

Land-Rich Economies, Education and Economic Development

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Abstract

We analyze the emergence of large-scale education systems in a setup where growth is associated with changes in the configuration of the economy. The model is based on three central elements: first, individual preferences over consumption goods generate changes in the composition of individual spending as income grows, embodied in Engel curves. Second, the production of sophisticated services is intensive in human capital. Third, investment in human capital by individual households faces borrowing constraints. Our model uses an overlapping generation framework similar to the one in Galor and Moav (2003). As that paper does, we also model the incentives that the economic élite may have (collectively) to accept taxation destined to finance the education of credit-constrained workers. In our model this incentive does not necessarily arise from a complementarity between physical and human capital in manufacturing. Rather, we emphasize the demand for human-capital-intensive services by high-income groups. The argument model seems capable to account for salient features of the development of Latin America in the 19th century, where, in particular, land-rich countries such as Argentina established an extensive public education system and a sophisticated service sector before developing significant manufacturing activities.

1 Introduction

Explanations for differences in economic development have traditionally stressed structural factors, with arguments based on conditions such as the abundance of

natural resources, the specialization in activities that offer good opportunities for technical improvements, high savings propensities and large capital formation, extensive markets or other circumstances that may encourage a faster pace of technological change (see, among others, Chenery and Syrquin, 1975, Chenery et al., 1986). More recently, a high rate of human capital accumulation was also identified as an important determinant of economic development (see, among others, Barro 1991; Barro and Lee, 2001; Mankiw et al., 1992 and Lucas, 1988). Lately, the emphasis has shifted to social factors, and especially to the incentive effects of institutions and culture (see, among others, North and Thomas, 1973; North, 1981; Landes, 1998; Engerman and Sokoloff, 2000 and Acemoglu et al., 2005).

There is clear evidence that incentives (economic, social and political) and the institutions that contribute to their definition matter for development. Nevertheless, institutions are influenced by political and economic structures. In other words, institutions matter but they are endogenously determined. Moreover, economic rules and constraints may well operate differently, and generate different outcomes according to the configuration of the economy. Thus, a better understanding of the process of economic development would require considering the joint determination of economic structure and social institutions.

Human capital accumulation seems to be a clear example of this interaction between institutions and structural factors. In a world with imperfect capital markets, low-income workers are constrained in their private investment in education. Thus, the nature (and, more starkly, the presence or absence) of a public school system may critically determine the extent and the evolution of human capital accumulation. But different societies develop different school systems. The social decisions on education are certainly influenced by broad political and ideological factors, but they also respond to economic considerations and, therefore, they depend on the structure of the economy, to the extent that this conditions the matrix of interests of various groups and their relative influence. For instance: the perceived returns to education from the perspective of politically powerful groups are likely to be lower in subsistence agrarian economies than in industrial countries. In turn, changes in a society's levels of schooling and literacy would affect the social structure and, perhaps, the political institutions that determine the educational institutions themselves.

The United States and Canada developed primary education from the colonial time. Instead, and despite being the source of enormous wealth at the time, the British colonies in the Caribbean basin were very slow to organize schooling institutions that would serve broad segments of the population. Even the Latin American countries, such as Argentina and Uruguay, which were more progressive in this respect in the nineteenth and early twentieth centuries, lagged more than fifty years behind the U.S. and Canada in providing primary schooling and attaining high levels of literacy. Most of Latin America was unable to achieve these standards until well into the twentieth century, if then (Mariscal and Sokoloff, 2000). This timing in establishing public school systems with broad

coverage correlates with actual level of development in the Americas, but that does not necessarily imply a direction of causality.

Why some countries invested heavily in the education of the population while others lagged behind? Galor and Moav (2003) –GM from now on– provide an interesting explanation: capitalists might find optimal to invest in the education of the labor force. They specifically model the origin of large-scale systems of public education, taking into account the incentives that the economic elite may (collectively) have to accept taxation destined to finance the education of credit-constrained workers. Due to the complementarity between physical and human capital in manufacturing production, the capitalists are prime beneficiaries of the accumulation of skills by the labor force. They can gain from tax-financing the emergence of a public education system as a way to increase the supply of factors in order to raise the productivity of their assets in existing activities.

The argument seems relevant to North America, but it would have difficulties explaining why Latin America lagged behind, and why some countries of the region developed educational systems earlier than others. Galor et al. (2005) extends the analysis in GM by assuming that human skills contribute to increase the productivity of industrial capital, but provide no benefits for landlords as such. Then, if landlords have veto power over policies, they can block or delay the growth of public education (see also Bourguignon and Verdier (2000) for a complementary explanation). This hypothesis can account for the Latin American delay, but still does not rationalize the intermediate cases of the Southern Cone, which started as early as in the 1860s to develop an important schooling system, with a polity under the dominance of landholders, and well before they developed a manufacturing sector. In this paper we extend the model in GM to interpret these experiences. In our model, education emerges in certain cases as a policy proposed by landlords, who are not necessarily engaged in the production of manufactured goods, since the demand for these may be wholly satisfied by imports.

Our model also has features in common with traditional models of trade with multiple factors and goods (see, for example, Leamer, 1987), with a particular specification of three commodities: two tradeable goods (agricultural and industrial) and services (non-tradeables), and four factors (land, physical capital, unskilled labor and skilled labor, which are not assumed to be perfect substitutes). In this simple model, we focus on the basic properties of comparative advantages, ignoring technological change.

The analysis that follows is based on three central elements: First, individual preferences over consumption goods imply changes in the composition of individual spending as income grows, embodied in Engel curves. Second, the production of sophisticated services (which are typically non-tradeable, in otherwise open economies) is intensive in human capital. Third, as it has often been pointed out in the economic growth literature, investment in human capital by individual households faces borrowing constraints (see, for example, Banerjee and Newman, 1991; Galor and Zeira, 1993, Benabou, 1996).

A key channel in our model is the demand for human-capital-intensive services of high-income groups. The derived demand for skills that emerges when the incomes of certain groups of the population become sufficiently high emerges in a setup with multiple goods, where consumption preferences are non-homothetic and "high quality services" require the input of educated workers. We also assume that the quantity and quality of labor are not perfect substitutes. This implies that the number of high-income agents may have strong effects on how many individuals are subsidized to accumulate human capital. Thus, the size of the elite, as the group who demands "sophisticated services" would have repercussions on the size of the group of educated workers. The model can then rationalize a link between historical conditions, especially with regard to the distribution of land, and social choices regarding the scope and the financing of the education system.

The argument presented here seems capable of accounting for some salient features of the development of the Southern Cone of Latin America in the 19th century. In particular, land-rich countries such as Argentina established an extensive public education system and a sophisticated service sector before developing industrial activities. The rise of education in Argentina in the last half of that century (associated with the emblematic figure of President Domingo Faustino Sarmiento) is widely considered one of the key events in the country's history, and it took place when the country clearly had a economy based on agriculture. Meanwhile, in other Latin-American countries, where the property of natural resources was (even) more concentrated than in Argentina, a significant public education system did not appear until much latter, in the 20th century (see Mariscal and Engermann, 2000). This feature of our analysis matches the argument in Sokoloff and Engermann (2000), who argued that the greater degree of inequality in Latin America, as compared to North America, played an important role in explaining the different behaviors regarding the establishment of educational institutions.

The starting point in our analysis is a simple agrarian economy, where the capital stock is accumulated by landlords, while the rest of the population is in the subsistence sector. At first, even landlords only consume agricultural goods, although they leave bequests (which is necessary for an interesting dynamics to arise). In such a setting, there can be early comers to industrialization, that is, economies which grow in a world with no significant supply of industrial goods, or no significant trade in those goods. If the capitalists/landlords accumulate sufficient capital, they will start demanding manufacturing goods which, in this case, must be locally supplied. In the appendix, we briefly discuss this case, where a capitalist-financed accumulation of human capital can emerge as a way to supply skilled labor to the industrial sector. The basic framework also may account for instances where, once there is a well-developed international market for manufactured goods, labor-abundant economies would start industrial activities for the world market, even when their income levels are too low to induce widespread domestic demand for those goods (this case is also discussed

briefly in the appendix). Instead, in the land-rich economies we concentrate on, the demand for industrial goods will initially be satisfied by imports. Here, the accumulation of human capital would be triggered by the consumption of services.

The rest of the paper is organized as follows. The next section describes our basic model. In section 3 we analyze the evolution of an agrarian economy and briefly comment on possible alternative paths that may be followed by economies of different structural configurations. Section 4 deals with the case where large-scale educational systems appear in land-rich economies, which have not gone through a previous stage on industrialization. Conclusions are presented in section 5.

2 The Basic Model

We use a simple general equilibrium, overlapping generations, framework. At very low levels of income, agents only consume agricultural goods, and leave no bequest to their (single) descendant. As income grows, individuals are assumed to start generating bequests and, further on, to diversify their spending by including manufactured goods, and eventually services, into their consumption basket. Bequests can be used to accumulate physical capital or to finance education. Agricultural goods can be produced with a subsistence (labor-only) technology or with a “capitalist” (land-physical capital) technology. The production of manufactured goods uses capital, labor, and labor skills. Agricultural and industrial goods can be traded abroad. Services are assumed to be non-tradeable and to be produced by skilled labor, with a technology such that the quantity of services produced depends linearly on the average skills of the workers involved in production, and non-linearly on their number; it will be assumed that the amount of services delivered to an individual consumer “saturates” when the number of participating workers reaches a certain maximal level.

2.1 The Agents

Agents are divided into several groups, depending on their ownership of factors. Landowners own land and capital, but, for simplicity, it is assumed that they are not potential suppliers of labor. Workers receive an homogeneous basic endowment of “raw skills”; they can become differentiated by their additional skills acquired through education. In some cases, workers may own capital. Workers can be employed either in a subsistence sector, or in the labor-using activities of manufacturing and services. The setup is one of overlapping generations, with a structure similar to that in GM. Individuals live two periods; each member of a generation has a single offspring. The agents born in period t receive (already in that period) a bequest from their parent; this must be non-negative, but may be zero. The bequest may be taxed; the agent allocates the remaining

resources to acquire capital or to purchase private education (if he is a worker and chooses to do so). Assets generate income in the next period. Young agents do not consume (or, which is equivalent, their consumption is included in that of their parent). When adults, in period $t + 1$, the agents of generation t participate in production, obtain income, consume, and can transfer a bequest to their offspring. Then, they leave the scene.

The definition of preferences is based on the following criteria. At very low levels of income, adult agents are assumed to consume all their income in agricultural goods, without leaving bequests. There is a threshold beyond which individuals start to “save for their offspring”, although their consumption basket still consists only of agricultural goods. This sequence allows the accumulation of capital in an economy where consumption is purely agricultural. When income exceeds another critical value, the agent consumes industrial goods; when income is high enough, she also demands services. Regarding the incentive for leaving a bequest, the individual derives utility directly from the amount of resources transmitted to the offspring, independently of the use of bequest by the next generation. This implies, in particular, that savings depend only on the income of the adult agent, and not on the future expected of return on assets¹.

Preferences and the associated demand curves have functional specifications that depend on the level of income, and are defined as variants of Stone-Geary functions, with an ordering of the goods which are part of the consumption basket at different levels of income. There are four stages: i) consumption of agricultural goods (A), only; ii) consumption of A and positive bequests; iii) consumption of A and industrial (I) goods as well as bequests; iv) consumption of goods A , I and services (N) and bequests. The transitions from stage to stage imply changes in the marginal propensity to spend in different consumption goods.

2.1.1 Consumption of Agricultural Goods and No Bequests

In this region, the utility function is simply:

$$u = \ln c_A \text{ if } c_A \leq \tilde{c}_{A1}$$

where c_A is the consumption of good A of the individual. In this region, the individual consumption reduces to:

$$c_A = i$$

with i being the adult-age income in terms of good A .

¹This assumption does not greatly affect the qualitative results emphasized in the paper. However, it may have strong implications in some contexts. In particular, this type of savings function allows the existence of states where the marginal net product of capital is negative. Also, initial differences in endowments may have no effect on steady state consumption, while that would not happen, say, with standard Euler equations if all agents face the same interest rate, since the ratio of marginal utilities of any two agents would be conserved over time.

2.1.2 Consumption of Agricultural Goods with a Positive Bequest

After the consumption of good A has reached the first threshold:

$$u = (1 - \beta) \ln(c_A - \tilde{c}_{A1}) + \beta \ln b' \text{ if } \tilde{c}_{A1} < c_A \leq \tilde{c}_{A2} \text{ or } 0 < b' \leq \tilde{b}'_2 \quad (1)$$

where b' is the bequest², and $(\tilde{c}_{A2}, \tilde{b}'_2)$ is the basket with the minimum levels of consumption of agricultural goods and bequests for which the agents start diversifying their consumption, and begin to demand industrial goods. It may be noted that one condition is enough to remain in this stage: the assumption is that both, c_A or b' , must be above their threshold value to induce a transition to the next stage.

Given the income constraint:

$$i = c_A + b'$$

the sizes of the bequest and the consumption of the agricultural good in this region are:

$$b' = \beta(i - \tilde{c}_{A1})$$

and

$$c_A = (1 - \beta)(i - \tilde{c}_{A1}) + \tilde{c}_{A1}$$

For simplicity, and in order to have demand curves for goods A and bequests without discontinuous jumps in the transition between this consumption stage and the next, we will assume that the upper thresholds $\tilde{c}_{A2}, \tilde{b}'_2$ correspond to the demands at a threshold level of income, \tilde{i}_2 . That is:

$$\tilde{b}'_2 = \beta(\tilde{i}_2 - \tilde{c}_{A1}) \text{ and } \tilde{c}_{A2} = (1 - \beta)(\tilde{i}_2 - \tilde{c}_{A1}) + \tilde{c}_{A1}$$

Furthermore, we will assume that the coefficient of bequests in the utility function is the same, β , for all the stages in which bequests are positive, implying that the marginal propensity to save is constant.

2.1.3 Consumption of Industrial and Agricultural Goods

In this stage, when the income exceeds \tilde{i}_2 , the agent is assumed to include industrial goods in the consumption basket. Preferences are now expressed as:

$$u = (1 - \beta)\alpha_{A3} \ln(c_A - \tilde{c}_{A2}) + (1 - \beta)\alpha_{I3} \ln c_I + \beta \ln(b' - \tilde{b}'_2)$$

if $\tilde{c}_{A2} < c_A$ and $\tilde{b}'_2 < b'$; and $c_A \leq \tilde{c}_{A3}$ or $b' \leq \tilde{b}'_3$ or $0 < c_I \leq \tilde{c}_{I3}$

²In this stage, it is natural to define the bequest in terms of agricultural goods. The assumption that utility from bequests depends on their value measured in goods A will be maintained for the following stages.

If p_I indicates the price of manufactures relative to that of agricultural goods, bequests and consumption are given by:

$$\begin{aligned} b' &= \beta(i - \tilde{i}_2) + \tilde{b}'_2 \\ c_A &= \tilde{c}_{A2} + (1 - \beta)\alpha_{A3}(i - \tilde{i}_2) \\ p_I c_I &= (1 - \beta)\alpha_{I3}(i - \tilde{i}_2) \end{aligned}$$

The transition from this stage to the next cannot be specified as a uniquely determined threshold level of income in terms of good A , since the demand for good I (and, therefore, the level of income for which limit \tilde{c}_{I3} is reached) depends on the price p_I . This implies that, in general, this specification of preferences will imply a discontinuity in demands-bequests in the passage to the consumption-of-services stage.

2.1.4 Consumption of Physical Goods and Services

If all three conditions are satisfied ($c_A > \tilde{c}_{A3}$, $b' > \tilde{b}'_3$, $\tilde{c}_I > \tilde{c}_{I3}$), the individual consumes services. These services are produced by workers endowed with human capital: the utility derived by the individual depends on the number of workers, n , and their average human capital, h . The consumption of services would be:

$$c_N = h\psi(n)$$

In this application we will assume, for simplicity, that the demand for services is satisfied by the maximal amount of workers \tilde{n} , above which the function ψ remains constant; the value $\psi(\tilde{n})$ is normalized to \tilde{n} . The consumer's spending on services would be:

$$p_N c_N = \tilde{n} w_h h$$

where w_h is the wage per unit of human capital.

Preferences have the form:

$$u = (1 - \beta)\alpha_{A4} \ln(c_A - \tilde{c}_{A3}) + (1 - \beta)\alpha_{I4} \ln(c_I - \tilde{c}_{I3}) + (1 - \beta)\alpha_{N4} \ln h + \beta \ln(b' - \tilde{b}'_3)$$

The bequest and the demands for consumer goods are derived from the expressions:

$$\begin{aligned} b' &= \beta(i - \tilde{c}_{A3} - p_I c_{I3} - \tilde{b}'_3) + \tilde{b}'_3 \\ c_A &= (1 - \beta)\alpha_{A4}(i - \tilde{c}_{A3} - p_I \tilde{c}_{I3} - \tilde{b}'_3) + \tilde{c}_{A3} \\ p_I c_I &= (1 - \beta)\alpha_{I4}(i - \tilde{c}_{A3} - p_I \tilde{c}_{I3} - \tilde{b}'_3) + p_I \tilde{c}_{I3} \\ \tilde{n} w_h h &= (1 - \beta)\alpha_{N4}(i - \tilde{c}_{A3} - p_I \tilde{c}_{I3} - \tilde{b}'_3) \end{aligned}$$

2.2 Technologies and Equilibrium Conditions

As stated above, there are three goods: an agricultural good, A , an industrial good, I , and a service, N . Both A and I can be traded internationally, while N is by assumption a non-traded good. We will assume that there are no international capital movements. Therefore, young generations must finance physical investment and education with the bequest transferred by the previous generation. The trade balance is assumed to be zero in every period.

The factors of production are four: raw labor, L , human skills, h , land, T (in fixed supply) and physical capital, X . In what follows, the emphasis will be placed on the accumulation of capital in sector A : capital will be (loosely) interpreted as "cattle", and identified with good A .

Good A can be produced with two technologies³. One of those technologies ("subsistence") is characterized by using only unskilled labor, with constant return, and generates a quantity \tilde{w} of output per unit of employment. While in operation, this technology induces an elastic supply of labor at that wage⁴. An agent with income \tilde{w} only demands agricultural goods.

The other way of producing agricultural goods is with a technology that uses land and capital. For simplicity, we suppose that each production unit, owned by a landlord, must occupy a fixed surface of land, \bar{T} ; the output of that unit would be:

$$y_A = f(X^A) + (1 - \delta)X^A$$

where X^A is the capital stock used in agriculture (or, in this context, the size of the herd), which has been carried over from the previous period, while δ is a fixed depreciation rate.

Human capital (incorporated in skills) is produced through education. For simplicity, the inputs of this activity are assumed to consist uniquely of good A . The skills of an individual in period $t + 1$ are a function of the resources spent on her education in t :

$$h_{t+1} = h(e_t)$$

with $h' > 0$, $h'' < 0$.

The third good, N , is some type of urban, relatively sophisticated service, whose production requires skilled labor. As stated above, from the point of view of an individual demanding good N , the amount of services consumed depends

³For the purpose of our main discussion, the technology for producing industrial goods need not be specified, provided that the international price p_I is low enough so as to discourage production in the land-rich economy. The representation of the industrial sector is briefly treated in the appendix, where we sketch a model of early industrialization.

⁴The individuals in this "subsistence" sector do not play an active role in the model, but they provide a reservoir of workforce (à la Lewis) which, we will assume, is not exhausted in the relevant range of variables. In principle, there is no presumption that the wage in that sector is necessarily very low (although, by assumption, it does not induce a diversified consumption). The reservation wage could also be interpreted without changing the model as the income required to induce immigration. This representation would be relevant for the Argentine case of the late nineteenth and early twentieth centuries.

on the number of workers providing those services and their average human capital:

$$y_N = \psi(n)h$$

It will be assumed that there are decreasing returns in the quantity n of service production, and that the function ψ reaches its maximum for a certain value \tilde{n} . This implies that, while the supply of services is proportional to the quality of human capital incorporated in its production, the number of workers per consumer of services would approach a limit. This representation has important consequences, since it implies that, in order to reduce the price of their consumption basket, the group that demands services would have an interest in increasing the skills of, at most, \tilde{n} workers per consumer.

3 Growth and structural evolution

3.1 An agricultural economy

This case is a small variant of a simple Solow model. In the initial condition, it is assumed that only good A is produced and consumed. The only non-trivial outcomes in the economy depend on the decisions made by the landlords on the level of bequests and, therefore, on the future size of the capital stock.

The generation and use of income by a representative landlord (agent A) is described by :

$$i^A(X) = f(X^A) + (1 - \delta)X^A = c_A^A + b^{A'}$$

where i^A is the income of agent A , c^A and $b^{A'}$ are his consumption and bequests. The latter, received by the offspring of A can only be used to build up capital for next period. Then: $b^{A'} = X^{A'}$, the capital stock available next period. Then, the dynamics of X will be given by:

$$X^{A'} = b^{A'} = \max[\beta(f(X^A) + (1 - \delta)X^A - \tilde{c}_{A1}), 0]$$

where, as defined in section 2.1.1, \tilde{c}_{A1} is the minimum level of consumption for which bequests are positive. If the productivity of X and/or the initial capital stock are too low or agents are too inclined to consume (\tilde{c}_{A1} high) the economy gets trapped in a subsistence equilibrium. Otherwise, it will undergo accumulation. We assume that this is the case.

The economy has a potential steady state at a capital stock X_P^* such that:

$$(1 - \beta(1 - \delta))X_P^* = \beta(f(X_P^*) - \tilde{c}_{A1})$$

In Figure 1, we represent how this steady state may arise. There, Id is the function $X^{A'} = X^A$, while $I_{c_A} = -\beta\tilde{c}_{A1}$. It is easy to see that the existence of steady states ensues if the following conditions on the values of the parameters are fulfilled:

- A high value of β .
- A high productivity of X^A .
- A low threshold consumption \tilde{c}_{A1}

The arrows indicate the dynamic pattern of accumulation. Low amounts of X^A lead the economy to the subsistence stage. On the other hand, high amounts of initial capital will decrease until the high steady state is attained. Notice, on the other hand, that the lowest steady state, X^L is unstable. So, generically, we will speak only of X^H as *the* steady state X_P^* .

The demand for industrial goods would arise for a capital stock \bar{X}_I such that the corresponding income is:

$$f(\bar{X}_I) + (1 - \delta)\bar{X}_I = \tilde{c}_{A2} + b'_2$$

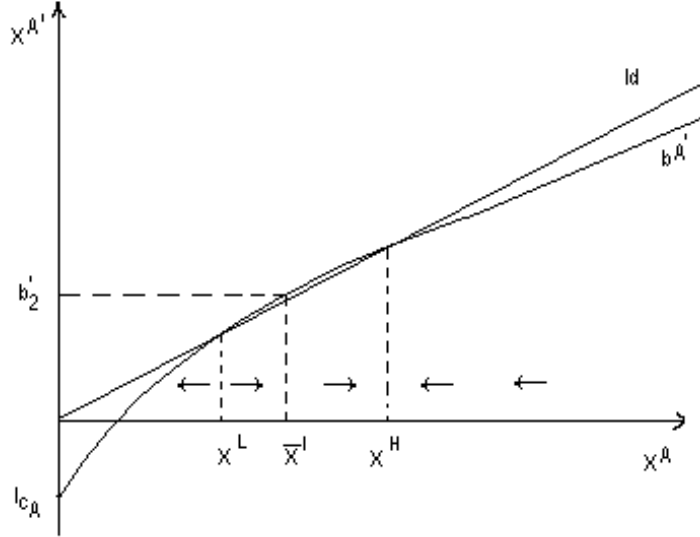
Using the dynamic characterization of $b^{A'}$ this expression amounts to:

$$b'_2 = \frac{\beta}{1 - \beta}(\tilde{c}_{A2} - \tilde{c}_{A1})$$

Landlords will start demanding industrial goods if the saving propensity β sufficiently high and the difference the consumptions thresholds is relatively low

The demand for industrial goods will emerge if $\bar{X}_I < X_P^*$ (see Figure 1). If that condition holds, the behavior regarding consumption and bequests will change before the potential steady state is reached. In an open economy, the new demand for manufactures does not necessarily change the configuration of production: simply, some goods A may be sent abroad to pay for the imports of I . However, alternatively, it is possible that the economy produces the industrial goods consumed locally (as if in a closed economy), or, also, it may happen that manufacturing activities get started "for exports" before there is a domestic demand for the produced goods. These alternative scenarios of "early industrialization" are sketched in the Appendix.

Figure 1



4 The rise of public education in a land-rich economy

An economy with (i) abundant land, (ii) a high price of labor⁵, (iii) a certain degree of capital accumulation, which has reached the stage where there is a significant demand for manufactures at a time when industrial goods are available internationally at low prices, may, instead of developing a sizeable manufacturing sector, go directly to the production of non-tradeable services. This would happen if the rate of return to capital in agriculture, if all the capital stock were allocated to that sector, exceeds the rate of return in manufacturing:

$$f'(b) + 1 - \delta > r_I$$

In this discussion of a land-rich economy we will assume that the condition holds.

A young generation of landlords will anticipate a demand for services by its members if the bequests that they receive are such that their future income as adults exceeds the corresponding threshold:

$$f(b) + (1 - \delta)b > \tilde{c}_{A3} + p_I \tilde{c}_{c^A} + \tilde{b}'_3 = \tilde{i}_3(p_I)$$

⁵That is, a high \tilde{w} , either because the agricultural sector is sufficiently productive, or the relevant supply of labor at the margin comes from immigration, which implies transportation and settlement costs.

In order for the consumption of services to emerge, the income of the representative landlord must attain the critical level $\tilde{i}_3(p_I)$ at a capital stock \overline{X}_S such that $\overline{X}_S \leq X_P^{**}$, where X_P^{**} is a potential steady state in the dynamics described by:

$$X' = b' = \beta(i(X) - \tilde{i}_2) + \tilde{b}'_2$$

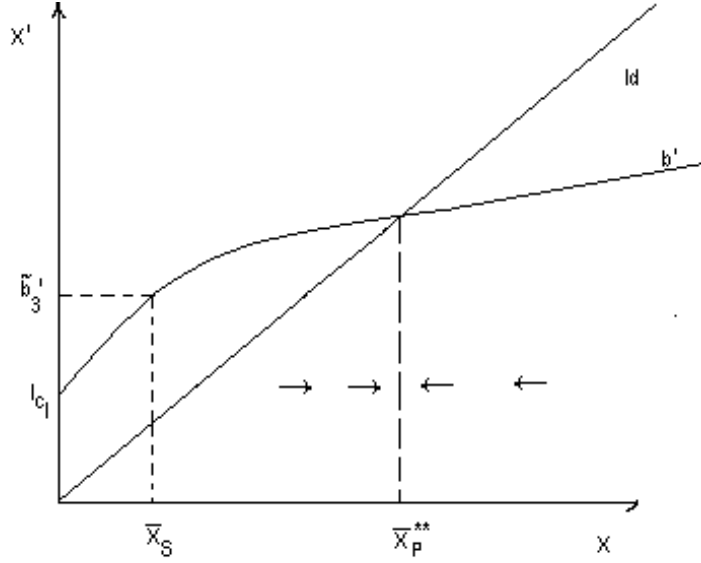
In Figure 2, we show that a steady state (generically only one) exists only if β , $i'(X)$ (the marginal productivity of capital) and the constant $I_{c_I} = \tilde{b}'_2 - \beta\tilde{i}_2$ are high enough. On the other hand, the transition to the consumption of services happens if the threshold level of bequests, \tilde{b}'_2 is low enough.

4.1 The Emergence of Public Education

The demand for services will induce a demand for skills. We assume that the skills required for the provision of services require some kind of formal education, and cannot be acquired through other means like on-the-job training. This implies that there will not be a direct arbitrage between subsistence employment and working in services: subsistence workers cannot migrate to services without receiving education. But subsistence workers are credit-constrained and, of course, in a world where human capital is inalienable, individual landlords will not have incentives to pay for the education of young workers. This implies that the only alternative for the would-be consumers (the young landlords) to induce a given supply of services is to act as a group to provide education, more or less massively, according to the number of workers required. As in GM, capitalists, with foresight about their future demands, would accept to be taxed to finance education for some workers. Here, the incentive would derive from their desire to diversify their consumption basket.

By assumption, the services consumed by an individual landlord are represented as $c_N = \tilde{n}h$, where \tilde{n} is the maximal number of service suppliers per consumer, and h their average level of skills. It may be noted that the landlord does not derive utility at the margin from increasing the number of agents that participate in the supply of services, but only from a higher quality of those services. Therefore, educated workers will receive retribution only on account of their skills, so that their income is proportional to their human capital: $w_h h$. Additionally, we assume for the time being that the educated workers who work in the service sector have low enough incomes so that their spending is only in agricultural goods, without leaving bequests or diversifying consumption.

Figure 2



At this stage, government decisions simply reflect the interests of the landlords, group A . If there is spending in public education, it will be financed by a tax on bequests (a lump-sum transfer from landlords to the government). That is, at this stage, taxes directly reduce the accumulation of physical capital.

Since \tilde{n} service workers are demanded per landlord, public education will cover the corresponding number of individuals. For a “per student” spending in education of size e , the disposable income and the budget constraint of the representative landlord will be:

$$i^A = f(b - \tilde{n}e) + (1 - \delta)(b - \tilde{n}e) = c_A^A + p_I c_I + \tilde{n}w_h h + b'$$

where $b - \tilde{n}e$ represents the after- tax bequests, which equal the amount of capital purchased by the landlords, and $\tilde{n}w_h h$ is the spending on services of the representative landlord, with w_h the wage per unit of skills. The notation c_A^A indicates the consumption of agricultural goods of landlords (it may be recalled here that the skilled workers demand agricultural goods produced in the capitalist, non-subsistence sector). In the case of the consumption of industrial goods and services and the transmission of bequests, those indices are redundant here, since such variables are non-zero only for landlords.

The market demands of agent A are:

$$\begin{aligned} c_A^A &= \tilde{c}_{A3} + (1 - \beta)\alpha_{A4}(i^A - \tilde{i}_3) \\ p_I c_I &= p_I \tilde{c}_{I3} + (1 - \beta)\alpha_{I4}(i^A - \tilde{i}_3) \\ \tilde{n}w_h h &= (1 - \beta)\alpha_{N4}(i^A - \tilde{i}_3) \end{aligned}$$

This last equation implies that, provided \tilde{n} workers receive education, their total income depends negatively on the per-capita spending in education, e , because the aggregate value of spending in services depends positively on the income of group A , with falls with the size of the tax on bequests.

The bequests left by this generation of landlords will be:

$$b = \tilde{b}'_3 + \beta(i^A - \tilde{i}_3)$$

Proposition 1 *The supply of education is determined by:*

$$(1 - (1 - \beta)\alpha_{N4})(f'(b - \tilde{n}e) + 1 - \delta) = w_h h'(e)$$

Proof: *The planner has to choose e to maximize the utility of agent A subject to the restrictions given by the demands of the agent and to $h = h(e)$:*

$$u^A = (1 - \beta)[\alpha_{A4} \ln(c_A^A - \tilde{c}_{A3}) + \alpha_{I4} \ln(c_I^A - \tilde{c}_{I3}) + \alpha_{N4} \ln \tilde{n}h(e)] + \beta \ln(b^A - \tilde{b}'_3)$$

This utility can be rewritten as:

$$v^A = \kappa_A + (1 - (1 - \beta)\alpha_{N4}) \ln(i^A - \tilde{i}_3) + (1 - \beta)\alpha_{N4} \ln \tilde{n}h(e) - (1 - \beta)\alpha_{I4} \ln p_I$$

Using the definition of i^A , the problem of the planner reduces to:

$$-\tilde{n}(1 - (1 - \beta)\alpha_{N4}) \frac{1}{i_A - \tilde{i}_3} (f'(b - \tilde{n}e) + 1 - \delta) + (1 - \beta)\alpha_{N4} \frac{h'(e)}{h(e)} = 0$$

Which, recalling the expression for the demand for services $\tilde{n}w_h h$ becomes the desired result. \square

The intuition of this result is simple. Given that w_h is the marginal valuation of the skills of qualified workers, the value of an additional unit of education-per-worker is $\tilde{n}w_h h'$, since the extra spending on education will allow to educate the maximal amount of workers for each consumer, \tilde{n} . In order to produce those skills, the representative landlord must reduce his capital accumulation by \tilde{n} units of goods. But the opportunity cost for the landlord group is smaller than the agricultural output foregone: a reduction of this output does not reduce one-to-one the consumption c_A^A , because the fall in the value of spending in services diminishes the income and the consumption of agents h . This is why the condition that determines the value of e implies a pro-education bias, with respect to the solution that simply equates the marginal returns to investment

in both sectors ($w_h h' = f'(b - \tilde{n}e) + 1 - \delta$). Another way of viewing this result is that, when increasing the supply of skills, all the additional services to be produced will be consumed by the A group, while an increase in the output of agricultural goods will be shared between agents A and h , because the latter will benefit from a rise in the value of spending on services.

To summarize:

Lemma 1 *The dynamics of the system are determined by:*

- *Income of agents A:*

$$i^A = f(b - \tilde{n}e) + (1 - \delta)(b - \tilde{n}e)$$

- *Demand for services:*

$$\tilde{n}w_h h(e) = (1 - \beta)\alpha_{N4}(i^A - \tilde{i}_3)$$

- *Supply of services (or allocation of bequests):*

$$w_h h'(e) = (1 - (1 - \beta)\alpha_{I4})(f'(b - \tilde{n}e) + 1 - \delta)$$

- *Dynamics of bequests:*

$$b^{A'} = \tilde{b}'_3 + \beta(i^A - \tilde{i}_3)$$

Proof: *Results from the characterizations in section 2.* \square

The dynamics of the wages of skilled labor are important, in particular, to analyze the supply conditions of manufactured goods and, thus, the potential for industrialization after an agriculture-plus-services stage. As it can be seen, the accumulation of capital raises both the supply and the demand for h . But the magnitude of the shifts depends on the technologies in education and agriculture, represented by the functions h and f . The wage would tend to decline if the growth of human capital is fast relative to that of physical capital, and that would depend on the intensity of decreasing returns on both types of investment. It would seem more or less intuitive that, at first, the demand for services, and indirectly for skills, would start from a low level, and both w_h and h would be small. The wage would then increase as the demand for services grows. If the productivity of education falls less quickly than the productivity of investment in sector A , then at some point the wage would decrease, as investment gets increasingly directed towards education.

In any case, the total spending in services and, therefore, the income of the \tilde{n} educated workers would increase monotonically with the income of group A and, consequently, with the output of the agricultural good.

4.2 Moving Ahead: Brief Comments on Subsequent Phases

When the economy has a significant size of educated population, as capital accumulation proceeds, it is likely that both the configuration of output and spending, and the determinants of public policies will continue to evolve. Here, we will only mention briefly, and in mostly qualitative terms, some alternative paths that may be followed.

Possible Emergence of Manufacturing It is possible that, at some point, the effect of decreasing returns in the primary goods sector and an expansion of the supply of skills may result in the emergence of a manufacturing sector⁶. This may also occur if, for some reason, the international price of industrial goods increases relative to those of agricultural commodities. Then, capital would flow to manufacturing. This would change the political economy in several ways. One issue would be whether (as assumed in the exercises in the appendix) landlords "transform" themselves into entrepreneurs with interests in both traded sectors, or whether they are lenders of resources to a new group of industrial entrepreneurs (the division of the *élite* has been an often mentioned feature of resource-based economies with an incipient industrialization). Also, it is probable that the group of educated workers start to gain political influence: with the emergence of manufacturing, they would have "mixed" interests as suppliers of services, as workers in the manufacturing sector and, if their income is sufficient, as consumers of industrial goods. In addition, the inflow of workers from the subsistence sector to the (mainly urban) industrial sector may also create a new significant group of influence, with interests in raising the demand for industrial labor. That configuration is likely to generate an interesting (and complicated) dynamics of policies (especially in terms of industrial protection and the spending in education) and capital accumulation.

Public and Private Education With or without the appearance of manufacturing, if the accumulation of capital in the agricultural sector grows enough, at some point the \tilde{n} skilled workers may start to leave bequests. Their young descendants would then use some of their resources to acquire assets. One may consider two cases: (i) one where, for some reason, the educated individuals can only invest in private education (which would be the case, say, if there was no organized market where they can invest in agricultural capital, or lend to landowners), and (ii) one where there is a credit market in which agents trade assets. It may be assumed, for example, that public education is financed by a tax on bequests, at the same rate for both groups, and that at this stage

⁶A pertinent question for this discussion would be whether human capital has a "multi-purpose" feature, or it would tend to be sector specific. Another important (and not easy to specify) characteristic of the economy would be the shape of the production function of education, since it would influence the path of the wages of skilled labor.

the political economy changes so that now the government contemplates the interests of skilled workers (group H) with some weight.

Intuitively, if there is no capital market, the tax on H is irrelevant from the point of view of agent A , since in this setting, the bequest is going anyway (by assumption) to be used entirely to purchase education. Individuals of group H would want that the income (and, of course, the spending) of A be as large as possible (as long as they are educated so as to belong to the group of service suppliers). Also, from the point of view of the representative H agent, a purchase of private education by the group would not raise income, since it lowers the price of services in proportion to the human capital which is generated. Then, it may be expected that, if the weight of agents H in the planner's preference is zero, the condition that determines the allocation of bequests between education and physical capital will be the same as in the case where skilled workers do not save. That is: the A planner would reduce one-to-one the expenditure in public education as the private investment of the group H increases (although, the pro-education bias would remain, for the reasons stated above). Curiously, perhaps, it would seem that the addition of individuals H in the planner's preferences would tend to reduce the expenditures on public education: the already established skilled workers H favor a low tax rate, since the tax on the bequests of landlords reduces the demand for their services.

If there is no restriction on lending by group H , the situation would change. Two additional considerations arise here: (i) the planner has to recognize that the tax level and the investment in education of skilled workers are linked through an arbitrage between lending and acquiring human capital, and (ii) the skilled workers are now creditors and, in that position, they gain from high interest rates, and then from a low capital stock in agriculture. The problem now appears quite complicated. In particular, while in the case without financial savings the interests of group H were consistent with the maximization of the income of landlords in order to increase the demand for their services, now this is partially offset by the impact on their revenue as lenders. In any case, these brief comments suggest that, in an economy such as that described, the provision of education may give rise to non-trivial political games.

Diversified Consumption of Skilled Workers If skilled workers get rich enough in the process of capital accumulation, they would start to diversify their consumption basket. However, the appearance of a demand for industrial, tradeable goods by that group does vary noticeably the pattern of evolution: the economy will become more open as demand shifts from locally produced agricultural goods to imported manufactures, without much change elsewhere. The case would be different if the wage of skilled workers rises to the point where they also demand services. There would then be a "secondary" demand for skills (and for new skilled workers), on the part of the agents who previously were selling services to landlords/capitalists. From a modeling perspective, this

would pose questions about the treatment of the production of services as a function of the quantity and quality of labor employed (or, concretely, about whether each “incumbent ” skilled worker now demands \tilde{n} new workers for his consumption of services). This would have implications on how large would be the growth of the pool of educated workers. Also, the incentives of policy-makers change. Intuitively, an *A* planner, for example, recognizes that there are no “exclusive” goods any more, consumed only by landlords. An increment in the supply of skills would also benefit the educated workers as consumers. The provision of public education would be discouraged accordingly, from the point of view of landlords. However, the *A* planner would likewise internalize the fact that a lower supply of skills increases the wage of educated workers, and raises their demand for services, which would crowd out the demand by landlords. The two effects would be weighed when considering taxation and spending in education.

5 Conclusion

We have presented a model that can rationalize different patterns in the emergence of educational systems, in a way that can be pertinent in accounting for contrasts between the experiences of countries in the American continent in the 19th century. As a representation of economic development, at this stage the range of validity of the model is limited by the fact that we disregard phenomena like capital movements and, especially, technical change which, of course, should be central elements in a more general analysis. However, as it is the model seems useful to highlight different motives for the *élite* to finance the education of low-income workers.

The model focuses on the demand for human-capital-intensive services of high-income groups. This channel can generate a demand for education, and appears because we adopt a setup with multiple goods, where consumption preferences are non-homothetic and the demand for skill-intensive commodities emerges at comparatively high levels of income. We also assume that the quantity and quality of labor are not perfect substitutes; consequently, the number of high-income agents may have strong effects on how many individuals are subsidized to accumulate human capital.

We have tried to represent some aspects of the interaction between the behavior of private agents, the changes in the economic structure and the sequence of policy choices. The resulting model can describe different types of economic evolution without necessarily relying on exogenous political factors as the only cause of the divergence of economic performances. Since institutions are clearly a crucial determinant of economic behavior, the eventual aim would be to represent their co-evolution with the economic and social structures.

Several kinds of economies, with different qualitative behaviors, could be identified. The first kind is that of early comers to industrialization. These are

economies where, in the process of capital accumulation, agricultural productivity is high enough to generate a widespread demand for manufactured goods, which must be produced internally. The growth of the agricultural-industrial economy (with a bias towards industry, due to the higher income elasticity of the demand for the corresponding goods) may lead to the emergence of a demand for skills.

A second class of economies are those which are well endowed with labor, and where agricultural productivity is not enough to trigger industrialization "for the domestic market", but can engage in labor intensive manufacturing for exports if and when an international market for those goods develop. In this basic setup, we merely refer to the first steps of industrialization for these economies. Further work should certainly consider with more detail the processes of technical change and the increase in the supply and demand for human capital in production: here, it should be expected that education relates more or less directly with the requirements of an international-market-oriented manufacturing sector.

Our focus was on resource-abundant economies where income growth is such that a large demand for industrial goods appears at a time when the supply by early comers is already well developed. Straightforward comparative advantage implies that those economies will import manufactures. If the demand for "sophisticated" services starts for incomes above a certain threshold, increases in the value of the output of primary goods can imply that, at some moment, a demand for skilled labor may appear in order to satisfy that consumption by high-income groups. These groups, then, would not oppose the emergence of public education to increase the skills of a set of workers, the number of which would depend on the number of landlords who demand services. Hence, the diffusion of education would depend on the size of the elite and, indirectly, on the degree of concentration of land ownership. The growth of an educated class can change the political balance, and the incentives to provide public education, by incorporating into the picture a new influential group, and also by giving rise to a population who in some cases may self-finance the acquisition of skills of descendants. A large manufacturing activity may or may not arise "spontaneously". Over time, a new political economy of industrial protection is likely to result from the interplay of the interests of landlord, capitalists, skilled workers (at first, mainly occupied in services), and unskilled workers, if they participate in political decisions. Quite different paths seem possible according to how the implicit conflicts are processed.

The model we have presented was inspired in part by the Argentine experience, where a strong public education movement appeared well before the demand for skills in manufacturing acquired some importance. Of course, the political decision to make substantial investments in education had a number of motives, and cannot be simply attributed to the wish to "lower the costs of services for the landlords". Clearly, the desire to integrate immigrants to the national society and, in general, to promote "civilization" (a much cited and discussed concept at the time) played a very large role. However, training a

large number of individuals for "civilized life" presupposes, at least implicitly, the expectation that the resulting skills will find demand in "civilized jobs". In fact, for several decades, the newly educated workers were readily absorbed in a growing economy and, particularly, in the service sector.

6 References

Acemoglu, D.; S. Johnson and J. Robinson (2005): "Income and Democracy", NBER Working Papers: 11205.

Banerjee, A. and A. Newman (1991): "Risk-Bearing and the Theory of Income Distribution", *Review of Economic Studies* 58: 211-235.

Barro, R. (1991): "Economic Growth in a Cross Section of Countries", *Quarterly Journal of Economics* 106: 407-433.

Barro, R. and J-W. Lee (1994): "Sources of Economic Growth", *Carnegie-Rochester Conference Series on Public Policy*, 1-46.

Benabou, R. (1996): "Equity and Efficiency in Human Capital Investment: The Local Connection", *Review of Economic Studies* 63: 237-264.

Bourguignon, F. and T. Verdier (2000): "Is Financial Openness Bad for Education? A Political Economy Perspective on Development", *European Economic Review* 44: 891-903.

Chenery, H. and M. Syrquin (1975): **Patterns of Development, 1950-1970**, Oxford University Press for the World Bank, New York.

Chenery, H.; S. Robinson and M. Syrquin (1986): **Industrialization and Growth: A Comparative Study**, Oxford University Press for the World Bank, New York.

Engerman, S. and K. Sokoloff (2000): "Institutions, Factor Endowments, and Paths of Development in the New World", *Journal of Economic Perspectives* 14: 217-232.

Galor, O. and O. Moav (2001): "Das Human Kapital", CEPR Discussion Paper 2701, Centre for Economic Policy Research, London.

Galor, O.; O. Moav and D. Vollrath (2005): "Land Inequality and the Emergence of Human Capital Promoting Institutions", Brown University Economics Working Paper 05-03.

Galor, O. and J. Zeira (1993): "Income Distribution and Macroeconomics", *Review of Economic Studies* 60: 35-52.

Landes, D.S. (1998): **The Wealth and Poverty of Nations: Why Some are so Rich and Some so Poor**, Norton, New York.

Lucas, R. (1988): "On the Mechanics of Economic Development", *Journal of Monetary Economics* 22: 3-42.

Mankiw, N.; D. Romer and D. Weil (1992): "A Contribution to the Empirics of Economic Growth", *Quarterly Journal of Economics* 108: 737-773.

Mariscal, E. and K. Sokoloff (2000): "Schooling, Suffrage, and Inequality in the Americas, 1800-1945", in S. Haber (ed.) **Political Institutions and Economic Growth in Latin America**, Hoover.

North, D. (1981): **Growth and Structural Change**, Norton, New York.

North, D. and R. Thomas (1973): **The Rise of the Western World**, Cambridge University Press, Cambridge.

7 Appendix

7.1 Early industrialization: a preliminary sketch of an argument

Consider an economy that accumulates agricultural capital *before* there is a significant international supply of industrial goods. If capital accumulation proceeds to the point where landlords start demanding industrial goods, they must be produced locally since the economy is closed for all practical matters. Then, it is clear that production would diversify into manufacturing as a result of the new composition of consumption demands. Thus, if and when the income of landlords reaches the threshold where their consumption diversifies, there would be a shift of capital into manufacturing, and the dynamics would change compared with the agricultural stage. Now, the logic of capital-skills complementarity would apply. With certain technologies, manufacturing skills may be acquired through on-the-job training (apprenticeship), at some point, the provision of public education may be in the interest of capitalists, and the GM argument would apply.

However, once the early-comers to industrialization have engaged in that path, the economies that lag behind in capital accumulation need not follow the

same sequence: once there is an active international market where manufactures trade for primary goods, the late-comers may industrialize “prematurely”, or alternatively, become producers of services for high-income groups without first developing manufactures. Regarding the first possibility, standard international trade arguments indicate that an economy with suitable factor endowments can produce industrial goods for the world market, independently of domestic consumption. This would be more likely if landlords are sufficiently frugal and entrepreneurial while agriculture is not-too-productive (which speeds up the arrival of the moment where investment in manufacturing becomes profitable at the margin relative to accumulating agricultural capital) and there is a large supply of labor capable of moving from a subsistence sector to manufactures (à la Lewis). Also here the provision of education would be likely to be predicated on a perceived demand for more skilled industrial workers.

We refer to those two cases of industrialization in the sketch that follows. The new assumptions are:

Industrial goods are produced with unskilled labor, skills, and physical capital:

$$y_I = g(L^I, X^I, h^I)$$

where L^I is the number of workers employed used in manufacturing, X^I is the amount of capital used in sector I and h^I the average skill of the work applied in the industry. That is: each worker carries his basic (unskilled) labor force enhanced by h units of acquired skills. We postulate a Cobb-Douglas production function:

$$y_I = \gamma_I (L^I)^{\rho_L} (h^I)^{\rho_H} (X^I)^{\rho_X}$$

We assume that $\rho_L + \rho_X = 1$, i.e. that output grows in proportion to the input of capital and labor at any fixed level of skills. If production depends only on the aggregate amount of skills (*effective labor*) then $\rho_L = \rho_H$; however, we will suppose that there is a proper contribution of unskilled labor, so that $\rho_L > \rho_H$. Each “uneducated” worker is assumed to carry a basic level of skills h_0 for potential use in sector I . If the wage of a worker with skills h in manufacturing is $w + w_h h$ (where w would be the return on zero-skilled labor, and w_h the return per unit skill), we will assume that there is an elastic supply of uneducated workers at wage \tilde{w} . In turn, if there is an active manufacturing sector, in the relevant range, wages in that sector for a worker with h_0 skills do not exceed \tilde{w} at a level of employment that would occupy the entire pool of subsistence workers.

7.2 Export-led industrialization

This case would represent an economy which, with suitable factor endowments, produces good I for the world market, even without a widespread consumption

of that good. Given the specification of the production function and the assumption that uneducated labor is supplied elastically at wage \tilde{w} , and assuming that capital is perfectly mobile between sectors, if $h_0 > 0$ is the level of skills of workers without education for the purpose of working in manufacturing, we have that:

Proposition 2 *Capital X is allocated to sector I if*

$$f'(X_P^*) + 1 - \delta \leq r_I(p_I, \tilde{w}, h_0)$$

where r_I is the value of the marginal product of capital in manufacturing if the amounts of capital and labor are determined optimally, given that the (international) price of the industrial good is p_I , the (subsistence) wage is \tilde{w} , and labor has the basic (zero-education) level of skills h_0 . If that condition is satisfied, by continuity, the equality would hold for a level of the total capital stock $\tilde{X}_I < X_P^*$, where X_P^* , as in the text, is the capital stock at steady state that would be attained in a purely agricultural economy. Here, \tilde{X}_I indicates the minimal level of capital accumulation for which manufacturing production would start.

The above condition means that, when the total capital stock is that of the potential steady state of an agricultural economy, the return to capital in manufacturing exceeds the return to capital in agriculture. This will be more easily satisfied with low subsistence wages, not-too-productive agriculture and frugal capitalists; of course high productivity and/or high prices of good I tend induce production. It may be noted that, here, by assumption, the skills of workers are fixed at h_0 , and the manufacturing industry faces an elastic supply of labor such that the wage of an uneducated worker is: $w + w_h h_0 = \tilde{w}$. Therefore, given three parameter h_0 , the rate of return to capital in manufacturing would be a function only of the subsistence wage in terms of the industrial good.

Then, if and when the total capital stock reaches the threshold \tilde{X}_I capital would move into manufacturing. Assuming for simplicity that capitalists/landlords will not or cannot buy education and there is no public education for credit constrained workers, that only agricultural goods are consumed and that the return on labor skills does not induce saving by workers, the system is described by:

$$\begin{aligned} i_K &= f(X_A) + (1 - \delta)X_A + (X - X_A)r \\ f'(X_A) + 1 - \delta &= r = r_I(p_I, \tilde{w}, h_0) \\ b'^K &= \beta i_K - \tilde{c}_{A1} = X' = X'^A + X'^I \end{aligned}$$

The first equation defines the income of the capitalists (agents K , who are at the same time) as the output of the agricultural sector plus the return on

capital invested in manufacturing. The second equation specifies the equilibrium allocation of the capital inherited from the previous generation and the rate of return. The third group of equations establishes the bequest, and specifies that it must be used to install future capital, denoted X' in both sectors.

The system determines the evolution of the aggregate and sectoral capital stocks. It can be seen that, as long as there is a reservoir of workers, and there is no education, the rate of return in manufacturing stays constant. In this process of industrialization, all additional capital goes to sector I and industrial employment increases by drawing workers from the subsistence sector at a constant capital-labor ratio. This is clearly a result "à la Lewis".

We can study the evolution of wages. As stated before, if the wage of a worker with skills h is given by $w + w_h h$, the arbitrage condition with subsistence employment implies $\tilde{w} = w + w_h h_0$, assuming that the supply of non-educated labor is elastic. Then, if manufacturing starts production, equilibrium in the supply and demand of skills implies that:

Proposition 3 *In equilibrium:*

$$\frac{\tilde{w}}{w_h h_0} = \frac{\rho_L}{\rho_H}$$

In order to analyze the potential demand for education, it matters to consider how the main variables respond to changes in the supply of skills.

Lemma 2 *For a given level of skills, h , the demands for labor and skills in manufacturing imply the following properties in equilibrium:*

- *Wages:*

$$\frac{\partial w_h h}{\partial h} \geq 0 ; \frac{\partial w}{\partial h} \geq 0$$

- *Return to capital*

$$\frac{\partial r}{\partial h} \geq 0.$$

- *Labor-Output ratio:*

$$l(p_I, \tilde{w}, h) = \frac{L}{X_I} = \frac{r}{w + w_h h}, \frac{\partial L/X_I}{\partial h} < 0$$

• **Proof:** Immediate consequence of Lemma 1. \square

Consider now the existence of a social planner representing the capitalist-landlord agents (K). In analogy with the presentation in Galor and Moav (2003), the planner may tax agents K (the agents who leave bequests) in order to finance public education. Here, it should be stressed, the planner would only have an interest in educating the L agents who will work in industry I (and not the whole pool of subsistence workers). That is: the expenditure in education would be:

$$E = Le = X_I l(h(e))e$$

where e is the cost of education per worker and l the labor/capital ratio, which depends on h . The allocation of resources would be driven by the maximization of the total returns to agents K derived from agriculture and industrial activities.

Lemma 3 *The goal of the planner is summarized in the following condition:*

$$r'_I(h)h'(e)(1 + le + \frac{X_I l(h(e))e}{f''(X_A)}) = r_I(h(e))(l(h(e)) + l'(h(e))h'(e)e)$$

Proof: *The objectives of the planner are represented by the following maximization problem;*

$$\max f(X_A) + (1 - \delta)X_A + r_I(h(e))X_I$$

subject to

$$X_A + X_I + X_I l(h(e))e = b$$

and

$$f'(X_A) + 1 - \delta = r_I(h(e))$$

The solution yields the condition on returns. \square

The intuition is that a marginal increase in the skills per worker increases the unit return to industrial capital, but lowers investment in sector I by the direct impact of the expenditure, given the fixed amount of bequests, while the transfer of capital from agriculture operates in the opposite direction. The measure of the opportunity cost takes into account that an increase in h affects education expenditures by modifying the demand for labor, and thus the number of individuals to be educated. It may be expected that the level of education and acquired skills increases with capital accumulation. The economy would then go through a phase of growing incorporation of workers to industry, who would be educated in the process. The growth in wages in manufacturing may induce at some point savings by the workers, and dilute their difference with the capitalists. However, a full “demise of the class structure” (GM) does not seem a necessary result.

7.3 Early industrialization for the domestic market

The discussion in the previous exercise assumed that the price p_I was determined in the international market. But, if there is no developed world market (or the country is the "first comer"), industrial goods cannot be purchased abroad, but must be produced internally when the demand arises. Production diversifies in parallel with consumption.

The economy would now be described by the following equations:

- Demand for industrial goods:

$$p_I y_I = (1 - \beta) \alpha_{I3} (i^K - \tilde{i}_2)$$

where the notation is as before, and i^K is the income of the landlord/capitalists.

- Income of agents K :

$$i^K = f(X_A) + (1 - \delta)X_A + r_I(p_I, \tilde{w}, h)X_I$$

where, as before, X_A, X_I are the capital stocks in each sector, r_I the rate of return of capital in manufacturing, and h the average level of skills of the labor force in I .

- Supply of good I .

$$y_I = y_I(p_I, \tilde{w}, h)$$

- Allocation of capital:

$$f'(X_A) + 1 - \delta = r_I(p_I, \tilde{w}, h)$$

- Employment in manufacturing:

$$L = X_I l(p_I, \tilde{w}, h)$$

- Allocation of bequests

$$b = X_A + X_I + Le$$

where the possibility of allocating resources to education has been considered.

- Supply of skills:

$$h = h(e)$$

- Dynamics of bequests

$$b' = \beta(i^K - \tilde{i}_2) + \tilde{b}'_2$$

The system can be completed by specifying the choices on education, which could be determined, as before, by a government that optimizes on behalf of group K .