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 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 the fertility reduction; *ii)* the distribution of income affects growth by its impact on fertility; and iii) the subjective subsistence level of consumption plays an important role in determining the economy's growth path. Empirical tests on a sample of 22 countries from 1987 to 1998 provide strong support for the prediction that the decline in labor income significantly influences birth rates.

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 posed an intellectual challenge ever 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, fertility fell rather than rose as income grew during the past 150 years in the West and in the other parts of the developed world. Empirical evidence on the inverse relationship between the level of fertility and the level or the growth rate 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 modeling the transition *from* the "Malthusian" stage - featuring positive relationship between population growth and level of income per capita - *to* the "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 a sharp decline in real incomes and caused fertility reduction. This paper proposes means to reconcile 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 suggesting 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 perceived subsistence level of consumption on economic growth.

The paper develops an equilibrium model of micro-economic behavior of individuals with savings and fertility choices. The model describes an environment in which the number of children is chosen in a utility-maximizing framework, in the tradition of Becker (1960), Razin and Ben-Zion (1975), and Becker and Barro (1988). To derive nonergodic behavior from the otherwise standard model of economic growth, however, a subsistence level of consumption is introduced. In that sense, the model is closely related to the work by Azariadis (1996) and Jones (2000). My work though extends their studies in two primary ways. First, following Zak (1999), a special emphasis is placed on specifying the human capital accumulation, which depends on both the random inheritable factors and the parental nurture given to children. Second, I derive a structural break that produces a nonergodic demographic transition, i.e., a state in which fertility declines as incomes decrease, rather than impose strict assumptions to extract such a behavior from the model.

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 of agents to have children falls. This occurs because the utility function at or near subsistence consumption is such that the income effect on fertility dominates the substitution effect as the economy goes through depression.[1] 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.[2] 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. This stands in contrast to the finding of Zak (1999), 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.

Analyzing the dynamics of the model reveals novel implications regarding the effect of population's views about the subsistence level of consumption on the growth path of economy. Initial conditions determine country's long-run development. However, 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 and human capital, a higher perceived subsistence consumption level increases the proportion of people with income below a certain threshold. As a result of the domination of the income effect over the substitution effect, the aggregate number of births decreases. This in turn increases the intergenerational transmission of human capital and raises the potential for economic development.

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 to market economies. 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 directions for future research.

2 An Overview of the Post-Communist Great Depression

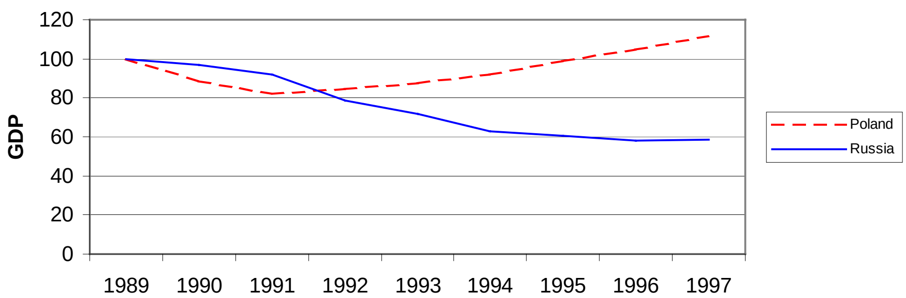
One of the major motivations to study the relationship between fertility and income during the transition from planned to market economy is the empirical data. Although experiences varied from country to country, the transition generally featured a sharp fall in output and real wages, coupled by an increase in unemployment, income inequality, and poverty. As noted by Milanovic (1998), the depth of the post-Communist depression is best assessed by comparing it to the 1929-33 Great Depression. As an illustration, Figure 1 shows the GDP for Russia and Poland during 1989-97, using 1989

[1] In the model of Jones (2000), this effect is called a subsistence effect.
[2] 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).

as a base year, while Figure 2 plots the GDP for the United States and Germany during 1929-37, using 1929 as a base year. The depression in Poland, though deeper than the one in Russia during the first two years, was not as severe as the depressions in the other three countries. The Polish trough, reached in 1991, was approximately 18 percent below the 1989 level. Since 1992, Poland grew consistently and, by 1996, the Polish GDP was above its base level. By contrast, out of the four countries, Russia experienced the deepest and longest depression. Russia's GDP plunged throughout the whole period, and in 1997 was 42 percent below its 1989 level.

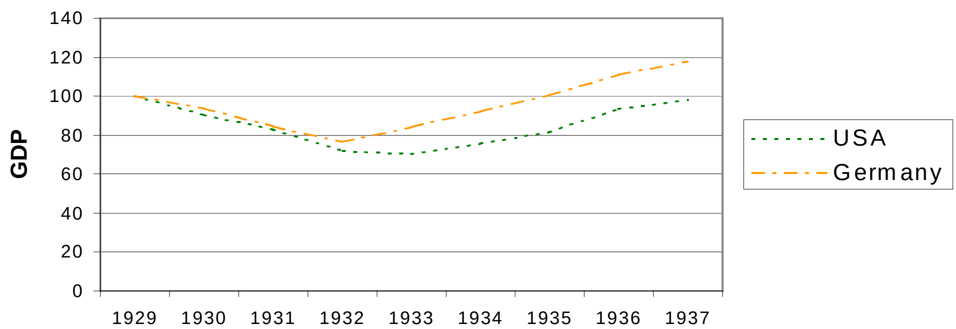
The effects of the Great Depression and the post-Communist transition on the fertility choices were also similar. As shown in Figures 3 and 4, each of the four countries experienced a decline in the birth rates. For Germany and the United States, the lowest fertility rates were reached in 1933. Births increased in the following years, however, and in Germany, by 1934, fertility exceeded its 1929 level. The fertility decline in Russia and Poland was deeper and longer-lasting. Indeed, Russia experienced the most severe fertility reduction that almost matched the decline path of its GDP. In 1997 the fertility rate in Russia was almost 40 percent below its base level, while in Poland the births per woman declined by almost 30 percent.

Figure 1. GDP in Poland and Russia, 1989-97



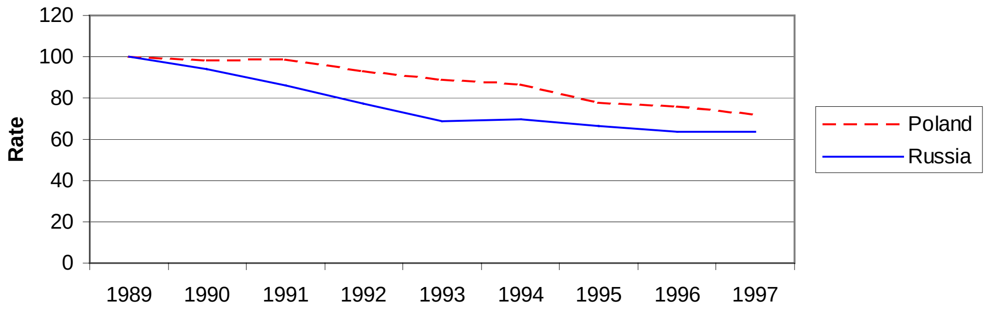
Note: 1989 = 100.
Source: World Bank: World Development Indicators, GDP at market prices (constant 1995 US$), 1999.

Figure 2. GDP in USA and Germany, 1929-37



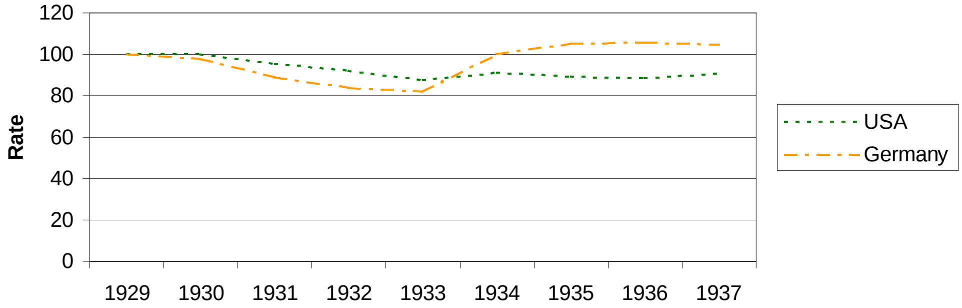
Note: 1929 = 100.
Source: Liesner (1989, table US.2 and table G.2).

Figure 3. Fertility Rates in Russia and Poland, 1989-1997



Note: 1989 = 100.
Source: World Bank: World Development Indicators, Fertility rate, total (births per woman), 1999.

Figure 4. Fertility Rates in USA and Germany, 1929-37



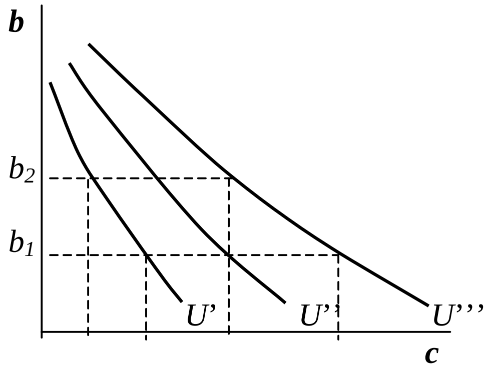
Note: 1929 = 100.
Source: For the United States: Statistical Abstract of the United States (1944-45). For Germany: Mitchell (1992).

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 5 where, the household becomes less willing to trade consumption for children as it becomes poorer within a critical range.[3] In particular, when income is sufficiently low relative to the subsistence level of

[3] For a formal presentation of the critical range of labor income, see equation (11).

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 5. Indifference Curve Map at Subsistence Consumption



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

During depression the percentage of people who are poor because their income is below a certain threshold goes up. In addition, abrupt and unfavorable economic developments have impact on the population’s view about the subsistence level of consumption, i.e., the minimum acceptable income to make ends meet. Milanovic and Jovanovic (1999) find that, while the official poverty line stayed the same, the subjective estimate of the minimum income for an adult Russian decreased by about 1.7 percent each month from March 1993 to September 1996. The decrease in the subjective poverty line happens as people adapt to the new and worse conditions, and adjust their expectations accordingly. This paper takes into account both the objective poverty line as a constant level of subsistence consumption and the subjective poverty line as a subsistence consumption level generated by a process of habit formation.

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. 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 so that a child’s human capital is a function of a single parent’s human capital.[4] In old age, agents are retired and consume from the principal and interest on their savings.

[4] This permits avoiding the issue of marriage matching and obviates the need to model cross-over, mutation and linkage between genetic alleles which occurs when two parents supply genetic material to children.

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 the current labor income (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 each agent chooses to have at the beginning of the adult period.

When utility is logarithmic, the lifetime utility maximization problem for agent *i* born at time *t* - 1 is

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

$$\text{if } c_{1,t}^i \geq x_{1,t} \text{ and } c_{2,t+1}^i \geq x_{2,t+1}$$

subject to

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

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 ($x_{1,t}, x_{2,t+1}$) are the subsistence consumption levels in youth and old age, being generated by a process of habit formation. 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 and is related to the long-run rate of fertility.[5]

The production and rearing of children are time intensive (Birdsall, 1988). In addition, the theory suggests that higher income and technology may reduce fertility by increasing wages and thus the value of time (Schultz, 1981). I shall therefore assume that higher wages – due to greater human or physical capital per worker - 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, $e_t^i = D\left(w_t h_t^i\right)^\rho$, where $0 < D < 1 \Big/ \left\{\left(w_t h_t^i\right)^{\rho-1} b_t^{i*}\right\}$ is a scale parameter and $\rho > 1$ is the constant elasticity of the cost of children with respect to the labor income.[6]

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 type *i* agent at time *t* for savings and the number of children are

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

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[5] The assumption $b_t^i \geq \bar{b} > 0$ is necessary for describing the asymptotic behavior of the system, but is not crucial to the analysis over the period discussed in this paper.

[6] The assumption about 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.

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

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

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 subsistence consumption, $x_{1,t}$, and positively related to the discounted value of the next-period level of subsistence consumption, $x_{2,t+1}/R_{t+1}$. The optimal number of children, (3), increases as the preference for children rises and falls as the 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.[7] 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). 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

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

for $\tilde{\omega}$ a random variable that determines the inherited portion of human capital and $\theta > 0$ specifies the dilution effect on parental nurturing from having multiple children.[8] The factor $\tilde{\omega}$ includes both genetic traits and social and cultural factors (memes) that parents inculcate into children. Let $\tilde{\omega}$ ~ G, where G has strictly positive support and $E\{\tilde{\omega}\} = \omega > 1$. Specifying the mean of $\tilde{\omega}$ to exceed unity captures the significant increases in average IQ scores during the post-war period. In fact, the average IQ scores in developed countries have increased from 10% to 25% between the 1950s and 1980s.[9]

Consider an agent who receives the average genetic "draw", ω. If she is a single child, then her human capital will exceed her parent's (since $\omega > 1$). If, on the other hand, this child is born into a household in which the number of children is high, she may

[7] 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.

[8] The "production function" for human capital in (4) is similar to that used by Lucas (1988) when each family has a single child.

[9] This is known as the "Flynn effect" after Flynn (1987).

have less human capital than her parent. Thus the distribution of inheritable traits via $\tilde{\omega}$ and the parental nurturing have a fundamental impact on fertility rates and 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, [10]

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

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},[11]

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

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

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

where a^{i*} is given by (2).The evolution of the working population of agents of type i is

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

where b^{i*} is given by (3). That is, next period's working population is the aggregate number of births in the current period.

A *competitive equilibrium* for the model above is a set of prices $\{w_t , R_{t+1}\}_{t=0}^{\infty} \forall i$, 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) equations (4), (9), and (10);

(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, perceived subsistence level of consumption and labor income. In particular, the optimal number of children, which has been defined in equation (3), is a continuous function of labor income that follows the pattern depicted in Figure 6.[12] 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 $\overline{\overline{wh^i}}$).[13]

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*

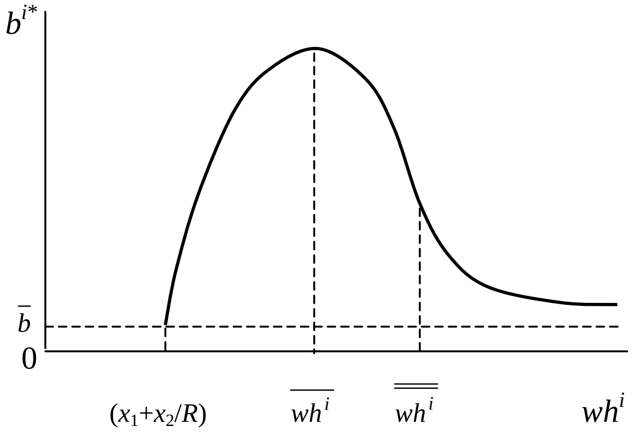
$$w_t h_t^i < \overline{w_t h_t^i} \equiv \frac{\rho}{\rho - 1}\left(x_{1,t} + x_{2,t+1} / R_{t+1}\right) \tag{11}$$

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

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

Lemma 1 demonstrates if labor income declines sufficiently relative to the current and discounted future subsistence levels of consumption, children become less affordable and births decrease. This income effect works in the opposite direction of the substitution effect that generates increase in fertility. Indeed, when consumption drops to near subsistence levels, however, necessities - such as food, housing, and clothing - become the main cost of rearing children. Under these conditions, the income effect dominates the substitution effect, reducing the birth rates.

Figure 6. Fertility Versus Income



Note that the threshold $\overline{w_t h_t^i}$ need not be equal to the sum of the subsistence levels of consumption. In fact, since $\rho > 1$, $\overline{w_t h_t^i}$ is above the sum of the 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 cost of children with respect to labor income, ρ.[14] Thus, in countries with pro-natal policies, and hence lower ρ and higher $\overline{w_t h_t^i}$, lesser decline in income would induce fertility reduction. In the former communist countries relatively cheap and good facilities for childcare still existed during the first years of the transition when the fertility decline was the most dramatic. [15] Therefore, the elasticity of cost of children with respect to labor income, ρ, had to be relatively low. This means that the threshold $\overline{w_t h_t^i}$ was relatively high, and less drastic decline in income was sufficient to generate reduction in aggregate birth rates.

[14] Note that ρ is constant from individual's point of view, but it could vary between countries depending on incentives for fertility.

[15] See Frijters and van Praag (1994, p.10). As an additional evidence, Milanovic (1998, p.36) reports that the share of social transfers (inclusive of health and education) in the GDP was high pre-transition and increased during the transition

Lemma 2 shows if a parent has a low level of human capital she will, on average, produce children who also have little human capital, leading to an intergenerational poverty trap.[16]

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

$$h_t^i < \psi(k_t) \tag{12}$$

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

Lemma 2 demonstrates that the threshold for negative human capital growth falls as physical capital per worker increases. This is the result of income affecting family size decisions. As in Galor and Tsiddon (1997), parents with high levels of human capital, and therefore high incomes, are unlikely to have children whose human capital is less than their own. On the other hand, parents who have low human capital and earn low wages may produce children who have less human capital than their parents. In the context of the model, this cycle is only broken by children who receive extraordinary good genetic draws, $\tilde{\omega}$, that permit them to escape poverty, or by sufficient growth in the physical capital per worker.

The model also permits characterizing the relationship between the number of births and the shape of the distribution of labor income. Economic depressions are usually accompanied by sharply increasing income inequality.[17] Theorem 1 demonstrates that, for an economy with a significant fraction of the population with income below the 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, 1971) 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.[18]

Theorem 1 *If the number of individuals with labor incomes below $\overline{wh^i}$ is large, 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 a certain threshold increases, children become less affordable and aggregate births decrease. In other words, since higher income variance means that providing for the subsistence consumption level is more at risk, the result is an unwillingness of people to have children. This theorem does

[16] Proofs are contained in the Appendix.
[17] For empirical evidence of increased income inequality during the post-communist transition, see Kakwani (1996) and Milanovic (1998).
[18] 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.

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 fertility and growth, consider a special case where agents within a generation have the mean level of human capital and the factor relating children's human capital to their parent's human capital is set to its expected value, ω, for all agents. Assume also subsistence levels of consumption $(x_{1,t}, x_{2,t+1}) = (x_1, 0)$. In words, young agents have constant and identical perceptions about the minimum acceptable income to make ends meet, i.e., their perceptions coincide with the official minimum income for an adult. The level of subsistence consumption for the old generation is equated to zero.[19] The dynamics of the model in per worker terms are given by

$$k_{t+1} = Ak_t^{\rho\alpha} h_t^{\rho(1-\alpha)} \tag{13}$$

$$h_{t+1} = Bk_t^{\rho\alpha\theta} h_t^{1+\rho\theta(1-\alpha)} \left[(1-\alpha)k_t^{\alpha} h_t^{1-\alpha} - x_1\right]^{-\theta} \tag{14}$$

where $A \equiv \beta D(1-\alpha)^{\rho}\gamma^{-1}$ and $B \equiv \left[\omega^{1/\theta} D(1-\alpha)^{\rho}(1+\gamma)\gamma^{-1}\right]^{\theta}$. Depending on the value of ρ, there is at least one interior steady state $(\bar{k}, \bar{h})$ given by the solution of

$$B^{1/\theta} A^{-1}\bar{k} - (1-\alpha)A^{-1/\rho}\bar{k}^{1/\rho} + x_1 = 0 \tag{15}$$

$$\bar{h}^{\rho(1-\alpha)} = A^{-1}\bar{k}^{1-\rho\alpha} \tag{16}$$

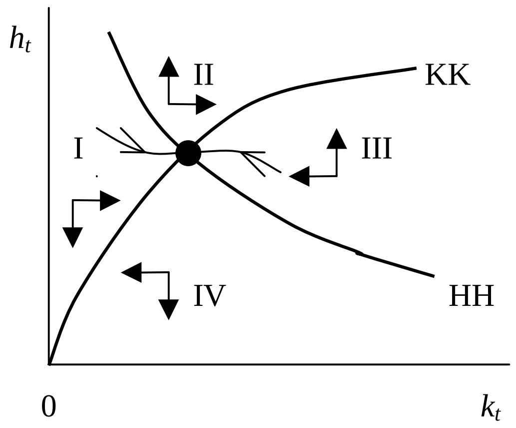
Lemma 3 *A first order approximation of the dynamical system given by (13) and (14) has only real eigenvalues.*

Theorem 2 *The interior steady states given by the solution of (15) and (16) are locally saddle-point stable.*

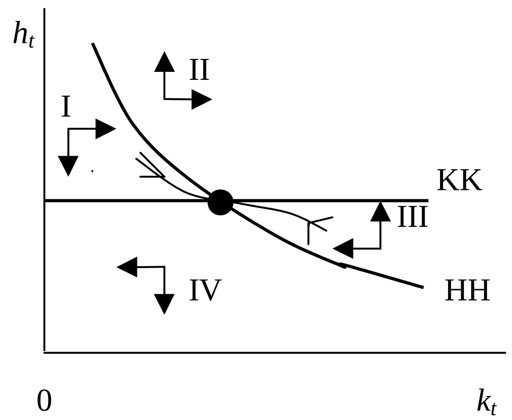
Figure 6 depicts the phase portraits of the dynamics for all admissible parameter values. The phase portraits in the figure are partitioned by the curves where physical capital is constant, denoted by KK, and where average human capital is constant, HH. The interior steady state has, as Theorem 2 demonstrates, 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 $(\bar{k}, \bar{h})$.

[19] 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 Lemma 4 demonstrates, focusing on the effect of the perceived subsistence consumption level by the young generation on the growth path of an economy.

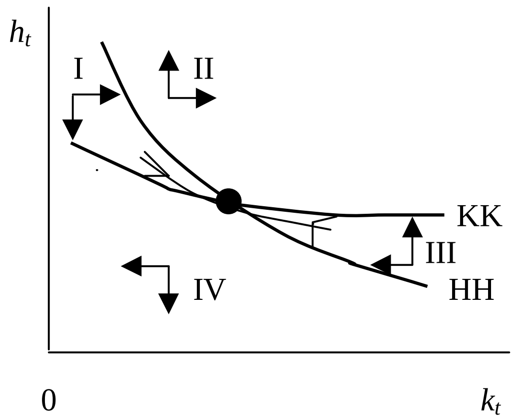
Figure 6. The dynamics. (a) $\rho < 1/\alpha$ (b) $\rho = 1/\alpha$ (c) $\rho > 1/\alpha$



(a)



(b)



(c)

For initial values of k_0 and h_0 in region IV, the phase arrows in Figure 6 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 proven in Lemma 2) 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."[20] 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 6 provides a through illustration of the dynamics for all admissible parameter values. Note, however, that the share of capital α is typically measured as being near one third (e.g., Stokey and Rebelo, 1995; Christiano, 1988). In this case, diagrams (6b) and (6c) would be of interest only if the cost of children increased at or faster than the cube of labor income. This is not plausible since the rate, ρ, at which cost of children increases in labor income depends to a large extent on policies for encouraging or discouraging fertility. As noted in the previous section, countries with pro-natal policies would have lower ρ. Since a generally pro-children stance (as reflected in free health care and education) has been still existent in transition economies, I concentrate on $\rho < 1/\alpha$, i.e., $\rho < \approx 3$ in the analysis that follows.

As follows from (14), changes in the perceived subsistence level of consumption x_1 have different effects on the HH curve depending on the stocks of physical and human capital.

Lemma 4 *The effect of the subsistence level of consumption on the HH curve along which the average human capital is constant is given by*

$$\begin{cases} \partial h_t / \partial x_1 < 0 & \text{if} \quad k_t < k^* \equiv A\left[B^{1/\theta}\rho/(1-\alpha)\right]^{\rho/(1-\rho)} \\ & \quad \text{and } h_t < h^* \equiv A^{-\alpha/(1-\alpha)}\left[B^{1/\theta}\rho/(1-\alpha)\right]^{(1-\alpha\rho)/[(1-\rho)(1-\alpha)]} \\ \partial h_t / \partial x_1 > 0 & \text{otherwise.} \end{cases} \tag{17}$$

Lemma 4 shows that the question of what the population views as a minimum acceptable income has important implications for the economic development. Consider a relatively poor economy with stocks of physical and human capital below the critical values k^* and h^*. An increase in the 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 7. Specifically, 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.[21]

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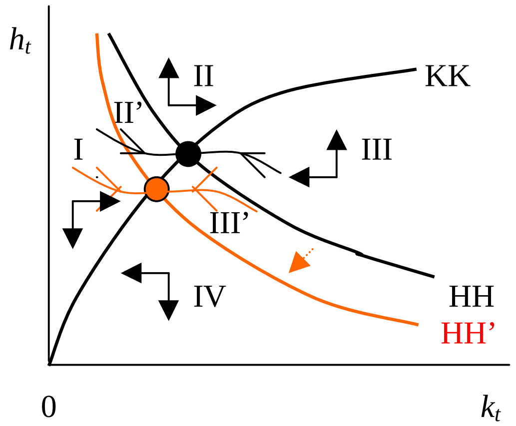
[20] See Azariadis (1996) on the interpretation of various steady states as poverty traps.

[21] 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.

In summary, for an economy with stocks of physical and human capital below the critical values k^* and h^*, a higher perceived subsistence level of consumption means a higher potential for long-run growth. 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, however, is the adaptation of population to the worsening circumstances. People "learn" how to survive with fewer resources. Probably of greater importance is that, as Lemma 1 proves, the willingness of people to have children falls once labor income decreases below a certain threshold. 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. It is thus somewhat ironic that while decrease in real income makes more people feel poor according to the objective poverty line, the same reduction in real income makes people "less demanding" (both in terms of consumption and children) and, therefore, has a positive effect on the future economic development. In other words, in times of economic depression, the higher the population pockets of social resilience and patience, the higher the country's potential for long-run growth.

Figure 7. Effect of an increase in the perceived subsistence consumption for $k_t < k^*$ and $h_t < h^*$



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, as mentioned in Section 2, Milanovic and Jovanovic (1999) find that realization of seemingly ever worsening conditions leads the public to scale down its expectations of what the minimum "tolerable" income is. In fact, they show that the decline in subjective poverty line coincides approximately with the decrease in real income. Taking this into account and following Azariadis (1996), suppose now subsistence levels of consumption defined as $\left(x_{1,t}, x_{2,t+1}\right) = \left(\bar{x} k_t^{\alpha} h_t^{1-\alpha}, 0\right)$, where $\bar{x}$ is a share-of-GNP parameter. Under this assumption, the dynamics of the model in per worker terms are given by

$$k_{t+1} = A k_t^{\rho\alpha} h_t^{\rho(1-\alpha)} \quad (18)$$

$$h_{t+1} = Ck_t^{\alpha\theta} h_t^{1+\theta(1-\alpha)(\rho-1)} \tag{19}$$

where $A \equiv \beta D(1-\alpha)^{\rho}\gamma^{-1}$ and $C \equiv \left[\omega^{1/\theta} D(1-\alpha)^{\rho}(1+\gamma)(1-\alpha-\bar{x})^{-1}\gamma^{-1}\right]^{\theta}$, 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

$$\bar{k} = AC^{-\rho/[\theta(\rho-1)]} \tag{20}$$
$$\bar{h} = \left[A^{\alpha} C^{(1-\rho\alpha)/[\theta(\rho-1)]}\right]^{-1/(1-\alpha)} \tag{21}$$

Lemma 5 *A first order approximation of the dynamical system given by (17) and (18) has only real eigenvalues.*

Theorem 3 *The interior steady state given by (20) and (21) is locally saddle-point stable.*

Lemma 6 *Increases in the fraction of subsistence consumption shift inward the HH curve along which the average human capital is constant.*

Lemma 6 shows that increasing the fraction of subsistence consumption in the 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. Figure 7, which presents graphically the results of Lemma 4, can be also used as a graphical presentation of Lemma 6. Note that specifying the level of subsistence consumption as a fraction of GNP does not permit deriving a structural break as it was done in Lemma 4. Nevertheless, the results in Lemma 6 are relevant to any economy when the perceived subsistence level of consumption is proportional to the GNP.

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.[22]

Table 1 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[23] and controlling for increased democracy.

Table 1. Regression 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

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

[22] 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.

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

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

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.[24] 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 recent economic literature. Cross country regressions, using both the level and the growth rate of income per capita as dependent variable, provide empirical support for the existing theories of demographic transition, á la Becker et al. (1990), Galor and Weil (1996), and others. The transition experience of post communist countries in Eastern and Central Europe and the former Soviet Union, however, seems to some extent to go against these conclusions. While trying to explore the puzzle of positive relationship between fertility and income observed in transition economies, this paper should not be taken a warning signal against the main strand of economic literature. It does hope,

[24] Other recent papers which examine the dramatic fall in fertility during the transition are Becker and Hemley (1998), Chase (1996), and Cornia and Paniccia (1996). These papers suggest other channels through which economic and social variables affect fertility choices.

however, to trigger additional theoretical as well as empirical research to explain this puzzle.

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's flexibility derives from relaxing the assumption of many growth models that human capital always accumulates. By focusing on familiar influences, the model permits human capital to decumulate when parental nurturing is sufficiently diluted by large family size or when physical capital per worker is sufficiently low.

The model reveals two 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. As a result, the steepest fertility reduction occurred in the countries that experienced the deepest economic depression. Second, increases in income inequality decrease the aggregate number of births. The dynamical analysis presents novel results about the role that the perceived subsistence level of consumption plays in determining the growth path of economy. Countries that begin with sufficient physical or average human capital are generally attracted to the sustained growth path, while countries that have paucity of capital of either type remain at a low level of income per worker permanently. However, the model shows that higher perceived subsistence level of consumption can 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.

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 $(x_{1,t}, x_{2,t+1}) = (x_{1,t}, 0)$. 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

$$h^i_{t+1} = B' k_t^{\alpha\rho\theta} \left(h^i_t\right)^{1+\rho\theta(1-\alpha)} \left[(1-\alpha)k_t^{\alpha}\left(h^i_t\right)^{1-\alpha} - x_{1,t}\right]^{-\theta} \tag{22}$$

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

Using (22), the human capital of children h^i_{t+1} is less than that of their parents if

$$(B')^{1/\theta} k_t^{\rho\alpha}\left(h^i_t\right)^{\rho(1-\alpha)} - (1-\alpha)k_t^{\alpha}\left(h^i_t\right)^{1-\alpha} + x_{1,t} < 0 \tag{23}$$

Let $G\left(h^i_t, k_t\right) \equiv (B')^{1/\theta} k_t^{\rho\alpha}\left(h^i_t\right)^{\rho(1-\alpha)} - (1-\alpha)k_t^{\alpha}\left(h^i_t\right)^{1-\alpha} + x_{1,t} = 0$. Following the implicit function theorem since $\partial G\left(h^i_t, k_t,\right)/\partial h^i_t$ is strictly monotonic and nonvanishing $\forall k_t \geq 0$, there exists a differentiable and invertible function $\psi(k_t)$ such that

$$h^i_t = \psi(k_t) \tag{24}$$

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 (1971).

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. 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 $\int_0^{\mu} b^i dF < \int_0^{\mu} b^i dG$. 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 a simple mean preserving spread exceeds the increase in fertility by relatively wealthy agents ■

Next, I prove Lemma 3 and Theorem 2, following the method in Azariadis (1993). For simplicity, the proofs utilize an additional assumption that the subsistence consumption levels $(x_{1,t}, x_{2,t+1}) = (0,0)$. Since the subsistence levels of consumption are considered exogenous constant parameters in the dynamic analysis so far, incorporating them into the proofs would not alter the qualitative nature of the results presented below. The proofs are long and rather tedious, so they are sketched here.

Proof. [Lemma 3] 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 (13) and (14), noting that the characteristic polynomial $p(\lambda)$ can be written as $p(\lambda) = \lambda^2 - (TR)\lambda + DET = 0$. Let $\Delta = TR^2 - 4DET$ be the discriminant of the characteristic polynomial. Clearly, the eigenvalues of the Jacobian are real if and only if $\Delta \geq 0$. Since

$$TR = \rho\alpha + 1 + \theta(1 - \alpha)(\rho - 1) > 0 \quad (25)$$
$$DET = \rho\alpha > 0 \quad (26)$$

it is straightforward to show that $\Delta \geq 0$ ■

Proof. [Theorem 2] The proof of this theorem is based on the proof of Lemma 3. Evaluating the characteristic polynomial $p(\lambda)$ at $\lambda = 1$ and $\lambda = -1$ results in

$$p(1) = -\theta(1 - \alpha)(\rho - 1) < 0 \quad (27)$$
$$p(-1) = 1 + 2\rho\alpha + \theta(1 - \alpha)(\rho - 1) > 0 \quad (28)$$

indicating that $-1 < \lambda_1 < 1 < \lambda_2$. Hence the steady states are saddles ■

Proofs of Lemma 5 and Theorem 3 are omitted because of their similarity to the proofs of Lemma 3 and Theorem 2.

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