 (0.010)
Constant	0.296** (0.025)	0.323** (0.041)
R^2	0.525	0.666

Notes: White heteroskedasticity-consistent standard errors in parentheses.
* = significant at 5 percent; ** = significant at 1 percent.

The cross-sectional analysis presented in Table 2 provides a general statistical framework to examine the predictions of the formal model, but it might not tell the whole story. In order to capture the evolution of the relevant variables through time, the predictions of the model are further tested using a cross-country time-series analysis. The data span from 1979 through 1998 for 24 transition countries.[32] All independent variables are lagged to instrument the variables the theory identifies as jointly endogenous with births (i.e. the formal derivations are part of a general equilibrium model), as well as to capture dynamic changes in the underlying structure. To account for the quadratic relationship between fertility and labor income shown in Figure 4, squares of the proxies for physical and human capital are included in the analysis.[33] The income inequality is not included because of the unreliable nature of data discussed above. The results of using the FGLS procedure with country fixed effects are reported in Table 3.

Table 3. Fertility: Transition Countries, 1979-98.

	Fertility	
GDP per capita	0.0025** (0.0004)	0.0032** (0.0006)
(GDP per capita)^2	-1.61E-07** (-4.50E-08)	-1.89E-07** (4.92E-08)

[31] When included in the cross-section analysis, the length of democratic experience had insignificant effect on fertility.

[32] Bosnia and Herzegovina, Yugoslavia, and Turkmenistan are excluded from the analysis because of lack of data.

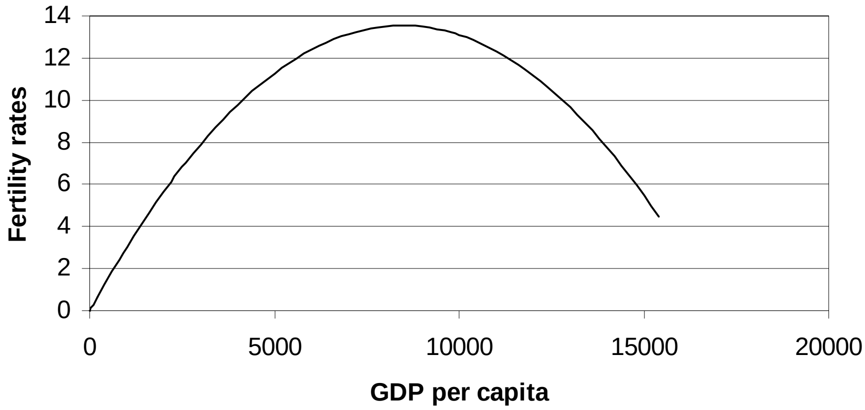
[33] The quadratic relationship does not hold for incomes greater than $\overline{\overline{wh^i}}$, but is true in the domain relevant for this analysis.

Secondary school enrollment		0.1485* (0.0616)
(Secondary school enrollment)^2		-0.0007* (0.0003)
Freedom House index (inverted)		-0.4729 (0.7138)
R^2	0.3737	0.7778

Notes: White heteroskedasticity-consistent standard errors in parentheses.
Coefficients for country dummies are not shown to conserve space.
* = significant at 5 percent; ** = significant at 1 percent.

The coefficients on real GDP per capita and secondary school enrollment carry the expected and significant signs. Indeed, fertility has a quadratic relationship with labor income, initially increasing, and then decreasing at a certain point. As illustrated in Figure 7, that point for the whole region is an average GDP per capita of approximately $8,500 (constant 1995 US$), while the maximum birth rate is 13.54.[34] As in the cross-country analysis, the effect of the increased democracy, proxied by the inverted Freedom House index, on fertility is insignificant.

Figure 7. Fertility versus GDP per capita



In sum, countries with steeper decline in per capita income have experienced deeper decline in fertility rates, as the model predicts. Perhaps it is possible to explain the remarkable fertility reduction through some other variable, or through a series of stochastic shocks to populations and technology, without including an effect of income on fertility. However, given that model based on prevailing growth models in the economic literature provides such a good explanation of the data, it is not clear why one would want to abandon the explanatory power of per capita income for an alternative explanation of the data.

7 Conclusion

The inverse relationship between income and fertility is a well-established result in the economic literature. The transition experience of post communist countries in Eastern and Central Europe and the former Soviet Union, however, goes

[34] In 1998 the average GDP per capita in constant 1995 US$ for the 24 transition countries was around $2,400 and the average birth rate was 12.1.

against these conclusions. While exploring the puzzle of a positive relationship between fertility and income observed in transition economies, this paper should be seen as an extension of the standard economic literature.

The paper presents a heterogeneous agent endogenous growth model in which children inherit human capital from parents. In addition, parents care about the number of children they rear, which has a dilution effect on the human capital inherited by each child. The model also includes level of subsistence consumption, modeled both as a constant in absolute terms and as a share-of-GNP parameter. The dynamics of the model show that interplay between fertility choices and the perceived subsistence level of consumption contribute to our understanding of growth experiences, from poverty traps to sustained growth.

The model reveals three novel results about fertility choices in times of deep economic depression. First, a reduction in labor income below a certain threshold reduces the desire to have children, and, therefore, fertility decreases. Second, increases in income inequality decrease the aggregate number of births. Third, higher perceived subsistence level of consumption could push a relatively poor country from the area of poverty trap to the region of sustained growth. This is achieved by fertility reduction, which in turn causes an accelerated accumulation of human capital.

The close connection established in this paper between economic events and demographic outcomes in the transition countries implies that the currents fertility trend will not stabilize and reverse if the ongoing process of impoverishment continues and if public policy is either aloof or focused on narrow sectoral responses in the areas of lifestyles, health intervention and family-support measures. This paper has underscored the importance of improvement of the economic well-being, entailing inflation control, support for the minimum wage and family and housing allowances, as well as of adequate tax collection and regulatory measures. Governments can engineer successful development programs by implementing policies affecting fertility that do not ignore economic realities.

Ceteris paribus, a turn-around in fertility trend can take place if the economic climate improves steadily and significantly, thus influencing the expectations about the future economic outcomes that appear to exert sizable influence on the decision to have a child. In this regard, prospects for poverty alleviation appear not entirely negative, and broadbased, equitable economic growth could reabsorb much of the existing poverty. Furthemore, in view of the still low income inequality and the high level of human capital in relation to other regions of the world, the introduction of broadbased policy measures could lead to demographic stabilization and recovery in most transition countries.

There are several possible extensions that would add realism to the model. First, in order to keep the dynamics of the model tractable, all agents were assumed identical. This assumption should be relaxed in future research to gain a fuller understanding of the effect of fertility, the distribution of human capital, and the subsistence level of consumption on economic growth. Second, permitting children to be produced by the mating of agents identified by their sex, rather than by parthenogenesis, would permit an exploration of how the mixing of genes affects growth. Third, implicit in the model is an assumption that markets work without frictions or externalities. Future research could take into consideration the effects of an inefficient institutional environment, especially with respect to institutions that affect property rights and economic transactions.

Appendix

This appendix provides proofs for lemmas and theorems that are either instructive or novel. Other proofs are omitted to save space, but are available from the author upon request. The proof of Lemma 2 is provided first.

Proof. [Lemma 2] For simplicity, assume subsistence consumption levels $\left(x_{1,t}^{i}, x_{2,t+1}^{i}\right) = \left(x_{1,t}^{i}, 0\right)$. Substituting the optimal value for b^i from (3) and the value of the labor income (7) into the law of motion for human capital (4) produces

$$h_{t+1}^{i} = Bk_t^{\alpha\rho\theta}\left(h_t^i\right)^{1+\rho\theta(1-\alpha)}\left[(1-\alpha)k_t^{\alpha}\left(h_t^i\right)^{1-\alpha} - x_{1,t}^{i}\right]^{-\theta} \tag{25}$$

where $B \equiv \left[\varpi^{1/\theta} D(1+\gamma)(1-\alpha)^{\rho}\gamma^{-1}\right]^{\theta}$.

Using (25), the human capital of children h_{t+1}^{i} is less than that of their parents if

$$B^{1/\theta}k_t^{\rho\alpha}\left(h_t^i\right)^{\rho(1-\alpha)} - (1-\alpha)k_t^{\alpha}\left(h_t^i\right)^{1-\alpha} + x_{1,t}^{i} < 0 \tag{26}$$

Let $G\left(h_t^i, k_t\right) \equiv B^{1/\theta}k_t^{\rho\alpha}\left(h_t^i\right)^{\rho(1-\alpha)} - (1-\alpha)k_t^{\alpha}\left(h_t^i\right)^{1-\alpha} + x_{1,t}^{i} = 0$. Following the implicit function theorem and assuming $\partial G\left(h_t^i, k_t\right)/\partial h_t^i$ is strictly monotonic and nonvanishing $\forall k_t \geq 0$, there exists a differentiable and invertible function $\psi(k_t)$ such that

$$h_t^i = \psi(k_t) \tag{27}$$

where $\psi'(k_t) < 0 \ \forall k_t \geq 0$ ■

The proof of Theorem 1 is next and follows a method similar to the one used in Rothschild and Stiglitz (1970).

Proof. [Theorem 1] Let F be the nondegenerate distribution of labor income at a particular point in time for a given level of capital stock, K, and let G be a distribution derived from F via a simple mean preserving spread (MPS). Denote $\mu > 0$ as the mean of both distributions. By Lemma 1, for incomes below the threshold $\overline{wh^i}$, the desired number of children increases monotonically in labor income wh^i, and is concave. For concreteness, suppose that $\mu < \overline{wh^i}$. Increasing the mass of agents with incomes less than the mean reduces fertility, since $\int_{\bar{b}}^{\mu} b^i dF < \int_{\bar{b}}^{\mu} b^i dG$. Increasing the mass of agents with incomes between μ and $\overline{wh^i}$ raises fertility. However, as a result of the concavity of $b(wh^i)$ for labor incomes below $\overline{wh^i}$, the decrease in fertility by relatively poor agents after an MPS exceeds the increase in fertility by relatively wealthy agents. The same conclusion applies for the range of incomes above $\overline{\overline{wh^i}}$: since the desired number of children decreases monotonically and is concave in labor income, an MPS of the distribution of labor income decreases aggregate births. Only for incomes between $\overline{wh^i}$ and $\overline{\overline{wh^i}}$, an MPS increases fertility. However, if a relatively large fraction of the population has incomes below $\overline{wh^i}$, the overall effect of an MPS of the distribution of labor income is a fertility reduction ■

Next, I proceed to prove Theorem 2, following the method in Azariadis (1993). For simplicity only, the proof utilizes an additional assumption that the subsistence consumption levels $\left(x^i_{1,t}, x^i_{2,t+1}\right) = (0,0)$. The proof utilizes the following lemma.

Lemma 3 *A first order approximation of the dynamical system given by (13) and (14) has only real eigenvalues.*

Proof. [Theorem 2] Since this is a planar system, the two eigenvalues can be characterized using the trace (*TR*) and determinant (*DET*) of the Jacobian of the local approximation of the system of transitional dynamics given by (15) and (16), noting that the characteristic equation $p(\lambda)$ can be written as $p(\lambda) = \lambda^2 - (TR)\lambda + DET = 0$.

Direct calculation reveals that

$$TR = \rho\alpha + 1 + \theta(1 - \alpha)(\rho - 1) > 0 \tag{28}$$

$$DET = \rho\alpha > 0 \tag{29}$$

and by Lemma 3, the roots to the characteristic equation are real.
Evaluating the characteristic equation $p(\lambda)$ at $\lambda = 1$ and $\lambda = -1$ results in

$$p(1) = -\theta(1 - \alpha)(\rho - 1) < 0 \tag{30}$$

$$p(-1) = 1 + 2\rho\alpha + \theta(1 - \alpha)(\rho - 1) > 0 \tag{31}$$

indicating that $-1 < \lambda_1 < 1 < \lambda_2$. Hence the steady state is a saddle ■

Proofs of Theorems 3 and 4 also utilize the assumption that the subsistence consumption levels $\left(x^i_{1,t}, x^i_{2,t+1}\right) = (0,0)$.

Proof. [Theorem 3] Observe that the growth in output can be written as

$$g \equiv \frac{y_{t+1}}{y_t} = \left(\frac{k_{t+1}}{k_t}\right)^{\alpha}\left(\frac{h_{t+1}}{h_t}\right)^{1-\alpha} \tag{32}$$

which is equivalent on a BGP to

$$\frac{y_{t+1}}{y_t} = \left(\frac{y_t}{y_{t-1}}\right)^{\alpha}\left(\frac{\varpi}{\bar{b}^{\theta}}\right)^{1-\alpha}$$

(33)

by using (19) and (20). Since output growth is constant on the BGP,

$$\frac{y_{t+1}}{y_t} = \frac{y_t}{y_{t-1}} = g$$

(34)

Therefore, $g = \varpi / \bar{b}^{\theta}$ ■

Proof. [Theorem 4] Following Barro and Sala-i-Martin (1995), I analyze the dynamics at a point on the BGP by transforming the system into one in which there is a steady state. Defining the new variable $z_t \equiv k_t / h_t$, the dynamical system on the BGP can be written as

$$z_{t+1} = \frac{\beta(1-\alpha)}{(1+\gamma)}\frac{\bar{b}^{\theta}}{\varpi} z_t^{\alpha}$$

(35)

This new system has the steady state

$$\bar{z} = \left[\frac{\beta \bar{b}^{\theta}(1-\alpha)}{\varpi(1+\gamma)}\right]^{\frac{1}{1-\alpha}}$$

(36)

Taking the Jacobian of the new system and evaluating $\bar{z}$ one can show that the eigenvalue α (0, 1). Therefore, the BGP is stable ■

Proof. [Theorem 5] Using (16), the HH curve along which the average human capital is given by

$$B^{1/\theta} k_t^{\rho\alpha} (h_t)^{\rho(1-\alpha)} - (1-\alpha) k_t^{\alpha} (h_t)^{1-\alpha} + x_{1,t} = 0$$

(37)

Let $G(h_t, k_t) \equiv (37)$. Following the implicit function theorem and assuming $G(h_t, k_t)$ is monotone increasing in h_t $\forall k_t \geq 0$, it follows that $\partial h_t / \partial x_{1,t} < 0$ ■

Proofs of Theorems 6 and Theorem 7 are omitted because of their similarity to the proofs of Theorems 3 and 4.

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