Foreign Investments, Enforcement Constraints and Human Capital Accumulation

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Abstract

This paper relates two stylized fact in the economics of growth and development. The first is the absence of significant flows of capital towards poor countries. The second is the apparent low rate of accumulation of human capital in poor economies. We construct an overlapping generation model with thresholds in human capital accumulation. The rate of return to investments in human capital is determined by the stock of foreign capital in the 'advanced' sector of the economy, which is the engine of growth. Enforcement problems tend to reduce foreign investments in equilibrium below their first-best level. This feeds back into a low rate of investment in human capital. Both a cases with homogeneous and one with heterogeneous population are studied. In the latter people in the host country disagree about the political attitude towards foreign investments. The less educated lobby for nationalization and redistribution, whereas the more educated support the enforcement of property rights, anticipating a higher level of foreign investments and higher wages in the modern sector. The resulting political equilibrium is discussed. Multiple equilibria are possible at some critical stage of development.

Foreign Investments, Enforcement Constraints and Human Capital Accumulation.

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A number of papers have recently emphasised the role of thresholds in economic development (Azarziadis and Drazen, 1990; Ciccone, 1994; Rodriguez, 1993). The various mechanisms proposed boil down to reduced forms characterised by some region of increasing returns to the accumulation of physical or human capital, implying that the marginal productivity of capital is low at earlier stages of development. Some recent papers (Gali, 1993; Zilibotti, 1994; and Gali and Zilibotti, 1994) have stressed, alternatively, the role of market imperfections in intermediate good markets, showing that when the degree of market imperfections is inversely related to the size of the market the model generates dynamics which are isomorphic to those of models with increasing returns.

Most of these models assume a closed economy. Two distinct issues should be considered when factor movements across countries are allowed. The first is why tradable capital does not fly towards poor stagnating countries. The second is why the accumulation of 'local factors' which are not mobile across countries remains low in such economies. The point of this paper is that identifying the causes which prevent the inflow of productive resources (not only physical capital, but also managerial capabilities, technical knowledge, etc.) from more advanced countries into a poor economy can also help explain why indigenous people find little economic incentive to invest into acquiring skills and accumulating human capital. The key assumption is that there is a technological complementarity in the 'modern' industrial sector of the economy between skilled labour and foreign capital, as opposed to a traditional sector which only employs unqualified labour.

A key determinant of the level of foreign direct investments (fdi) inflow is the degree to which property rights are enforced. Fdi's are low when political instability and incentive problems make feel investors unsafe about the control over the resources invested, due to nationalisation, taxation etc.. Barro (1991) finds that two indices of political instability, regarded as measures of adverse influences on property rights (p. 432) have a very strong predictive power in cross-country growth regressions. Some direct evidence of a negative effect of enforcement constraints on growth is found by Giovannetti, Marcet and Marimon (1993) with reference to some African countries.

The issue of property right enforcement has been recently discussed in the growth literature by a number of authors. Benhabib and Rustichini (1991) assume an heterogeneous two-group population and show that the poor definition of property rights may negatively affect the investment and growth rate of the economy through the emergence of incentive constraints. Persson and Tabellini (1991a) relate the property right issue to that of income distribution. They assume that heterogeneous agents vote about a linear tax schedule on

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capital to finance lump-sum redistribution. The higher the degree of inequality, the higher the petition for redistribution and the equilibrium tax rate, and the lower the growth rate. The opposite conclusion is reached by Saint-Paul and Verdier (1991) who argue that inequality is positively correlated with growth, since it causes more pressure for redistribution in the form of public education. Other papers include Perotti (1990), Alesina and Rodrik (1991) and Bertola (1991). In all these papers, the conflict is about redistributing a stock of resources owned by members of the social community in a way that could be either favourable or unfavourable to growth.

The issue becomes even more severe, however, when some productive resources are owned by foreigners, whose interests are not represented, in principle, by local governments. There is always an incentive for the government to prevent them from appropriating the market reward of their participation to the productive process. When both local agents and governments are finitely lived and non-altruistic, there is a problem of time-consistency inherent to foreign investment decisions. In this paper the issue is solved by allowing the host country to pre-commit itself to enforce the property rights by delegating power to a 'committee of foreign capitalists'. However, the condition for this political solution to be viable through the support of the majority of voters imposes a constraint on the amount of foreign investments which can flow into the country at each period. This implies that in equilibrium there are less foreign investments than in a first-best world.

A related paper to ours is Marcet and Marimon (1992), which analyses the relationship between incentive constraints, financing opportunities and growth in the framework of a stochastic growth model. One advantage of their infinite horizon approach is to consider explicitly reputational issues which are instead ignored in our paper. Our paper is less general, but tries to handle, through the construction of a highly stylised and simplified model, a wider range of potentially related issues, like foreign investments, political equilibrium and human capital accumulation. Furthermore, in their paper the enforcement constraint only affects the speed of convergence to the steady-state, whereas in our model it can generate poverty traps and path-dependent solutions.

The main features of our model are the following:

a) the government of the host country can 'expropriate' the resources invested by the foreigners and redistribute them among the local population. However, fdi's have a component of specific knowledge that cannot be seized, and the host country cannot run the productive process combining the nationalised and the local resources at the same level of efficiency as the investor would do. The loss caused by this productivity fall is suffered particularly by the more highly skilled workers.

b) fdi's are an essential factor for the development of a 'modern' sector. We assume a dual economy in which productivity growth takes place only in the sector which is fdi-intensive (the 'modern' sector). On aggregate, growth in per-capita term is entirely driven by the development of the modern sector;

c) the average and marginal productivity of fdi's is increasing in the stock of human capital available in the host country. Foreign capital and human capital are assumed to be the only factors which enter a constant returns to scale production function of final goods in the modern sector;

d) the host country is populated by overlapping generations of two-period lived agents. They can save in two forms: either by investing in education when young and using their expertise in the modern sector when old, or by storing the resources earned in the first period when employed in the traditional sector. Accumulated knowledge can be transmitted from one generation to its offspring.

e) to accumulate human capital is costly to the indigenous inhabitants. The opportunity-

cost is given by the time spent in education rather than in production during the youth. The aggregate investment in education in the host country is a non-decreasing function of the wage rate in the modern sector;

f) the enforcement problem reduces the amount of foreign capital per efficiency unit of human capital which enters the country. This causes a lower wage in the modern sector than in a first-best world and affects negatively the accumulation of human capital and the growth rate of the economy.

The solution of the model is simple and unsurprising when agents are assumed to be identical. Given the structure of preferences and technology, the economy will converge to either a stationary or a steady-growth solution depending on whether the initial human capital endowment is above or below a critical level. The enforcement problem affects the threshold, and leads a set of economies that would converge to the good equilibrium in a first-best world to converge to the 'bad' equilibrium.

The model produces richer dynamics when agents are heterogeneous in their individual human capital endowments. The intergenerational transmission of human capital is assumed to take place partly inside each dynasty (family education), partly as a social process (school education). The stock of productive knowledge held by each agent is a function of the human capital of his parents, of the total human capital accumulated in the society when he is young and of his personal investment in education. People belonging to different dynasties choose, in general, different levels of investment in human capital. Furthermore, more educated people gain more from selling their labour services in the 'modern' sector. So, rich people are less inclined to 'seize' the foreign investments than poor, less educated people. The main 'results' are the following:

a) the extent to which the enforcement problem binds depends on the distribution of income. Particularly, it is more severe when the 'median voter' has low education compared with the average human capital. A very unequal distribution of human capital in which a majority of uneducated people live together with an elite of highly educated people is unfavourable to growth. A highly egalitarian distribution is not the most favourable situation, though;

b) growth increases inequality in the beginning, when the inflow of foreign investment induces people from better educated families to undertake high investment in education, whereas poor people find it optimal not to invest in education. At a later stage, however, growth is equalising, since people progressively switch into investing time in education and those dynasties which have less human capital than average benefit more from the process of social transmission of knowledge produces. The result is a 'convergence' of individual productivities to a uniform growing level. This evolution is coherent with the traditional Kuznet's curve argument also captured by recent models about growth and distribution (Aghion and Bolton, 1992);

c) multiple equilibria are possible in the model, for a full-dimensional set of initial distributions of knowledge. In one type of equilibrium, the majority of local workers anticipate low wages in the modern sector and do not invest in education. These expectations are confirmed by the behaviour of the foreign investors who anticipate unfavourable political conditions and enter with a low amount of foreign investments per efficiency unit of human capital. This implies low wages in the modern sector. In the other type of equilibrium the opposite happens: a high level of foreign investments flow into the country, and the majority of workers invest in education. The expectations which generate this behaviour are again self-fulfilling. It is possible for the initial selection of the equilibrium to have long-lasting consequences, namely to determine whether an economy is to converge to a long-run stationary equilibrium or to a self-sustained growth path.

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The chapter is structured as follows. We first describe the basic model with identical agents and no enforcement constraints (section 1). Then, we extend the analysis to the case of heterogeneous population (section 2). In section 3 we introduce the enforcement constraint and relate it to the political equilibrium. A simple simulation is presented in section 4. Policy implications and conclusions are discussed in section 5. Three appendices contain some analytical parts.

1 The basic model

An economic system is populated by overlapping generations of two period-lived identical agents belonging to a continuum of dynasties. The successive generations have a constant size, whose measure is assumed to be unity. In the first period of their life agents choose to allocate their time between working in a 'traditional' household activity and receiving formal education (leisure is worthless). The goods produced by a young person can be stored for one period and consumed by the same agents when old. Alternatively, we can imagine that first-period savings can be invested in a non-productive asset, like foreign currency, which plays the role of a store of value. In the second period, agents sell their labour force in the modern sector. Here they earn a wage which is proportional to their productivity (h). This income, together with the savings of the previous period, is entirely consumed in the second period. For convenience, we assume that a young worker is entirely unskilled, and is worthless in the modern sector, as well as an old worker is unsuitable for working in the traditional sector.

Agents have standard intertemporally separable logarithmic preferences and do not care about their offspring. There is no uncertainty. A representative member of the generation which is young at time t solves the following programme:

$$\max_{s_t, u_t} V_t = \log c_t + \beta \log c_{t+1} \qquad (1)$$

$$s.t. \qquad c_t \leq w(1 - s_t)(1 - u_t)$$
$$c_{t+1} \leq s_t R w(1 - u_t) + w_{t+1}^M h_{t+1}$$
$$h_{t+1} = (\delta + u_t^{1-b}) h_t$$
$$0 \leq s_t \leq 1; \quad 0 \leq u_t \leq 1.$$

where w is the wage rate in the traditional activity, w_{t+1}^M is the wage rate per efficiency unit in the modern sector, β ($0 < \beta < 1$) is the time-discount factor, s_t is the saving rate out of the income earned in the first period, u_t is the share of time spent in education, R is the gross rate of return paid by the storage technology, δ ($0 < \delta < 1$) is one minus the depreciation rate of the human capital inherited from the former generations without any personal investment. The parameter b is such that $0 \leq b < 1$, meaning that there are non-increasing returns to the individual investment in education. The representative agent takes as given the stock of human capital of the previous generation, h_t, and the wage rate in each activity.

The First Order Conditions ($V_{u_t} \leq 0$, $V_{s_t} \leq 0$) of this problem can be expressed - after simple manipulations- as follows:

$$w_{t+1}^M h_t [\beta(1 - b) - u_t(1 + \beta(1 - b)) - \delta u_t^b] \leq s_t \left[u_t^b R(1 - u_t)(1 + \beta)w \right] \qquad (2)$$

$$w\beta R u^b(1 - u_t) - w_{t+1}^M h_t(u_t + \delta u_t^b) \leq s_t \left[u_t^b R(1 - u_t)(1 + \beta)w \right] \qquad (3)$$

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where strict inequality in (2) and (3) implies, respectively, $u_t = 0$ and $s_t = 0$ (slackness conditions). Notice that no corner solutions at which either $u_t = 1$ or $s_t = 1$ (or both) can be a maximum, since this would imply consumption at time t to be zero and the utility to be minus infinity. So, the gradient of the value function evaluated in the optimum is always non-positive.

When $b > 0$ (strictly decreasing returns to the individual investment in human capital) and $h_t > 0$, the optimum u_t is always positive. This is evident from the fact that (2) never holds for $u_t = 0$. Let us consider, first, strictly interior solutions. By using (2) and (3) to eliminate s_t, we obtain:

$$u_t = \left[\frac{(1-b)w_{t+1}^M}{wR} h_t \right]^{\frac{1}{b}} \tag{4}$$

The second condition which needs to hold is that $s_t > 0$. From the inspection of (2), it results that this condition is satisfied if and only if: ....

$$(1-b)\beta - [1 + (1-b)\beta]u_t \geq \delta u_t^b \tag{5}$$

Call u^* the value of u_t for which (5) holds with equality (figure 1). Then $u_t = \left[\frac{(1-b)w_{t+1}^M}{wR} h_t \right] < u^* \Rightarrow s_t > 0$. One can check that this condition is both necessary and sufficient for the solution to be strictly interior.

FIGURE 1 here

It can also be verified that any corner solution at which $s_t = 0$[1] will be characterised by $u_t = u^*$. This solution is independent of the state variable h_t.

Finally, it is useful to obtain the limit behaviour of the policy function when $h_t \to 0$. In this case, the logarithmic preferences generate the simple solution:

$$\lim_{h_t \to 0} s_t = \frac{\beta}{1+\beta}; \quad lim_{h_t \to 0} u_t = 0$$

The characterization of the equilibrium dynamics requires us to obtain the value of w_t^M. To this end, consider the technology of the productive sectors in the economy. In the 'traditional' activity only physical labour of young people is used, and there is no technical progress. Formally:

$$y_t^T = w(1 - u_t) \tag{6}$$

having normalized the measure of the labour force to one, as already said. In the modern sector, output is produced by using human capital and imported resources. For analytical convenience, we assume that each vintage of fdi's is productive for only one period. In the basic case described in this section, each mature agent's belonging to a particular generation is endowed with the same amount of human capital. The production function is assumed to be Cobb- Douglas, of the form:

$$y_t^M = k_t^{1-\alpha} h_t^\alpha \tag{7}$$

Human capital is supplied inelastically by mature people. Foreign investors decide at time $t-1$ the amount k_t which is invested in the host country and which becomes productive at time t. They are assumed to act competitively, taking as given the opportunity-cost of resources given by the international one-period interest rate, r, and paying wages to workers at the value of their marginal productivity. This means that the level of foreign investment

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[1] Agents cannot issue debts when young.

will be set at the following level[2]:

$$k_t = \left[\frac{(1-\alpha)}{r} \right]^{\frac{1}{\alpha}} h_t \tag{9}$$

and the wage per efficiency unit paid to workers will be:

$$w_t^M = a \left[\frac{(1-a)}{r} \right]^{\frac{1-\alpha}{\alpha}} \tag{10}$$

So, in a world with no enforcement problems the wage per efficiency unit paid in the modern sector is constant. Notice that in an economy characterised by a growing stock of human capital, this means that per-capita wages are growing over time.

Since we have established that w^M is constant over time, the only state variable which determines the solution to (2) and (3) will be h_t. In particular, we have the following cases:

$$h_t = 0 \quad \Rightarrow \quad u_t = 0; \quad s_t = \frac{\beta}{1+\beta}$$

$$0 < h_t < \frac{wRu^\circ}{(1-b)w^M} \quad \Rightarrow \quad u_t = u(h_t); s_t = s(h_t)$$

$$h_t \geq \frac{wRu^\circ}{(1-b)w^M} \quad \Rightarrow \quad u_t = u^\circ; s_t = 0$$

The function $u(h_t)$ is defined in (4). Clearly, $u'(h_t) > 0$. The behaviour of $s(h_t)$ can be derived by totally differentiating (2) (the details are in appendix 1). This establishes that $s'(h_t) < 0$ in all the relevant range.

We can now establish the main result for the basic case dealt with in this section:

Proposition 1 *Let the parameters be such that $\delta + u^\circ > 1$. Define $h^{thr} \equiv \frac{wR}{(1-b)w^M}(1-\delta)^{\frac{b}{1-b}}$ and g_t as the growth rate of human capital from t to $t+1$. Then:*

○ *if $h_0 > h^{thr}$, then the equilibrium path will be such that:*

$u_{t+1} \geq u_t; s_{t+1} \leq s_t; h_{t+1} > h_t$

and will converge to a steady-growth path in which

$s = 0; u = u^\circ; g = (\delta + u^\circ - 1)$.

○ *if $h_0 < h^{thr}$, then the equilibrium path will be such that:*

$u_{t+1} \leq u_t; s_{t+1} \geq s_t; h_{t+1} < h_t$

and will converge to a steady-state in which

$s = \frac{\beta}{1+\beta}; u = 0; g = 0; y = y^T$.

○ *if $h_0 = h^{thr}$, then the equilibrium path will be stationary and such that, for all t:*

$u = \left[\frac{(1-b)w^M h^{thr}}{wR} \right]^{\frac{1}{b}}; \quad s = \frac{w^M h_t[\beta(1-b) - u_t(1+\beta(1-b)) - \delta u_t^b]}{u_t^b R(1-u_t)(1+\beta)w}; \quad h = h^{thr}$

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[2]One could assume, alternatively, that foreign investors' decisions are taken according to a joint profit maximization principle. In this case, less fdi's per efficiency unit of human capital would enter. Precisely, we would have:

$$k_t = \left[\frac{(1-\alpha)^2}{r} \right]^{\frac{1}{\alpha}} h_t \tag{8}$$

The change is qualitatively unessential for our argument.

PROOF - Since we know that $u'(h_t) > 0$ and $s'(h_t) < 0$, it is then sufficient to prove that $h_t > (<)h^{thr} \Leftrightarrow h_{t+1} > (<)h_t$ in order to ensure that the Proposition holds true. By substituting (4) into the human capital accumulation

equation, we obtain:

$$h_{t+1} = \left[\delta + \frac{(1-b)w^M}{wR}h_t^{(1-b)}\right]h_t. \tag{11}$$

One can check that the term inside square brackets takes on the unit value when $h_t = h^{thr}$ and is larger (smaller) than one when $h_t > (<)h^{thr}$. $\square$

The following pictures give an intuitive representation of the dynamics described by the Proposition. When $h_0 > h^{thr}$, h_t grows over time (figure 2), since $\delta + u_t > 1$. Then, u_t grows and s_t falls over time (figure 3). The opposite occurs when $h_0 < h^{thr}$ (figure 4).

FIGURES 2, 3, 4 here

2 Heterogeneous agents.

We now extend the analysis to the case of an heterogeneous population, whose members belonging to each generation differ in the levels of education and skill. Let $F_t(h)$ denote the distribution function of each generation over human capital levels (so $F_t(h_c)$ is the proportion of old people whose human capital is inferior to h_c at time t), and let $f_t(h)$ be the corresponding density function.

Two main changes are introduced here with respect to the previous section. The first, merely technical, is that we restrict the analysis to the case in which there are constant returns to scale to the individual investments in education. This means to restrict the parameter b in (1) to be zero. The second, more substantial, concerns the process of transmission of human capital between generations. We assume that knowledge is transferred between generations through both a family and a social channel. As before, individual investment in education increases the power of this process of transmission. We formalize this idea through the following transition equation:

$$h_{t+1}^i = (\delta + u_t^i)(\gamma h_t^{av} + h_t^i) \tag{12}$$

where i ($i \in R$, $0 \le i \le 1$) indexes dynasties, $h_t^{av} \equiv \int_0^\infty f_t(h^i)h_t^i di$ is the average human capital at time t, and γ is a constant which indicates the importance of the social channel of transmission (e.g. public education) of knowledge between generations.

The programme (1) can be now reformulated, with reference to the member of the dynasty i who is young at time t, as follows:

$$\max_{s_t^i, u_t^i} V_t^i = \log c_t^i + \beta \log c_{t+1}^i \tag{13}$$

$$s.t. \quad c_t^i \le w(1 - s_t^i)(1 - u_t^i)\cdot$$
$$c_{t+1}^i \le s_t^i Rw(1 - u_t^i) + w^M h_{t+1}^i$$
$$h_{t+1}^i = (\delta + u_t^i)(\gamma h_t^{av} + h_t^i)$$
$$0 \le s_t^i \le 1; \quad 0 \le u_t^i \le 1.$$

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where h_t^i and $f_t(h^i)$ are given. The First Order Conditions can be expressed as:

$$-\frac{1}{1-u_t^i} + \beta\frac{w^M(h_t^i+\gamma h_t^{AV})-rs_t^i w}{rs_t^i w(1-u_t^i)+w^M(\delta+u_t^i)(h_t^i+\gamma h_t^{AV})} \leq 0 \tag{14}$$

$$-\frac{1}{1-s_t^i} + \beta\frac{w(1-u_t^i)}{rs_t^i w(1-u_t^i)+w^M(\delta+u_t^i)(h_t^i+\gamma h_t^{AV})} \leq 0 \tag{15}$$

It is easy to verify that only corner solutions exist. For technical reasons that will become clear soon, we assume that $\beta > \delta$ throughout the rest of the work. The solution can be summarized as follows. Define the human capital 'endowment' of a young agent at time t as $\hat{h}_t^i \equiv (h_t^i + \gamma h_t^{AV})$. Then:

○ $\forall \{i,t\}$ such that $\hat{h}_t^i < h^* \equiv \frac{\beta w}{\delta w^M}$:

$$u_t^i = 0; \quad s_t^i = \frac{\beta w - \delta w^M \hat{h}_t^i}{(\beta+r)w} \tag{16}$$

○ $\forall \{i,t\}$ such that $\hat{h}_t^i \geq h^* \equiv \frac{\beta w}{\delta w^M}$:

$$u_t^i = u^* = \frac{\beta - \delta}{1+\delta}; \quad s_t^i = 0 \tag{17}$$

When the population is heterogeneous, it turns out that young agents coming from poor, uneducated families have less incentive to invest in education than those coming from better educated families. We will refer to h^*, the level of human capital endowment that makes workers indifferent between investing or not in education, as the 'critical level of human capital'.

We now determine at which conditions an individual dynasty accumulates human capital at a positive or negative rate in the time interval between one generation and its offspring. Remember that part of the process of transmission of knowledge depends on institutional features of an economy, like the establishment of a system of compulsory primary education (cfr. the parameter γ) and on the size of the aggregate human capital (h_t^{AV}). As a result, the degree of inequality, if we control for differences in the individual investments in education, tends to decrease as the stock of knowledge grows over successive generations. Some relatively poor dynasties may accumulate human capital at a positive rate even when their members do not invest in education. To the opposite, some relatively rich dynasties may decumulate human capital even when their members do invest in education. The precise conditions are stated in the following Lemma.

Lemma 1 *Define $\underline{h}_t = \frac{\delta\gamma}{1-\delta}h_t^{AV}$, and $\overline{h}_t = \frac{1+\delta}{\beta-\delta}\gamma h_t^{AV}$.*
Then:

○ $\forall j$ *s.t.* $h_t^j < \underline{h}_t$, $h_{t+1}^j > h_t^j$

○ $\forall k$ *s.t.* $h_t^k > \overline{h}_t$, $h_{t+1}^k < h_t^k$

PROOF - Consider an agent from dynasty j who is young at time t and chooses $u_t^j = 0$. From (12):

$$h_{t+1}^j = \delta\left(1 + \gamma\frac{h_t^{AV}}{h_t^j}\right)h_t^j$$

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then: $h_{t+1}^j \geq (<) h_t^j \Leftrightarrow \delta \left(1 + \gamma \frac{h_t^{AV}}{h_t}\right) \geq (<)1$

from which the first part of the Lemma is established.

The second part is established similarly, using the condition (12) for an agent who chooses $u = u^*$. □

To rule out uninteresting cases, we will impose parameter restrictions such that a society whose all members invest in education ($u_t^i = u^*$, $\forall i$) accumulates human capital, whereas a society in which no member invest in education ($u_t^i = 0$, $\forall i$), decumulates human capital. This is guaranteed by the following assumption.

Assumption 1 $\frac{1}{\delta} > (1 + \gamma) = \left(\frac{1+\delta}{\beta+\delta^2}\right) \frac{1}{\theta}$

for some $\theta \in (0,1)$

One can check from (12) that this implies that the income of a homogeneous population ($h_t^i = h_t^{AV}$, $\forall i$) which chooses $u_t = u^*$ grows over time, whereas the income of a homogeneous population which chooses $u_t = 0$ falls over time. The role of the constant θ will become clear soon. A corollary which follows from this assumption is that all agents who invest in education and belong to a less educated dynasty than average will add to the stock of human capital of their parents, whereas all agents who do not invest in education and belong to a more educated dynasty than average will remain below the level of education/productivity achieved by their parents.

In a world with heterogeneous population, the relation between short-run and long-run equilibrium is less straightforward than that given by Proposition 1 in the second section. The state of the system is now defined by the entire distribution of human capital across dynasties, and, in general, we will observe at any moment some dynasties accumulating and some others decumulating human capital. The dynamics of average human capital is in general ambiguous unless the entire distribution of wealth is specified.

Still, we can construct some useful intuition. If the initial state of the system ($t = 0$) is such that a richer part of the population invests in education whereas a poorer part does not, we observe the tendency for the density function to accumulate about two levels of human capital which evolve over time. Consider, for example, a case in which agents with an original endowment h_0^* (the 'critical level of human capital') ends up with more human capital than the parents if they invest in education and less human capital than the parents if they do not invest (figure 5). Then, dynasties with an initial human capital endowment just below h_0^* will decline over time in terms of their stock of knowledge. However, very poor dynasties ($h_0^j < \underline{h}_0$) will increase their human capital stock by the effect of the social channel of transmission. Dynasties with an initial human capital endowment just above h_0^* will increase their human capital stock. Finally, very rich dynasties ($h_0^j > \bar{h}_0$) will experience negative accumulation.

FIGURE 5 here

Imagine that the resulting average human capital has grown from period zero to period one and keeps growing for the following periods. This causes a rightward shift over time of both $\underline{h}$ and $\bar{h}$ (figure 6). If the members of the 'poor' dynasties (i.e. those originarily below the critical level h_0^*) kept choosing $u_t = 0$ for all t and the rich dynasties kept choosing $u_t = u^*$ for all t, then the density function would converge to a two-spikes distribution such that the human capital and income of both groups grows at the same rate. The mass of the population, in other words, would concentrate at two growing points, 'close' to $\underline{h}_t$ and

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$\bar{h}_t$. This cannot be, however, the long-run outcome. At some point in time, there will be a generation whose all members (both 'rich' and 'poor') will find it optimal to invest in education. Since that moment, the income of the poor dynasties will grow faster than that of the rich dynasties, and the economy will converge to a steady-growth equilibrium in which the differences across dynasties tend to vanish.

FIGURE 6 here

According to this sketchy picture, earlier stages of development appear characterised by growing inequality. Later stages of development, however, are characterised by decreasing inequality , since poor dynasties invest the same in education as rich ones but gain more from the process of social transmission of knowledge. Nothing ensures, unfortunately, that this case is general, and one could construct other examples in which the average human capital always decreases over time or follows mixed patterns. It is possible, however, to identify a set of initial conditions which guarantees that the equilibrium dynamics necessarily converge to the 'good' long-run equilibrium. Let us define $F_t(\hat{h})$ be a generic distribution function of the young population over (inherited) human capital levels at time t. Then the folllowing can be proved (see Appendix 2):

Proposition 2 *If* $F_0(\hat{h}^j = h^*) < 1 - \theta \Rightarrow$

(i) $h_{t+1}^{AV} > h_t^{AV} \ \forall \ t \geq 1;$

(ii) the economy converges to the long-run equilibrium with the maximum growth rate, $g = (\delta + u^*)(1 + \gamma)$, *where* $u^i = u^*$, $\forall i$.

3   The enforcement constraint.

In this section we introduce the possibility for the host country's government to seize the foreign resources before the productive process is set. Given the Cobb-Douglas technology, a constant share of the production in the modern sector is appropriated by the foreign investors as a reward to the productive resources invested. The complement of this share represents the income earned by the inhabitants of the host country from the activity of the modern sector. This can be compared with the income which can be obtained by nationalising the foreign resources.

An important assumption is that the country cannot nationalise the capital and manage the productive activity efficiently without the cooperation of foreign investors. We imagine, to motivate this assumption, that some non-seizable factor,like specific knowledge, managerial capabilities etc. be owned by foreign investors. The government can, however, seize the tangible assets and obtain an income which is assumed to be proportional to the amount of capital planted in the previous period. We will refer to this income as 'scrap value of capital' and indicate it by ψk_t[3]. We will structure the sequence of the relevant decisions as

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[3] In our notation k_t is the capital which is productive at time t. The formulation proposed in the text can be interpreted as if the country can do no better than to sell the machinery seized on the international market. Alternatively, one could assume that the country can still operate a certain number of efficiency units of foreign capital in the modern sector. However, in this case we should impose an additional assumption, namely that the relative contribution of the local factor to the production process be smaller when the foreigners are expropriated than when they are not. This makes the loss to the indigenous population from not running the process at full efficiency decreasing with the level of foreign investments, a fact which is essential, as it will become clear soon, in order to have interior solutions. Informally speaking, we want the productivity of the local factor to be strongly reduced by the withdrawal of the non-seizable component. The case which we consider is the extreme one in which the local factor looses its productivity entirely.

follows. At the beginning of period t foreign investments are planted in the host country; such vintage of investments becomes productive only at time $t+1$. Meanwhile, also at time t, the young workers who contemplate being employed in the modern sector in the following period decide the time to invest in education. At the beginning of time $t+1$ elections are called and this generation, just become mature (the newborn do not have right to vote at this stage), chooses the government in a two-party system. Of the parties which run the competition, the party A, 'liberal', is credibly committed to enforce property rights over the entire mandate. The party B, to the opposite, is believed (regardless of its explicit programme) to nationalise the foreign capital and to redistribute in equal shares to the members of the voting generations of the income obtained. We will show that it is indifferent to assume, alternatively, that party B is expected, when in power, to tax at full rate the profits of foreign capitalists.

We need to justify this political structure, in which apparently the two parties only cover the two radical options, whereas a continuum of tax rates on foreign investors' income seem to be viable policies. First, we stress that governments remain in power for only one period, implying that no party may act strategically to build a reputation to the eyes of foreign investors.[4]. Consider the case in which the government can decide to tax profits at the end of the production process. Then, a time-consistent strategy for the local government will be necessarily characterised by the full taxation of the corporate income belonging to the foreigners. The expectations about the behaviour of party B simply come from this time-consistency issue. Notice that if party B's victory were anticipated, no foreign investment at all would be observed in equilibrium. How to justify then the existence of a party, the 'liberals', which supports property right enforcement and never deviates from its electoral manifesto? One might argue that the leaders of this party obey some ideological convictions or have a moral commitment to the future generations (it will become clear soon why). More realistically, we can think that they receive financing and bribes from foreign investors. As marxist literature would say, party A's leaders are 'agents of the foreign capital'. Leaving aside ethical issues, it is possible that the current generation find it optimal to 'tie his government's hands' and choose delegate the political power to party A rather than to party B.

We have then the following scenario. Party B's leaders are expected to operate under any circumstance in the interest of the electors. This sounds, to the hears of foreign investors, as the threat of facing ex-post taxation at the full rate. Party A's propaganda stresses instead that property rights are intangible. This sounds credible to foreign investors, on whose behalf these politicians in fact speak. Consider now the event of party B's electoral victory. The investors, anticipating full taxation, put themselves 'on strike', leaving the country alone with the tangible assets which can be seized but withdrawing all the intangible assets which are necessary to carry on the productive activity (something like this happened in Allende's Chile and in the Sandinist Nicaragua). If party A wins, instead, the modern sector will be active and no seizure will occur.

To summarize, it is unessential how radical the party B's manifesto is. The game is in fact structured in such a way that a party which is loyal to the interests of the local electors will always tax foreign capital income at the full rate. The threats of taxation or nationalisation turn out to be observationally equivalent in our framework. It is instead essential that *(i)* governments remain in power for only one period and are linked to only one (non-altruistic) generation, *(ii)* there is a party which acts, ex-post, on behalf of the investors rather than the electors. This party may gain, ex-ante, the support of the majority of the country,

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[4]The lack of consideration for reputational issues is certainly a major limitation of the model which is open to further research. However, we expect the technically issues that this would arise to be non-trivial.

because it represents the actual instruments through which credible precommitment may be taken by the indigenous population, and *(iii)* some assumption is made about the way in which the benefit from the seizure-taxation is redistributed to the local agents. Though the actual form in which the redistribution takes place is unessential, we do not consider the potentially interesting, and certainly non-trivial, issue to endogenize the fiscal policy by allowing for a multi-party system in which any redistribution mechanism may be proposed by a party or a coalition.

Now, we compute what constraint the enforcement problem imposes on the foreign investors' decisions, given that they need to act so as to induce the party A's victory. This is easy to determine when the population is entirely homogeneous The party A will win the elections held at time t if and only if:

$$\psi k_t \leq w^M h_t = \alpha k_t^{1-\alpha} h_t^\alpha \tag{18}$$

This condition can be rewritten as:

$$k_t \leq \left(\frac{a}{\psi}\right)^{\frac{1}{\alpha}} h_t \tag{19}$$

We assume that, in the equilibrium, the foreign investors can coordinate their decisions and thus avoid creating the conditions for a victory for party B. This means that they will optimally restrict the inflow of investments in such way that (19) always holds. We will refer to (19) as the 'enforcement constraint' condition. Clearly, such a constraint is not binding (strict inequality) under certain parameter configurations. In these cases the results of the previous section carry over. We will focus, however, on those cases in which such constraint is binding, by assuming, throughout the rest of the chapter, that:

$$\frac{a}{\psi} < \frac{1-\alpha}{r} \tag{20}$$

When (20) holds, the wage rate in the modern sector is lower in the presence of incentive problems than under first-best Pareto efficiency. In particular, we have now:

$$w^M = \alpha \left(\frac{\alpha}{\psi}\right)^{\frac{1}{\alpha}} \tag{21}$$

This means that the threshold level h^{thr} which guarantees convergence to a sustained growth path is now larger than in the previous section (cfr. Proposition 1).

4 Heterogeneous population and the enforcement constraint

When the population is heterogeneous, the relation between political equilibrium and foreign investments acquires new dimensions. Agents are no longer unanimous in their political attitude. The 'rich' will find their interests represented by the liberal attitude of the party A, whereas the 'poor' will lobby for nationalisation and redistribution, supporting the party B. The solution of the electoral competition will be determined by the will of a decisive individual, the 'median voter'. As the intuition might suggest, if the median voter has a marginal preference for the party A over the party B, just more than half population, i.e. those who are at least as rich as him, will support the party A, and just less than half population, i.e. those who are less wealthy than him, will support the party B.

The characterisation of the political equilibrium is not trivial, though. The key issue is that agents take their decisions about education before the election, and these decisions affect their political choice. If a voter marginally prefers the party A after having invested in education, for instance, he would have come up with a preference for party B had he chosen, ceteris paribus, not to invest in personal education in the previous period. As in the previous sections, no outcome in which the foreign capital is seized is an equilibrium. In the equilibrium, foreign capitalists are careful enough to restrain the inflow of investments below the level that would trigger a 'bad' political outcome. However, when the population is heterogeneous it is possible to have interesting multiple equilibria in which all agents take time-consistent decisions.

To fix ideas, we construct a particular example in a game-theoretical framework, before moving to the general case. Consider a three-class society with an homogeneous politically decisive 'middle class' which has a positive measure in the total population. A representative middle class agent chooses, at time t, to invest (E) or not to invest (NE) a fixed amount of time in education depending on his expectations about the wages paid in the modern sector. The 'rich' and the 'poor' class find it optimal, respectively, to invest and not to invest time in education, and their decisions can be treated as exogenous and ignored. This allows us to discuss the model in the form of a two-player game between the middle class and the foreign investors. The latter choose high (H) or low (L) investment in tradable resources on the basis of their expectations about the political equilibrium. If they choose H (L), high (low) wages are paid in the modern sector in the second period[5]. With an opportune choice of the pay-offs (see section 5) it happens that the middle class, if it chooses E in the first period, always finds it optimal to support the party A in the second stage and the property rights are safeguarded. But if it chooses NE in the first period, it only supports the party A in the second stage if L is chosen by foreign investors. Otherwise it supports the party B, since the potential gain from seizing the foreign resources is larger than the benefit from working in the modern sector when H occurs. Figure 7 gives the extensive form representation of the game. Notice that only the political decision of the local people is taken with perfect information about the opponent's choice, whereas all investment decisions in the first stage are taken without knowledge of the behaviour of the other 'player'. This motivates the dashed oval in the figure (according to usual conventions this means that the representative foreign investor ignores the first-stage choice of the middle class when he takes his decision).

FIGURE 7 here

It can be checked, by using backward induction, that this game has two sub-game perfect Nash Equilibria, given by the sequences of actions $((E, H), A)$ and $((NE, L), A)$, respectively. More precisely, the two equilibrium strategy pairs are:

- Foreign investors choose H; middle class agents choose E in the first stage and vote for the party A under any circumstance in the second stage;

- Foreign investors choose L; middle class agents choose NE in the first stage and vote for the party A conditional on H (information set reached at equilibrium) and for party B conditional on L (information set not reached at equilibrium).

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[5]In fact, the wages are also affected by the investments in education, being decreasing with the social stock of human capital. However, as we will show, this second effect is never entirely offsetting (namely the wages given H and E are always larger than the wages given L and NE) when a positive proportion of the population does not invest in human capital. This fails to occur when the population is homogeneous, explaining so why multiple equilibria did not arise in that case. The reason is that the potential increase in the marginal product of labour brought about by more foreign investments is entirely offset by the increase in the supply of efficiency units of labour leaving wages unchanged.

The first Nash Equilibrium dominates the second one in welfare terms.

Having built the intuition through the example, we move now to show that the case for multiple equilibria does not depend on the particular distribution of human capital assumed in this example. First, we discuss how the enforcement constraint is modified by the heterogeneity of the population. Before taking their decisions, foreign investors speculate about the political equilibrium which will prevail in the following period, that is to say about the attitude of the median voter in the next election. By maintaining the assumption that if the capital is seized, the income obtained is equally distributed within the local population[6] equation (18) becomes:

$$w^M h_t^{med} \geq \psi k_t \tag{22}$$

When (22) holds, there is a majority in the country which supports the party A and no seizure occurs. In an equilibrium, foreign investors choose a level of k such that (22) holds with equality. The wage rate per efficiency unit in the modern sector keeps being determined by the marginal productivity of human capital, meaning that $w_t^M = \alpha \left(\frac{k_t}{h_t^{AV}}\right)^{(1-\alpha)}$. Using this condition, we can rewrite (22) - taking equality - as:

$$\alpha \left(\frac{k_t}{h_t^{AV}}\right)^{(1-\alpha)} h_t^{med} = \psi k_t \tag{23}$$

It is clear from this expression that we no longer have a time-invariant $\frac{k}{h}$ ratio like in (8), and that neither the wage in the modern sector, w^M, nor the 'critical level of human capital', h°, are now constant and time-invariant.

As the game-theoretical example suggested, we have two types of candidate equilibria. We will call *equilibrium of type 1* an equilibrium in which the median voter chooses to invest in education, and *equilibrium of type 2* one in which the median voter does not invest in education. In each type of equilibrium all agents adopt optimal, time-consistent rules. This implies, amongst the other things, that under no circumstance does the decisive agent vote for the party B after investing in education at the previous period. Some people (i.e. the 'poor') may be dissatisfied with the political equilibrium which prevails, but all agents are 'realistic' enough to take decisions which are optimal on the basis of the effective political outcome rather than on their political 'desires'. In other words, the political equilibrium is always perfectly anticipated by all agents. Some non-decisive agents might choose to invest in education at time t based on the (correct) expectations about the one period-ahead wage rate in the modern sector, and then, at time $t+1$, support the party B, because the nationalisation would still make them better off. The event of a victory of the party B would be welcome by such agents, though it would make them regret about the choice of youth. This inconsistency will never show up, anyway, since the political equilibrium is always in favour of the party A.

Let us define formally the two types of equilibria.

Definition 1 *An equilibrium is characterised by the following conditions[7]:*

$$\alpha \left(\frac{k_{t+1}}{h_{t+1}^{AV}}\right)^{(1-\alpha)} h_{t+1}^{med} = \psi k_{t+1} \tag{24}$$

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[6] A natural extension could be to allow party B to device a redistribution schedule which maximises its chances of winning the election. This would imply, informally speaking, to redistribute nothing to the richest, whose support would be very costly to achieve, little to the poorest, whose support is easily bought, and most of the resources seized to the 'marginal voters'. This policy would make tougher the electoral task for party A and more serious the effects of the incentive constraint on investments.

[7] We remind that $\hat{h}_t^i \equiv h_t^i + \gamma h_t^{AV}$ is the capital-endowment of an agent who is young at time t, apologizing with the reader for the proliferation of notation

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$$\alpha \left(\frac{k_{t+1}}{h_{t+1}^{AV}}\right)^{(1-\alpha)} h_t^* = \frac{\beta w}{\delta} \qquad (25)$$

$$\int_0^{h_t^*} \delta \hat{h}_t^i f(\hat{h}_t^i) \, di + \int_{h_t^*}^{\infty} (\delta + u^*) \hat{h}_t^i f(\hat{h}_t^i) \, di = h_{t+1}^{AV} \qquad (26)$$

An equilibrium is said to be of type 1 iff:

$$u_t^{med} = u^* \qquad (27)$$

$$h_t^* \leq \hat{h}_t^{med} \qquad (28)$$

and is said to be of type 2 iff:

$$u_t^{med} = 0 \qquad (29)$$

$$h_t^* \geq \hat{h}_t^{med} \qquad (30)$$

The condition (25) is the familiar definition of 'critical level' of human capital endowment. Notice from (26) that h_{t+1}^{AV} is a decreasing function of h_t^*, since the higher h_t^* the lower the proportion of people who invests in education at time t in equilibrium. In the characterisation of each type of equilibrium, the time-consistency requisites are expressed by (28) and (30), respectively. The former says that should the median voter invest in education, the ex-post 'critical level of human capital' determined by the equilibrium wage rate in the modern sector, cannot be higher than the endowment of the median voter, $\hat{h}_t^{med}$; otherwise, the median voter would regret about his choice of investing in education. The opposite must hold true should he not invest in education when young. Given the distribution of human capital across dynasties at time t, the equilibrium solution(s) is (are) found, by solving (24), (25) and (26) for the endogenous variables h_t^*, h_{t+1}^{AV} and k_{t+1} and checking whether either of the pairs of conditions (27)-(28) and (29)-(30), or both, hold.

The next proposition establishes that, for any distribution of human capital endowment, there exists (at least) one equilibrium outcome determined by the choices of a generation of indigenous agents (investment in education and political election) and foreign investors.

Proposition 3 *Let $F(\hat{h})$ be a generic continuous distribution function over inherited human capital. Then for any $F(\hat{h})$ there exists an equilibrium of either type 1 or type 2 (or both) according to Definition 1.*

PROOF. Rewrite (26) as $h_{t+1}^{AV} = h(h_t^*, f_t(h))$, where $h_1 < 0$. Then, rearrange (24) and (25) to obtain:

$$k_{t+1} = \left(\frac{\alpha}{\psi}\right)^{\frac{1}{\alpha}} h(h_t^*, .)^{\frac{\alpha-1}{\alpha}} (\delta + u_t^{med}) \hat{h}_t \qquad (31)$$

$$k_{t+1} = \left(\frac{\beta w}{\alpha \delta}\right)^{\frac{1}{1-\alpha}} (h_t^*)^{\alpha-1} h(h_t^*, .) \qquad (32)$$

and, by eliminating k_{t+1}:

$$\left(\frac{\alpha}{\psi}\right)^{\frac{1}{\alpha}} \left(\frac{\alpha \delta}{\beta w}\right)^{\frac{1}{1-\alpha}} (\delta + u_t^{med}) \hat{h}_t = (h_t^*)^{\alpha-1} h(h_t^*, .)^{\frac{1}{\alpha}} \qquad (33)$$

which we rewrite as:

$$\Gamma (\delta + u_t^{med}) \hat{h}_t^{med} = \zeta (h_t^*, f(h_t)) \quad , \quad \zeta_1 (h_t^*, f(h_t)) < 0 \qquad (34)$$

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where Γ is a constant term. From (34) it is clear that in equilibrium, given the state variables $f(h_t)$ and $\hat{h}_t^{med}$:

$$(h_t^\circ \mid u_t^{med} = u^\circ) < (h_t^\circ \mid u_t^{med} = 0) \qquad (35)$$

Now, assume that a type 1 equilibrium does not exist. This implies that

$$(h_t^\circ \mid u_t^{med} = u^\circ) > \hat{h}_t^{med}$$

But then, from the inequality (35):

$$(h_t^\circ \mid u_t^{med} = 0) > \hat{h}_t^{med}.$$

So, an equilibrium of type 2 exists.

Suppose, to the opposite, that a type 2 equilibrium does not exist. This implies:

$$(h_t^\circ \mid u_t^{med} = 0) < \hat{h}_t^{med}.$$

But then, again from (35):

$$(h_t^\circ \mid u_{t-1}^{med} = u^\circ) < (h_t^{med} \mid u_{t-1}^{med} = u^\circ).$$

So, an equilibrium of type 1 exists. This completes the proof of the Proposition. □

It is also easy to establish that multiple equilibria exist for a non-trivial set of initial distributions. From (34), observe that, given $\hat{h}_t^{med}$, it is always possible to choose a density function $\tilde{f}(h_t)$ (and a corresponding distribution function $\tilde{F}(h_t)$) having the given median such that:

$$(\tilde{h}_t^\circ \mid u_t^{med} = u^\circ) < \hat{h}_t^{med} < (\tilde{h}_t^\circ \mid u_t^{med} = 0) \qquad (36)$$

where $\tilde{h}_t^\circ$ is the value of h^* originating from the distribution $\tilde{F}$. So, the range of multiple equilibria is non-empty. Furthermore, the continuity of (34) ensures that for any function $\tilde{F}$ there exist a neighbourhood of functions such that a condition analogous to (36) which continues to be satisfied.

Figure 8 provides an intuitive geometric argument. The locus (1) represents the positive association between k_{t+1} and h_t° described by the enforcement condition (31), whereas the locus (2), negatively sloped, represents the condition (32). Notice that u_t^{med} shifts schedule (1), whereas it does not affect the schedule (2). When $u_t^{med} = u^\circ$ (type 1 equilibrium), there are more foreign investments and higher wages in the modern sector (lower h_t°) than when $u_t^{med} = 0$ (type 2 equilibrium). In the case represented, multiple equilibria exist.

FIGURE 8 here

The analysis of the transitional dynamics towards a long-run equilibrium is complicated here by the fact that h^* is not time-invariant. So, we should keep track not only of the dynamic path of h_t^{AV} but also of that of h_t°. The conditions given by Proposition 2 are no longer sufficient to ensure that convergence to a 'good' long-run equilibrium occurs. It turns out that, in fact, sufficient conditions for the economy to converge to the high growth long-run equilibrium can still be found, but they are more restrictive and involve 'distributional issues'. Such conditions are given in the Appendix 3.

5 Long-run equilibria and historical accidents. Pallas-land vs. Lotus-land.

We have shown that multiple equilibria are an intrinsic feature of our model. Should we believe that structurally identical countries which select different equilibria at some stage of their history are destined to converge to alternative long-run equilibria? In other words,

do historical accidents have long-lasting consequences? We will show that according to our model two countries that have achieved altogether different levels of economic development may have had, at some past stage, identical conditions and opportunities.

In this section, we specify the initial distribution of knowledge and we give an example of non-uniqueness of the long-run outcome for given initial conditions. We leave to future research a more detailed study of the issue and the derivation of more general analytical results.

Consider the three-class economy in whose framework we have discussed the game of a previous section. A fourth of the population belongs to the 'poor' class, a fourth to the 'rich' class, and half of the population belong to the middle class. Each class consists of identical individuals. Though special the case is, we believe that a large class of distributions (particularly, symmetric and lowly skewed) would generate similar dynamics.

At time $t = 0$, the old middle class agents are two times as productive, and the rich three times as productive as the poor. The productivity of the poor is normalised to one. The other parameters are chosen as follows:

$$\beta = 0.875, \ \delta = 0.5, \ w = 1.714, \ \alpha = 0.5, \ \psi = 0.25$$

It is easy to check that, with this parameter choice, the following relations hold:

$$u^* = 0.25, \quad w_{t+1}^M = \frac{h_{t+1}^{med}}{h_{t+1}^{AV}}, \quad h_t^* = 3\frac{h_{t+1}^{AV}}{h_{t+1}^{med}}$$

where the expression for the 'critical level of human capital' is easily derived from (40). The representative member of the middle class is, obviously, the median voter.

When the first generation, alive at time $t = (0,1)$, is considered, there are two equilibria. In the type 1 equilibrium, the middle class and the rich invest in education, there is a high level of foreign investments, the wage rate per efficiency unit is $w_1^M = 1.06$, and the critical level of human capital endowment is $h_0^* = 2.73 < \hat{h}_0^{med} = 3$. This implies that it is optimal for both the rich and the middle class (not for the poor) to invest in education in the first stage. As a result, the average productivity grows from 2 at time $t = 0$ to 2.125 at time $t = 1$. In the type 2 equilibrium, instead, the middle class does not invest in education, and the equilibrium is characterised by less foreign investments, a lower wage rate per efficiency unit ($w_1^M = 0.86$), and a critical level of human capital endowment of $h_0^* = 3.5 > \hat{h}_0^{med} = 3$. So, in this case it is optimal to invest in education only for the rich (3.5 < 4), and the average productivity falls from 2 to 1.75.

If alternative sets of self-fulling expectations are viable in the first period, the future faced by the following generations is uniquely determined. Imagine that two countries, Pallas-land and Lotus-land[8], shared identical conditions, like those just described, at the beginning of their history, but in Pallas-land the type 1 equilibrium occurred in the first period, whereas in Lotus-land the type 2 equilibrium occurred. In the second period, the Palladiensis face a unique type 1 equilibrium. One can check that neither a type 1 equilibrium in Lotus-land, nor a type 2 equilibrium for Pallas-land exist. Pallas-land is destined to the route of progress and development, Lotus-land to an inexorable decline.

Let us follows the path taken by these two economies (figures 9 and 10). In Pallas-land, the first years are characterised by an irresistible escalate of the middle class, with the productivity and income of both the poor and the rich growing only moderately (figure 9.a). At the sixth generation, the gap between the rich and the poor is almost unchanged (in fact it is slightly wider) with respect to the initial difference, whereas the middle class

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[8] In Greek mythology, Pallas was the goddess of sciences. Lotus was a legendary plant inducing luxurious languor when eaten. In a well-known episode of the 'Odyssey', Ulysses and his mates land at the island of the Lotus-eaters, and risk loosing the recall of the fatherland Ithaca by eating the flower.

has almost caught-up with the rich group. Since then, the social redemption of the lower class starts. At the ninth generation, the gap between the richest and the poorest is less than half as much it used to be, and continues to fall in the following periods, as the figure shows. The figure 9.b shows why this happens. At the seventh generation, also the poor start investing in education and their income grows at the highest rate.

In Lotus-land, to the opposite, the society continuously forgets something of what their ancestors could do[9]. As far as the first couple of generations is concerned, rich people do invest in education, and their productivity declines more slowly than that of the other classes. However, since the third generation, all the inhabitants of Lotus-land give up devoting time to education and the decline is generalised (figures 10.a and 10.b)

FIGURES 9.a, 9.b, 10.a, 10b here

6 Policy implications and conclusions.

Two main points are identified by our discussion. On the one hand high initial levels of human capital are a favourable condition to avoid the lock-in into a stationary equilibrium. The existence of thresholds in the accumulation of human capital had been already revealed by the study of the basic case with homogeneous population. On the other hand, the lower the human capital of the median voter compared with the average human capital, the higher the total amount of human capital that the society needs to be endowed with in order to sustain a type 1 equilibrium and to take-off into sustained growth. This point emerges as a non-obvious effect of the relation between political equilibrium, property right enforcement and profitability of individual investments in education.

To study this point more closely, consider some economies which are identical in all but the distribution of human capital. It is clear that a very unequal distribution is not a good pre-condition for growth. Take the extreme case in which more than half the population has no human capital at all, whereas high competence and skills are concentrated in the hands of a minority. In this case, there will be no development of the modern sector, because the political pressure for seizure and redistribution of the foreign resources would be overwhelming should any positive amount of foreign investment enter the country. On the other hand, a perfectly egalitarian society in which all people have the same amount of human capital, though a more favourable environment, is not the best situation for activating the growth process. Imagine that the initial aggregate stock of human capital is too low for promoting sustained growth in an egalitarian society. Still, it is possible that a less egalitarian society, in which the same total human capital is concentrated in the hands of a *majoritarian* group, can sustain a take off process. The reason is that in this society there is a firmer support for property rights enforcement from the dominant class which, by squeezing the interests of the 'poor', is consistent with a higher inflow of foreign investments, higher wages in the modern sector and a higher rate of human capital accumulation. The 'ideal' distribution[10] of a given stock of knowledge would be to give (just more than) half the population all the human capital equally distributed among the members and the remnant (just less than) half population nothing at all.

We can try to relate this rather abstract discussion to more realistic scenarios, in order to

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[9] If one finds this possibility unrealistic, he can think that some type of knowledge gets in fact obsolete as time goes on, and can no longer be productively used together with foreign capital in a modern industrial sector.

[10] Obviously, we mean 'ideal' for a social planner who aims at maximizing the growth rate of the economy, without any regard for equity or other welfare considerations.

draw meaningful policy implications. Assume that in a less developed country there exists an elite with a relatively high endowment of knowledge or capabilities and a large majority of uneducated unskilled people. Should the government use its budget for education for the elite to acquire higher human capital, say by paying grants for studying abroad? Or should it give priority, to the opposite, to plans for large-scale basic literation of the mass of uneducated people? According to the model, as far as pure growth objectives are concerned, neither policy is ideal. If the first policy is adopted, the few highly educated people are likely never to find good opportunities at home, because the political environment will remain unfavourable to foreign investments and modernization. Possibly, they will be induced to spend their competence abroad. If the second policy is adopted, the government budget may get too much 'disperse' to produce significant effects. The expenditure should target the formation of a substantial, majoritarian middle class, whose interests are coincident with those of foreign investments and modernization. The change in the social structure puts the basis for credible protection of property rights, increase of salaries in the modern sector and large 'spontaneous' investments in human capital from the current and future generations.

The model is viable to a 'right-wing' interpretation as providing the rationale to a period of non-democratic rules, with the repression of the political rights of the lower classes at an early stage of development. Even more, it seems to suggest that a government controlled by agents of foreign capital is the most desirable thing for the growth perspectives of a less developed country, because it creates a powerful instrument of pre-commitment which favours foreign investments. To defend this argument from ethically-based criticism, one could argue that a non-democratic 'oligarchic' government would operate in fact on behalf not only of the alive wealthy groups (and foreigners), but also of the future generations whose welfare is affected by the accumulation of human capital and which would be damaged by the 'selfishness' of a democratic government. However, repressive policies are always subject to the uncertainty that political outbreaks occur, and are likely not to be the best option. An opposite political interpretation, more in tune with the views of the author, is that the model indicate to the 'liberal party' (A) the need of being sensitive to social issues and introducing in its electoral programme some redistributive policies. In particular, it would be advisable to tax at a highly progressive rate the incomes earned by the richest groups of the local population in the modern sector and rebate them lump-sum. Tax schedules can be designed in such a way that they hit the most wealthy groups, but not the middle class (i.e. the median voter), and they do not affect the amount of investments in education (the rich finds it optimal to invest in education even if his income is going to be taxed up to some extent). The perspective of income redistribution enlarges on the other hand the share of supporters of property right enforcement at a given level of foreign investments, and makes more foreign investments enter the country in equilibrium. If we insist on the interpretation of the liberal party as an agency controlled by international investors, we could also argue that it might be optimal for them to accept (by introducing a populistic note in the electoral programme of party A) a certain degree of taxation, so as to enlarge the support to the defense of property rights and reduce the extent to which foreign investments need to be 'rationed' due to the enforcement problem.

The model generates a number of empirical implications. First, though the effects of both human capital accumulation and foreign investments (or enforcement constraints) on growth were already emphasised by several authors in the existing literature, they were treated as unrelated issues. This model predicts that one should find a positive correlation between the rate of foreign investments to GDP and the rate of human capital accumulation, and that this correlation is more than just a spurious effect. Second, the distribution of income affects growth through its effect on the degree to which the property right enforcement constraint is

binding. Third, the model predicts a growing gap between the wages paid in the traditional activity and (the average of) those paid in the modern sector. This measures in fact the the rate of human capital accumulation, and should be positively correlated to the ratio of foreign investments to GDP and to the growth rate of the economy. We leave to future work the empirical investigation.

The limitations of the model are very important. The spirit of the work is clearly not to put emphasis on realism, but just to emphasise a dramatic stylised scenario. When reputational issues are introduced the extent of the time-consistency issue is weakened. It seems plausible to conjecture, however, that the effects of the enforcement issue on the rate of foreign investments do not vanish when some positive degree of altruism between generation is allowed. The overlapping generation parable contains other unrealistic features, like the assumption that the young always work in the traditional sector, whereas the old always work in the modern sector. This should be taken as no more than a simplified representation of the issue faced by agents when they choose between allocating time in immediately productive activity and improving their future productivity by devoting time to education. Finally, the model unrealistically predicts that the same party always stays in power. This could be modified by adding some source of uncertainty whose realization is observed just before the election, affecting the political outcome. Notice that in this extension random events could have strongly permanent effects at some critical stage of development, reinforcing the path-dependent nature of the dynamic solution.

7 Appendix

7.1 Appendix 1

We prove here that $s'(h_t) < 0$ for interior solutions in the basic model. This fact is used in the proof to Proposition 1. First, substitute (4) into u_t^b in the left hand-side of (2) (taken with equality) and get:

$$w_{t+1}^M h_t [\beta(1-b) - u_t(1 + \beta(1-b)) - \delta u_t^b] = s_t \left[\frac{(1-b)w_{t+1}^M h_t}{wR} R(1 - u_t)(1 + \beta)w \right]. \quad (37)$$

Then, rearrange to obtain:

$$s_t = \frac{\beta(1-b) - u_t[1 + \beta(1-b)] - \delta u_t^\beta}{(1-b)(1 - u_t)}. \quad (38)$$

By differentiating the last expression, it turns out that:

$$\frac{ds_t}{du_t} = -\frac{(1 - u_t)\left(1 + b\delta u_t^{b-1}\right) + u_t + \delta u_t^b}{(1 - u_t)(1 + \beta)(1 - u_t)^2} < 0. \quad (39)$$

Since from (4) it follows that $u'(h_t) > 0$, then we have proved that in an interior solution $s'(h_t) < 0$.

7.2 Appendix 2

PROOF of Proposition 2 - Consider (12). By integrating on both sides, over i we get:

$$
\begin{aligned}
h_1^{AV} &= \left(\delta + \int_0^\infty u_0^i f_0(h^i)di \right) \left(\int_0^\infty h_0^i f_0(h^i)di + \gamma h_0^{AV} \right) \\
&= \delta(1 + \gamma)h_0^{AV} + u^*(1 - F_0(\hat{h}^j = h^*))\gamma h_0^{AV} + u^* \left(\frac{\int_{h^*}^\infty h_0^i f_0(h^i)di}{h_0^{AV}} h_0^{AV} \right) \\
&\geq \delta(1 + \gamma)h_0^{AV} + u^*(1 - F_0(\hat{h}^j = h^*))(1 + \gamma)h_0^{AV} \\
&> \theta(\delta + u^*)(1 + \gamma)h_0^{AV} > h_0^{AV}.
\end{aligned}
$$

where the first inequality follows from the fact that $\frac{\int_{h^*}^\infty h_0^i f_0(h^i)di}{h_0^{AV}} \geq (1 - \dot{F}_0(\hat{h}^j = h^*))$, since the richest x per cent of the population holds at least x per cent of total wealth. The second inequality follows, instead, from the Assumption 1.

Since $h_1^{AV} > h_0^{AV}$, then $F_1(\hat{h}^j = h^*) \leq F_0(\hat{h}^j = h^*)$. The previous argument applies recursively for all $t \geq 1$, so $h_{t+1}^{AV} > h_t^{AV}, \forall t$.

Also, $h_{t+1}^{AV} > h_t^{AV} \Rightarrow \underline{h}_{t+1} > \underline{h}_t, \forall t$. Then $\exists T$ such that $\underline{h}_t > G, \forall t \geq T$. Since then, $\hat{h}_{t+1}^j > \hat{h}_t^j, \forall j$. Then, $\exists \tilde{T}$ such that $\hat{h}_t^j > G, \forall j, \forall t \geq \tilde{T}$. This implies that $u_t^i = u^*, \forall i, \forall t \geq \tilde{T}$. That $g \to (\delta + u^*)(1 + \gamma)$ as $t \to \infty$ follows from (12). $\square$

7.3 Appendix 3

It is convenient to write explicitly the relation between the 'critical level of human capital' at time t and the ratio between the median and the average human capital at time $t + 1$

which holds in equilibrium. By eliminating k_{t+1} from (24) and (25), and rearranging, we obtain:

$$h_t^\circ = \left(\frac{\beta w \psi^{\frac{1-\alpha}{\alpha}}}{\delta \alpha^{\frac{1}{\alpha}}}\right) \left(\frac{h_{t+1}^{AV}}{h_{t+1}^{med}}\right)^{\frac{1-\alpha}{\alpha}} \tag{40}$$

The following Lemmas establish important facts for proving the main result.

Lemma 2 *If in the equilibrium $u_t^{med} = u^\circ$ (type 1 equilibrium), and $h_t^{med} < h_t^{AV}$, then $h_t^\circ < h_{t-1}^\circ$.*
If in the equilibrium $u_t^{med} = 0$ (type 2 equilibrium), and $h_t^{med} > h_t^{AV}$, then $h_t^\circ > h_{t-1}^\circ$.

PROOF - First part. Under the assumptions of the first statement, the equation (12) implies that $\frac{h_{t+1}^{med}}{h_t^{med}} > (\delta + u^\circ)(1 + \gamma)$, and that $\frac{h_{t+1}^{AV}}{h_t^{AV}} \le (\delta + u^\circ)(1 + \gamma)$. So, $\frac{h_{t+1}^{AV}}{h_{t+1}^{med}} < \frac{h_t^{AV}}{h_t^{med}}$, which implies, by (40), $h_t^\circ < h_{t-1}^\circ$.

Second part. Under the assumptions of the second statement, the equation (12) implies that $\frac{h_{t+1}^{med}}{h_t^{med}} < \delta(1 + \gamma)$, and that $\frac{h_{t+1}^{AV}}{h_t^{AV}} \ge \delta(1 + \gamma)$. So, $\frac{h_{t+1}^{AV}}{h_{t+1}^{med}} > \frac{h_t^{AV}}{h_t^{med}}$, which implies, by (40), $h_t^\circ > h_{t-1}^\circ$. □

Definition 2 *Let G be defined as h_t° evaluated at an equilibrium in which $h_{t+1}^{med} = h_{t+1}^{AV}$. Then, from (24), (25) and (40):*

$$G \equiv \frac{\beta w \psi^{\frac{1-\alpha}{\alpha}}}{\delta \alpha^{\frac{1}{\alpha}}}.$$

Lemma 3 *If a type 1 equilibrium occurs at time T and $h_T^{med} > h_T^{AV}$, then $h_{T+1}^{med} > h_{T+1}^{AV}$. Hence, if only type 1 equilibria occur for $t > T$, and $h_T^{med} > h_T^{AV}$, then $h_t^\circ < G$, $\forall\, t \ge T - 1$.*
If a type 2 equilibrium occurs at time T and $h_T^{med} < h_T^{AV}$, then $h_{T+1}^{med} < h_{T+1}^{AV}$. Hence, if only type 2 equilibria occur for $t > T$, and $h_T^{med} < h_T^{AV}$, then $h_t^\circ > G$, $\forall\, t \ge T - 1$.

PROOF - For the first part, apply directly (12) and obtain:

$$
\begin{aligned}
h_{T+1}^{med} \;-\; & h_{T+1}^{AV} = (\delta + u^\circ)(h_T^{med} + \gamma h_T^{AV}) - \\[4pt]
-\; & \delta(1 + \gamma)h_T^{AV} - u^\circ \left(\int_{h_T^\circ}^{\infty} h^i f(h^i)\,di + (1 - F_T(\hat{h} = h_T^\circ))\gamma h_T^{AV}\right) = \\[4pt]
=\; & F_T(\hat{h} = h_T^\circ)\gamma h_T^{AV} + \delta(h_T^{med} - h_T^{AV}) + u^\circ \left(h_T^{med} - \int_{h_T^\circ}^{\infty} h^i f(h^i)\,di\right)
\end{aligned}
$$

which is greater than zero if $h_T^{med} > h_T^{AV}$ (notice that the integral is smaller than h_T^{AV}). This implies from (40) that $h_T^\circ < G$. The rest of the statement follows from the recursive structure of the result.

For the second part, analogously:

$$
\begin{aligned}
h_{T+1}^{med} - h_{T+1}^{AV} \;=\; & \delta(h_T^{med} + \gamma h_T^{AV}) - \\[4pt]
-\; & \delta(1 + \gamma)h_T^{AV} - u^\circ \left(\int_{h_T^\circ}^{\infty} h^i f(h^i)\,di + (1 - F_T(\hat{h} = h_T^\circ))\gamma h_T^{AV}\right) = \\[4pt]
=\; & \delta(h_T^{med} - h_T^{AV}) - u^\circ \left(\int_{h_T^\circ}^{\infty} h^i f(h^i)\,di + (1 - F_T(\hat{h} = h_T^\circ))\gamma h_T^{AV}\right)
\end{aligned}
$$

which is smaller than zero if $h_T^{med} > h_T^{AV}$. Then, again, apply recursion. □

Figure 11 gives a visualisation of the facts involved in the Lemmas. When only type 1 equilibria occur for $t \geq 0$, we have two possible cases: either $h_0^* < G$ ($h_0^{med} > h_0^{AV}$) - like in the case represented in the figure -, and G bounds from above h_t^* the dynamics of h^* being in general ambiguous, or $h_0^* > G$ ($h_0^{med} < h_0^{AV}$), and $h^*_t < 0$, at least as far as $h_t^* \geq G$. The opposite happens when only type 2 equilibria occur.

FIGURE 11 here

The following Proposition uses the Lemmas 2 and 3, and jointly gives conditions for a sequence of type 1 equilibria to exist. The result is a generalisation of the Proposition 2.

Proposition 4 *Let $F_0(\hat{h})$ be the distribution function over initial human capital endowments. If the initial conditions are such that:*

- *either (i) $h_0^{med} \geq h_0^{AV} \geq \frac{G}{1+\gamma}$, and (ii) $F_0(\hat{h} = G) < 1 - \theta$*

- *or (i) $h_0^{AV} < h_0^{med}$, (ii)$\hat{h}_0 > h_0^*$, and (iii) $F_0(\hat{h} = h_0^*) < 1 - \theta$*

then there exists a path characterised by a sequence of type 1 equilibria such that $h_{t+1}^{AV} > h_t^{AV}$, $\forall\ t \geq 1$, which converges to the long-run equilibrium with the maximum growth rate, where $u^i = u^*$, $\forall\ i$.

PROOF - Consider the first set of conditions. The Lemma 3 ensures that G is an upper bound to h_t^*, if a sequence of type 1 equilibria occurs for $t \geq 0$. The strategy of the proof is similar to that of the Proposition 2, with the upper bound G being treated similarly to the fixed h^*. The condition (i) guarantees that a type 1 equilibrium exists[11] in the first period: since $h_0^{med} > h_0^{AV}$, then $\hat{h}_0^{med} > (1+\gamma)h_0^{AV} > G \geq h_0^*$. The condition (ii) guarantees that $h_1^{AV} > h_0^{AV}$: since $G \geq h_0^*$, then $F_0(\hat{h} = h_0^*) \leq F_0(\hat{h} = G) \leq 1 - \theta$.

Then, verify that the problem has a recursive structure and that *(a)* $h_{t+1}^{AV} > h_t^{AV}$, $\forall\ t \geq 1$, and *(b)* type 1 equilibria exist for all $t \geq 1$. To verify (a), observe that $F_1(\hat{h} = G) \leq F_0(\hat{h} = G) < 1 - \theta$, since the offspring of all agents with a human capital endowment $\hat{h}_0^j > G$ certainly has $\hat{h}_1^j > G$, whereas that of some agents with $\hat{h}_0^j < G$ may have $\hat{h}_1^j > G$. This ensures that $h_1^{AV} \geq h_0^{AV}$. The last inequality, together with (i) implies that (b) necessarily holds true for $t = 1$, so a type 1 equilibrium also exists at $t = 1$. The argument applies recursively for $t > 1$.

The rest of the proof is identical to that provided in the Proposition 2.

Consider the second set of conditions. In this case, the Lemma 2 ensures that, if a sequence of type 1 equilibria occurs, then $h_{t+1}^* < h_t^*$, $\forall\ t \geq 0$. The conditions (ii) and (iii) ensure that a type 1 equilibrium exists in the first period, and that $h_1^{AV} > h_0^{AV}$. The rest of the prove is based on the recursive structure of the problem and is analogous to that given for the first part. □

To give sufficient conditions for convergence to the 'bad equilibrium', in which no activity in the modern sector exists, is less straightforward. The technical difficulty lies in finding simple conditions which guarantee that the average human capital falls over time when a

---

[11]It is possible to find less restrictive conditions, but at the cost of going through a list of algebraically intriguing and uninteresting different cases. Notice that in this case it is not sufficient to impose $\hat{h}_t^{med} > G$ when $t = 0$, in order to ensure that it holds also true for $t \geq 1$, since there is no restriction which ensures that $\hat{h}_t^{med}$ grows over time. In the second set of conditions this is instead sufficient, since $h_t^{med} < h_t^{AV}$, where h_t^{AV} grows over time along the equilibrium path, and h_t^{med} must grow, in a type 1 equilibrium, faster than the average human capital.

sequence of type 2 equilibria arise. It is intuitive, however, that the occurrence of a type 2 equilibria at the initial time tends to be associated with the future decline of an economy.

REFERENCES

Aghion P. and Bolton P. (1991). 'A Trickle-down Theory of Growth and Development', mimeo.

Alesina A. and Rodrik D. (1992). 'Distribution, Political Conflict, and Economic Growth', in Cukierman A., Hercowitz Z. and Leidermann L. (eds.) (1992). Political Economy, Growth and Business Cycles. MIT Press, Cambridge MA.

Azariadis C. and Drazen A. (1990). 'Threshold externalities in economic development'. Quarterly Journal of Economics, May, pp. 501-526.

Barro R. (1991). 'Economic growth in a cross section of countries'. Quarterly Journal of Economics, vol. 106 , n. 2, pp. 408-43.

Benhabib J. and Rustichini A. (1991). 'Social Conflict, Growth and Income Distribution', mimeo.

Bertola G. (1991). 'Market Structure, and Income Distribution in Endogenous Growth Models', mimeo.

Ciccone A. (1994). 'Human Capital and Technical Progress: Stagnation, Transition and Growth', mimeo, University of Stanford.

Gali J. (1993). 'Product Diversity, Endogenous Markups and Development Traps', mimeo, Universitat Pompeu Fabra, Barcelona.

Gali J. and Zilibotti F. (1994). 'Endogenous Growth and Poverty Traps in a Cournotian Model', Annales d'Economie et Statistique, forthcoming.

Giovannetti G., Marcet A. and Marimon R. (1993).'Growth, Capital Flows and Enforcement Constraints: the Case of Africa'. European Economic Review (forthcoming).

Lucas R.E. Jr. (1988). 'On the mechanics of economic development'. Journal of Monetary Economics, 22, pp. 3-42.

————— (1992). 'Making a Miracle'. Econometrica, vol. 61, n. 2, pp. 251-72.

Marcet A. and Marimon R. (1992). 'Communication, Commitment and Growth'. Journal of Economic Theory, vol. 58, n.2, pp. 219-49.

Perotti R. (1990). 'Political Equilibrium, Income Distribution and Growth', mimeo.

Persson T. and Tabellini G. (1991). 'Is Inequality Harmful for Growth? Theory and Evidence'. mimeo.

————— 'Growth, Distribution and Politics' in Cukierman A., Hercowitz Z. and Leidermann L. (eds.) (1992). Political Economy, Growth and Business Cycles. MIT Press, Cambridge MA.

Piketty T. (1993). 'Imperfect Capital Markets and Persistence of Initial Wealth Inequalities', mimeo, London School of Economics.

Rodriguez A. (1993). 'The Division of Labor and Economic Development', mimeo, University of Stanford.

Saint-Paul G. and Verdier T. (1991). 'Education, Growth and Democracy', mimeo.

Zilibotti F. (1994). 'Endogenous Growth and Intermediation in an Archipelago Economy', Economic Journal (forthcoming).
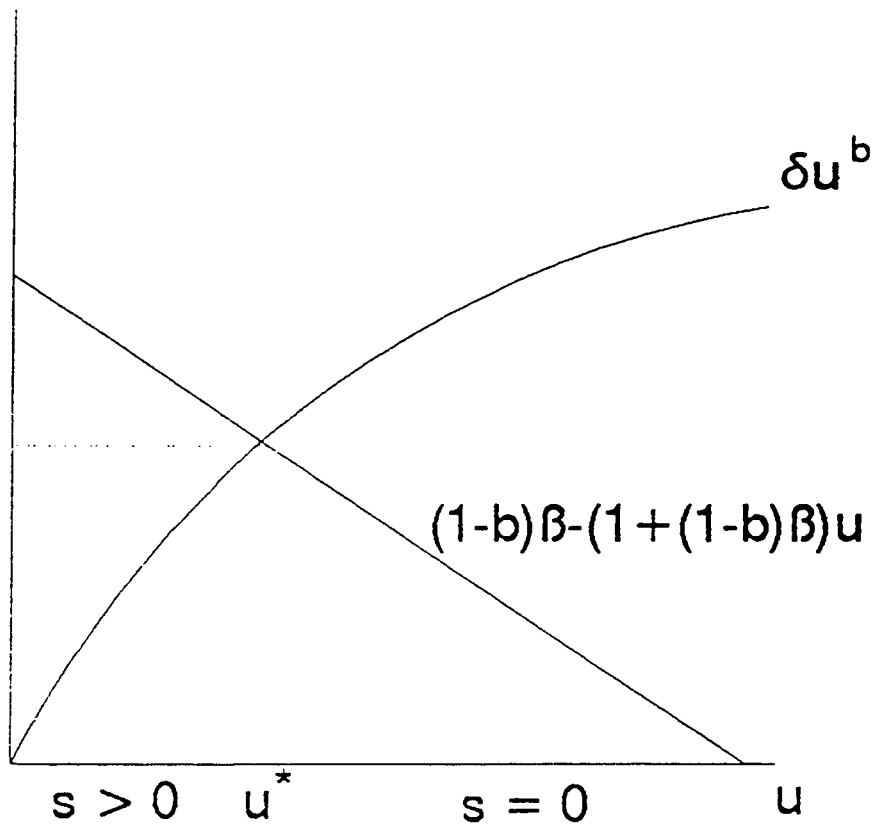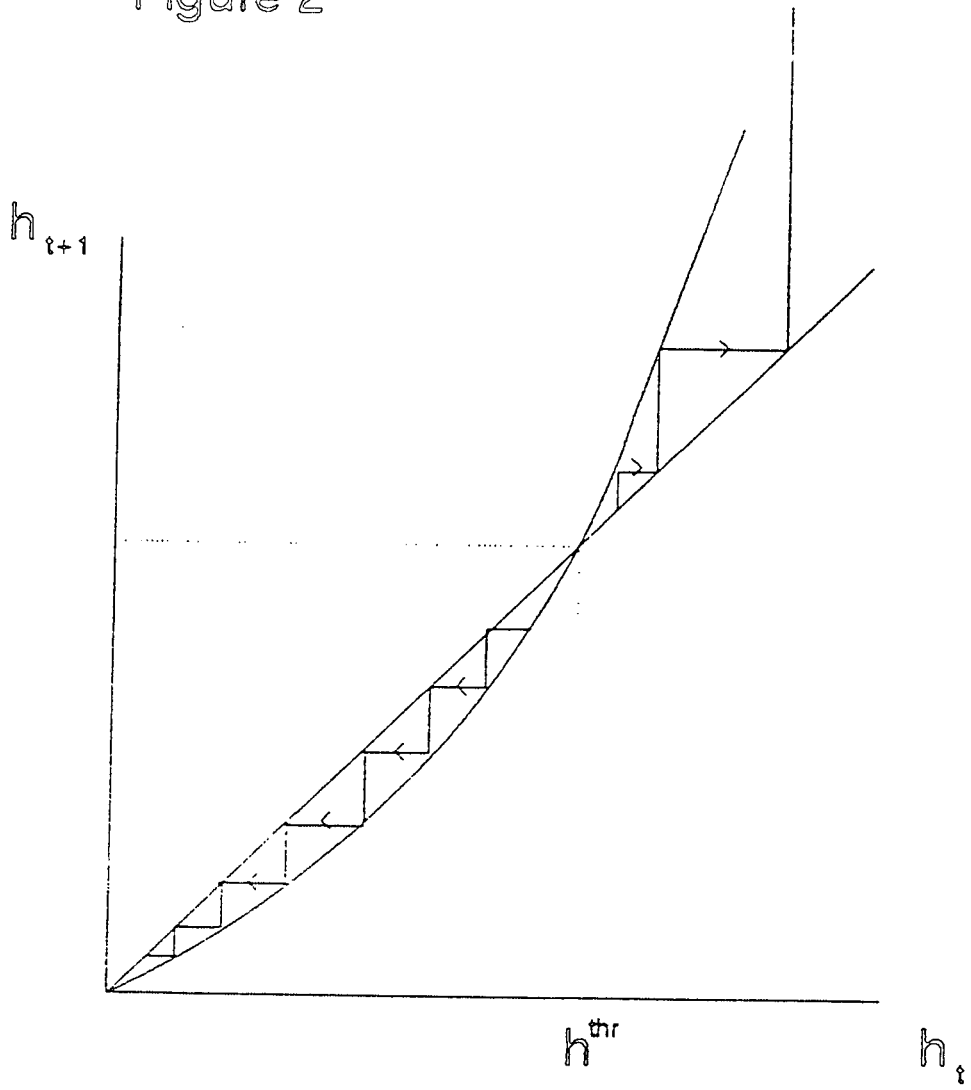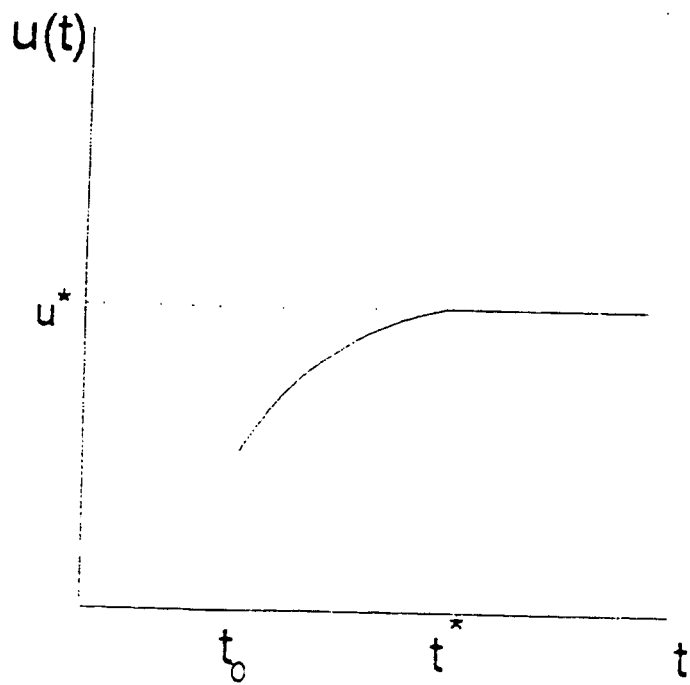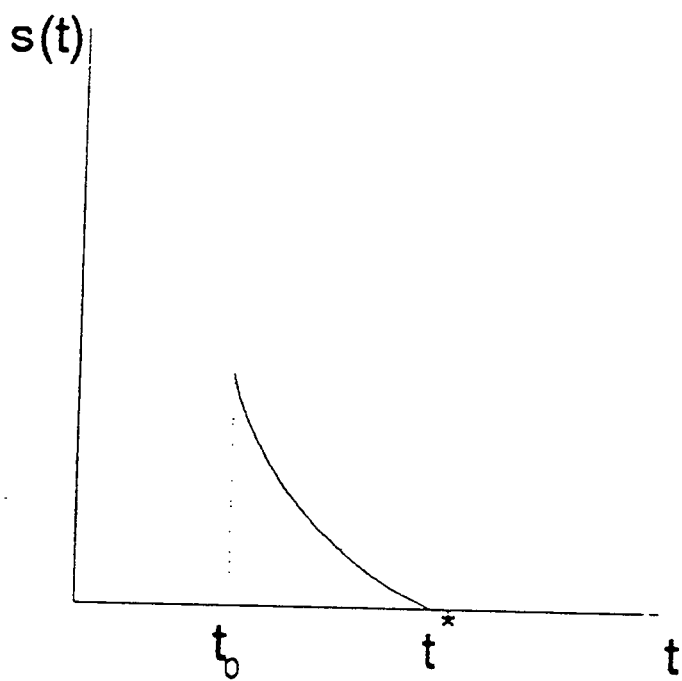
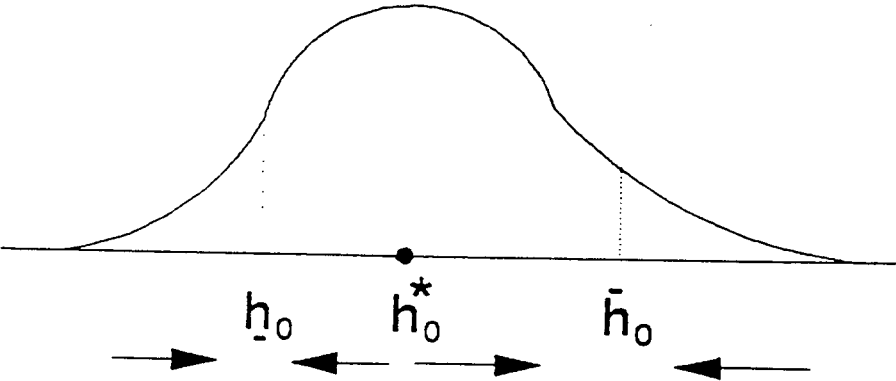# Figure 1

Figure 2

Figure 3
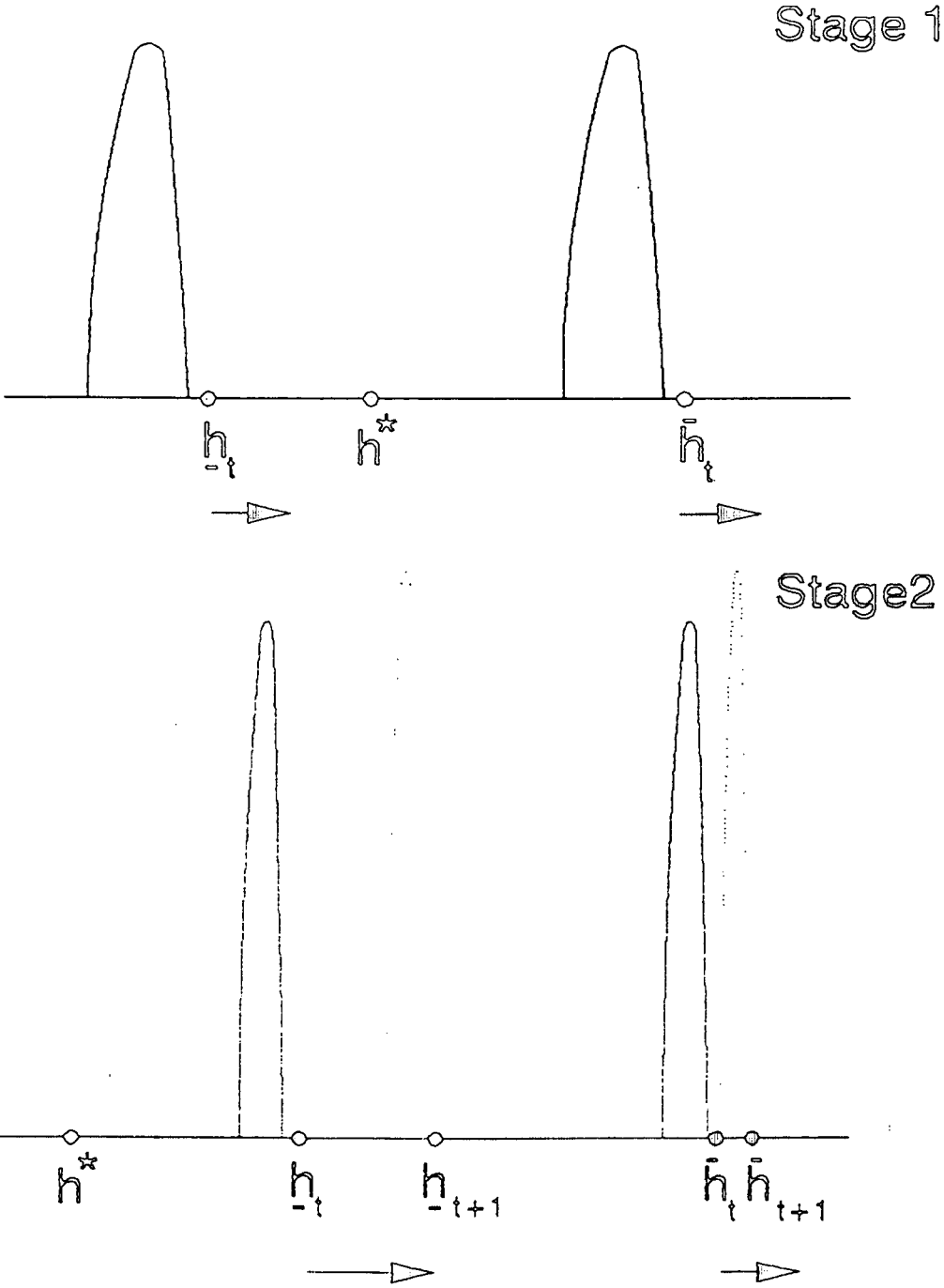
Figure 4

Figure 5

Figure 6

Stage 1
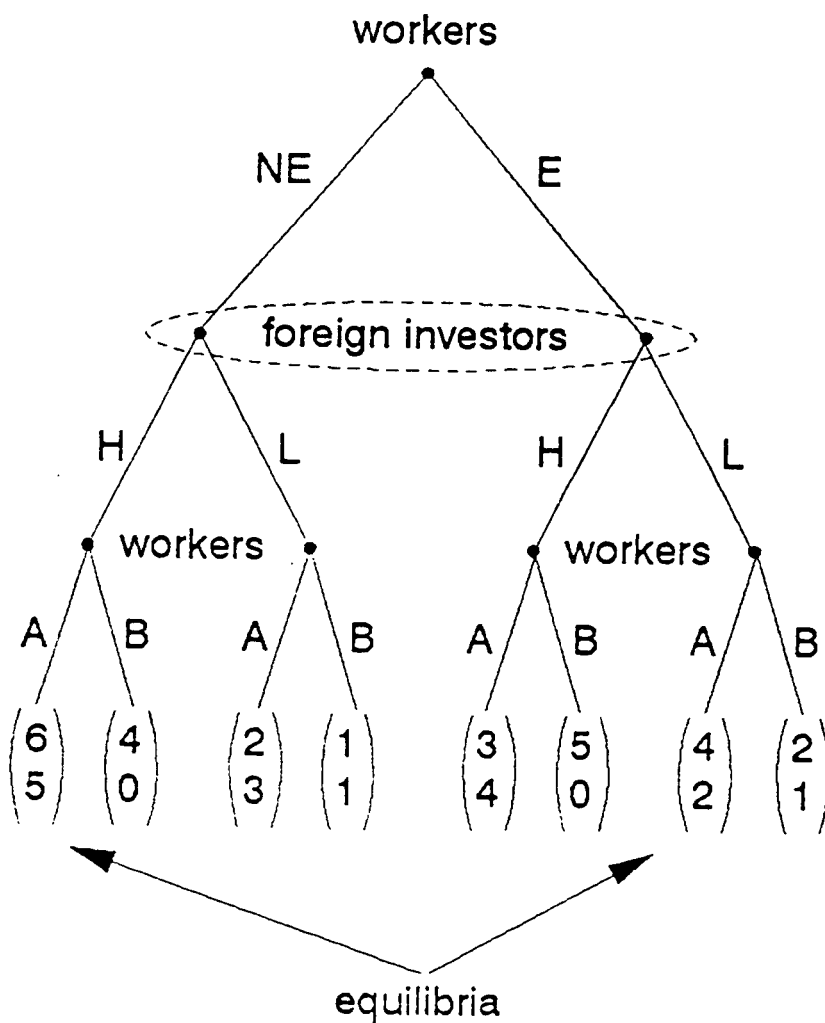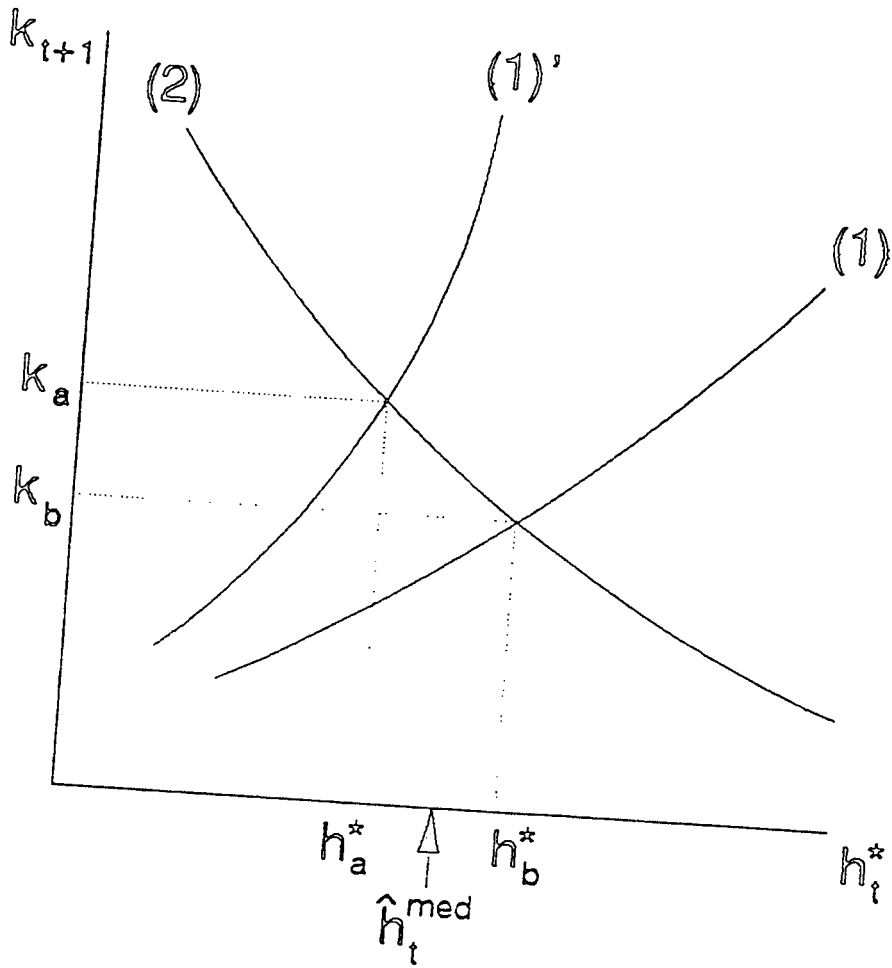
Stage2
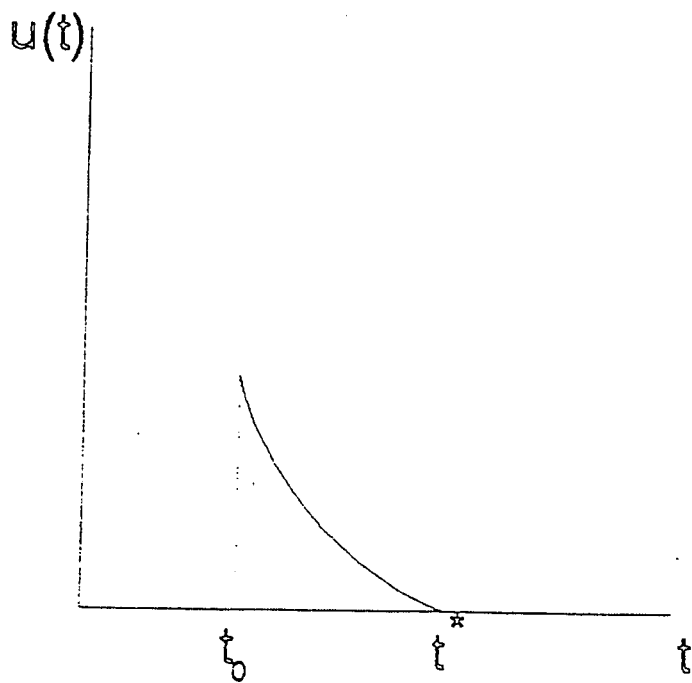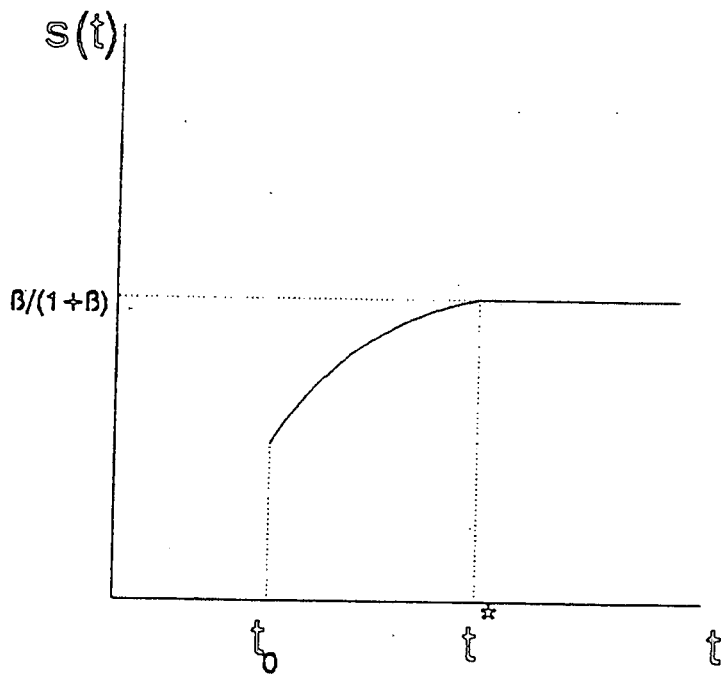
Figure 7

Figure 8

$\{k_a, h_a^*\}$: type 1 equilibrium.
$\{k_b, h_b^*\}$: type 2 equilibrium.
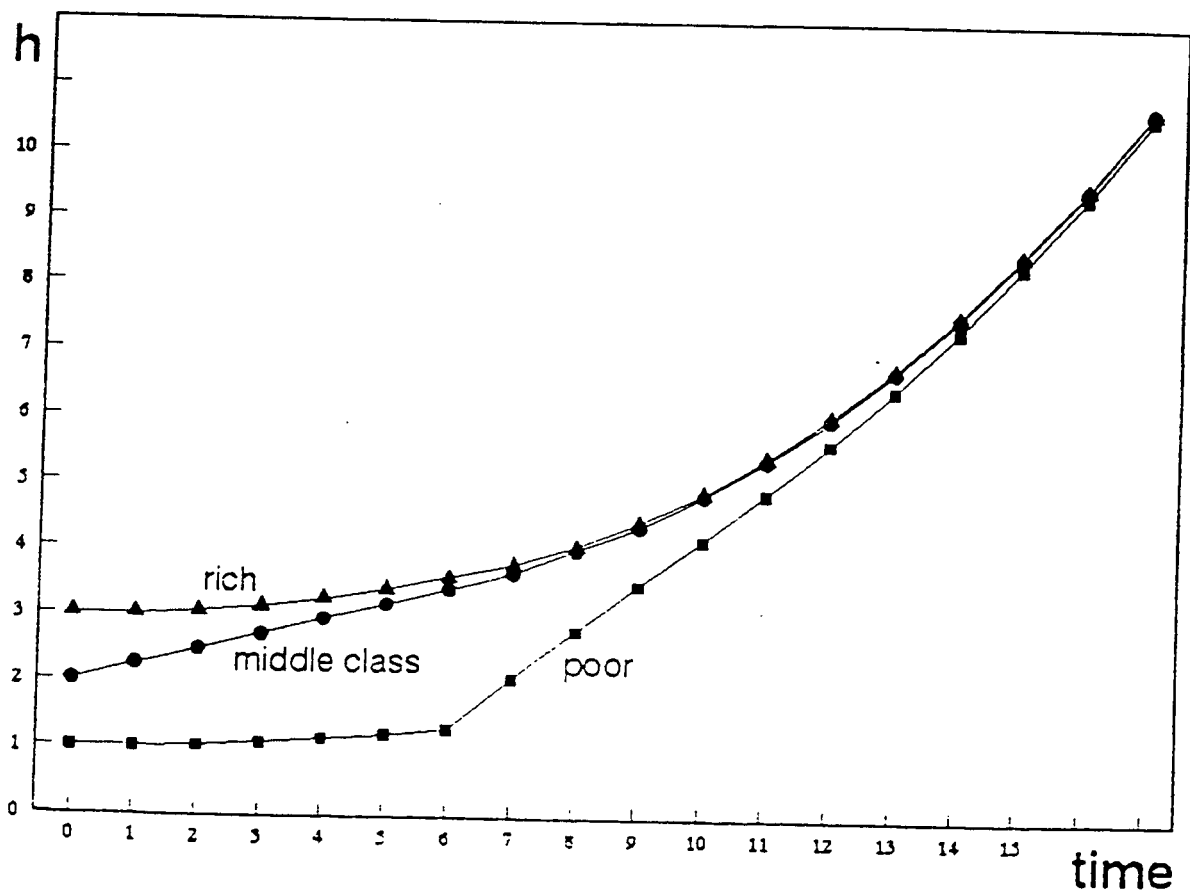
Figure 9.a

Pallas-land: productivity

Figure 9.b

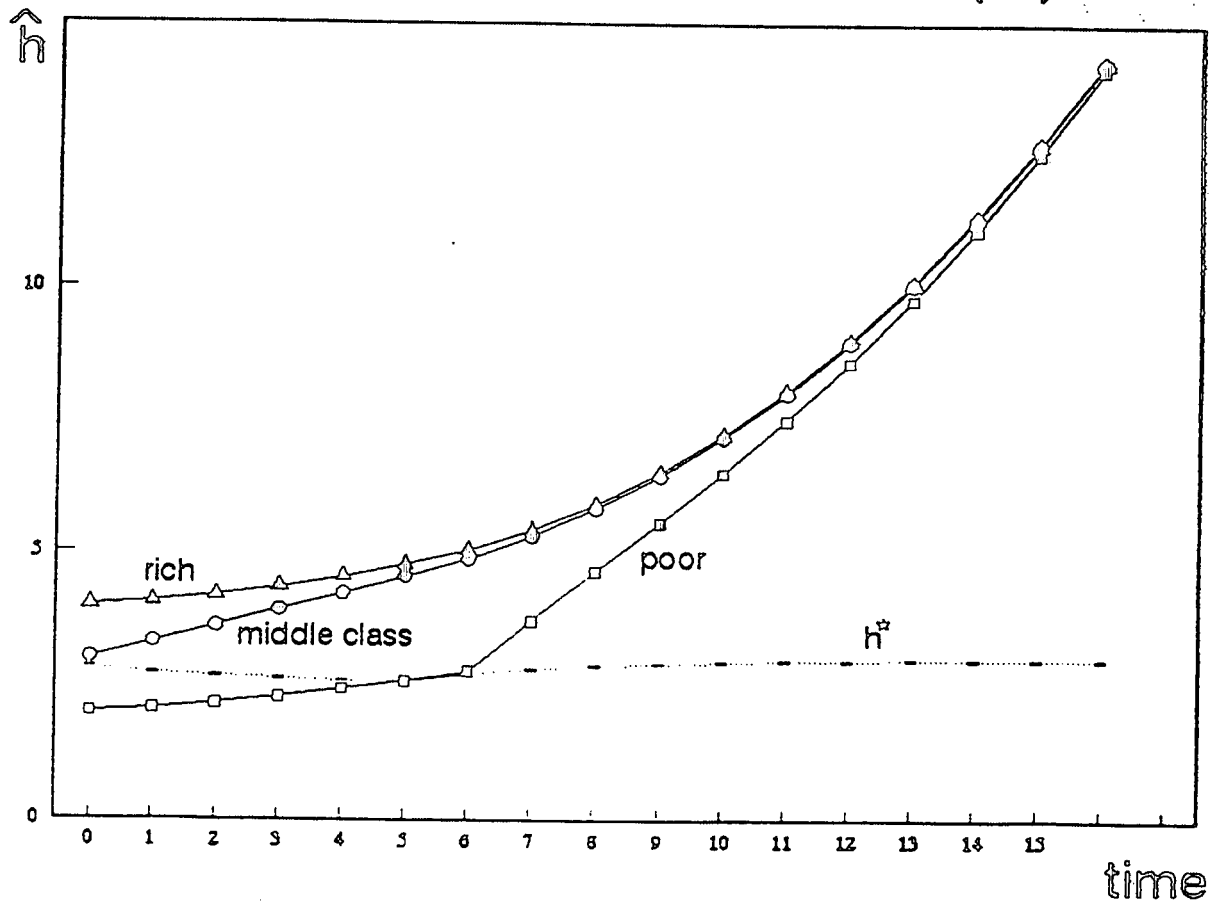## Pallas-land : human capital endowments ($\hat{h}$) and critical level (h^*)
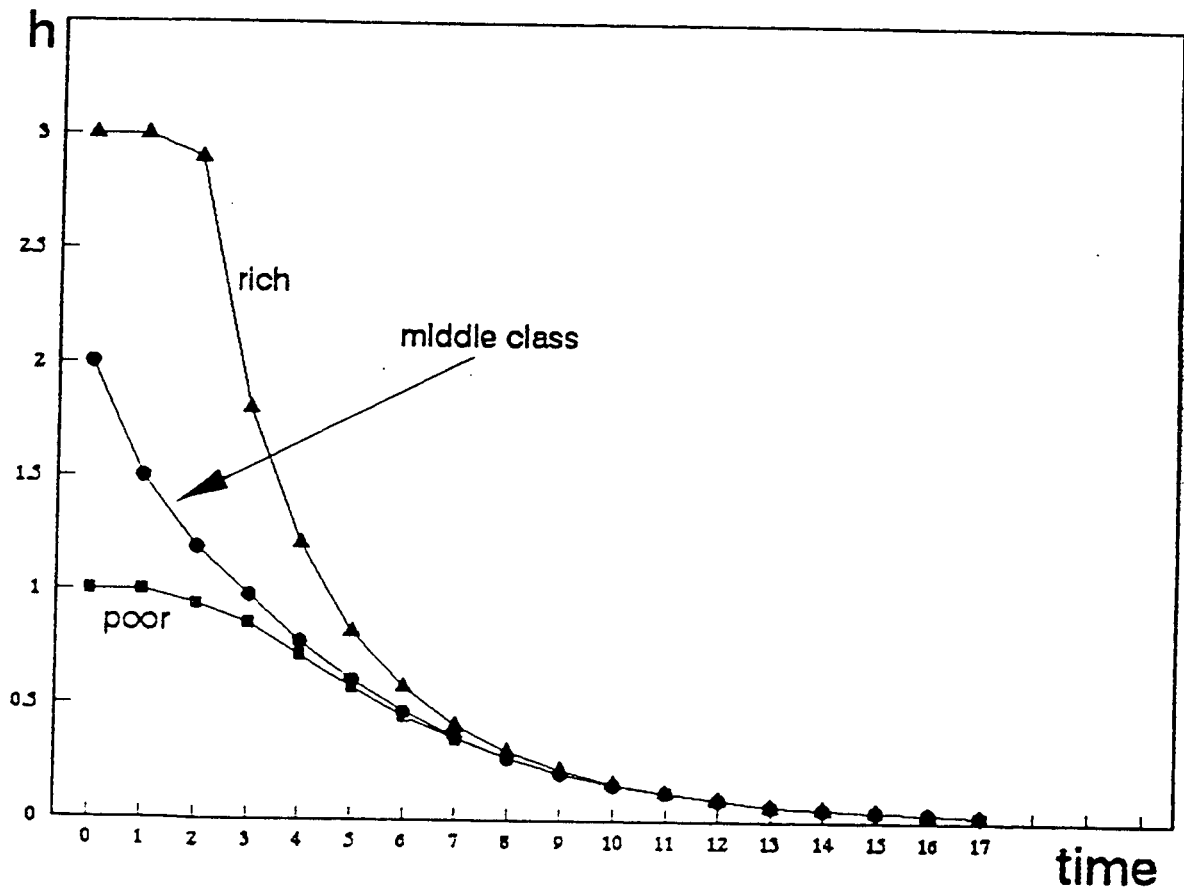
Figure 10.a

Lotus-land : productivity

Figure 10.b

Lotus-land : human capital endowments ($\hat{h}$) and critical level ($\overset{\star}{h}$)
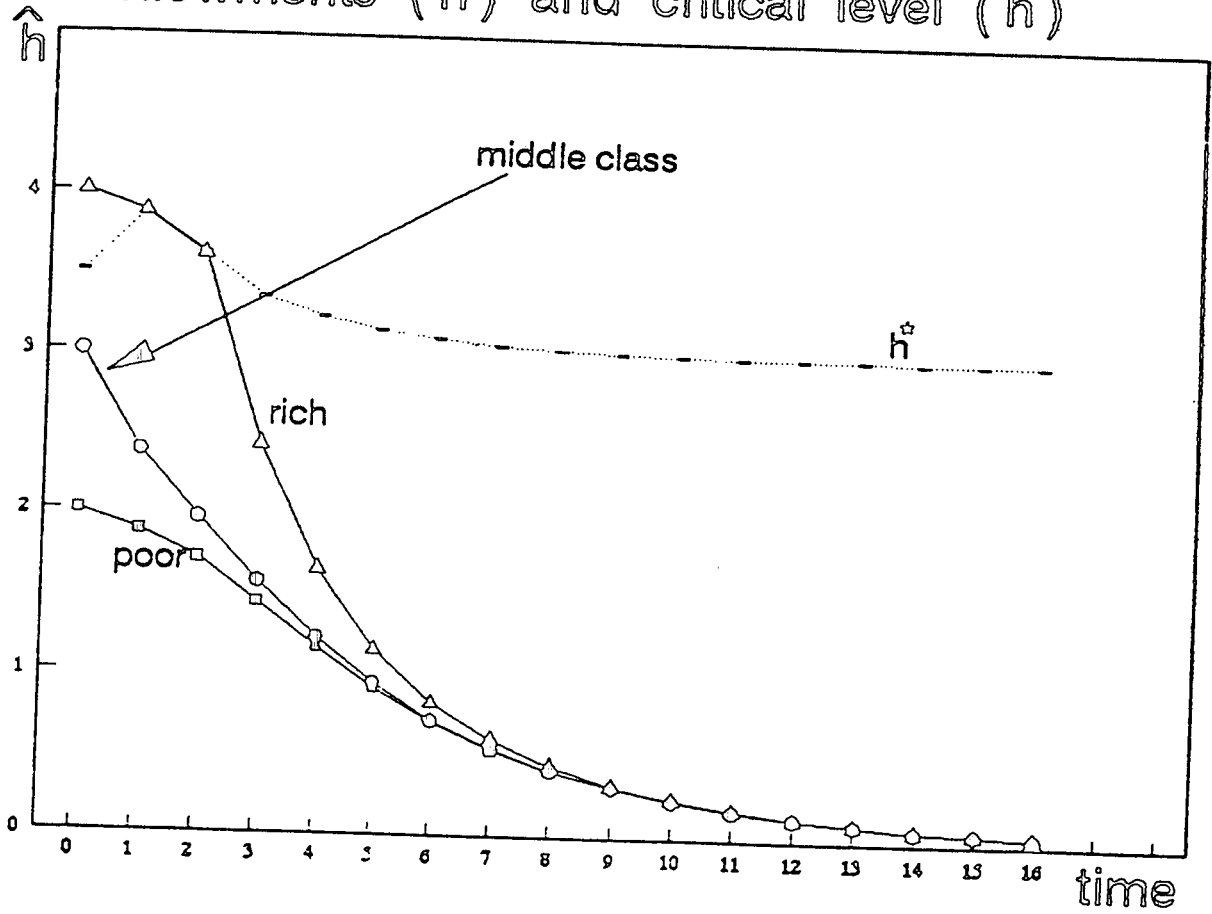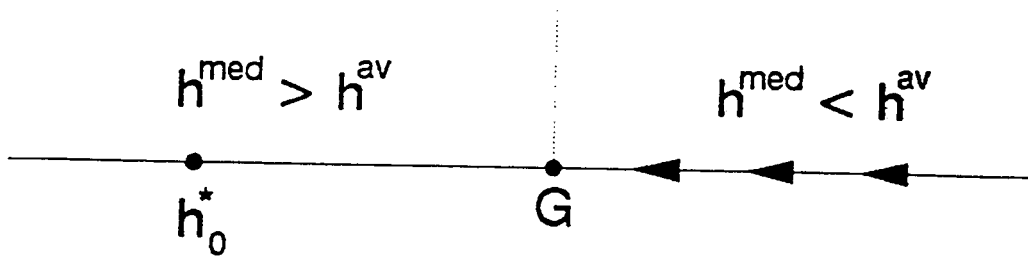
Figure *11*

type 1 equilibrium

$$h^{med} > h^{av} \qquad\qquad h^{med} < h^{av}$$

$$h_0^* \qquad\qquad G$$

type 2 equilibrium

$$h^{med} > h^{av} \qquad\qquad h^{med} < h^{av}$$

$$G \qquad h_0^{*\,\prime}$$
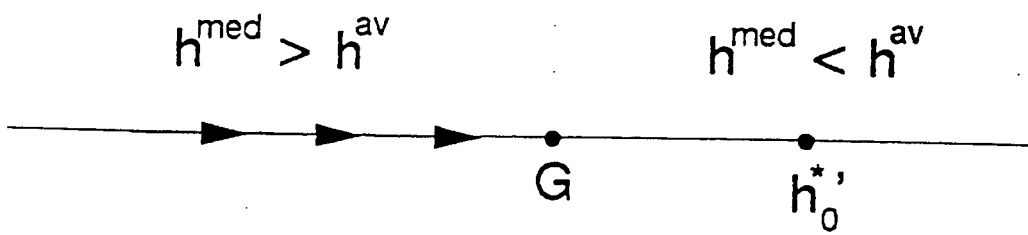
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