Can More Gender Equality Lead to Higher Fertility?

Nils-Petter Lagerlöf*

Department of Economics

York University

4700 Keele Street

Toronto M3J 1P3

Canada

E-mail: lagerlof@econ.yorku.ca

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Abstract: We set up a two-sex overlapping-generations model with endogenous fertility. Due to a coordination process across houdeholds, parental human-capital investment may differ between sons and daughters. In societies with plenty of gender discrimination children are cheap to rear, since women's time is cheap, so they tend to have large families, invest little human capital in each child, and have stagnant incomes. Equal societies tend to have small families and growing levels of income. However, the relationship between gender equality and fertility among non-growing economies is the exact opposite: among countries too unequal to exhibit sustained growth, those with relatively with more gender equality have higher steady-state fertility.

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1. Introduction

Economic development seems connected to the status of women. Whether measured by gender differences in education and life expectancy, indexes of legal rights for women, or percentage of women in parliament, gender equality is positively correlated with per-capita income across countries [see Dollar and Gatti (1999)]. The picture is similar when looking at trends in schooling for different regions of the world. The ratio of female years of schooling over that of males has been constant at around .95 in the OECD world 1960-90. In developing countries this ratio has been considerably lower, but it has increased from .56 in 1960, to .69 in 1990. East Asian and Pacific countries, however, have displayed a more emphasized increase, from .59 in 1960 to .84 in 1990 [Barro and Lee (1993, 1996)].

Interestingly, those regions which have experienced the sharpest increase in gender equality (such as OECD the past century[1] and East Asia more recently) are the very same ones which have escaped poverty. Moreover, this has been paralleled by a fall in fertility rates. Thus, it is often argued that educating women could be a key to economic development, and a break on the population explosion [see e.g. Sen (1997) and Summers (1998)]. The issue has also inspired an empirical growth literature [see e.g. Barro and Lee (1993, 1994, 1996), Stokey (1994), Hill and King (1995), Dollar and Gatti (1999), Klasen (2002), and Knowles et al. (2001)].

However, most of these empirical studies fail to provide any explicit theoretical

[1] See Olsen (1994) for the U.S.

model of growth and gender heterogeneity, so it is not clear how to interpret the regressions. Also, any convincing interpretation should be consistent with micro evidence on how gender equality affects fertility: namely that fertility is increasing with the income of the male spouse, but falling with that of the female spouse. [See Butz and Ward (1979), Heckman and Walker (1990), and Schultz (1995).]

This paper builds on work by Lagerlöf (2003). We set up a two-sex overlapping-generations model, where fertility is endogenous, and subject to both a goods cost, and a time cost. There is also gender discrimination, expressed by parents' division of human-capital investment between sons and daughters. Our results are consistent with the mentioned micro evidence: fertility increases with male income, but falls with female income. They also broadly match the macro evidence described above. In a society with much gender discrimination children are cheap, since women's time is cheap. So unequal societies tend to have large families, and invest little in quality (i.e., human capital). As a result, they are less likely to exhibit sustained growth in human capital, and more likely to end up in a poverty trap, with non-growing levels of income. Equal societies tend to have small families and growing levels of income. Also, among growing economies, the more equal ones have lower fertility and grow faster.

The novelty here compared to Lagerlöf (2003) is twofold. First, we focus only on cross-country patterns in the world today, and not on changes in gender equality over long periods of time, such as those associated with the birth and spread of Christianity.

Second, we use a general equilibrium setting, where factor prices are determined as the marginal products of labor and capital. This complicates the analysis a great deal, due to an interdependence of the wage rate and fertility. Among growing economies, the wage rate converges to an expression which we can solve for analytically, and we get the standard result of more gender equality leading to lower fertility (and more growth). More surprisingly, the relationship between gender equality and fertility among non-growing countries is exactly the opposite. Countries with more gender equality (although still too unequal to exhibit sustained growth) have higher fertility than the less equal.

The first part of the intuition is similar to that of Lagerlöf (2003) and comes from fertility being costly in both time and goods. The goods cost can be thought of as spending on food and clothes, which becomes less important as income levels grow over time, but matters to economies stuck in a poverty trap. The time cost, which measures the cost of foregone income, matters most to rich and growing economies, but less to poor. A rise in female income relative to that of males induces lower fertility, in poor countries as well as rich, but the associated increase in human capital investment in children raises the income of the next generation. Therefore, the next generation (men and women alike) becomes richer compared to their parents. Since this is still a poor economy, where the goods cost of children matters, a proportional increase in income of both parents induces higher fertility. As the economy stabilizes in a new non-growing steady state, fertility turns out to be proportional to the wage rate.

The second part of the intuition has to do with the general equilibrium framework. In Lagerlöf (2003) the wage rate is exogenous and constant, so fertility is unchanged in the new steady state. In the setting used here the wage rate in the new steady state is higher, and so is fertility.

Earlier attempts to endogenize fertility in growth models date back over a decade [see Becker and Barro (1988), Barro and Becker (1989), and Becker et al. (1990)]. Barro and Becker (1989) and Barro and Sala-i-Martin (1995, Ch. 9) show that the combination of both a time and goods cost can lead to differences in fertility behavior between poor and rich countries, using general equilibrium frameworks, but do not study the implications of an explicit gender gap in income.

Attempts to explicitly allow for gender heterogeneity in growth models are relatively recent.[2] Most two-sex models assume exogenous gender differences: Davies and Zhang (1995) put son-preferences in the utility function of the parents. Galor and Weil (1996) assume two types of labor: "brains," of which men and women have equal amounts, and "brawns," with which only men are endowed. Elul et al. (1997) assume that men marry younger women. Echevarria and Merlo (1999) assume that women bear children at a certain biological time cost, and thus work less than their spouses. Dasgupta (2000) lets production take place in an informal and a formal sector, and assumes that men can enter the formal sector directly, whereas women have to spend some time in the informal sector

[2] For an overview, as well as a good motivation for the two-sex approach, see Echevarria and Moe (2000).

before being able to enter the formal sector.[3]

The way we model gender discrimination relies on no exogenous differences between men and women, except that of *heterosexuality*: men are matched with women, and women with men. We assume that a parent couple cares about the total income of the households into which their children enter as they grow up. Therefore, not only the offspring's income matter, but also that of his/her future spouse, who is educated by some other family. Families thus play a (normal form) coordination game against each other. From the viewpoint of one atomistic parent couple, a daughter (son) may not need much education, simply because she (he) is expected to marry a man (woman), who – taking the equilibrium behavior of other families as given – may be better educated, and earn a higher income. Gender discrimination can thus arise in a Nash equilibrium, despite the sexes being symmetric. In that sense, our model captures the concept of *gender roles*, or *gender stereotypes*: if everyone else behaves in a discriminatory manner, it is optimal for the atomistic player to do the same.[4]

[3] In a related but different context, Cole et al. (1992) examine the interaction between growth and *status*, the latter being a ranking device determining marriage outcomes. Most of the other papers link growth and gender heterogeneity via the fertility decision, whereas Cole et al. (1992) study the capital accumulation coming from bequests, and the way they interact with status.

[4] This explains why we observe educational discrimination on the basis of gender, but not why women in particular are discriminated against. We do not argue that "biology" does not matter. In fact, coordination can amplify (small) biological differences between the sexes. See the discussion in Hadfield (1999) and Francois (1998) who model similar coordination mechanisms in different contexts. Nerlove et al. (1984) analyze similar coordination in a one-sex model.

Modelling gender inequality in this way gives some indirect policy implications. Since gender inequality, and thus poverty, originates from coordination, a shift to sustained growth could potentially be achieved by re-coordinating on a less discriminatory equilibrium. A tentative conclusion is therefore that campaigns to mitigate the gender bias in education may enhance growth. This relates to the idea of a "cooperative" way of reducing fertility rates and boosting economic development, as suggested by e.g. Sen (1997).[5]

The rest of this paper is organized as follows. Section 2 sets up the model. It describes the composition of the cost of rearing children, sets up the maximization problem of each couple, derives the Nash equilibrium in each period. Then the production side is described and the dynamics analyzed, first for growing economies, then for non-growing. Finally, Section 2 analyzes the dynamics and stability properties. Section 3 gives a concluding summary.

2. The Model

The structure of this model is similar to that in Lagerlöf (2003). Individuals live in overlapping generations for three periods: childhood, adulthood (or working age), and retirement (or old age). Individuals are either males or females and when entering adulthood they marry randomly into pairs. The sexes have identical abilities at birth, but may be endowed with different amounts of human capital

[5]This type of policy implication does not arise in most other frameworks, such as that of Galor and Weil (1996), who let gender inequality be generated by (exogenously assumed) differences in the types of labor men and women are endowed with.

by their parents before marriage.

A period-t adult male is endowed with h_t^m units of human capital, and a female in the same generation is endowed with h_t^f units of human capital. There are no differences within the sexes: men belonging to the same generation have equal amounts of human capital, and the same for women. Each unit of human capital earns a wage, w_t, per unit of time supplied on the labor market. Different from the case in Lagerlöf (2003) this wage rate is endogenous. The wage is the same for both sexes, so there is in that sense no gender discrimination on the labor market.

A couple formed by adults in period t is referred to as couple t. Given their joint income, $w_t(h_t^m + h_t^f)$, couple t decides how many children to have, n_t, half of whom are daughters, and half are sons. They also endow each child with h_{t+1}^i $(i = m, f)$ units of human capital, where the super-indices indicate the human capital of a daughter (f), and a son (m), respectively. In a standard fashion, we talk about fertility, n_t, as quantity of children, and human capital, $h_{t+1}^m + h_{t+1}^f$, as quality.

2.1. The child rearing cost

To rear children carries three types of cost: a time cost, a consumption goods cost, and the cost of buying human capital to invest in the children. Let the sum of the first two components be denoted q_t.

Consider a couple active in period t, where (for whatever reason) the man has more human capital than the female, $h_t^m > h_t^f$. If they chose to have few enough children only one spouse's time is needed for their upbringing. (That this is indeed the case will be guaranteed by restricting attention to a certain set of Nash equilibria; see below.)

Let the time cost be b units of time per child, and the goods cost a units of the consumption good per child. The female spouse has lower human capital and earns less than the male so she undertakes the whole time cost. She earns $w_t h_t^f$ per unit of time and spends b units of time per child; the couple thus foregoes $bw_t h_t^f$ in lost income per child. The sum of the goods and time cost per child is thus given by

$$q_t = a + bw_t h_t^f. \tag{1}$$

2.2. Consumption and saving

The parent couple acts as one individual, and care about the (potential) income earned in the households into which their children enter. This is given by the wage rate in the next period, w_{t+1}, times the sum of the human capital levels of their own children, and that of their sons- and daughters-in-law. The parents care about their own consumption (in old and working age), and the number of children they have. We assume that all these goods are collective to the couple, abstracting from intra-couple allocation conflicts. The utility function is given by

$$\begin{aligned} U_t = \ln(c_{1t}) + \alpha \ln(n_t) + \delta \ln(c_{2t+1}) \\ +\beta \left[\ln \left[w_{t+1}(h^m_{t+1} + \overline{h}^f_{t+1}) \right] + \ln \left[w_{t+1}(\overline{h}^m_{t+1} + h^f_{t+1}) \right] \right], \end{aligned} \tag{2}$$

where c_{1t} and c_{2t+1} is consumption in working and old age, respectively. Recall that h^f_{t+1} and h^m_{t+1} denote the human capital of couple t's daughters and sons, respectively. The same variables with a bar denote the human capital of his/her spouse, which is the same as the human capital of any man or woman belonging to the same generation as their children. The wage times the sum of these two constitutes the earnings of the households into which the children enter in period $t + 1$. (More precisely, this is the potential earnings, since the actual earnings depend on the number of children, due to the time cost.)

α, β, and δ are the weights put on fertility, children's quality, and old-age consumption, respectively. We have normalized the weight on working-age consumption to unity. We assume the following, which is explained later:

Assumption 1.

$$1 + 2\beta + \delta > \alpha > \beta. \tag{3}$$

2.3. Budget constraints

Working age consumption of couple t is given by

$$c_{1t} = w_t(h^m_t + h^f_t) - s_t - n_t \left[q_t + p(h^m_{t+1} + h^f_{t+1}) \right], \tag{4}$$

where s_t denotes couple t's saving, and $2p$ is the (exogenous) cost of acquiring one unit of human capital in terms of the consumption good.[6] As described above, q_t is the time and goods cost of rearing one child [see (1)].

[6] The couple has $n_t/2$ sons and invests h^m_{t+1} in each, at a price of $2p$. Thus, the total cost of human capital expenditure on sons is $n_t p h^m_{t+1}$, and similarly for daughters. This gives (4).

Old-age consumption is given by

$$c_{2t+1} = s_t(1 + r_{t+1}), \tag{5}$$

where r_{t+1} denotes the real interest rate on savings held from period t to period $t+1$.

2.4. Utility maximization

Maximizing (2), subject to (4) and (5), the first-order conditions for s_t and n_t say that

$$s_t = \frac{\delta w_t(h_t^m + h_t^f)}{1 + \alpha + \delta}, \tag{6}$$

and

$$n_t = \frac{\alpha w_t(h_t^m + h_t^f)}{(1 + \alpha + \delta)\left[q_t + p(h_{t+1}^m + h_{t+1}^f)\right]}. \tag{7}$$

The first-order conditions for h_{t+1}^m and h_{t+1}^f, taking $\overline{h}_{t+1}^f$ and $\overline{h}_{t+1}^m$ as given, can be written:[7]

$$\begin{aligned} \beta\left[h_{t+1}^m + \overline{h}_{t+1}^f\right]^{-1} &\leq \alpha\left[q_t + p\left(h_{t+1}^m + h_{t+1}^f\right)\right]^{-1}, \\ \beta\left[\overline{h}_{t+1}^m + h_{t+1}^f\right]^{-1} &\leq \alpha\left[q_t + p\left(h_{t+1}^m + h_{t+1}^f\right)\right]^{-1}. \end{aligned} \tag{8}$$

The weak inequalities are due to the non-negativity constraint on human capital. If $h_{t+1}^m > 0$ in optimum, the first weak inequality in (8) holds with equality, and

[7] This can be seen by substituting (4), (6) and (7) into the objective function in (2) and taking first-order conditions with respect to h_{t+1}^m and h_{t+1}^f.

similarly for the second weak inequality if $h_{t+1}^f > 0$. If h_{t+1}^m is constrained to zero, the first inequality is strict, and vice versa with the second inequality if h_{t+1}^f is constrained to zero.

The left-hand sides capture the marginal benefit to the atomistic parent couple of endowing their children with human capital. The higher is the income of the future spouses of their children ($\overline{h}_{t+1}^f$ and $\overline{h}_{t+1}^m$), the lower is the marginal utility for the atomistic parent couple of increasing their children's family income. Thus, a high average level of human capital among men induces the atomistic parent couple to invest little in their daughter's human capital, and vice versa if the average human capital level of women is high.

The right-hand sides of (8) give the marginal cost of increasing human capital investment in children, as implied by the associated reduction in fertility, as follows from the budget constraint (4).

2.5. Nash equilibrium

The players of the (normal form) game are the parent couples, and they choose simultaneously how much to invest in sons and daughters, taking as given the same choices by the other parents. In a (symmetric pure strategy) Nash equilibrium there are no differences within the sexes, so $h_{t+1}^m = \overline{h}_{t+1}^m$ and $h_{t+1}^f = \overline{h}_{t+1}^f$. This makes the two conditions in (8) coincide, and therefore the non-negativity constraints cannot be binding: the first-order conditions in (8) hold with equality. Moreover, we see that the sum of male and female human capital can be written as

$$h^m_{t+1} + h^f_{t+1} = \left(\frac{\beta}{\alpha - \beta}\right)\frac{q_t}{p}. \tag{9}$$

In fact, this demonstrates that in every period t there is a continuum of Nash equilibria.

Remark 1. Any combination of h^m_{t+1} and h^f_{t+1} which satisfies (9) is a Nash equilibrium (as long as they are both non-negative).

Note also from the Assumption 1 that $\alpha > \beta$ ensures that (9) is positive, which amounts to assuming an interior solution. If α approached β the couple would tend to choose an arbitrarily small number of children, investing an arbitrarily large amount of human capital in each (fraction of a) child.

2.6. Gender equality

Define the following measure of gender equality:

$$\mu_t = \frac{h^f_t}{h^m_t}. \tag{10}$$

As follows from Remark 1, any non-negative level of μ_t is a Nash equilibrium, as long as (9) holds (lagged one period). There is nothing linking gender equality in one period to that in the next. Any sequence of (non-negative) μ_t's is consistent with a Nash equilibrium in the game played between different parent couples in each respective period. However, later in the paper we shall assume that gender equality does not change over time. In other words, we are going to assume that parent couples in period t coordinate on the same Nash equilibrium as their parent generation $t-1$ did.

We shall only consider Nash equilibria where

$$\mu_t \in (\frac{\alpha-\beta}{1+\beta+\delta}, 1). \tag{11}$$

The upper bound in (11) simply serves to focus our attention on the empirical regularity that women tend to have lower human capital than men, $h_t^m > h_t^f$. (However, as long as there are no exogenous differences between the sexes, there is always a mirror imaged equilibrium in which men have lower human capital.) The lower bound serves to ensure that the couple is equal enough so that (on those growth paths we are to consider) the couple has few enough children that only one spouse's time is needed to take care of them. [See Appendix A.2.] If this was not the case, the marginal cost of having an extra child would make a discrete jump at some fertility level, where the father started making a positive time input. Note that Assumption 1 implies that the lower bound is less than unity.

2.7. Fertility

Using (9) and (7) we can write fertility as

$$n_t = \left(\frac{\alpha-\beta}{1+\alpha+\delta}\right)\frac{w_t(h_t^m+h_t^f)}{a+bh_t^f w_t} = \left(\frac{\alpha-\beta}{1+\alpha+\delta}\right)\frac{w_t(1+\mu_t)}{\frac{a}{h_t^m}+bw_t\mu_t}, \tag{12}$$

where the second equality comes from (10).

2.8. Production

In period t, a representative firm produces output (Y_t) of the single consumption good, using a constant returns to scale production function of Cobb-Douglas type, with inputs physical capital (K_t), and efficiency units of labor (L_t). Letting ρ denote the capital share of output we can write the production function as

$$Y_t = K_t^{\rho} L_t^{1-\rho}. \tag{13}$$

The total number of couples in working age in period t is denoted N_t, so that the working force in terms of efficiency units is given by

$$L_t = N_t \left[h_t^m + h_t^f (1 - bn_t) \right]. \tag{14}$$

(Recall that we are considering equilibria where $h_t^m > h_t^f$, so that all time spent rearing children is levied on the female.)

Letting lower case letters denote per-couple terms of all variables, given by dividing them by N_t, we can write the production function as

$$y_t = k_t^{\rho} \left[h_t^m + h_t^f (1 - bn_t) \right]^{1-\rho}. \tag{15}$$

Profit maximization equates the factor prices to their respective marginal products, in a standard fashion, so that

$$w_t = (1 - \rho) \left[\frac{k_t}{h_t^m + h_t^f (1 - bn_t)} \right]^{\rho}, \tag{16}$$

and similarly for r_{t+1}, which turns out to play no role in the rest of the analysis, due to the logarithmic utility.

2.9. Dynamics

Each of the N_t couples has $n_t/2$ children of each sex, and it takes one offspring of each sex to form a new couple. Therefore the number of couples evolves according to $N_{t+1} = (n_t/2)\, N_t$. Since physical capital is made up of the previous period's saving the per-couple physical capital stock evolves according to

$$k_{t+1} = \frac{s_t}{n_t/2} = \left(\frac{2\delta}{\alpha - \beta}\right)\left[a + bh_t^f w_t\right], \tag{17}$$

where the second equality comes from (6), and (12). Using the notation in (10), i.e., $\mu_t = h_t^f/h_t^m$, and (9), we can write the ratio of physical capital, over male human capital, as

$$\frac{k_{t+1}}{h_{t+1}^m} = \frac{2\delta(1+\mu_{t+1})}{p\beta}. \tag{18}$$

Lagging (18) one period, using (10) again, the wage rate in (16) can be written as

$$w_t = (1-\rho)\left[\frac{2\delta/(\beta p)}{1 - b\left(\frac{\mu_t}{1+\mu_t}\right) n_t}\right]^{\rho} \equiv \omega(n_t;\mu_t). \tag{19}$$

The economy may exhibit sustained growth, or converge to a non-growing steady state: a poverty trap. We now examine under which conditions each scenario occurs. Sustained growth in output requires that both human and physical capital exhibit sustained growth. Since their ratio is constant [see (18)] we can look at the growth of human capital.

Let the ratio $\mu = h_t^f/h_t^m$ be constant over time. This amounts to assuming that each economy coordinates on the same Nash equilibrium over time. [See the discussion below (10).] From (1) and (9), we see that the growth rate of male human capital h_t^m (as well as the total human capital of each household $h_t^m + h_t^f$) is given by

$$\gamma_{t+1} = \frac{h_{t+1}^m}{h_t^m} = \frac{\overbrace{h_{t+1}^m(1+\mu)}^{h_{t+1}^m + h_{t+1}^f}}{h_t^m(1+\mu)} = \left(\frac{\beta/p}{\alpha-\beta}\right)\left[\frac{\frac{a}{h_t^m} + b\mu w_t}{1+\mu}\right]. \tag{20}$$

2.9.1. Growing economies

The economy exhibits sustained growth if the right-hand side of (20) approaches something greater than unity as h_t^m approaches infinity. To examine when this is the case we must determine the limit of w_t as h_t^m approaches infinity. Start by looking at the asymptotic behavior of fertility. From (12) we see that

$$\lim_{h_t^m \to \infty} n_t \equiv n^* = \frac{\frac{\alpha-\beta}{1+\alpha+\delta}}{b\left(\frac{\mu}{1+\mu}\right)}. \tag{21}$$

(Recall that we are holding the ratio $\mu = h_t^f/h_t^m$ constant so h_t^f approaches infinity together with h_t^m.) Using (21) and (19), the asymptotic wage rate can be written

$$\lim_{h_t^m \to \infty} w_t \equiv w^* = (1-\rho)\left[\left(\frac{1+\alpha+\delta}{1+\beta+\delta}\right)\left(\frac{2\delta}{\beta p}\right)\right]^{\rho}, \tag{22}$$

which gives the asymptotic growth rate

$$\lim_{h_t^m \to \infty} \gamma_{t+1} \equiv \gamma^* = \left(\frac{(\beta/p)(1-\rho)}{\alpha - \beta} \right) \left[\left(\frac{1+\alpha+\delta}{1+\beta+\delta} \right) \left(\frac{2\delta}{\beta p} \right) \right]^{\rho} \left(\frac{b\mu}{1+\mu} \right). \tag{23}$$

If the right-hand side of (23) exceeds unity the economy will exhibit sustained growth, at the (gross) rate γ^*; if it falls below unity the economy converges to a non-growing poverty trap. [An illustration is given later in Figure 3.] Since the factor $\mu/(1+\mu)$ in (23) in increasing in μ, we conclude the following:

Result 1. An economy with more gender equality (greater μ) is more likely to exhibit sustained growth.

Result 2. Among economies exhibiting sustained growth, the growth rate is higher for those with more gender equality (greater μ).

2.9.2. Non-growing economies

Now consider economies for which the right-hand side of (23) falls below unity. We want to find out how the fertility rate among such economies varies with gender equality (given that gender equality is low enough to rule out sustained growth). One problem now arises: for finite h_t^m the fertility rate cannot be determined explicitly. We must instead determine the fertility and wage rates implicitly and jointly. To do this, start by rewriting (12) as

$$w_t = \frac{a}{h_t^m} \left[\frac{n_t/(1+\mu_t)}{\left(\frac{\alpha-\beta}{1+\alpha+\delta}\right) - b\left(\frac{\mu_t}{1+\mu_t}\right) n_t} \right] \equiv \sigma(n_t, h_t^m; \mu_t). \tag{24}$$

Setting (24) and (19) equal to each other, we get wage and fertility rates which are consistent with a labor market equilibrium. This is illustrated in Figure 1, where $\sigma(n_t, h_t^m; \mu_t)$ is given in (24), and $\omega(n_t; \mu_t)$ in (19).

The graph of $\sigma(n_t, h_t^m; \mu_t)$ shows the demand for children. A higher wage implies both a higher income, but also a higher time cost of children. As long as the child rearing cost contains a positive consumption goods element ($a > 0$) an increase in the wage rate does not increase the time cost as much as income. Therefore the demand for children increases with the wage rate. If $a = 0$ fertility equals n^* independently of the wage rate, due to the logarithmic utility.

The graph of $\omega(n_t; \mu_t)$ shows how the wage, given by the marginal product of labor, increases as fertility increases and female labor supply falls.

As h_t^m grows (at a given μ) the graph of $\sigma(\cdot)$ shifts down and the fertility rate increases. If h_t^m grows without bound n_t approaches n^*. [Since a/h_t^m simultaneously approaches zero (24) does not tell us that the wage rate approaches infinity as n_t approaches to n^*.]

The graphs of $\sigma(\cdot)$ and $\omega(\cdot)$ both have positive slope, so they may intersect more than once: there may exist more than one labor market equilibrium. Intuitively, a high wage rate implies a high demand for children and therefore low female labor supply. This in turn makes the marginal product of labor high, sustaining the high wage rate. In the rest of the paper we are not going to explore this possibility of multiple equilibria. To ensure uniqueness we impose the following parametric restriction:

Assumption 2.

$$\left(\frac{\alpha-\beta}{1+\alpha+\delta}\right) > \frac{4\rho}{1-\rho}. \tag{25}$$

We can now state the following, which is proven in Appendix A.1.

Proposition 1. Under Assumption 2, in every period t there exists a unique equilibrium fertility rate n_t, for any (non-negative) levels of h_t^m and μ.

In other words, if the relationship between the exogenous parameters (ρ, α, β, and δ) is such that (25) holds, the graphs of $\sigma(\cdot)$ and $\omega(\cdot)$ intersect only once, so there is only one labor market equilibrium at a given level of h_t^m and μ.

Fertility in non-growing economies. Consider a steady-state level of h_t^m, at which the right-hand side of (20) equals unity. Denote this by $(h^m)^0$, and the associated wage rate by w^0. These are given by

$$\left(\frac{\beta/p}{\alpha-\beta}\right)\left[\frac{a/(h^m)^0 + b\mu w^0}{1+\mu}\right] = 1. \tag{26}$$

We next use (24) to write w^0 as a function of the associated fertility rate n^0:

$$w^0 = \sigma(n^0, (h^m)^0; \mu) = \frac{a}{(h^m)^0}\left[\frac{n^0/(1+\mu)}{\left(\frac{\alpha-\beta}{1+\alpha+\delta}\right) - b\left(\frac{\mu}{1+\mu}\right)n^0}\right]. \tag{27}$$

Then, using (26) to substitute $(h^m)^0$ away some algebra tells us that

$$w^0 = \left[\frac{1+\alpha+\delta}{\beta}\right]pn^0. \tag{28}$$

That is, the fertility rate in a non-growing steady state is proportional to the equilibrium wage rate. If the wage rate is higher in the steady state associated with a higher μ, the same must hold for the fertility rate. We thus need to look at the joint determination of the fertility and wage rates, by using $\omega(n;\mu)$ in (19), and (28) above, and see how they vary with μ.

The determination of the steady-state fertility and wage rates of a non-growing economy is shown in Figure 2. It contains the graphs of (28), and $\omega(n;\mu)$ in (19). Note that they intersect twice, but the steady-state fertility rate n^0 is given by the lower intersection. It can be seen that the fertility rate at the upper intersection exceeds n^* defined in (21).[8] This cannot be the steady-state fertility rate, since for any finite level of h_t^m [like $(h^m)^0$], and any given μ, fertility must fall below the associated n^* (see Figure 1).

As shown, an increase in gender equality (from μ to μ' in Figure 2) shifts up the $\omega(n;\mu)$-graph, and the new intersection is associated with a higher steady-state fertility rate. We can thus state the following result:

Result 3. Among non-growing economies, those with more gender equality (greater μ) have higher steady-state fertility rates.

In Figure 2 it may look as if non-growing economies have lower fertility rates than growing economies, since n^0 falls below n^*. However, n^* here refers to the fertility rate of a non-growing economy, had it (counterfactually) exhibited

[8]To see this recall that the right-hand side of (23) must fall below unity for the economy to not be be growing. Using (21) and (19) we see that this implies that $\left[\frac{1+\alpha+\delta}{\beta}\right] pn^* > \omega(n^*;\mu)$.

sustained growth. Whether, or not, a country exhibits sustained growth depends on gender equality, which also determines the fertility rate. In other words, non-growing countries can have higher fertility rates because they have less gender equality (lower μ), which is also the reason why they are not growing in the first place.

2.10. Stability

So far we have examined the behavior of economies on a sustained growth path, or at a steady-state equilibrium, respectively. For completeness we examine how these economies evolve dynamically around their respective equilibria. For instance, we want to confirm that the equilibria are stable.

Using (7) and (9) we can rewrite the growth rate in (20) as

$$\gamma_{t+1} = \left(\frac{1}{p}\right)\left(\frac{\beta}{1+\alpha+\delta}\right)\frac{w_t}{n_t}. \tag{29}$$

In Figure 1 we can interpret w_t/n_t as the slope of a line from the origin to the intersection point. As h_t^m increases and shifts $\sigma(\cdot)$ down, the intersection moves along the graph of $\omega(\cdot)$. Since $\sigma(\cdot)$ must always intersect $\omega(\cdot)$ from below, w_t/n_t is falling in h_t^m. From (29) we see that this must also hold for the growth rate γ_{t+1}:

$$\frac{\partial\gamma_{t+1}}{\partial h_t^m} = \left(\frac{1}{p}\right)\left(\frac{\beta}{1+\alpha+\delta}\right)\underbrace{\frac{\partial\left[\frac{w_t}{n_t}\right]}{\partial h_t^m}}_{<0} < 0. \tag{30}$$

This is illustrated in Figure 3. At a given level of gender equality (μ) the growth rate is falling in initial male human capital. This is the mirror image of the increasing demand for children as male income rises: as male earnings rise parents can afford more children, and thus spend less on quality, implying lower human capital investment in each child. This rise in fertility may seem to contradict the empirical pattern of falling fertility rates in the developed world the last hundred years. However, we must recall that gender equality is held constant here. If gender equality improves the growth function shifts, as shown in Figure 3. This can cause a simultaneous (temporary) fall in fertility, and rise in growth rates.

3. Conclusions

This paper sets up an overlapping-generations model with gender heterogeneity, and heterosexual matching. Parents invest in their sons' and daughters' education, taking into account that the children are going to form households with someone of the opposite sex when they grow up. Gender discrimination may arise, because if other households discriminate between human-capital investment in sons and daughters, it is optimal for the atomistic household to do the same. The reason is that a parent couple knows that their daughter will marry a man, so the "endowment" of income in her future household is going to be relatively big, and vice versa for sons. Discrimination thus occurs as a Nash equilibrium in a coordination game, despite the absence of any differences in abilities between the sexes.

This model is an extension of that used by Lagerlöf (2003). The implications of gender equality for growth and development originates from the quantity-quality trade-off in the fertility choice. Different from Lagerlöf (2003) we use a general equilibrium setting, where the wage rate is endogenous, and depends in labor supply, which in turn depends on fertility rates.

Some results and mechanisms are similar to those in Lagerlöf (2003). In particular, changes in gender equality have different implications for rich clubs compared to poor. Significant increases in gender equality in our model can push poor countries to sustained growth, but small increases in gender equality may not.

The result which contrasts most with Lagerlöf (2003) is that the new and more gender-equal non-growing steady state has higher fertility than the steady state that prevailed before the increase in gender equality. Fertility is proportional to the wage rate in both settings, but only when the wage rate in endogenous – as it is here, but not in Lagerlöf (2003) – do we get the result that fertility is higher in the new steady state. In Lagerlöf (2003) the wage rate was exogenous so the fertility rate was unchanged in the new steady state.

Many possible theoretical extensions have been left out here, but could be interesting to explore in future work. For instance, just as in Nerlove et al. (1984), we assume that parents must choose their children's education before they know who their children marry. In our setting, parents have some more information: they know that their children are going to marry someone of the opposite sex, and this gives rise to gender discrimination. An interesting extension would be to let parents also know that their children will marry someone who is about equally well educated. Sending a daughter to college not only increases her future income, but possibly also that of her future spouse. To explore this one would need to relax the crucial assumption that there is no heterogeneity within sexes, only between them.

There are other potential extensions: as in any game with multiple pure strategy Nash equilibria it would be of interest to examine mixed strategy equilibria as well. However, this turns out to be quite complex. For instance, due to the fact that fertility is endogenous, the number of spouses with certain characteristics will depend on the actions between which the players (the parent couples) randomize. In a static setting, this could potentially be overcome, but at the cost of the ability to study e.g. poverty traps.

A. Appendix

A.1. Proof of Proposition 1.

To make the proof easy to follow, we are going to derive a couple of lemmas along the way. First let $D(n_t, h_t^m)$ be the difference between $\omega(\cdot)$ and $\sigma(\cdot)$, in (19) and (24):

$$D(n_t, h_t^m) = (1-\rho)\left[\frac{2\delta/(\beta p)}{1-b\left(\frac{\mu}{1+\mu}\right)n_t}\right]^{\rho} - \frac{a}{h_t^m}\left[\frac{n_t/(1+\mu)}{\left(\frac{\alpha-\beta}{1+\alpha+\delta}\right)-b\left(\frac{\mu}{1+\mu}\right)n_t}\right]. \qquad \text{(I)}$$

The interpretation of (I) is that, given some value of h_t^m, the fertility rate which is consistent with a labor market equilibrium must be such that $D(n_t, h_t^m) = 0$.

We first note that, for every h_t^m, there exists some equilibrium fertility rate:

Lemma 1. For every h_t^m there exists some $\widehat{n} \in (0, n^*)$ for which $D(n_t, h_t^m) = 0$.

Proof. From (21) and (I) we have

$$\lim_{n_t \to n^*} D(n_t, h_t^m) = -\infty, \tag{II}$$

and

$$D(0, h_t^m) = (1-\rho)(2\delta/\beta p)^\rho > 0. \tag{III}$$

From the continuity of $D(n_t, h_t^m)$ it must be zero at some $n_t \in (0, n^*)$. ■

Next, let $\widehat{h} : (0, n^*) \to \mathsf{R}_{++}$ be such that $D\left(n_t, \widehat{h}(n_t)\right) = 0$, i.e.,

$$\widehat{h}(n_t) = \frac{\left[\frac{an_t/(1+\mu)}{\left(\frac{\alpha-\beta}{1+\alpha+\delta}\right)-b\left(\frac{\mu}{1+\mu}\right)n_t}\right]}{(1-\rho)\left[\frac{2\delta/(\beta p)}{1-b\left(\frac{\mu}{1+\mu}\right)n_t}\right]^\rho}. \tag{IV}$$

This means that, for any $\widehat{n} \in (0, n^*)$ there exist some level of $h_t^m = \widehat{h}(\widehat{n})$ at which $\widehat{n}$ is consistent with a labor market equilibrium, i.e., $D\left(\widehat{n}, \widehat{h}(\widehat{n})\right) = 0$.

Let $D_1(\cdot)$ denote the partial derivative of $D(\cdot)$ with respect to its first argument. We are now ready to state the following lemma.

Lemma 2. Consider any $\widehat{n} \in (0, n^*)$. If, for any such point $\widehat{n}$,

$$D_1\left(\widehat{n}, \widehat{h}(\widehat{n})\right) < 0, \tag{V}$$

then $n_t = \widehat{n}$ is the unique solution to $D\left(n_t, \widehat{h}(\widehat{n})\right) = 0$.

Proof. $D_1\left(\widehat{n},\widehat{h}(\widehat{n})\right) < 0$ and $D(\widehat{n},\widehat{h}(\widehat{n})) = 0$ together imply that whenever $D\left(n_t,\widehat{h}(\widehat{n})\right)$ intersects the n_t axis it must do so from above; it cannot intersect it from below. From the continuity of $D(\cdot)$ it follows that the intersection must be unique. ■

What we need to investigate is thus whether, or not, (V) holds. Under the parametric condition in Assumption 2 we shall see that it does.

To see this, we first make the algebra somewhat simpler to handle by rewriting $D(\cdot)$ in (I) as follows (for convenience, we rename the arguments):

$$D(x,y) = A\left[1 - Bx\right]^{-\rho} - \frac{E}{y}\left[\frac{x}{G - Bx}\right], \tag{VI}$$

where

$$A = (1-\rho)\left(\frac{2\delta}{\beta p}\right)^{\rho}, \tag{VII}$$

$$B = b\left(\frac{\mu}{1+\mu}\right), \tag{VIII}$$

$$E = \frac{a}{1+\mu}, \tag{IX}$$

and

$$G = \left(\frac{\alpha - \beta}{1+\alpha+\delta}\right). \tag{X}$$

After some algebra, we see that the (partial) derivative of $D(\cdot)$ with respect to its first argument becomes

$$D_1(x,y) = \rho BA\,[1-Bx]^{-(1+\rho)} - \frac{E}{y}\,[G-Bx]^{-2}\left\{\underbrace{[G-Bx]-x[-B]}_{=G}\right\}. \quad \text{(XI)}$$

Evaluating $D_1(x,y)$ at $y=\widehat{h}(x)$, where $D(x,y)=0$ in (VI), we see that

$$D_1(x,\widehat{h}(x)) = A\,[1-Bx]^{-\rho}\left[\frac{\rho B}{1-Bx} - \frac{G}{x(G-Bx)}\right]. \quad \text{(XII)}$$

From (XII), we see that $D_1(x,\widehat{h}(x)) < 0$ when

$$\rho B\,[x(G-Bx)] < G\,[1-Bx]\,, \quad \text{(XIII)}$$

or

$$P(x) \equiv x^2 - \left[\frac{(1+\rho)G}{\rho B}\right]x + \left[\frac{G}{\rho B^2}\right] > 0. \quad \text{(XIV)}$$

[It can be confirmed that the denominators within square brackets in (XII) are indeed both strictly positive, since $x < n^*$, given by (21).] What remains to prove is that, if (25) holds, $P(x) > 0$. To see this, note that $P''(x) > 0$, and it has a global minimum at $x = \frac{(1-\rho)G}{2\rho B}$. Thus, if $P\left[\frac{(1-\rho)G}{2\rho B}\right] > 0$, $P(x) > 0$ always holds. Using (X) and (XIV), we see that this amounts to

$$\frac{\alpha-\beta}{1+\alpha+\delta} > \frac{4\rho}{1-\rho},$$

which is Assumption 2. ■

A.2. The lower bound on gender equality

In (11) we restricted attention to certain Nash equilibria. The restriction that $\mu < 1$ is obvious. We now explain why we cannot let μ fall below $(\alpha-\beta)/(1+\beta+\delta)$. Recall that, at any given level of μ, n_t is increasing in h_t^m, and as h_t^m approaches infinity, n_t approaches n^*. Thus, n_t cannot exceed n^*. To ensure positive female labor supply at all h_t^m it suffices to show that the fertility rate n^* implies positive labor supply by the female spouse, i.e., $1 - bn^* > 0$. Use (21) to see that:

$$bn^* = b\left[\frac{\frac{\alpha-\beta}{1+\alpha+\delta}}{b\left(\frac{\mu}{1+\mu}\right)}\right] < 1. \quad \text{(XV)}$$

If $\mu > (\alpha - \beta)/(1 + \beta + \delta)$ it is easily seen that (XV) holds. This gives the lower bound in (11).

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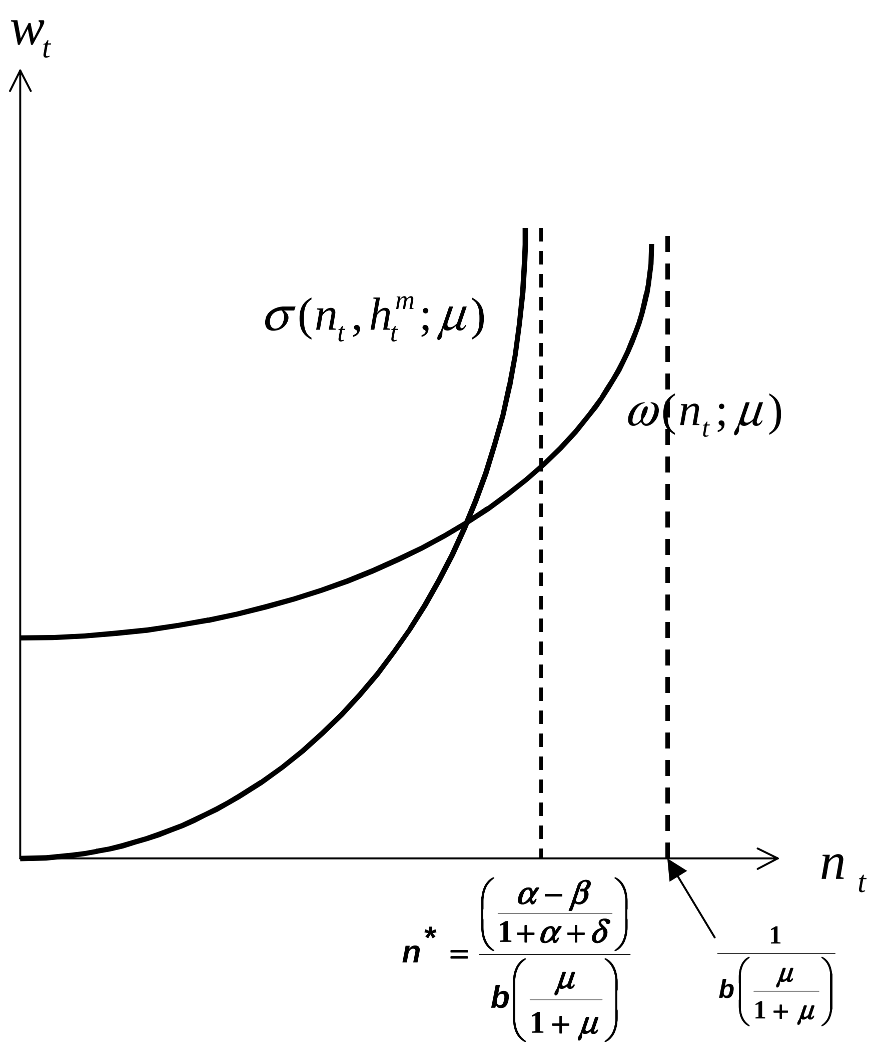

Figure 1: Determining wage and fertility rates for non-growing economies.

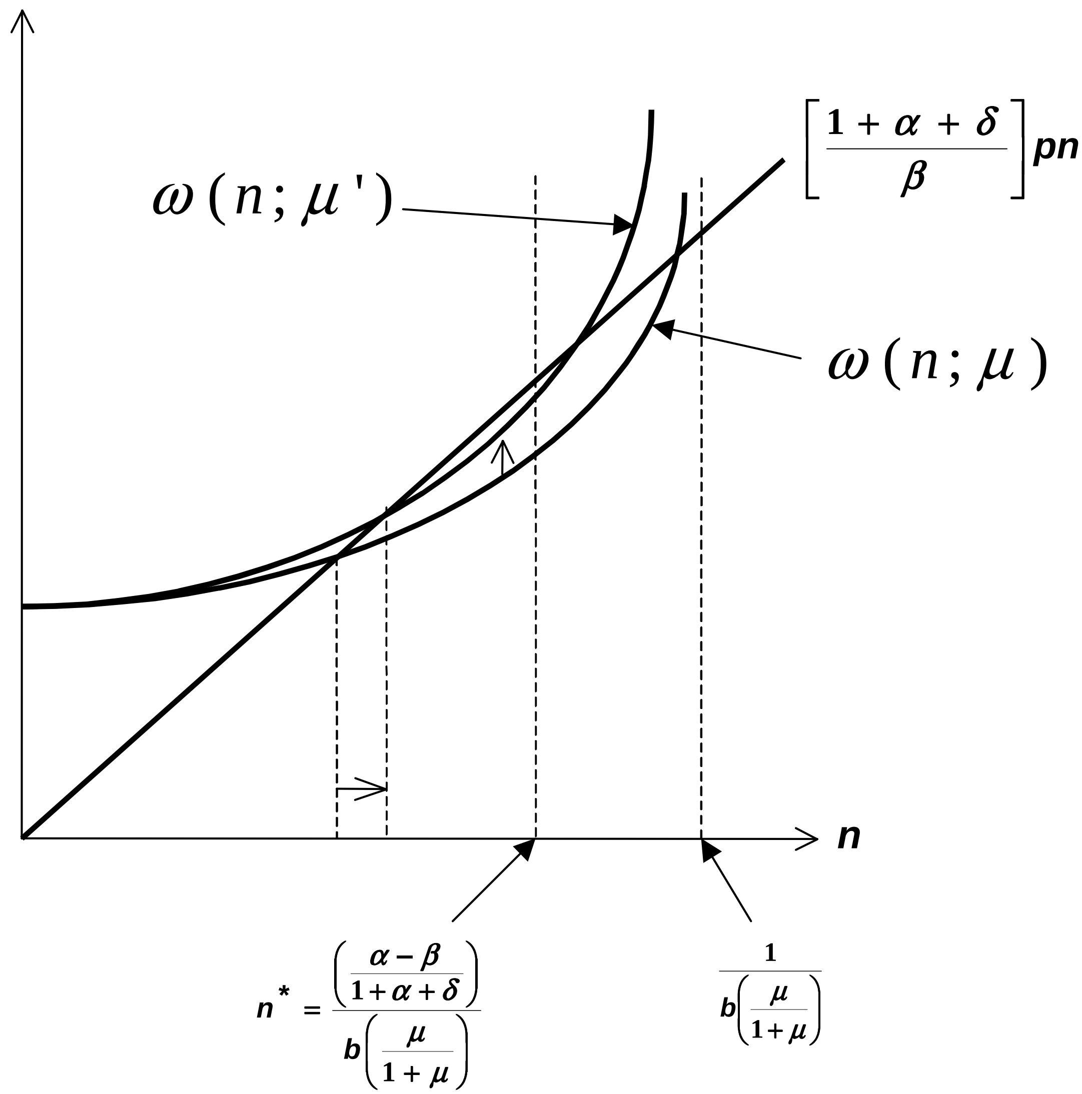

Figure 2: Effects on steady-state fertility when gender equality increases in non-growing economies.

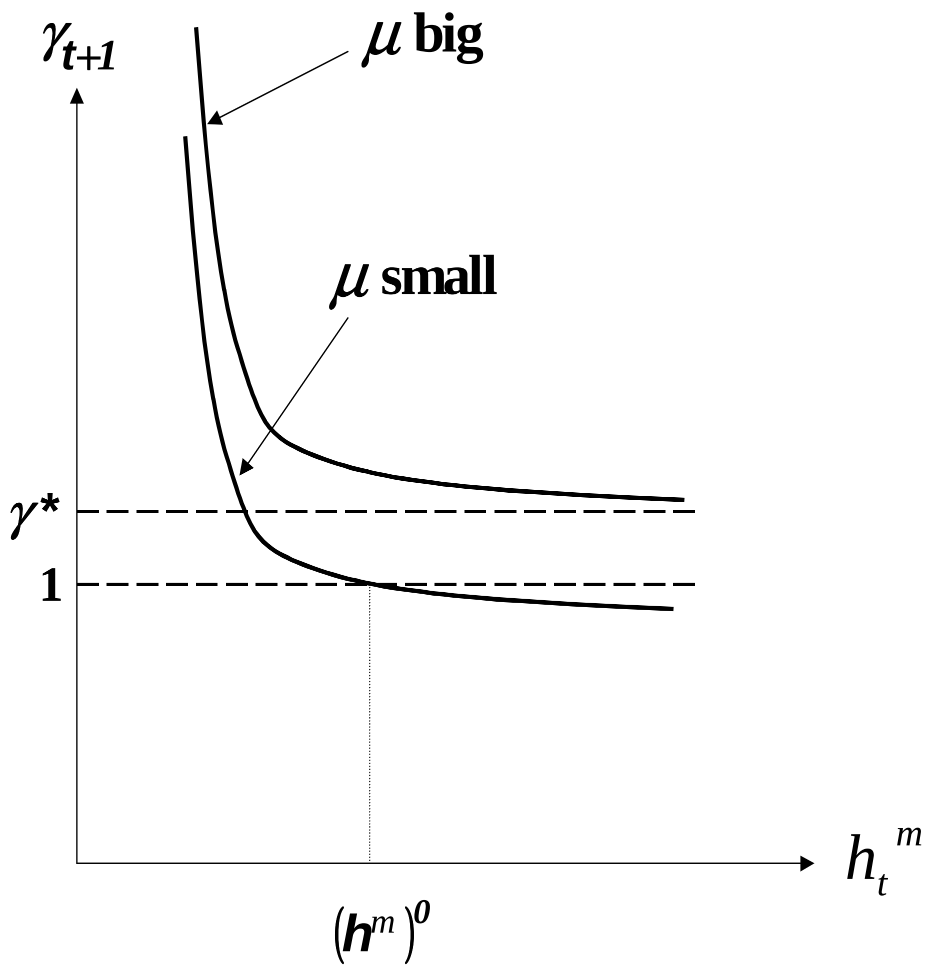

Figure 3: Stability.