Review of Economic Studies (2009) **76**, 143–179 0034-6527/09/00060143$02.00

Inequality in Landownership, the Emergence of Human-Capital Promoting Institutions, and the Great Divergence

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First version received August 2005; *final version accepted March* 2008 (*Eds.*)

This paper suggests that inequality in the distribution of landownership adversely affected the emergence of human-capital promoting institutions (*e.g.* public schooling), and thus the pace and the nature of the transition from an agricultural to an industrial economy, contributing to the emergence of the great divergence in income *per capita* across countries. The prediction of the theory regarding the adverse effect of the concentration of landownership on education expenditure is established empirically based on evidence from the beginning of the 20th century in the U.S.

1. INTRODUCTION

The last two centuries have been characterized by a great divergence in income *per capita* across the globe. The ratio of GDP *per capita* between the richest and the poorest regions of the world has widened considerably from a modest 3 to 1 ratio in 1820 to an 18 to 1 ratio in 2001 (Maddison, 2001). The role of geographical and institutional factors, human-capital formation, ethnic, linguistic, and religious fractionalization, colonization, and globalization has been the centre of a debate about the origin of the differential timing of the transition from stagnation to growth and the remarkable change in the world income distribution.

This paper suggests that inequality in the distribution of landownership adversely affected the emergence of human-capital promoting institutions (public schooling and child labour regulations), and thus the pace and the nature of the transition from an agricultural to an industrial economy, contributing to the emergence of the great divergence in income *per capita* across countries.[1] The theory further suggests that some land-abundant countries that were characterized by

1. Most of the existing studies (*e.g.* Hall and Jones, 1999), attribute the differences in income *per capita* across countries largely to differences in total factor productivity (TFP), whereas some (*e.g.* Manuelli and Seshadri, 2005) provide evidence in favour of the dominating role of human capital. Nevertheless, it should be noted that even if the direct role of human capital is limited, it has a large indirect effect on growth via its effect on technological progress and the implementation of growth-enhancing institutions (Glaeser, La Porta, Lopez-De-Silanes and Shleifer, 2004).

an unequal distribution of land were overtaken in the process of industrialization by land-scarce countries in which land distribution was rather equal.

The transition from an agricultural to an industrial economy has changed the nature of the main economic conflict in society. Unlike the agrarian economy, which was characterized by a conflict of interest between the landed aristocracy and the masses, the process of industrialization has brought about an additional conflict between the entrenched landed elite and the emerging capitalist elite. The capitalists who were striving for an educated labour force supported policies that promoted the education of the masses, whereas landowners, whose interest lay in the reduction of the mobility of the rural labour force, favoured policies that deprived the masses from education.

The process of industrialization raised the importance of human capital in the production process, reflecting its complementarity with physical capital and technology. Investment in human capital, however, has been suboptimal due to credit market imperfections, and public investment in education has been therefore growth enhancing.[2] Nevertheless, human-capital accumulation has not benefited all sectors of the economy. In light of a lower degree of complementarity between human capital and land,[3] a rise in the level of education increased the productivity of labour in industrial production more than in agriculture, decreasing the return to land due to labour migration and the associated rise in wages. Landowners, therefore, had no economic incentives to support these growth enhancing educational policies as long as their stake in the productivity of the industrial sector was insufficient.[4]

The proposed theory suggests that the adverse effect of the implementation of public education on landowners' income from agricultural production is magnified by the concentration of landownership.[5] Hence, as long as landowners affect the political process and thereby the implementation of education reforms, inequality in the distribution of landownership is a hurdle for human-capital accumulation, slowing the process of industrialization and the transition to modern growth.[6]

Economies in which land was rather equally distributed implemented earlier public education and benefited from the emergence of a skilled-intensive industrial sector and a rapid process of development. In contrast, among economies marked by an unequal distribution of landownership, land abundance that was a source of richness in early stages of development, led in later stages to under-investment in human capital, an unskilled-intensive industrial sector, and a slower growth process. Thus, variations in the distribution of landownership across countries generated variations in the industrial composition of the economy, and thereby the observed diverging development patterns across the globe.[7]

2. See Galor and Zeira (1993), Fernandez and Rogerson (1996), Benabou (2000), and Galor and Moav (2004).

3. Although rapid technological change in the agricultural sector may increase the return to human capital (*e.g.* Foster and Rosenzweig, 1996), the return to education is typically lower in the agricultural sector, as evident by the distribution of employment. For instance, as reported by the U.S. Department of Agriculture (1998), 56·9% of agricultural employment consists of high-school dropouts, in contrast to an average of 13·7% in the economy as a whole. Similarly, 16·6% of agricultural employment consists of workers with 13 or more years of schooling, in contrast to an average of 54·5% in the economy as a whole.

4. Landowners may benefit from the economic development of other segments of the economy due to capital ownership, household's labour supply to the industrial sector, the provision of public goods, and demand spillover from economic development of the urban sector.

5. The proposed mechanism focuses on the emergence of public education. Alternatively, one could have focused on child labour regulation, linking it to human-capital formation as in Doepke and Zilibotti (2005), or on the endogenous abolishment of slavery (*e.g.* Lagerlof, 2003) and the incentives it creates for investment in human capital.

6. Consistent with the proposed theory, Besley and Burgess (2000) find that over the period 1958–1992 in India, land reforms have raised agricultural wages, despite an adverse effect on agricultural output.

7. As established by Chanda and Dalgaard (2008), variations in the allocation of inputs between the agriculture and the non-agriculture sectors are important determinants of international differences in TFP, accounting for between 30% and 50% of these variations.

The prediction of the theory regarding the adverse effect of the concentration of landownership on education expenditure is confirmed empirically based on data from the beginning of the 20th century in the U.S. Variations in public spending on education across states in the U.S. during the high-school movement are utilized in order to examine the thesis that inequality in the distribution of landownership was a hurdle for public investment in human capital. In addition, historical evidence suggests that, indeed, the distribution of landownership affected the nature of the transition from an agrarian to an industrial economy and has been significant in the emergence of sustained differences in human-capital formation and growth patterns across countries.

The next section places the research in the context of the existing literature. Sections 3 and 4 develop the theoretical model and its testable predictions. Section 5 provides anecdotal historical evidence that is consistent with the proposed hypothesis. Section 6 examines empirically the hypothesis that the concentration of landownership had an adverse effect on education expenditure based on the U.S. experience during the high-school movement, and Section 7 offers some concluding remarks.

2. RELATED LITERATURE

The central role of human-capital formation in the transition from stagnation to growth is underlined in unified growth theory (Galor, 2005). This research establishes theoretically (Galor and Weil, 2000; Galor and Moav, 2002) and quantitatively (Doepke, 2004; Fernandez-Villaverde, 2005; Lagerlof, 2006) that the rise in the demand for human capital in the process of industrialization and its effect on human-capital formation, technological progress, and the onset of the demographic transition have been the prime forces in the transition from stagnation to growth. As the demand for human capital emerged, variations in the extensiveness of human-capital formation and therefore in the rate of technological progress and the timing of the demographic transition significantly affected the distribution of income in the world economy (Voigtlander and Voth, 2006; Galor and Mountford, 2006, 2008).

The proposed theory suggests that the concentration of landownership has been a major hurdle in the emergence of human-capital promoting institutions. Thus the observed variations in human-capital formation and in the emergence of divergence and overtaking in economic performance is attributed to the historical differences in the distribution of landownership across countries. In addition to our own findings that land inequality had a significant adverse effect on education expenditure in the U.S., the predictions of the theory are consistent with the findings by Deininger and Squire (1998) and Easterly (2007) about the inverse relationship across countries between land inequality (across landowners), on the one hand, and human-capital formation and growth, on the other hand.[8]

The role of institutional factors has been the focus of an alternative hypothesis regarding the origin of the great divergence. North (1981), Landes (1998), Mokyr (1990, 2002), Parente and Prescott (2000), Glaeser and Shleifer (2002), and Acemoglu, Johnson and Robinson (2005) have argued that institutions that facilitated the protection of property rights, enhancing technological research and the diffusion of knowledge, have been the prime factor that enabled the earlier European take-off and the great technological divergence across the globe.

The effect of geographical factors on economic growth and the great divergence have been emphasized by Jones (1981), Diamond (1997), Sachs and Warner (1995), and Hibbs and Olsson (2005). The geographical hypothesis suggests that favourable geographical conditions permitted an earlier transition to agriculture in Europe and made it less vulnerable to the risk associated

8. Furthermore, Banerjee and Iyer (2005) show that historically landlord-dominated districts of West Bengal in India fare worse on agricultural productivity and schooling than small-holder districts.

with climate and diseases, leading to the early European take-off, whereas adverse geographical conditions in disadvantageous regions, generated permanent hurdles for the process of development.

The exogenous nature of the geographical factors and the inherent endogeneity of the institutional factors led researchers to hypothesize that initial geographical conditions had a persistent effect on the quality of institutions, leading to divergence and overtaking in economic performance.[9] Engerman and Sokoloff (2000), ES, provide descriptive evidence that geographical conditions that led to income inequality, brought about oppressive institutions (*e.g.* restricted access to the democratic process and to education) designed to maintain the political power of the elite and to preserve the existing inequality, whereas geographical characteristics that generated an equal distribution of income led to the emergence of growth promoting institutions. Acemoglu *et al.* (2005), AJR, provide evidence that reversals in economic performance across countries have a colonial origin, reflecting institutional reversals that were introduced by European colonialism across the globe. "Reversals of fortune" reflect the imposition of extractive institutions by the European colonialists in regions where favourable geographical conditions led to prosperity, and the implementation of growth enhancing institutions in poorer regions.[10]

The proposed theory differs in several important dimensions from the earlier analysis of the relationship between geographical factors, inequality, and institutions. First, it suggests that a conflict of interest between landowners and landless individuals, and in particular, among the economic elites (*i.e.* industrialists and landowners), rather than between the ruling elite and the masses as argued by ES and AJR, brought about the delay in the implementation of growth enhancing educational policies.[11] Hence, in contrast to the viewpoint of ES and AJR about the persistent desirability of extractive institutions for the ruling elite, the proposed theory suggests that the implementation of growth-promoting institutions emerges in the process of development as the economic interest of the two elites in the efficient operation of the industrial sector dominates. Second, consistent with existing cross-sectional evidence and the evidence presented in this paper, the theory underlines the adverse effect of unequal distribution of landownership (rather than wealth inequality as suggested by ES) in the timing of educational reforms. Third, the theory focuses on the direct economic incentive (*i.e.* the adverse effect of education reforms on the land rental rate) that induces the landed elite to block education reforms, rather than on the effect of political reforms on the distribution of political power and thus the degree of rent extraction. Hence, unlike ES, and AJR, even if the political structure remains unchanged, economic development may ultimately trigger the implementation of growth promoting institutions.[12]

A complementary approach suggests that interest groups (*e.g.* landed aristocracy and monopolies) block the introduction of new technologies and superior institutions in order to protect their political power and thus maintain their rent extraction. Olson (1982), Mokyr (1990), Parente and Prescott (2000), and Acemoglu and Robinson (2006) argue that this type of conflict, in the context of technology adoption, has played an important role throughout the evolution of

9. The role of ethnic, linguistic, and religious fractionalization in the emergence of divergence and "growth tragedies" has been linked to their effect on the quality of institutions (Easterly and Levine, 1997).

10. Additional aspects of the role of colonialism in comparative developments are analysed by Bertocchi and Canova (2002). Brezis, Krugman and Tsiddon (1993), in contrast, attribute technological leapfrogging to the acquired comparative advantage of the current technological leaders in the use of the existing technologies (via learning by doing).

11. The role of a conflict of interest within economic elites in economic and political transformation was examined earlier by Lizzeri and Persico (2004), Llavador and Oxoby (2005) and others.

12. In contrast to the political economy mechanism proposed by Persson and Tabellini (2000), where land concentration induces landowners to divert resources in their favour via distortionary taxation, in the proposed theory land concentration induces lower taxation so as to assure lower public expenditure on education, resulting in a lower economic growth. The proposed theory is therefore consistent with empirical findings that taxation is positively related to economic growth and negatively to inequality (*e.g.* Benabou, 1996; Perotti, 1996). Bowles (1978) discusses the incentives of landlords to restrict access to education in order to preserve a relatively cheap labour force.

industrial societies.[13] Interestingly, the political economy interpretation of our theory suggests, in contrast, that the industrial elite would relinquish power to the masses in order to overcome the desire of the landed elite to block economic development.[14]

Empirical research is inconclusive about the significance of human capital rather than institutional factors in the process of development. Some researchers suggest that initial geographical conditions affected the current economic performance primarily via their effect on institutions. Acemoglu *et al.* (2005), Easterly and Levine (2003), and Rodrik, Subramanian and Trebbi (2004) provide evidence that variations in the contemporary growth processes across countries can be attributed to institutional factors whereas geographical factors are secondary, operating primarily via variations in institutions. Moreover, Easterly and Levine (1997), and Alesina, Devleeschauwer, Easterly, Kurlat and Wacziarg (2003) demonstrate that geopolitical factors brought about a high degree of fractionalization in some regions of the world, leading to the implementation of institutions that are not conducive for economic growth and thereby to diverging growth paths across regions.

Glaeser *et al.* (2004) revisit the debate whether political institutions cause economic growth, or whether, alternatively, growth and human-capital accumulation lead to institutional improvement. In contrast to earlier studies, they find that human capital is a more fundamental source of growth than political institutions (*i.e.* risk of expropriation by the government, government effectiveness, and constraints on the executives). Moreover, they argue that poor countries emerge from poverty through good policies (*e.g.* human-capital promoting policies) and only subsequently improve their political institutions.

Finally, the paper contributes to the political economy approach to the relationship between inequality, redistribution, and economic growth. This literature argued initially that inequality generates political pressure to adopt redistributive policies and that the distortionary taxation that is associated with these policies adversely affects investment and economic growth (Alesina and Rodrik, 1994; Persson and Tabellini, 1994). Existing evidence, however, does not support either of the two underlying mechanisms (Perotti, 1996). In contrast, the proposed theory suggests that inequality (in the distribution of landownership) is in fact a barrier for redistribution and growth promoting educational policy, provided that landowners have sufficient political power. This mechanism resembles the one advanced by Benabou (2000) in his exploration of the relationship between redistribution and growth. He demonstrates that a country would implement an efficient tax policy and converge to a higher income steady state, provided that the initial level of inequality is low and that the better-endowed agents have therefore limited interest to lobby against it. Otherwise the efficient redistribution will be blocked, perpetuating initial inequality and confining the economy to a low-income steady state.[15]

3. THE BASIC STRUCTURE OF THE MODEL

Consider an overlapping generations economy in a process of development. In every period the economy produces a single homogeneous good that can be used for consumption and investment. The good is produced in an agricultural sector and in a manufacturing sector using land, physical, and human capital as well as raw labour. The stock of physical capital in every period is the output

13. Barriers to technological adoption that may lead to divergence are explored by Caselli and Coleman (2001), Howitt and Mayer-Foulkes (2005) and Acemoglu, Aghion and Zilibotti (2006) as well.

14. See Lizzeri and Persico (2004) and Ghosal and Proto (2005) as well.

15. This mechanism is echoed in Gradstein (2007) which argues that the support for the protection of property rights is greater the more equal is the distribution of income and the smaller is the political bias. Similarly, Bourguignon and Verdier (2000) suggest that if political participation is determined by the education (socioeconomic status) of citizens, the elite may not find it beneficial to subsidize universal public education despite the existence of positive externalities from human capital. See also Benabou (2002) for the trade-offs between redistribution and economic growth.

produced in the preceding period net of consumption and human-capital investment, whereas the stock of human capital in every period is determined by the aggregate public investment in education in the preceding period. The supply of land is fixed over time. Physical-capital accumulation raises the demand for human capital and output grows due to the accumulation of physical and human capital.[16]

At the outset, the economy consists of three groups of individuals: a homogeneous group of landowners, a homogeneous group of landless capitalists and workers who are landless and do not own capital initially. In the process of development, physical capital is accumulated by all groups.

3.1. *Production of final output*

The output in the economy in period t, y_t, is given by the aggregate output in the agricultural sector, y_t^{A}, and in the manufacturing sector, y_t^{M},

$$y_t = y_t^{\mathrm{A}} + y_t^{\mathrm{M}}. \tag{1}$$

3.1.1. The agricultural sector. Production in the agricultural sector occurs within a period according to a neoclassical, constant-returns-to-scale (CRS) production technology, using labour and land as inputs. The output produced at time t, y_t^{A}, is

$$y_t^{\mathrm{A}} = F(X_t, L_t), \tag{2}$$

where X_t and L_t are land and the number of workers, respectively, employed by the agricultural sector in period t. Hence, workers' productivity in the agricultural sector is independent of their level of human capital. The production function is strictly increasing and concave, the two factors are complements in the production process, $F_{XL} > 0$, and the function satisfies the neoclassical boundary conditions that assure the existence of an interior solution to the producers' profit-maximization problem.

Producers in the agricultural sector operate in a perfectly competitive environment. Given the wage rate per worker, w_t^{A}, and the rate of return to land, ρ_t, producers in period t choose the level of employment of labour, L_t, and land, X_t, so as to maximize profits. That is, $\{X_t, L_t\} = \arg\max[F(X_t, L_t) - w_t L_t - \rho_t X_t]$. The producers' inverse demand for factors of production is therefore,

$$\begin{aligned} w_t^{\mathrm{A}} &= F_L(X_t, L_t); \\ \rho_t &= F_X(X_t, L_t). \end{aligned} \tag{3}$$

3.1.2. Manufacturing sector. Production in the manufacturing sector occurs within a period according to a neoclassical, CRS, Cobb–Douglas production technology using physical and human capital as inputs.[17] The output produced at time t, y_t^{M}, is

$$y_t^{\mathrm{M}} = K_t^{\alpha} H_t^{1-\alpha} = H_t k_t^{\alpha}; \quad k_t \equiv K_t/H_t; \quad \alpha \in (0,1), \tag{4}$$

16. Alternatively, the rise in the demand for human capital could have been based on technological progress, and output growth could have been due to technological progress and factor accumulation. This specification would not alter the main qualitative results.

17. As will become apparent, the choice of a Cobb–Douglas production function assures that there is no conflict of interest among landless individuals regarding the optimal education policy, permitting the analysis to focus on the conflict between the landowners and the landless.

where K_t and H_t are the quantities of physical capital and human capital (measured in efficiency units) employed in production at time t. Physical capital depreciates fully after one period. In contrast to the agricultural sector, human capital has a positive effect on workers' productivity in the manufacturing sector.

Producers in the manufacturing sector operate in a perfectly competitive environment. Given the wage rate per efficiency unit of labour, w_t^{M}, and the rate of return to capital, R_t, producers in period t choose the level of employment of capital, K_t, and the number of efficiency units of labour, H_t, so as to maximize profits. That is, $\{K_t, H_t\} = \arg\max[K_t^\alpha H_t^{1-\alpha} - w_t^{\mathrm{M}} H_t - R_t K_t]$. The producers' inverse demand for factors of production is therefore

$$\begin{aligned} R_t &= \alpha k_t^{\alpha-1} \equiv R(k_t); \\ w_t^{\mathrm{M}} &= (1-\alpha) k_t^\alpha \equiv w^{\mathrm{M}}(k_t). \end{aligned} \tag{5}$$

3.2. *Individuals*

In every period a generation, which consists of a continuum of individuals of measure 1, is born. Individuals live for two periods. Each individual has a single parent and a single child. Individuals, within as well as across generations, are identical in their preferences and innate abilities, but they may differ in their wealth.

Preferences of individual i who is born in period t (a member i of generation t) are defined over second-period consumption, c_{t+1}^i, and a transfer to the offspring, b_{t+1}^i.[18] They are represented by a log-linear utility function

$$u_t^i = (1-\beta)\ln c_{t+1}^i + \beta \ln b_{t+1}^i, \tag{6}$$

where $\beta \in (0, 1)$.

In the first period of their lives individuals acquire human capital. In the second period of their lives individuals join the labour force, allocating the resulting wage income, along with their return to capital and land, between consumption and income transfer to their children. In addition, individuals transfer their entire stock of land to their offspring.[19]

An individual i born in period t receives a transfer, b_t^i, in the first period of life. A fraction $\tau_t \geq 0$ of this capital transfer is collected by the government in order to finance public education, whereas a fraction $1 - \tau_t$ is saved for future income.[20] Individuals devote their first period for the acquisition of human capital. Education is provided publicly free of charge. The acquired level of human capital increases with the real resources invested in public education. The number of efficiency units of human capital of each member of generation t in period $t+1$, h_{t+1}, is a

18. This form of altruistic bequest motive (*i.e.* the "joy of giving") is the common form in the recent literature on income distribution and growth. It is supported empirically by Altonji, Hayashi and Kotlikoff (1997). As discussed in Section 4, if individuals generate utility from the utility of their offspring the qualitative results remain intact. First period consumption may be viewed as part of the consumption of the parent.

19. This assumption captures the well-established observation (*e.g.* Bertocchi, 2006) that at least in early stages of development land is not fully tradable due to agency and moral hazard problems. It is designed to assure that landowners could be meaningfully defined as a distinct viable class. In the presence of a market for land, the anticipation of education reforms and the associated decline in rental rates would generate a decline in the price of land. Thus, as long as land is not fully tradable, landowners who would be the prime losers from the decline in the price of land would object to education reforms. If land would be fully traded, land holdings would be equivalent to any other asset holdings, and in contrast to historical evidence, landowners would not be a significant force in the political structure of the economy. The proportion of land-holding in the portfolio of each individual should not vary systematically across groups, and thus efficient education policy will be implemented.

20. As discussed below, an income tax rather than a bequest tax would complicate the analysis, but would not alter the qualitative results.

strictly increasing, strictly concave function of the government real expenditure on education per member of generation t, e_t.[21]

$$h_{t+1} = h(e_t), \tag{7}$$

where $h(0) = 1$, $\lim_{e_t \to 0^+} h'(e_t) = \infty$, and $\lim_{e_t \to \infty} h'(e_t) = 0$. Hence, even in the absence of real expenditure on public education individuals still posses one efficiency unit of human capital—basic skills—assuring the operation of the industrial sector in every time period.

In the second period of life, members of generation t join the labour force earning the competitive market wage w_{t+1}. In addition, individual i derives income from capital ownership, $b_t^i(1-\tau_t)R_{t+1}$, and from the return on landownership, $x^i \rho_{t+1}$, where x^i is the quantity of land owned by individual i. The individual's second-period income, I_{t+1}^i, is therefore

$$I_{t+1}^i = w_{t+1} + b_t^i(1-\tau_t)R_{t+1} + x^i \rho_{t+1}. \tag{8}$$

A member i of generation t allocates second-period income between consumption, c_{t+1}^i, and transfers to the offspring, b_{t+1}^i, so as to maximize utility subject to the second-period budget constraint:

$$c_{t+1}^i + b_{t+1}^i \le I_{t+1}^i. \tag{9}$$

Hence, the optimal transfer of a member i of generation t is,[22]

$$b_{t+1}^i = \beta I_{t+1}^i, \tag{10}$$

consumption $c_{t+1}^i = (1-\beta)I_{t+1}^i$, and the indirect utility function of a member i of generation t, v_t^i, is therefore monotonically increasing in I_{t+1}^i:

$$v_t^i = \ln I_{t+1}^i + \xi \equiv v(I_{t+1}^i), \tag{11}$$

where $\xi \equiv (1-\beta)\ln(1-\beta) + \beta \ln \beta$.

3.3. *Physical capital, human capital, and output*

The aggregate level of intergenerational transfers in period t, as follows from (10), is a fraction β of the aggregate level of income y_t. A fraction τ_t of this capital transfer is collected by the government in order to finance public education, whereas a fraction $1-\tau_t$ is saved for future consumption. The capital stock in period $t+1$, K_{t+1}, is therefore

$$K_{t+1} = (1-\tau_t)\beta y_t, \tag{12}$$

whereas the government tax revenues are $\tau_t \beta y_t$.

Let θ_{t+1} be the fraction (and the number—since population is normalized to 1) of workers employed in the manufacturing sector. The education expenditure per young individual in period t, e_t, is,

$$e_t = \tau_t \beta y_t, \tag{13}$$

21. A more realistic formulation would link the cost of education to (teachers') wages, which may vary in the process of development. As can be derived from Section 3.4, under both formulations the optimal expenditure on education, e_t, is an increasing function of the capital–labour ratio in the economy, and the qualitative results remain therefore intact.

22. Note that individual's preferences defined over the transfer to the offspring, b_t^i, or over net transfer, $(1-\tau_t)b_t^i$, are represented in an indistinguishable manner by the log-linear utility function. Under both definitions of preferences the bequest function is given by $b_{t+1}^i = \beta I_{t+1}^i$.

and the stock of human capital, employed in the manufacturing sector in period $t+1$, H_{t+1}, is therefore,

$$H_{t+1} = \theta_{t+1} h(\tau_t \beta y_t). \tag{14}$$

Hence, output in the manufacturing sector in period $t+1$ is,

$$y^{\mathrm{M}}_{t+1} = [(1-\tau_t)\beta y_t]^{\alpha}[\theta_{t+1} h(\tau_t \beta y_t)]^{1-\alpha} \equiv y^{\mathrm{M}}(y_t, \tau_t, \theta_{t+1}), \tag{15}$$

and the physical–human capital ratio $k_{t+1} \equiv K_{t+1}/H_{t+1}$ is,

$$k_{t+1} = \frac{(1-\tau_t)\beta y_t}{\theta_{t+1} h(\tau_t \beta y_t)} \equiv k(y_t, \tau_t, \theta_{t+1}), \tag{16}$$

where k_{t+1} is strictly decreasing in τ_t and in θ_{t+1}, and strictly increasing in y_t. As follows from (5), the capital share in the manufacturing sector is

$$(1-\tau_t)\beta y_t R_{t+1} = \alpha y^{\mathrm{M}}_{t+1}, \tag{17}$$

and the labour share in the manufacturing sector is given by

$$\theta_{t+1} h(\tau_t \beta y_t) w^{\mathrm{M}}_{t+1} = (1-\alpha) y^{\mathrm{M}}_{t+1}. \tag{18}$$

The supply of labour to agriculture, L_{t+1}, is equal to $1-\theta_{t+1}$, and the supply of land is fixed over time at a level $X > 0$. Output in the agriculture sector in period $t+1$ is, therefore,

$$y^{\mathrm{A}}_{t+1} = F(X, 1-\theta_{t+1}) \equiv y^{\mathrm{A}}(\theta_{t+1}; X). \tag{19}$$

As follows from the properties of the production functions both sectors are active in $t+1$ as long as $\tau_t < 1$. Hence, since individuals are perfectly mobile between the two sectors they can either supply one unit of labour to the agriculture sector and receive the wage w^{A}_{t+1} or supply h_{t+1} efficiency units of labour to the manufacturing sector and receive the wage income $h_{t+1} w^{\mathrm{M}}_{t+1}$.[23] Hence,

$$w^{\mathrm{A}}_{t+1} = h_{t+1} w^{\mathrm{M}}_{t+1} \equiv w_{t+1}, \tag{20}$$

and the fraction of employment in the manufacturing sector, θ_{t+1}, equalizes the marginal product of workers in the two sectors, and thus maximizes output *per capita* in the economy.

Lemma 1. *The fraction of workers employed by the manufacturing sector in period* $t+1$, θ_{t+1} *is uniquely determined:*

$$\theta_{t+1} = \theta(y_t, \tau_t; X),$$

where $\theta_X(y_t, \tau_t; X) < 0$, $\theta_y(y_t, \tau_t; X) > 0$, *and* $\lim_{y\to\infty} \theta(y_t, \tau_t; X) = 1$.
Moreover, θ_{t+1} *maximizes output in period* $t+1$, y_{t+1} :

$$\theta_{t+1} = \arg\max y_{t+1}.$$

Proof. Substituting (3), (5), and (16) into (20) it follows that

$$\Phi(\theta_{t+1}, y_t, \tau_t; X) \equiv F_L(X, 1-\theta_{t+1}) - h(\tau_t \beta y_t)(1-\alpha)\left(\frac{(1-\tau_t)\beta y_t}{\theta_{t+1} h(\tau_t \beta y_t)}\right)^{\alpha} = 0. \tag{21}$$

23. Even if mobility between the sectors is not fully unrestricted, the qualitative results would not be altered.

Hence, since $\partial\Phi(\theta_{t+1}, y_t, \tau_t; X)/\partial\theta_{t+1} > 0$, it follows from the Implicit Function Theorem that there exists a single-valued function $\theta_{t+1} = \theta(y_t, \tau_t; X)$, where the properties of the function are obtained noting the properties of the function $h(\tau_t \beta y_t)$ and $F_L(X, 1-\theta_{t+1})$. Moreover, since θ_{t+1} equalizes the marginal return to labour in the two sectors, and since the marginal products of all factors of production are decreasing in both sectors, $\theta_{t+1} = \arg\max y_{t+1}$. ||

Corollary 1. *Given land size, X, prices in period $t+1$ are uniquely determined by y_t and τ_t. That is,*

$$w_{t+1} = w(y_t, \tau_t; X);$$

$$R_{t+1} = R(y_t, \tau_t; X);$$

$$\rho_{t+1} = \rho(y_t, \tau_t; X).$$

Proof. As established in Lemma 1, $\theta_{t+1} = \theta(y_t, \tau_t; X)$, and the corollary follows noting (3), (5), (16), and (19). ||

3.4. *Efficient expenditure on public education*

This section demonstrates that the level of expenditure on public schooling (and hence the level of taxation) that maximizes aggregate output is optimal from the viewpoint of all individuals except for landowners who own a large fraction of the land in the economy.

Lemma 2. *Let τ_t^* be the tax rate in period t that maximizes aggregate output in period $t+1$,*

$$\tau_t^* \equiv \arg\max y_{t+1}.$$

(a) *τ_t^* equates the marginal return to physical capital and human capital:*

$$\theta_{t+1} w^{\mathrm{M}}(k_{t+1}) h'(\tau_t^* \beta y_t) = R(k_{t+1}).$$

(b) $\tau_t^* = \tau^*(y_t) \in (0,1)$ *is unique, and $\tau^*(y_t) y_t$, is strictly increasing in y_t.*
(c) $\tau_t^* = \arg\max y_{t+1}^{\mathrm{M}}$.
(d) $\tau_t^* = \arg\max (1-\tau_t) R_{t+1}$.
(e) $\tau_t^* = \arg\max \theta(y_t, \tau_t; X)$.
(f) $\tau_t^* = \arg\max w_{t+1}$.
(g) $\tau_t^* = \arg\min \rho_{t+1}$.

Proof.

(a) As follows from (15), (19), and Lemma 1, aggregate output in period $t+1$, y_{t+1} is

$$y_{t+1} = y(y_t, \tau_t; X) = y^{\mathrm{M}}(y_t, \tau_t, \theta(y_t, \tau_t; X)) + y^{\mathrm{A}}(\theta(y_t, \tau_t; X); X). \tag{22}$$

Hence, since, as established in Lemma 1, $\theta_{t+1} = \theta(y_t, \tau_t; X) = \arg\max y_{t+1,}$ it follows from the envelop theorem that

$$\frac{\partial y_{t+1}}{\partial \tau_t} = \frac{\partial y^{\mathrm{M}}(y_t, \tau_t, \theta_{t+1})}{\partial \tau_t}. \tag{23}$$

Furthermore, since $\tau_t^* = \arg\max y_{t+1}$ then $\partial y^{\mathrm{M}}(y_t, \tau_t^*, \theta_{t+1})/\partial \tau_t = 0$, and thus as follows from (15),

$$\theta_{t+1}(1-\alpha) h'(\tau_t^* \beta y_t) = \alpha \frac{\theta_{t+1} h(\tau_t^* \beta y_t)}{(1-\tau_t^*)\beta y_t}. \tag{24}$$

Noting 16, τ_t^* satisfies

$$\theta_{t+1}(1-\alpha)k_{t+1}^{\alpha}h'(\tau_t^*\beta y_t) = \alpha k_{t+1}^{\alpha-1}, \tag{25}$$

and the proof follows, noting that $\alpha k_{t+1}^{\alpha-1} \equiv R(k_{t+1})$, and $(1-\alpha)k_{t+1}^{\alpha} \equiv w^{\mathrm{M}}(k_{t+1})$.

(b) As follows from (24),

$$\frac{(1-\tau_t^*)\beta y_t}{h(\tau_t^*\beta y_t)} = \frac{\alpha}{(1-\alpha)h'(\tau_t^*\beta y_t)}. \tag{26}$$

Hence, since $h(\tau_t^*\beta y_t) \geq 1$ for all $\tau_t^*\beta y_t \geq 0$ and $\lim_{e_t \to 0^+} h'(e_t) = \infty$, it follows that $\tau_t^* = \tau^*(y_t) \in (0,1)$ for all $y_t > 0$. The uniqueness of τ_t^* follows from the properties of the function $h(\tau_t^*\beta y_t)$. Furthermore, $\tau^*(y_t)y_t$ is increasing in y_t. Suppose not. Suppose that $\tau^*(y_t)y_t$ is decreasing in y_t. It follows that τ^* is strictly decreasing in y_t, and therefore the L.H.S. of (26) is strictly increasing in y_t, whereas the R.H.S. is decreasing, a contradiction.

(c) As derived in part (a), since $\tau_t^* = \arg\max y_{t+1}$, it follows from the envelope theorem that

$$\tau_t^* = \arg\max y^{\mathrm{M}}(y_t, \tau_t, \theta(y_t, \tau_t; X)) = \arg\max[(1-\tau_t)\beta y_t]^{\alpha}[h(\tau_t\beta y_t)]^{1-\alpha}\theta_{t+1}^{1-\alpha}. \tag{27}$$

(d) Follows from part (c) noting that, as follows from (17), $(1-\tau_t)R_{t+1} = \alpha y_{t+1}^{\mathrm{M}}/(\beta y_t)$.

(e) As follows from part (c),

$$\tau_t^* = \arg\max[(1-\tau_t)\beta y_t]^{\alpha}[h(\tau_t\beta y_t)]^{1-\alpha}\theta_{t+1}^{1-\alpha}, \tag{28}$$

and therefore for any θ_{t+1},

$$\tau_t^* = \arg\max[(1-\tau_t)\beta y_t]^{\alpha}[h(\tau_t\beta y_t)]^{1-\alpha}. \tag{29}$$

Moreover, since

$$\begin{aligned}\theta_{t+1} &= \theta(y_t, \tau_t; X) = \arg\max y_{t+1} \\ &= \arg\max[(1-\tau_t)\beta y_t]^{\alpha}[h(\tau_t\beta y_t)]^{1-\alpha}\theta_{t+1}^{1-\alpha} + F(X, 1-\theta_{t+1}),\end{aligned} \tag{30}$$

it is strictly increasing in $[(1-\tau_t)\beta y_t]^{\alpha}[h(\tau_t\beta y_t)]^{1-\alpha}$, and therefore $\tau_t^* = \arg\max \theta(y_t, \tau_t; X)$.

(f) As follows from (3) and (20),

$$w_{t+1} = F_L(X, 1-\theta_{t+1}), \tag{31}$$

and therefore since w_{t+1} is monotonically increasing in θ_{t+1} it follows from part (e) that $\tau_t^* = \arg\max w_{t+1}$.

(g) Follows from part (f) noting that along the factor price frontier ρ_t decreases in w_t^{A} and therefore in w_t. ||

As established in Lemma 2 the value of τ_t^* is independent of the size of land, X. The size of land has two opposing effects on τ_t^* that cancel one another due to the Cobb–Douglas production function in the manufacturing sector. Since a larger land size implies that employment in the manufacturing sector is lower, the fraction of the labour force whose productivity is improved due to taxation that is designed to finance universal public education is lower. In contrast, the return to each unit of human capital employed in the manufacturing sector is higher, while the return to physical capital is lower, since human capital in the manufacturing sector is scarce.

Furthermore, since the tax rate is linear and the elasticity of substitution between human and physical capital in the manufacturing sector is unitary, as established in Lemma 2, the tax rate that maximizes aggregate output in period $t+1$ also maximizes the wage per worker, w_{t+1}, and the net return to capital, $(1-\tau_t^*)R_{t+1}$. Hence, there is no conflict of interest among individuals who do not own land regarding the optimal education policy.[24] Moreover, given the factor price frontier, since τ_t^* maximizes the wage per worker, w_{t+1}, it minimizes the rent on land, ρ_{t+1}.

As follows from Lemma 2, the desirable tax policy from the viewpoint of individual i depends on the income that the individual derives from land holding, $x^i\rho_{t+1}$, relative to the income that the individual generates from capital holding and wages, $w_{t+1}+b_t^i(1-\tau_t)R_{t+1}$. In particular, as established in the following proposition, individuals whose land income is sufficiently small relative to their capital and wage income would support the efficient tax policy.

Proposition 1. *Given (b_t^i, y_t, X), there exists a sufficiently low level of land holding by individual i, $\hat{x}_t^i$, such that the desirable level of taxation from the viewpoint of individual i is the level of taxation that maximizes output per capita, τ_t^*. $\hat{x}_t^i$ is inversely related to the level of b_t^i.*

Proof. Since the indirect utility function is a strictly increasing function of the individual's second-period wealth, I_{t+1}^i, the desirable level of taxation from the viewpoint of individual i maximizes $I_{t+1}^i = I^i(y_t,\tau_t,b_t^i,x^i;X) = w(y_t,\tau_t;X)+b_t^i(1-\tau_t)R(y_t,\tau_t;X)+x^i\rho(y_t,\tau_t;X)$. As established in Lemma 2, $w(y_t,\tau_t;X)+b_t^i(1-\tau_t)R(y_t,\tau_t;X)$ is maximized at an interior level τ_t^*, and $x^i\rho(y_t,\tau_t;X)$ is minimized by the same interior level τ_t^*. Hence, for all x^i, τ_t^* is the extremum of $I^i(y_t,\tau_t,b_t^i,x^i;X)$, and thus $\partial I^i(y_t,\tau_t^*,b_t^i,x^i,X)/\partial\tau_t = 0$. In particular for $x^i=0$, τ_t^* is a global maximum of $I^i(y_t,\tau_t,b_t^i,x^i;X)$. Thus, it follows from continuity that there exists $\hat{x}_t^i>0$ such that for all $x^i\in(0,\hat{x}_t^i)$, the extremum, τ_t^*, remains a global maximum of $I^i(y_t,\tau_t,b_t^i,x^i;X)$. Since $\partial\rho(y_t,\tau_t,b_t^i,x^i,X)/\partial\tau_t<\infty$, it follows from the continuity of $I^i(y_t,\tau_t^*,b_t^i,x^i,X)$ in x^i that there exists a sufficiently low level of x^i, $\hat{x}_t^i$, such that $\tau_t^* = \arg\max I_{t+1}^i$ for all $x^i\le\hat{x}_t^i$ (*i.e.* there exists a sufficiently low x^i such that τ_t^* maximizes I_{t+1}^i globally), where $\hat{x}_t^i$ is inversely related to the levels of b_t^i. ∥

3.5. *The class structure*

Suppose that in period 0 the economy consists of three homogeneous groups of individuals in the first period of their lives—landowners, capitalists, and workers. They are identical in their preferences and differ only in their initial wealth and landownership. Landowners are a fraction $\lambda\in(0,1)$ of all individuals in society who equally share the entire stock of land in the economy, X. Since landowners are homogeneous in period 0 and since land is bequeathed from parent to child and each individual has a single child and a single parent, it follows that the distribution of landownership in society is constant over time, where each landlord owns X/λ units of land. Capitalists are a fraction $\mu\in(0,1)$ of all individuals in society who equally share the entire initial stock of physical capital.[25] Finally, workers are a fraction $1-\lambda-\mu\in(0,1)$ of all individuals in society. They are landless and they do not own physical capital. Since individuals are initially

24. The absence of disagreement between the capitalists and workers about the optimal tax policy would hold as long as the production function is Cobb–Douglas. However, even if the elasticity of substitution was different from 1, in contrast to land owners, both groups would support public education although they would differ in their desirable tax rates. If the elasticity is larger than unity but finite, then the tax rate that maximizes the wage per worker would have been larger than the optimal tax rate and the tax rate that maximizes the return to capital would have been lower, yet strictly positive. If the elasticity of substitution is smaller than unity, the opposite holds.

25. Heterogeneity in capital holdings across capitalists will not affect the analysis since as established in the discussion that follows Lemma 2, there is no conflict of interest among the landless. Furthermore, if each landowner, as well, owns an equal stock of capital in the first period, the qualitative analysis will not be affected.

homogeneous within a group, the uniqueness of the solution to their optimization problem assures that their offspring are homogeneous as well. Hence, in every period a fraction μ of all adults are homogeneous descendants of the capitalists, a fraction $1 - \lambda - \mu$ are homogeneous descendants of workers, and a fraction λ are landowners. As the economy develops, members of all segments of society accumulate physical capital.

3.6. *Political mechanism*

In light of our interest in the effect of economic rather than political transitions on education reforms and economic growth, the political structure of the economy is designed as a stationary structure that is unaffected by economic development. In particular, we deliberately impose a crude political mechanism under which education reforms require the consent of the class of Landowners. Although economic development does not affect this political structure, it changes the economic incentives confronted by landowners and thereby affects their attitude towards educations reforms.

Clearly, even in democracies, the median voting model is not perfectly applicable. Strong interest groups, such as landowners, exert a larger influence on public policy relative to their representation in the population. For the sake of simplicity we adopt an extreme modelling approach that provides landowners as a group with a veto power against education reforms. The adoption of some alternative approaches, such as a lobbing model, or probabilistic voting model (Lindbeck and Weibull, 1987), would not change the qualitative results. Moreover, in order to focus on the conflict between Landowners and the remaining segments of the economy, we abstract from a potential conflict of interest among landowners, assuming land is equally distributed across landowners, and coordination among landowners is therefore not essential.[26]

Suppose, in particular, that changes in the existing educational policy require the consent of all segments of society.[27] In the absence of consensus the existing educational policy remains intact. Suppose further that consistently with the historical experience, societies initially do not finance education (*i.e.* $\tau_0 = 0$). It follows that unless all segments of society would find it beneficial to alter the existing educational policy, the tax rate will remain 0. Once all segments of society find it beneficial to implement educational policy that maximizes aggregate output, this policy would remain in effect unless all segments of society would support an alternative policy. Since the landless (*i.e.* workers and capitalists) are unified in their support for an efficient level of taxation in every time period, the consent of the landowners is the pivotal force in the implementation of the output maximizing education level.[28]

26. The introduction of inequality in land-holdings across landowners would not affect the qualitative results. It would have an ambiguous effect on the timing of education reforms. Large landowners would be expected to suffer a larger loss in rental rents due to education reforms and would be engaged in more intense lobbying activity to block these reforms, but their force will be diminished due to their smaller representation within the group of landowners.

27. For simplicity, it is assumed that the decision on the desirable tax rate is taken by the young generation. A more natural assumption would be to permit the parental generation to choose the desirable level of taxation and thus the resources that would be devoted to the education of their children. A departure from warm glow utility would achieve this goal at the cost of significant complications. In particular, if individuals' utility is defined over their offspring's income, parents would choose the desirable tax rate from the viewpoint of the child. This departure would maintain the crucial feature of a monotonic relationship between bequest and income, but since the total size of transfer will not necessarily be a constant fraction of wealth it would complicate the analysis unnecessarily. Similarly, the choice of an income tax rather than bequest tax would complicate the analysis. As long as the parental generation chooses the tax rate on their income, individuals would optimally allocate their income between their own consumption, transfer to their offspring, and finance of public education. Hence, as long as individuals take the tax structure into account when deciding how much to bequest, it would not affect the result qualitatively.

28. Landowners, as well as other owners of factors of production, influence the level of public schooling but are limited in their power to levy taxes for their own benefit. Otherwise, following the Coasian Theorem, the landed elite would prefer an optimal level of education, taxing the resulting increase in aggregate income.

3.7. *Landowners' desirable schooling policy*

The income of each landowner in the second period of life, I^L_{t+1}, as follows from (8) and Corollary 1, is

$$I^L_{t+1} = w(y_t, \tau_t; X) + (1-\tau_t)R(y_t, \tau_t; X)b^L_t + \rho(y_t, \tau_t; X)X/\lambda, \tag{32}$$

and b^L_{t+1}, as follows from (10) is therefore

$$b^L_{t+1} = \beta[w(y_t, \tau_t; X) + (1-\tau_t)R(y_t, \tau_t; X)b^L_t + \rho(y_t, \tau_t; X)X/\lambda] \equiv b^L(y_t, b^L_t, \tau_t; X, \lambda). \tag{33}$$

As summarized in the following Lemma, the economy advances and the share of land in aggregate output gradually declines, the stake of landowners in other sectors gradually increases, due to their labour and capital holdings, and their objection to education reforms therefore declines over time.[29]

Proposition 2. *In the absence of taxation in the initial period, that is,* $\tau_0 = 0$, *given the political mechanism,*

(a) *There exists a critical level of the aggregate capital inheritance of all landowner,* $\hat{B}^L_t$, *where* $B^L_t = \lambda b^L_t$, *above which their income under the efficient tax policy* τ^*_t *is higher than under* $\tau_t = 0$, *and the economy switches to* τ^*_t*—the tax rate that maximizes income per capita.*

$$\hat{B}^L_t = \frac{\lambda[w(y_t, 0; X) - w(y_t, \tau^*_t; X)] + X[\rho(y_t, 0; X) - \rho(y_t, \tau^*_t; X)]}{(1-\tau^*_t)R(y_t, \tau^*_t; X) - R(y_t, 0; X)} \equiv \hat{B}^L(y_t; X, \lambda).$$

(b) *The critical level of capital holdings,* $\hat{B}^L_t$, *above which the efficient tax policy is chosen,*

(i) *increases with the degree of land inequality in the economy, that is,*

$$\partial \hat{B}^L(y_t; X, \lambda)/\partial \lambda < 0;$$

(ii) *is 0 for a sufficiently low level of land inequality (i.e. for a sufficiently large* λ*). In particular,*

$$\lim_{\lambda \to 1} \hat{B}^L(y_t; X, \lambda) \leq 0.$$

(iii) *is 0 for a sufficiently large level of income per capita. In particular,*

$$\lim_{y_t \to \infty} \hat{B}^L(y_t; X, \lambda) \leq 0.$$

(iv) *Let* $\hat{t}$ *be the first period in which the efficient tax policy,* $\tau_t = \tau^*_t$, *is implemented. The efficient tax policy will remain in place thereafter, that is,*

$$\tau_t = \tau^*_t \quad \forall t \geq \hat{t}.$$

29. The proposed theory relies on the diminishing importance of land rents for the income of the economy over time, in accordance with the long-run trend in developed countries. For the U.K., Lindert (1986) documents that the share of land rent in national income in 1867 was 5%, falling to less than 0·5% in 1972–1973. A similar pattern is found for the U.S., where in 1900 the share of national income going to rent was 9·1%, by 1930 was 6·6%, and by 2005 was 0·7%. (The 1900 figure is from the U.S. Historical Statistics, series F186–191. The 1930 and 2005 figures are from the Bureau of Economic Analysis.) If land is used only in the agricultural sector, the decline in its rental rate in the process of development, to a level below a positive threshold, assures that landowners would ultimately support education reforms. If land is also used in the manufacturing sector, the results will not be affected qualitatively, as long as the share of land that is employed in the industrial sector is initially small. The rise in the rental rate on industrial land in the process of urbanization and its impact on the rise on the rental rate of land in the economy as a whole, would just accelerate the transition, since it will increase landowners' benefits from the process of industrialization.

(a) Noting that landlords are identical and their number is unchanged in the process of development, the tax policy that maximizes income of all landowners also maximizes the income of each landowner. As follows from (32), $\hat{B}^L_{t+1} = \hat{B}^L(y_t; X, \lambda)$ is the level of $B^L_t = \lambda b^L_t$ that equates the income of landowners in the case were $\tau_t = 0$ and $\tau_t = \tau^*_t$. $\hat{B}^L_{t+1}$ exists since as established in Lemma 2 $\tau^*_t = \arg\max(1-\tau_t)R_{t+1}$, and thus $(1-\tau^*_t)R(y_t, \tau^*_t; X) - R(y_t, 0; X) > 0$.

(b) (i) Follows directly from the derivation of $\hat{b}(y_t; X, \lambda)$, with respect to λ, noting that for a given y_t, λ has no effect on prices and that for $y_t > 0$, $\tau^*_t = \arg\max w_{t+1} > 0$, and therefore $\left[w(y_t, 0; X) - w(y_t, \tau^*_t; X)\right] < 0$.

(ii) Since the agriculture production function (2) is CRS, it follows that the aggregate return to land is

$$X\rho_{t+1} = F(X, 1-\theta_{t+1}) - w_{t+1}(1-\theta_{t+1}). \tag{34}$$

Hence, landlord's income, $\lambda I^i_{t+1} = \lambda w_{t+1} + (1-\tau_t)R_{t+1}B^L_t + X\rho_{t+1}$, is

$$\lambda I^L_{t+1} = w(y_t, \tau_t; X)[\lambda + \theta_{t+1} - 1] + (1-\tau_t)R(y_t, \tau_t; X)B^L_t + F(X, 1-\theta_{t+1}). \tag{35}$$

Since $\theta_{t+1} = \arg\max \rho_t = \arg\max F(X, 1-\theta_{t+1}) - w_{t+1}(1-\theta_{t+1})$, it follows from the envelope theorem that

$$\frac{\partial \lambda I^L_{t+1}}{\partial \tau_t} = \frac{\partial w(y_t, \tau_t; X)}{\partial \tau_t}\left[\lambda + \theta_{t+1} - 1\right] + \frac{\partial (1-\tau_t)R(y_t, \tau_t; X)}{\partial \tau_t} B^L_t. \tag{36}$$

Thus if $\lambda > 1 - \theta_{t+1} > 0$, it follows from Lemma 2 that for any $B^L_t \geq 0$,

$$\operatorname{sign}\left[\frac{\partial \lambda I^L_{t+1}}{\partial \tau_t}\right] \begin{cases} > 0 \text{ for } \tau < \tau^*_t \\ = 0 \text{ for } \tau = \tau^*_t \\ < 0 \text{ for } \tau > \tau^*_t, \end{cases} \tag{37}$$

and therefore for a sufficiently large λ the threshold is 0, that is, $\lim_{\lambda \to 1} \hat{B}^L(y_t; X, \lambda) \leq 0$.

(iii) As follows from Lemma 1, as $y_t \to \infty$, $\theta_{t+1} \to 1$ and therefore it follows from (36) that for any $B^L_t \geq 0$, (37) holds and hence $\lim_{y_t \to \infty} \hat{B}^L(y_t; X, \lambda) \leq 0$.

(c) As established in Proposition 1, the desirable tax policy from the viewpoint of landless (*i.e.* workers and capitalists) is τ^*_t. Hence, given that the political mechanism requires a consensus for changes in the tax policy, once the chosen tax rate is τ^*_t it will remain so thereafter.[30] ‖

Remark 1. There exists a range of agricultural production functions such that the desirable level of taxation from the viewpoint of landowners, τ^L_t, are $\tau_t = 0$ or $\tau_t = \tau^*_t$, in the range $\tau^L_t \in [0, \tau^*_t]$.[31] It should be noted that given the political mechanism, and the absence of taxation

30. It should be noted that, in fact, landowners optimal tax rate will remain τ^*_t thereafter, since education reforms would further increase the stake of landowners in the non-agricultural part of the economy.

31. In particular, the preferred tax rate from the viewpoint of landowners will be $\tau_t = 0$ or $\tau_t = \tau^*_t$ when the elasticity of substitution between labour and land is 0 or 1. (i) If the production function is Cobb–Douglas $F(X, L_t) = AX^\gamma L_t^{1-\gamma}$, as established in Appendix A, landowners would prefer either $\tau_t = 0$ or $\tau_t = \tau^*_t$ over any $\tau_t \in (0, \tau^*_t)$. (ii) If land and labour are perfect complements, as established in Proposition 5, as long as the wage rate is below the threshold level above which the demand for workers in agriculture is 0, landowners prefer the lowest level of industrial output, y^{M}_t, and hence $\tau_t = 0$. As the economy develops and the wage rate crosses this threshold, their preferred tax rate is τ^*_t since the return to land is 0 anyway.

in period 0, even if the desirable level of taxation from the viewpoint of a landowner, τ_t^L, is any level in the interval $(0, \tau_t^*)$, the tax rate that prevails in the economy in every period t is either 0 or τ_t^*. Under a different political structure the transition from a zero tax rate to τ_t^* could be a gradual process. The process of development will induce landowners to compromise (or support) increasingly higher levels of taxation and the qualitative results regarding the adverse effect of land inequality on the implementation of education reforms would remain intact.

4. THE PROCESS OF DEVELOPMENT

This section analyses the evolution of an economy from an agricultural to an industrial-based economy. It demonstrates that the gradual decline in the importance of the agricultural sector along with an increase in the capital holdings in landlords' portfolio may alter the attitude of landlords towards educational reforms. In societies in which land is scarce or its ownership is distributed rather equally, the process of development allows the implementation of an optimal education policy, and the economy experiences a significant investment in human capital and a rapid process of development. In contrast, in societies where land is abundant and its distribution is unequal, an inefficient education policy will persist and the economy will experience a lower growth path as well as a lower level of output in the long-run. Thus, land reforms that sufficiently reduce inequality in landownership permit an earlier implementation of an efficient education policy.

Proposition 3. *The conditional evolution of output per capita, as depicted in Figure 1, is given by*

$$y_{t+1} = \begin{cases} \psi^0(y_t) \equiv (\beta y_t)^\alpha \theta(y_t, 0; X)^{1-\alpha} + F(X, 1-\theta(y_t, 0; X)) & for\ \ \tau_t = 0; \\ \psi^*(y_t) \equiv [(1-\tau_t^*)\beta y_t)^\alpha [\theta(y_t, \tau_t^*; X) h(\tau_t^* \beta y_t))^{1-\alpha} & \\ \qquad + F(X, 1-\theta(y_t, \tau_t^*; X)) & for\ \tau_t = \tau_t^*, \end{cases}$$

where,

$$\psi^*(y_t) > \psi^0(y_t) \quad for\ y_t > 0.$$

$$d\psi^j(y_t)/dy_t > 0, \quad d^2\psi^j(y_t)/dy_t^2 < 0, \quad \psi^j(0) = F(X,1) > 0, \quad d\psi^j(y_t)/dX > 0, \quad and$$

$$\lim_{y_t \to \infty} d\psi^j(y_t)/dy_t = 0; \quad j = 0, *.$$

Proof. As follows from (1), (15), and (19), $y_{t+1} = y_{t+1}^{\mathrm{A}} + y_{t+1}^{\mathrm{M}} = [(1-\tau_t)\beta y_t)^\alpha [\theta_{t+1} h(\tau_t \beta y_t))^{1-\alpha} + F(X, 1-\theta_{t+1})$. Thus, noting that, $h(0) = 1$ the evolution of y_{t+1} as stated in the proposition is obtained. Since $\tau_t^* = \arg\max y_{t+1}$ and $\tau_t^* > 0$, it follows that $\psi^*(y_t) > \psi^0(y_t)$ for $y_t > 0$. As follows from Lemma 1 and Proposition 2, the properties of the functions $\psi^*(y_t)$ and $\psi^0(y_t)$ follows, noting that $\theta_{t+1} = \arg\max y_{t+1}$, $\tau_t^* = \arg\max y_{t+1}$ and applying the envelop theorem. ||

Note that the evolution of output *per capita*, for a given schooling policy, is independent of the distribution of land and income.

Corollary 2. *Given the size of land, X, there exists a unique $\bar{y}^0$ and a unique $\bar{y}^*$ such that*

$$\bar{y}^0 = \psi^0(\bar{y}^0);$$
$$\bar{y}^* = \psi^*(\bar{y}^*),$$

where $\bar{y}^* > \bar{y}^0$.

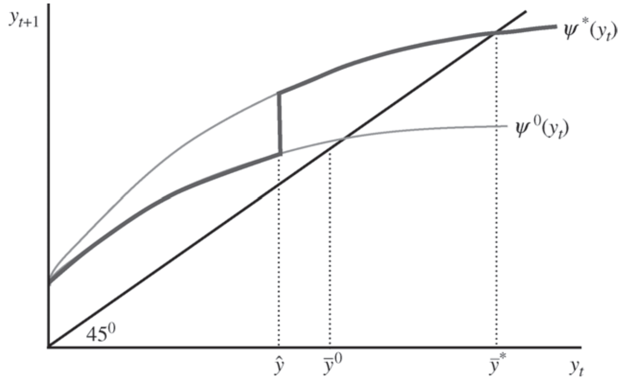

FIGURE 1

The evolution of income *per capita* before and after the implementation of education reforms

Proof. Follows from the properties of $\psi^*(y_t)$ and $\psi^0(y_t)$, as established in Proposition 3. ||

The evolution of income *per capita*, as depicted in Figure 1, and as follows from Propositions 2 and 3, is

$$y_{t+1} = \begin{cases} \psi^0(y_t) & for\ t < \hat{t} \\ \psi^*(y_t) & for\ t \geq \hat{t}. \end{cases}$$

Hence, the economy evolves on the lower trajectory dictated by $\psi^0(y_t)$ till time $\hat{t}$ (*e.g.* where the level of income is $\hat{y} \equiv y_{\hat{t}}$) and then moves to a higher trajectory that is governed by $\psi^*(y_t)$.

Proposition 4. *For a given set of initial conditions, (i.e. y_0, k_0, X, $h_0 = 1$, $B_0^L = \lambda\beta I_0^L < \hat{B}^L(y_0; X, \lambda)$ and therefore $\tau_0 = 0$), a less equal land distribution (i.e. a low level of λ) will generate a delay in the implementation of an efficient education policy and will therefore result in an inferior growth path. That is, a less equal distribution of landownership implies that the timing of the implementation of the efficient tax policy, $\hat{t}$, is delayed.*

Proof. As follows from (33), noting that $B_{t+1}^L = \lambda b_{t+1}^L = \lambda\beta I_{t+1}^L$, the evolution of aggregate capital holdings of landowners, for $\tau_t = 0$, and for $t > 0$ is

$$B_t^L = \beta[\lambda w_{t-1} + R_{t-1} B_{t-1}^L + X\rho_{t-1}]. \tag{38}$$

As established in Proposition 3, as long as $\tau_t = 0$, the evolution of income *per capita*, y_t, is independent of λ. Hence it follows from Corollary 1 that factor prices are independent of λ and therefore, as follows from (38), B_t^L is increasing in λ. Hence, noting that as established in Proposition 2 $\hat{B}^L(y_t; X, \lambda)$ is decreasing with λ, the lower is λ the larger is $\hat{t}$ (*i.e.* the later is the time period in which $B_t^L > \hat{B}_t^L$).

Proposition 5 (Persistence of Inefficient Education Policy). *If the productivity in the manufacturing sector is limited, and the degree of complementarity between land and labour is sufficiently high, then there exists a sufficiently high level of land inequality (i.e. a sufficiently low λ), such that inefficient education policy will persist indefinitely (i.e. $\hat{t} \to \infty$).*

Proof. Suppose that the production function in the agriculture sector is $y_t^{\mathrm{A}} = F(X, L_t) = \min\{X, L_t\}$, where, $X < 1$ (*i.e.* X is smaller than the size of the working population) to assure that some workers are employed in the industrial sector. Hence, for $w_t < 1$, $X = L_t = 1 - \theta_t$. As follows from (18) and (20), $w_t = (1-\alpha)y_t^{\mathrm{M}}/\theta_t$. Therefore, for $w_t < 1$,

$$\rho_t = 1 - w_t = 1 - \frac{1-\alpha}{\theta_t} y_t^{\mathrm{M}} = 1 - \frac{1-\alpha}{1-X} y_t^{\mathrm{M}}.$$

Suppose, for the sake of simplicity, that $X = \alpha$. Then, for $y_t^{\mathrm{M}} < 1$

$$w_t = y_t^{\mathrm{M}};$$

$$\rho_t = 1 - y_t^{\mathrm{M}}.$$

Hence, if for $y_t^{\mathrm{M}} < 1$, the income of all landowners, noting (17), is

$$\lambda I_t^L = \lambda w_t + \rho_t X + s_t^L \alpha y_t^{\mathrm{M}} = \alpha + [\lambda + \alpha(s_t^L - 1)] y_t^{\mathrm{M}},$$

where s_t^L is the share of landowners in the total capital stock. Since $s_t^L < 1$, it follows that for a sufficiently low λ landowners' income is decreasing with y_t^{M}, as long as $y_t^{\mathrm{M}} < 1$. Hence, since $\bar{y}^0 < \psi^*(\bar{y}^0)$, then if $\psi^*(\bar{y}^0) < 1$ landowners prefer $\tau_t = 0$, rather than $\tau_t = \tau_t^*$ when $y_t = \bar{y}^0$. ||

Corollary 3 (Land Reforms and Education Policy). *A land reform that reduces sufficiently the concentration of landownership in the economy (i.e. a sufficient increase in λ) would expedite the implementation of efficient education policy.*

Proof. Follows from Proposition 4. ||

Hence, consistent with historical anecdotes presented in the next section, land reforms would be expected to follow by education reforms.

Under the conditions specified in Proposition 5 there exists a steady-state equilibrium in which an inefficient education policy exists. In particular, as depicted in Figure 2, country A reaches a steady-state equilibrium at a level of income *per capita* $[\bar{y}^0]^{\mathrm{A}}$, prior to the implementation of education reforms that would have occurred if the level of income *per capita* in the economy would have reached $\hat{y}^{\mathrm{A}}$.

Thus, among countries where land inequality is higher (*i.e.* λ is smaller) a poverty trap, in which inefficient education policy persists may emerge. In particular, a country could reach the low income steady state $\bar{y}^0$ before reaching the point in which B_t^L is sufficiently large to bring about a policy shift. In contrast, for sufficiently equal economies, $\hat{t}$ is necessarily finite. In particular if landownership is equally distributed across members of society (*i.e.* if $\lambda = 1$), then as established in Proposition 2, the efficient tax policy is implemented in period 0.

Hence, the distribution of land within and across countries affected the nature of the transition from an agrarian to an industrial economy, generating diverging growth patterns across countries. Furthermore, land abundance that was beneficial in early stages of development, brought about a hurdle for human-capital accumulation and economic growth among countries that were marked by an unequal distribution of landownership. As depicted in Figure 2, some land-abundant countries, which were associated with the club of the rich economies in the pre-industrial revolution era and were characterized by an unequal distribution of land, were overtaken in the process of industrialization by land-scarce countries. The qualitative change in the role of land in the

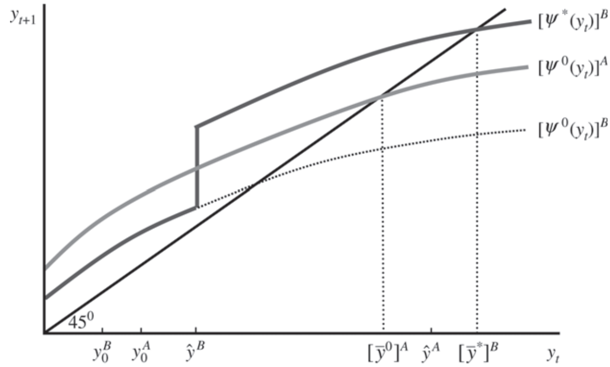

FIGURE 2

Overtaking. Country A is relatively richer in land, however, due to land inequality it fails to implement efficient schooling and is overtaken by country B

process of industrialization has brought about changes in the ranking of countries in the world income distribution.[32]

In the process of development, as long as the economy implements an efficient education policy, inequality subsides over time. In particular, inequality between workers and capitalists asymptotically disappear, whereas inequality between landowners and the landless subsides, due to the decline in the return to land. If the economy remains in a poverty trap, however, inequality between landowners and landless will not converge, while inequality between workers and capitalists will asymptotically disappear.[33]

Land inequality and wealth inequality may have a very different effect on education reforms. While inequality in landownership delays education reforms, inequality in the distribution of capital among the landless has no effect on the timing of education reforms, whereas a larger concentration of capital held by the landowners would expedite the implementation of education reforms.

5. HISTORICAL EVIDENCE

Historical evidence suggests that indeed the distribution of landownership has been a significant force in the emergence of sustained differences in human-capital formation and growth patterns across countries.

32. If the utility of individuals is defined over the discounted stream of utilities of their offspring, the qualitative results will not be affected. An earlier implementation of education reforms would raise the income of future members of a landowner's dynasty on the account of the contemporary income of the landowner. The optimal timing of the implementation of education reforms from the viewpoint of each landowner would depend, therefore, on the discount factor applied for future members of the dynasty. It would occur earlier than in the case in which individuals do not generate utility from the utility of their offspring, but would be still affected adversely by the degree of land inequality, since it determines the relative stake of landowners in other segments of the economy. In particular, if $\bar{y}^* < 1$, in the context of Proposition 5, there exists a sufficiently high level of land inequality such that inefficient education policy will persist indefinitely (*i.e.* landowners would not find it beneficial to implement education reforms in any time period). In this case, regardless of the discount factor applied to offspring the timing of education reforms will not be affected at all (*i.e.* $\hat{t} \to \infty$).

33. The distinction between workers and capitalists fades in the limit due to the simplifying structure of homothetic preferences. If preferences are non-homothetic, as in Galor and Moav (2006), inequality in the distribution of landownership, that would delay the implementation of efficient schooling would slow down this convergence process.

5.1. *Landownership and the level of education*

Anecdotal evidence suggests that the degree of concentration of landownership across countries and regions is inversely related to education expenditure and attainment. North and South America provide the most distinctive set of suggestive evidence about the relationship between the distribution of landownership, education reforms, and the process of development. The original colonies in North and South America had a vast amount of land per person and levels of income *per capita* that were comparable to the Western European ones. North and Latin America, however, differed in the distribution of land and resources. While the U.S. and Canada have been characterized by a relatively egalitarian distribution of landownership, in the rest of the new world land and resources have been persistently concentrated in the hand of the elite (Deninger and Squire, 1998).

Consistent with the proposed theory, persistent differences in the distribution of landownership between North and Latin America were associated with significant divergence in education and income levels across these regions (Maddison, 2001). Although all of the economies in the western hemisphere were developed enough in the early 19th century to justify investment in primary schools, only the U.S. and Canada were engaged in the education of the general population (Coatsworth, 1993; Engerman and Sokoloff, 2000).[34]

Variations in the degree of inequality in the distribution of landownership among Latin American countries were reflected in variation in investment in human capital as well. In particular, Argentina, Chile, and Uruguay, in which inequality in the distribution of landownership was less pronounced, invested significantly more in education (Engerman and Sokoloff, 2000). Similarly, Nugent and Robinson (2002) show that in Costa Rica and Colombia, where coffee is typically grown in small farms (reflecting lower inequality in the distribution of land) income and human capital are significantly higher than that of Guatemala and El Salvador, where coffee plantations are rather large.[35] Moreover, one of the principles championed by the Progressives during the Mexican Revolution of 1910 was compulsory, free public education. However, the achievement of this goal varied greatly by state. In the north, with a relatively more equitable land distribution, enrolment in public schools increased rapidly as industrialization advanced following the revolution. This is in contrast to the southern states, which were dominated by the *haciendas* who employed essentially slave labour. In these states there was virtually no increase in school enrolment following the revolution (Vaughan, 1982). Similarly, rural education in Brazil lagged due to the immense political power of the local landlords. Hence, in 1950, 30 years after the Brazilian government had instituted an education reform, nearly 75% of the nation was still illiterate (Bonilla, 1965).

5.2. *Land reforms and education reforms*

Evidence from Japan, Korea, Russia, and Taiwan indicates that land reforms were followed by, or occurred simultaneously with, significant education reforms. There are two interpretations for those historical episodes. First, as proposed explicitly by the theory, land reforms may diminish

34. One may view the civil war in the U.S. as a struggle between the industrialists in the north who were striving for a large supply of (educated) workers and the landowners in the south who wanted to sustain the existing system and to assure the existence of a large supply of cheap (uneducated) labour.

35. In contrast to the proposed theory, Nugent and Robinson (2002) suggest that a hold-up problem generated by the monopsony power in large plantations prevents commitment to reward investment in human capital, whereas smallholders can capture the reward to human capital and have therefore the incentive to invest. This mechanism does not generate the economic forces that permit the economy to escape this institutional trap.

the economic incentives of landowners to block education reforms. Second, a non-favourable shift in the balance of power from the viewpoint of the landed aristocracy brought about the implementation of both land and education reforms, consistently with the basic premise that landowners opposed education spending whereas others (*e.g.* the industrial elite) favoured it.

5.2.1. Japan and the Meiji restoration. Towards the end of Tokugawa regime (1600–1867), although the level of education in Japan was impressive for its time, the provision of education was sporadic and had no central control or funding, reflecting partly the resistance of the land-holding military class for education reforms (Gubbins, 1973). The opportunity to modernize the education system arrived with the overthrow of the traditional feudal structure shortly after the Meiji Restoration of 1868. In 1871, an Imperial Decree initiated the abolishment of the feudal system. In a sequence of legislation in the period 1871–1883, decisions on land utilization and choice of crops were transferred to farmers from their landlords, prohibitions on the sale and mortgage of farmland were removed, a title of ownership was granted to the legal owners of the land, and communal pasture and forest land was transferred from the ownership of wealthy landlords to the ownership of the central government. This legislation resulted in the distribution of land holdings among small family farms, which persisted until the rise of a new landlord system during the 1930's (Hayami, 1975, ch. 3).

Education reform and land reform evolved simultaneously. In 1872 the Educational Code established compulsory and locally funded education for all children between ages 6 and 14 (Gubbins, 1973, ch. 30). In addition, a secondary school and university system was funded by the central government. The Education Code of 1872 was refined in 1879 and 1886, setting the foundations for the structure of Japanese education until World War II. The progress in education attainment following the land reforms of the Meiji government was substantial. While in 1873 only 28% of school-age children attended schools, this ratio increased to 51% by 1883 and to 94% by 1903 (Passin, 1965).

5.2.2. Russia before the revolution. Education in Tsarist Russia lagged well behind comparable European countries at the close of the 19th century. Provincial councils dominated by wealthier landowners were responsible for their local school systems and were reluctant to favour education for the peasants (Johnson, 1969). Literacy rates in the rural areas were a mere 21% in 1896, and the urban literacy rate was only 56%. As the Tsar's grip on power weakened during the early 1900's the political power of the wealthy landowners gradually declined leading to a sequence of agrarian reforms that were initiated by the premier Stolypin in 1906. Restrictions on mobility of peasants were abolished, fragmented land-holdings were consolidated, and the formation of individually owned farms was encouraged and supported through the provision of government credit. Stolypin's reforms accelerated the redistribution of land to individual farmers and land-holdings of the landed aristocracy declined from about 35–45% in 1860 to 17% in 1917 (Florinsky, 1961).

Following the agrarian reforms and the declining influence of the landed aristocracy, the provision of compulsory elementary education had been proposed. The initial effort of 1906 languished, but the newly created representative Duma continued to pressure the government to provide free compulsory education. In the period 1908–1912, the Duma approved a sequence of significant increases in expenditures for education (Johnson, 1969). The share of the Provincial council's budget that was allocated to education increased from 20·4% in 1905 to 31·1% in 1914 (Johnson, 1969), the share of the central government's budget that was devoted to the Ministry of Public Education increased three-fold from 1·4% in 1906 to 4·9% in 1915, and the share of the entire population that was actively attending schools increased threefold from 1·7% in 1897 to 5·7% in 1915 (Dennis, 1961).

5.2.3. South Korea and Taiwan. The process of development in Korea was marked by a major land reform followed by a massive increase in governmental expenditure on education. During the Japanese occupation in the period 1905–1945, land distribution in Korea became increasingly skewed, and in 1945 nearly 70% of Korean farming households were simply tenants (Eckert, 1990). In 1948–1950, the Republic of Korea instituted the Agricultural Land Reform Amendment Act that drastically affected land-holdings.[36] The principle of land reform was enshrined in the constitution of 1948 and the actual implementation of the Agricultural Land Reform Amendment Act began on 10 March 1950.[37] This act prohibited tenancy and land renting, put a maximum on the amount of land any individual could own, and dictated that an individual could only own land if they actually cultivated it. Owner cultivated farm households increased sixfold from 349,000 in 1949 to 1,812,000 in 1950, and tenant farm households declined from 1,133,000 in 1949 to essentially 0 in 1950 (Yoong-Deok and Kim, 2000).

Land reforms were accompanied by soaring expenditure on education. In 1949, a new Education Law was passed within South Korea that focused specifically on transforming the population into a technically competent work-force capable of industrial work. This led to dramatic increases in the number of schools and students at all levels of education. Between 1945 and 1960 the number of elementary schools increased by 60% and the number of elementary students went up by a staggering 165%. In secondary education the growth is even more dramatic, with both the number of schools and the number of students growing by a factor of ten in the same time period. The number of higher education institutions quadrupled and the number of higher education students increased from only 7000 in 1945 to over 100,000 in 1960. In 1948, Korea allocated 8% of government expenditure to education. Following a slight decline due to the Korean war, educational expenditure has increased to 9·2% in 1957 and 14·9% in 1960, remaining at about 15% thereafter (Sah-Myung, 1983).

Taiwan experienced a similar path over the same period once the Japanese colonization ended. The government of Taiwan implemented a land reform in the time period 1949–1953. It enforced rent reductions, sold public land to individual farmers who had previously been tenants, and permitted the purchase of rented land. In 1948, prior to the land reform, 57% of farm families were full or part owners, 43% were tenants or hired hands. By 1959 the share of full or part owners had increased to 81%, and the share of tenants or hired hands dropped to 19% (Cheng, 1961).

A massive educational reform accompanied these land reforms. The number of schools in Taiwan grew by 5% per year between 1950 and 1970, while the number of students grew by 6% a year. The pattern of growth mirrors that of South Korea, with especially impressive growth of 11% per year in the number of secondary students and 16% per year in the number of higher education students. Funding for education grew from 1·78% of GNP in 1951 to 4·12% in 1970 (Lin, 1983).

In 1950 South Korea and Taiwan were primarily agricultural economies with a GDP *per capita* (measured in 1990 international dollars) of $770 and $936, respectively. South Korea and Taiwan lagged in GDP *per capita* well behind many countries within Latin America, such as Colombia ($2153) and Mexico ($2365), sharing with these countries a legacy of vast inequality

36. A major force behind this land reform was the aim of the U.S. provisional government after World War II to remove the influence of the large landowners (who were either Japanese or collaborators with the Japanese).

37. Formally the education reform took place prior to the land reforms, but the provision for land reform was enshrined in the constitution prior to the educational reform. The imminent land reform could have reduced the incentives for the landed aristocracy to oppose this education reform.

in the distribution of agricultural land. In contrast to the Latin American countries, the implementation of land reforms in South Korea and Taiwan and its apparent effect on education reforms affected their growth trajectory significantly, leading them to one of the most successful economic growth stories of the post-war period. From a level of income *per capita* in 1950 that placed them not only far behind the nations of Latin America but also behind Congo, Liberia, and Mozambique, these two countries have each grown at an average rate of nearly 6% per year between 1950 and 1998, leaving behind the countries of sub-Saharan Africa and overtaking the Latin American countries in this period. In 1998 South Korea and Taiwan had GDP *per capita* levels 150% higher than Colombia and 100% higher than Mexico (Maddison, 2001).

6. EVIDENCE FROM THE U.S. HIGH-SCHOOL MOVEMENT

The central hypothesis of this research, that land inequality adversely affected the timing of education reforms, is examined empirically using variations in public spending on education across states and over time in the U.S. during the high-school movement. Historical evidence from the U.S. on education expenditures and landownership in the period 1880–1940 suggests that land inequality had a significant adverse effect on educational expenditures during this period.[38]

During the first half of the 20th century the education system in the U.S. underwent a major transformation from insignificant to nearly universal secondary education. As established by Goldin (1998), in 1910 high-school graduation rates were between 9 and 15% in the Northeast and the Pacific regions and only about 4% in the South. By 1950 graduation rates were nearly 60% in the Northeast and the Pacific regions and about 40% in the South. Furthermore, Goldin and Katz (1997) document significant variations in the timing of these changes and their extensiveness across regions.

The high-school movement and its qualitative effect on the structure of education in the U.S. reflected an educational shift towards non-agricultural learning that is at the heart of the proposed hypothesis. The high-school movement was undertaken with the intention of building a skilled work-force that could better serve the manufacturing sector. Over this period, firms increasingly demanded skilled workers who could be effective managers, sales personnel, and clerical workers, and courses in accounting, typing, shorthand, and algebra were highly valued in the white-collar occupations. In addition, in the 1910s, some of the high-technology industries of the period started to demand blue-collar craft workers who were trained in mathematics, chemistry, and electricity (Goldin, 1999).

The proposed theory suggests that inequality in the distribution of landownership was significant in determining the pace of education reforms across the U.S. We exploit differences in education expenditures across states over the period 1900–1940 to identify the role of the land inequality on education expenditures, controlling for the level of income *per capita*, the percentage of the black population, and the urbanization rate within each state.[39]

6.1. *Data*

The level of expenditure per child within each state in the time period 1900–1940 is computed, utilizing data on the number of children in the state in each of the relevant years from the relevant

38. For other studies of the relationship between land and economic performance in the U.S. over this time period see Gerber (1991) and Caselli and Coleman (2001).

39. Consistently with the proposed theory and the empirical findings, Wright (1986) suggests that Southern governments, influenced heavily by land-holders, refused to expand enrolments and spending in education because the North which provided a significant outside option for educated workers would reap the benefits from it.

U.S. Census.[40] These expenditures are converted to 1920 dollars to match the income *per capita* estimates used.[41]

Education expenditure varied greatly over this period. For example, in 1900 the state of Alabama was spending \$3·16 (in 1920 dollars) per child on education. In contrast, Massachusetts had expenditures of \$44·57 per child, a 14-fold difference. By 1920, Alabama had expenditures of \$11·78 per child, while spending per child in Massachusetts had increased to \$45·09, only four times greater than Alabama's spending. In 1940, the gap had narrowed to less than a factor of three, \$35·61 for Alabama and \$102·87 for Massachusetts.

The degree of inequality in the distribution of landownership is captured in a consistent fashion with the structure of the model by the share of land held by large landowners. In particular, based on U.S. Census data, we trace the evolution of the share of land holdings by the minimal number of farms that constitute 20% of agricultural land in 1880 within each state, as outlined in Appendix B. For subsequent years, 1900 and 1920, the share of land held by this same number of the largest farms is measured. To illustrate the methodology, in Wisconsin in 1880 the largest 15,145 farms (11% of total farms) held 20% of the farmland. In 1900, the largest 15,145 farms held 16% of the land, declining to 12% in 1920. The qualitative results are not affected if we use alternatively as a benchmark the share of land holdings by the minimal number of farms that held 5%, 10%, 25%, 50%, or 80% of the land in 1880.

The evolution of land concentration across regions in the U.S. (as defined in Appendix C) exhibits the following patterns. For states in the Northeast, the average share rose from 20% in 1880 to 22% in 1900 and 24% in 1920. Southern states experienced a decline in the average share of land held by the largest farms from 20% in 1880 to 12% in 1900 and to only 8% by 1920. This decline in the share of land held by large farmers is mimicked in the West, where the share drops to 9% in 1900 and to 6% in 1920. Similarly, the Midwest experienced a decline from 20% in 1880 to 16% in 1900 to 13% in 1920.

Several other controls are included in the specifications. Variation in income *per capita* across states that would be expected to affect the variation in education expenditures. The percentage of the black population is included to ensure that the adverse effect of inequality in the distribution of landownership on educational expenditure does not reflect the adverse effect of the discrimination in the South (where land inequality is more pronounced), on educational expenditure.[42] The final control, the percentage of urban population is added for several reasons. Given economies of scale, it may be that more urbanized states in fact have lower expenditures per child due to their higher density. Furthermore, urbanization and industrialization are highly

40. The precise age ranges used in each census vary, but as these changes are common to all states, this does not introduce any bias into the results. The available age ranges are 5–17 years in 1880, 5–20 years in 1900, 7–20 years in 1920, and 5–19 years in 1950

41. The total population of school-age children in each state, rather than the actual number of students, is used because states could control their total expenditures by limiting the number of actual pupils (*e.g.* the exclusion of blacks from public education in the South during much of the period under study).

42. Black students often suffered not only from insufficient funding, but were also excluded from the education system entirely in many places. Margo (1990) identifies several avenues along which black students suffered in relation to their white peers during the periods of the study. Blacks also lived predominantly in the South, where land inequality was relatively high as a result of the plantation system. An additional avenue of influence for the black population (and labour in general) involves mobility. Wright (1970) argued that some Southern states limited education spending because of the fear that the educated workers would migrate out of their home states. However, while the amount of internal migration was large in absolute terms, relative to the size of the population it was much less important. Eldridge and Thomas (1957) calculate an index of interstate redistribution, which measures the percentage of the population that would have to be moved in any decade in order to match the previous decade's distribution by state. In 1900–1910, this index is 4·25%, and then is lower in every decade through 1940–1950. As this index also reflects changes in population distribution due to fertility differences between states, it overestimates the effect of internal migration. It thus seems likely that there was appreciable friction to labour mobility, and that local education expenditures could, to some extent, benefit local populations. Including net migration rates from Eldridge and Thomas (1957) as part of the empirical specifications that follow does not alter the results.

correlated, and urbanization may partly control for capital intensity across states and the higher demand for human capital in the urban sector.[43]

6.2. *Empirical specifications and results*

The empirical analysis examines the effect of inequality in the distribution of landownership (*i.e.* the land share of large landowners) in state i in period $t-1$, on log expenditure per child in state i in period t, $\ln e_{it}$, over four periods of observation: 1880, 1900, 1920, and 1940.[44] In particular, for $t = 1900, 1920, 1940$, and $t-1 = 1880, 1900, 1920$, respectively,

$$\ln e_{it} = \beta_0 + \beta_1 S_{i,t-1} + \beta_2 \ln y_{i,t-1} + \beta_3 U_{i,t-1} + \beta_4 B_{i,t-1} + \upsilon_{it} \tag{39}$$

where $S_{i,t-1}$ is the land share of large farms in state i in period $t-1$, $\ln y_{i,t-1}$ is the log income *per capita* in state i in period $t-1$, $U_{i,t-1}$ is the percentage of the urban population in state i in period $t-1$, $B_{i,t-1}$ is the percentage of the black population in state i in period $t-1$, and υ_{it} is the error term of state i in period $t-1$. This formulation captures the existence of a lag between the current economic conditions and their effect on the political structure and the implementation of educational policy.

There are several concerns in exploiting cross-states variations in the distribution of landownership, and education expenditures to assess the effect of inequality in the distribution of landownership on education expenditure.

First, an unobserved factor at the state level, which is correlated with the distribution of landownership, may have affected education expenditure. In order to overcome this concern we examine the first difference of equation (39), and estimate the effect of changes in land concentration on changes in education expenditures. This strategy permits the estimation of the parameter of interest, β_1, while allowing for a time invariant unobserved heterogeneity across states in the level of the log expenditure per child.

Second, an unobserved factor at the state level may have affected both the changes in the distribution of landownership and the changes in education expenditure. Our empirical strategy allows for linear unobserved heterogeneity across states in the time trend of log expenditure per child. Thus, the estimation of the effect of changes in land concentration on changes in education expenditures with state fixed effects, controls for a linear unobserved heterogeneity across states in the time trend of the log expenditure per child. Namely, we presume that changes in explanatory variables are not correlated with changes in the error term, even if the levels of the explanatory variables might be correlated with it. Although we do not control for a non-linear state trend, as will become apparent, the coefficient of interest is robust to the inclusion of the linear time trend, and thus one should not expect the non-linear specification to affect the significance of the results.

Third, one may be concerned about potential reverse causality from education expenditure to inequality in landownership. This concern is addressed in several dimensions. We regress education expenditure, e_{it}, on lagged concentration of landownership, $S_{i,t-1}$. The lagging allows for some control of potential reverse causality running from education expenditures to the land share

43. The theory predicts that the size of the capital stock interacts with inequality in landownership to determine the nature of education expenditure. While the measures of the aggregate capital stock per person by state is available, the inferences of the theory are about capital holdings by landowners, that is unavailable. Regardless, inclusion of the (log) aggregate capital stock per person in place of, or in addition to, the urban percentage does not alter any of the empirical results that follow. Moreover, the use of income *per capita* controls for some of the effect of capital per worker as well.

44. An alternate specification would be to examine the effect on the log of total expenditure $\ln E_{it}$ as opposed to the log of expenditure per child $\ln e_{it}$. This would eliminate any concern that expenditures per child were changing due to random fluctuations in the size of the population. Regressions using $\ln E_{it}$ as the dependent variable, and including the size of the log child population, as an explanatory variable, do not alter the results qualitatively.

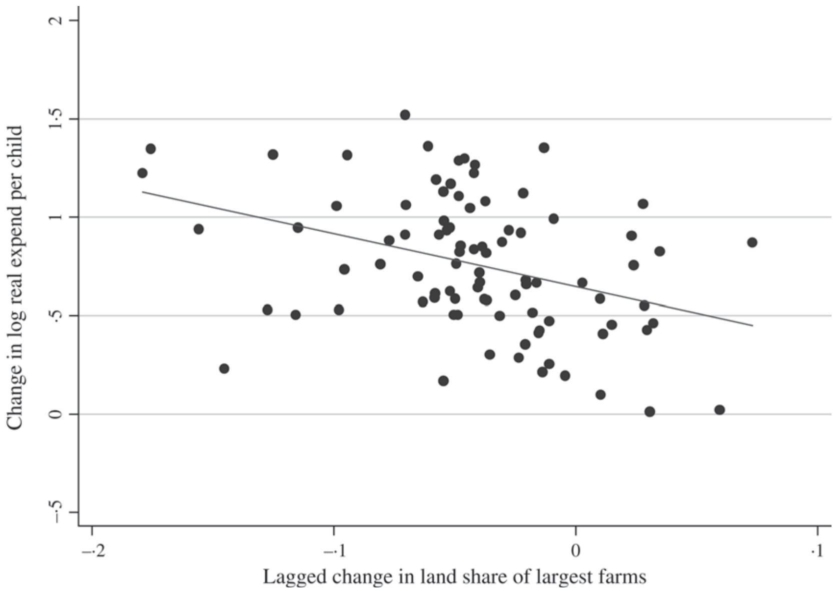

FIGURE 3

Changes in education expenditure per child and changes in the concentration in landownership

of the largest farms (*i.e.* it is reasonable that S in 1900 will affect e in 1920, but unlikely that S in 1920 will affect e in 1900). However, we might still capture reverse causation if there is serial correlation in education expenditures. This concern is handled in three different ways: (a) Since we estimate the effect of changes in land concentration on changes in education expenditures, the concern is the presence of serial correlation in the changes in education expenditure. However, we find that there is no serial correlation in the difference of education expenditures (while there is serial correlation in the level of education expenditures). (b) We control for state-specific time trends in education expenditure. (c) An instrument for concentration of landownership is developed that provides us with exogenous variation in the concentration of landownership, S_{t-1}, and permits us to establish the causal effect of land inequality on education expenditures.

Thus, we allow for a time invariant unobserved heterogeneity across states in the level of the log expenditure per child, η_i, and a linear unobserved heterogeneity across states in the time trend of the log expenditure per child, $\theta_i t$, as well as variations in the time effect at the national level, δ_t. Namely,

$$v_{it} = \eta_i + \delta_t + \theta_i t + \varepsilon_{it}. \tag{40}$$

First differencing (39) and utilizing (40) it follows that

$$\Delta \ln e_{it} = \beta_1 \Delta S_{i,t-1} + \beta_2 \Delta \ln y_{i,t-1} + \beta_3 \Delta U_{i,t-1} + \beta_4 \Delta B_{i,t-1} + \Delta \delta_{t-1} + \theta_i + \Delta \varepsilon_{it}, \tag{41}$$

where $\Delta \ln e_{it} \equiv \ln e_{it+1} - \ln e_{it}$ (*i.e.* the difference in the log expenditure per child in state i between 1920 and 1900 and between 1940 and 1920), $\Delta S_{i,t-1} \equiv S_{i,t} - S_{i,t-1}$ (*i.e.* the difference in land share of large farms in state i between 1900 and 1880 and between 1920 and 1900), and $\Delta\delta_{t-1} = \delta_t - \delta_{t-1}$. The lag operator is similarly defined for the rest of the explanatory variables. Given the empirical specification (41) and the available data, we have two possible observations for each state. Due to limitations in the data we have 79 total observations over 41 states, with three states having data only from 1920 and 1940.

TABLE 1

Correlations of variables

	$\Delta \ln e_{it}$	$\Delta S_{i,t-1}$	$\Delta \ln y_{i,t-1}$	$\Delta B_{i,t-1}$	$\Delta U_{i,t-1}$
$\Delta \ln e_{it}$	1·000				
$\Delta S_{i,t-1}$	−0·324**	1·000			
$\Delta \ln y_{i,t-1}$	0·411**	−0·013	1·000		
$\Delta B_{i,t-1}$	−0·460**	0·173	−0·173	1·000	
$\Delta U_{i,t-1}$	−0·034	0·322**	0·112	−0·250**	1·000

** indicates significance at the 5% level and * at the 10% level.

TABLE 2

Specifications for changes in per-child education expenditure

Explanatory variables	Dependent variable: change in log educational expenditure per child ($\Delta \ln e_{it}$)					
	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)
Change in land concentration	−2·71***	−2·67***	−2·16***	−2·12***	−2·34***	−3·68*
($\Delta S_{i,t-1}$)	(0·99)	(0·86)	(0·75)	(0·78)	(0·80)	(2·17)
Change in income *per capita*		0·84***	0·72***	0·72***	0·72***	0·71*
($\Delta \ln y_{i,t-1}$)		(0·15)	(0·13)	(0·13)	(0·17)	(0·41)
Change in % of the black population			−3·74***	−3·78***	−2·90***	−5·13**
($\Delta B_{i,t-1}$)			(0·59)	(0·73)	(0·96)	(2·17)
Change in % of the urban population				−0·05	−0·66*	−0·12
($\Delta U_{i,t-1}$)				(0·32)	(0·40)	(0·69)
National time fixed effects	No	No	No	No	Yes	No
State fixed effects (linear time trend)	No	No	No	No	No	Yes
R^2	0·11	0·27	0·39	0·39	0·48	0·38
Hausman statistic						2·16
Hausman *p*-value						0·71

Notes: *** denotes significance at the 1% level, ** at 5%, and * at 10%. S.E. are adjusted for clustering at the state level. All regressions have a total of 79 observations from 41 states. The null hypothesis of the Hausman test in column (6) is that there is no systematic difference in the point estimates between columns (4) and (6); the statistic is distributed $\chi^2(4)$. Data on log education expenditures per child ($\ln e_{it}$) is from the years 1900, 1920, and 1940, and data for all explanatory variables is lagged, taken from the the years 1880, 1900, and 1920.

The negative correlation between the changes in the log of education expenditure in state i, $\Delta \ln e_{it}$, and the lagged changes in land share of large farms in state i, $\Delta S_{i,t-1}$, is apparent in Figure 3 and is demonstrated by the fitted values plotted from an OLS regression.

Table 1 depicts the correlation between all variables utilized in the empirical specifications, in particular, the correlation coefficient between $\Delta \ln e_{it}$ and $\Delta S_{i,t-1}$, as depicted in Figure 3. The table indicates that lagged changes in the land share of large farms are negatively related to changes in education expenditures per child in the next period. Moreover, changes in education expenditures are positively associated with the lagged changes in log income *per capita* and negatively with the lagged changes in the percentage of the black population.

To undertake more rigorous empirical testing, we begin by assuming that $E(\Delta\varepsilon_{it}) = 0$ and $E(\Delta\varepsilon_{it}\,\Delta X) = 0$, where $X \equiv (S_{i,t-1}, \ln y_{i,t-1}, U_{i,t-1}, B_{i,t-1})$. In other words, we presume that the *changes* in explanatory variables are not correlated with *changes* in the error term, even though the levels of the explanatory variables might be correlated with the error term itself in (39). In addition, we begin by assuming that the time trend parameter, θ_i, is identical across states. Under these assumptions the specification in (41) can be estimated by OLS, with S.E.s adjusted for clustering by state, allowing for the differenced error terms for state i, $\Delta\varepsilon_{it}$, to be correlated across different time periods.

Table 2 depicts the results of this estimation in columns (1)–(5), establishing the negative effect of the lagged change in land share of large farms, $\Delta S_{i,t-1}$ on the change in log education expenditure *per capita* $\Delta \ln e_{it}$, alone and while controlling for the change in lagged income *per capita*, $\Delta \ln y_{i,t-1}$, the lagged change in the percentage of the urban population, $\Delta U_{i,t-1}$, and the lagged change in percentage of the black population, $\Delta B_{i,t-1}$. As indicated by the results in column (1) the effect of $\Delta S_{i,t-1}$ alone on the change in education expenditure, $\Delta \ln e_{it}$, is negative and highly significant. One would also expect that changes in education expenditures would reflect changes in income *per capita*. Controlling for the change in lagged income *per capita*, $\Delta \ln y_{i,t-1}$ in column (2), shows that indeed an increase in lagged income *per capita* has a highly significant, positive effect on education expenditure. Nevertheless, the negative effect of $\Delta S_{i,t-1}$ on the change in education expenditure, $\Delta \ln e_{it}$, remains stable and highly significant. Column (3) includes a control for the lagged change in percentage of the black population, $\Delta B_{i,t-1}$, to ensure that the adverse effect of inequality in the distribution of landownership on educational expenditure does not reflect the adverse effect of the discrimination in the South (where land inequality is more pronounced), on educational expenditure. As expected the effect of the change in the percentage of the black population on the change in educational expenditure is negative and highly significant. However, the effect of the change in the distribution of landownership remains negative and highly significant. Finally column (4) adds a control for the lagged change in the percentage of the urban population, $\Delta U_{i,t-1}$, capturing a potential adverse effect of urbanization on education expenditure due to economies of scale in education and its positive effect stemming from the correlation between industrialization and urbanization. The effect of the lagged changes in urbanization on changes in education expenditure is negative but insignificant. The negative effect of $\Delta S_{i,t-1}$ on the change in education expenditure remains stable, negative, and highly significant.

Hence, as follows from (39) and (41) the coefficient β_1 that measures the effect of the lagged change in land share of large farms, $\Delta S_{i,t-1}$, on the change in log education expenditure *per capita* $\Delta \ln e_{it}$, captures the effect of the lagged land share of large farms, $S_{i,t-1}$ on log education expenditure *per capita* $\ln e_{it}$. The size of the point estimate for $S_{i,t-1}$ is relatively stable over the first five specifications, suggesting that a 10 percentage point decline in $S_{i,t-1}$ would have increased expenditure per child at the following period by 21–27%. In particular, consider the difference between the land share of large farms in California and Vermont in 1920. In California $S_{1920} = 0{\cdot}096$ (which is at the 25th percentile of the distribution of S across states in the U.S.) and in Vermont $S_{1920} = 0{\cdot}215$ (which is at the 75th percentile). Using the estimates in column (4) this implies that Vermont's expenditure per child in 1920 would have been 25% higher if it had a land share of large farms as small as California's. That difference would have eliminated more than a third of the actual gap in expenditure per child that existed between California ($68 per child) and Vermont ($41 per child) in 1940. Column (5) establishes that the inclusion of a common time trend for all states does not affect the qualitative results, increasing slightly the absolute value of the point estimate on $\Delta S_{i,t-1}$.

Column (6) reports the estimation of equation (41) using state fixed effects, allowing for the time trend in education expenditures, θ_i, to vary by state, where all control variables are included. In comparison to columns (4) and (5) the absolute value of the point estimate of the effect of the change in the lagged land share of large farms has increased, but it is significant only at the 10% level, reflecting the reduction in the degrees of freedom. A rise in S.E. and a decline in significance is also observed in all other explanatory variables. The results in column (6) may seem to indicate that there is some state-specific time trend and that previously the change in the land share of large farms was a proxy for this state-specific effect. However, the Hausman test, report in column (6) of Table 2, comparing the fixed effects estimation to a random effects estimation, indicates that we cannot reject the null hypothesis that the two specifications differ only randomly.[45]

Since the model abstracts from inequality among landowners, the use of the explanatory variable, S (*i.e.* the land share of large farms), is appropriate. Nevertheless, it should be noted that the use of the Gini coefficient for farm size (*i.e.* land inequality among landowners), calculated using the same raw data used in creating the variable S, would not affect the qualitative results. In particular, if S is replaced by the Gini coefficient for inequality in landownership, land inequality still has an adverse effect on education expenditure. Furthermore, if both measures are used jointly, then the coefficient of land share of large farms remains negative ($-2{\cdot}15$) and significant at the 1% level, and the effect of the Gini coefficient also remains negative although insignificant.

6.3. *Instrumental variables estimation*

This section introduces an instrumental variables analysis to further enhance confidence about the identification of the effect of the concentration of landownership on education expenditure. In order to identify the effect of the concentration of landownership on education, we require a source of exogenous variation in the concentration of landownership that does not influence education spending directly. In light of the historical evidence provided by Engerman and Sokoloff (2000) regarding the positive effects of agricultural crops associated with economies of scale (*e.g.* cotton and sugar cane) on land inequality across the Western Hemisphere, one should expect that cross-state differences in climatic characteristics, and thus in the suitability for such crops, would generate variation in the concentration in landownership across states. Moreover, nationwide changes in the relative prices of agricultural crops that are associated with economies of scale would generate changes in the concentration of landownership over time. Thus, the interaction between nationwide changes in the relative prices of agricultural crops that are associated with economies of scale and variation in climatic characteristics across states (that are static in this short time period) would generate differences in the evolution of land concentration across states.

To illustrate the differential effect of agricultural prices over time on the concentration of landownership across states, consider the evolution of the price of cotton relative to the price of corn over the period 1880–1940, as obtained from the NBER Macrohistory Database (2007). The price of cotton relative to corn declined monotonically over the period of our study. The price of a pound of cotton relative to a bushel of corn was 0·321 in 1880, 0·252 in 1900, 0·236 in 1920, and 0·155 in 1940, and indeed over this period, in regions that were climatically more receptive to cotton production, the concentration of landownership held by the largest farms declined. In particular, 29 states produced no cotton in 1860, and their average change in land concentration was just $-0{\cdot}2\%$ over the period 1880–1940. Among states that produced some cotton in 1860, the average change in the land concentration of the largest landowners was $-2{\cdot}6\%$. Cotton production was most prevalent in the South, with this single crop accounting for over 40% of the total value of agricultural production in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Texas. Over this period the concentration of landownership by the largest farms declined in the South from 20% in 1880 to 12% in 1900 and to only 8% in 1920.

Our instruments are therefore the interaction between state-specific, but time invariant, climatic conditions and the nationwide changes in the price of cotton relative to corn.[46] The climatic measures are derived from state data on temperature, rainfall, and a measure of heating

45. Hence, the Hausman test indicates that the random effects specification is preferred. Furthermore, it is important to note that for this sample of data, the random effects estimates are identical to the OLS results we report in column (4), due to the fact that the estimated variance in η_i is 0.

46. The use of the price of cotton relative to wheat does not affect the results.

TABLE 3

Instrumental variable specifications for changes in per-child education expenditure

Explanatory variables	Dependent variable: change in log educational expenditure per child ($\Delta \ln e_{it}$)	
	OLS (1)	2SLS (2)
Change in land concentration	−2·34***	−3·23***
($\Delta S_{i,t-1}$)	(0·80)	(0·91)
Change in income *per capita*	0·72***	0·72***
($\Delta \ln y_{i,t-1}$)	(0·17)	(0·17)
Change in % of the black population	−2·90***	−2·58***
($\Delta B_{i,t-1}$)	(0·96)	(0·92)
Change in % of the urban population	−0·66*	−0·51
($\Delta U_{i,t-1}$)	(0·40)	(0·37)
National time fixed effects	Yes	Yes
R^2	0·48	
First stage F-statistic		13·49
First stage p-value		<0·001
Sargan test statistic		1·20
Sargan test p-value		0·27

Notes: *** denotes significance at the 1% level, ** at 5%, and * at 10%. S.E.s are adjusted for clustering at the state level. All regressions have 79 total observations, from 41 states. Data on log education expenditures per child ($\ln e_{it}$) are from 1900, 1920, and 1940, and data for all control variables is from 1880, 1900, and 1920. In column (2), the instruments for the difference in land concentration ($\Delta S_{i,t-1}$) are two variables that interact state-specific climate conditions with the price of cotton relative to the price of corn.. The F-test in column (2) tests the null hypothesis that the coefficient on both instruments in the first stage is 0; the statistic is distributed $F(2, 72)$. The Sargan test has a null hypothesis that both instruments are uncorrelated with the error term; the statistic is distributed $\chi^2(1)$.

days (capturing the variability of temperature throughout the year) obtained from the National Climatic Data Center (2007). As elaborated in Appendix D, using principal components two distinct climatic measures are extracted from this data. The interaction of these with the relative price data provides us with state-year-specific instruments for the concentration of landownership.

These instruments appear to satisfy the exclusion restriction, since there is no evidence that the human-capital intensity in the production of cotton over this period differs from the average in all other agricultural crops, and changes in the relative price of cotton, therefore, would not have a direct effect on education expenditure, but only indirectly through their effect on concentration of landownership, and possibly via changes in income, that are controlled for in the regressions.

The lagged differences of the instruments are used within a two-stage least squares estimation to supply exogenous variation in the lagged difference of $S_{i,t-1}$. Included in our specification are the lagged differences in log income *per capita*, the percentage of blacks, the percentage of urban population, and period-specific dummies. Column (1) of Table 3 replicates the OLS results for comparison purposes, and column (2) reports the second-stage results of the two-stage least squares estimation. As can be seen, the point estimate is now larger in absolute value than in the OLS estimates, and remains significant at the 1% level.

The first stage results show that our instruments are quite strong in explaining variation in $\Delta S_{i,t-1}$. As reported in the table, the F-test of the joint significance of the instruments has a value of 13·49, which is significant at less than 0·1%. Both instruments are individually significant in the first stage at 1%. As we have two instruments, there is the possibility of overidentification. However, a Sargan test of overidentification, as noted in the table, cannot reject the null hypothesis that both instruments are uncorrelated with the error term $\Delta \varepsilon_{it}$.

The results provide further support that we have identified a causal adverse effect of the concentration of landownership on the provision of education across states during this period of U.S. history.

7. CONCLUDING REMARKS

The proposed theory suggests that the concentration of landownership has been a major hurdle in the emergence of human-capital promoting institutions and economic growth. The rise in the demand for human capital in the process of industrialization and its effect on human-capital formation and on the onset of the demographic transition have been the prime forces in the transition from stagnation to growth. As the demand for human capital emerged, differences in the concentration of landownership across countries generated variations in the extensiveness of human-capital formation and therefore in the rapidity of technological progress and the timing of the demographic transition, contributing to the emergence of the great divergence in income *per capita* across countries. Land abundance, which was beneficial in early stages of development, generated in later stages a hurdle for human-capital accumulation and economic growth among countries in which landownership was unequally distributed, bringing about changes in the ranking of countries in the world income distribution.

The central hypothesis of this research that inequality in the distribution of landownership adversely affected the timing of education reform is examined and confirmed empirically, utilizing variations in the distribution of landownership and educational expenditure across states in the U.S. during the high-school movement. Furthermore, historical evidence suggests that consistent with the proposed hypothesis, land reforms in Japan, Korea, Russia, and Taiwan were associated with significant education reforms, and that variations in the distribution of landownership across and within North and South America have been a significant force in the emergence of sustained differences in human-capital formation and economic growth.

The paper implies that differences in the evolution of social structures across countries may reflect differences in the distribution of landownership. In particular, the dichotomy between workers and capitalists is more likely to persist in land-abundant economies in which landownership is unequally distributed. As argued by Galor and Moav (2006), due to the complementarity between physical and human capital in production, the capitalists were among the prime beneficiaries of the accumulation of human capital by the masses. They had therefore the incentive to financially support public education that would sustain their profit rates and would improve their economic well-being, although would ultimately undermine their dynasty's position in the social ladder and would bring about the demise of the capitalist–workers class structure. As implied by the current research, the timing and the extent of this social transformation depend on the economic interest of landowners. In contrast to the Marxian hypothesis, this paper suggests that workers and capitalists are the natural economic allies that share an interest in industrial development and therefore in the implementation of growth enhancing human-capital promoting institutions, whereas landowners are the prime hurdle for industrial development and social mobility.

APPENDIX A. LANDOWNERS' PREFERRED TAX RATE: COBB–DOUGLAS AGRICULTURAL TECHNOLOGY

Lemma A3. *The elasticity of θ_t with respect to y_t^{M}, $e_{\theta_t, y_t^{\mathrm{M}}} \in (0, 1)$.*

Proof. Suppose not. Suppose that $e_{\theta_t, y_t^{\mathrm{M}}} \leq 0$. Since $w_t = (1-\alpha)y_t^{\mathrm{M}}/\theta_t$ a rise in y_t^{M} and a decline in θ_t imply a rise in w and a reduction in the optimal number of workers in agriculture and hence a rise in θ_t. A contradiction. Suppose that $e_{\theta_t, y_t^{\mathrm{M}}} \geq 1$. since $w_t = (1-\alpha)y_t^{\mathrm{M}}/\theta_t$ a rise in y_t^{M} and a more than proportional rise in θ_t implies a decline in w_t and a rise in the optimal number of workers in agriculture and hence a decline in θ_t. A contradiction. ‖

Proposition A6. *If the agricultural production function is $F(X, L_t) = AX^\gamma L_t^{1-\gamma}$ then landowners' desirable tax rate $\tau_t^L \notin (0, \tau_t^*)$.*

Proof. As follows from (3), noting that $L_t = 1-\theta_t$,

$$\begin{aligned} w &= (1-\gamma)A\left(\tfrac{X}{1-\theta_t}\right)^{\gamma};\\ \rho_t &= \gamma A\left(\tfrac{X}{1-\theta_t}\right)^{\gamma-1}. \end{aligned} \tag{A.1}$$

Hence, along the factor price frontier

$$\rho_t = \gamma A^{1/\gamma}\left(\frac{w_t}{1-\gamma}\right). \tag{A.2}$$

Let $\pi_t \equiv y_t^{\mathrm{M}}/\theta_t$. It follows from (18) and (20) that $w_t = (1-\alpha)\pi_t$ and

$$\rho_t = \gamma A^{1/\gamma}\left(\frac{(1-\alpha)\pi_t}{1-\gamma}\right)^{(\gamma-1)/\gamma}. \tag{A.3}$$

Since the wage paid to each worker is equal in the two sectors, it follows from (A.1) that

$$(1-\gamma)AX^{\gamma}(1-\theta_t)^{-\gamma} = (1-\alpha)\pi_t, \tag{A.4}$$

and hence

$$\theta_t = 1-\left(\frac{(1-\gamma)AX^{\gamma}}{(1-\alpha)\pi_t}\right)^{1/\gamma}. \tag{A.5}$$

Note that θ_t is determined endogenously such that $\theta_t \in (0,1)$.

Since landlord's income in period t is $I_t^L = w_t + (1-\tau_t)R_t b_{t-1}^L + \rho_t X/\lambda$, it follows that the aggregate income of landowners, λI_t^L, is

$$\lambda I_t^L = \lambda(1-\alpha)\pi_t + s_t^L \alpha\theta_t\pi_t + X\rho_t, \tag{A.6}$$

where $w_t = (1-\alpha)\pi_t$, is the wage, $\alpha\theta_t\pi_t = \alpha y_t^{\mathrm{M}}$ is the share of capital in the industrial output, and s_t^L is the share of capital owned by landowners. Substituting (A.3) and (A.5) into (A.6)

$$\begin{aligned} \lambda I_t^L &= \lambda(1-\alpha)\pi_t + s_t^L\alpha\pi_t\left(1-\left(\tfrac{(1-\gamma)AX^{\gamma}}{(1-\alpha)\pi_t}\right)^{1/\gamma}\right) + X\gamma A^{1/\gamma}\left(\tfrac{(1-\alpha)\pi_t}{1-\gamma}\right)^{(\gamma-1)/\gamma};\\ &= \lambda(1-\alpha)\pi_t + s_t^L\alpha\pi_t + \left[\gamma\left(\tfrac{1-\alpha}{1-\gamma}\right)^{(\gamma-1)/\gamma} - s_t^L\alpha\left(\tfrac{1-\gamma}{1-\alpha}\right)^{1/\gamma}\right]XA^{1/\gamma}\pi_t^{(\gamma-1)/\gamma}. \end{aligned} \tag{A.7}$$

Hence,

$$\begin{aligned} \frac{\partial\lambda I_t^L}{\partial\pi_t} &= \lambda(1-\alpha) + s_t^L\alpha + \tfrac{\gamma-1}{\gamma}\left[\gamma\left(\tfrac{1-\alpha}{1-\gamma}\right)^{(\gamma-1)/\gamma} - s_t^L\alpha\left(\tfrac{1-\gamma}{1-\alpha}\right)^{1/\gamma}\right]XA^{1/\gamma}\pi_t^{-1/\gamma};\\ \frac{\partial\left(\lambda I_t^L\right)^2}{\partial^2\pi_t} &= \tfrac{1-\gamma}{\gamma^2}\left[\gamma\left(\tfrac{1-\alpha}{1-\gamma}\right)^{(\gamma-1)/\gamma} - s_t^L\alpha\left(\tfrac{1-\gamma}{1-\alpha}\right)^{1/\gamma}\right]XA^{1/\gamma}\pi_t^{-(1+\gamma)/\gamma}. \end{aligned} \tag{A.8}$$

Hence,

$$\frac{\partial\left(\lambda I_t^L\right)^2}{\partial^2\pi_t} \geq 0 \leftrightarrow s_t^L \leq \frac{\gamma(1-\alpha)}{\alpha(1-\gamma)}.$$

If, however, $s_t^L > \frac{\gamma(1-\alpha)}{\alpha(1-\gamma)}$, replacing $\frac{\gamma(1-\alpha)}{\alpha(1-\gamma)}$ for s_t^L in (A.7),

$$\begin{aligned} \lambda I_t^L &= \lambda(1-\alpha)\pi_t + s_t^L\alpha\pi_t + \left[\gamma\left(\frac{1-\alpha}{1-\gamma}\right)^{(\gamma-1)/\gamma} - s_t^L\alpha\left(\frac{1-\gamma}{1-\alpha}\right)^{1/\gamma}\right]XA^{1/\gamma}\pi_t^{(\gamma-1)/\gamma}\\ &= \lambda(1-\alpha)\pi_t + \frac{\gamma(1-\alpha)}{(1-\gamma)}\pi_t, \end{aligned}$$

which is strictly increasing in in π_t.

Hence, if $s_t^L = \frac{\gamma(1-\alpha)}{\alpha(1-\gamma)}$ landlords' income is strictly increasing in π_t and it follows from Lemma A3 that landowners prefer the highest possible value for y_t^{M}, and therefore $\tau_t^L = \tau_t^*$. Noting that $\frac{\partial \lambda I_t^L}{\partial s_t^L} > 0$ and $\frac{\partial (\lambda I_t^L)^2}{\partial \pi_t s_t^L} > 0$ it follows that $\tau_t^L = \tau_t^*$ for $s_t^L > \frac{\gamma(1-\alpha)}{\alpha(1-\gamma)}$.

If, however, $s_t^L < \frac{\gamma(1-\alpha)}{\alpha(1-\gamma)}$, landowners' income is a convex function of π_t, implying they prefer either the maximal or the minimal value of π_t. Therefore, it follows from Lemma A3 that landowners prefer the highest or lowest possible value for y_t^{M}, and hence $\tau_t^L \notin (0, \tau_t^*)$. ‖

APPENDIX B. CONSTRUCTION OF THE LAND SHARE DISTRIBUTION VARIABLES

The Census reports the distribution of number of farms by bin size (*e.g.* less than 20 acres, 20–49 acres, 50–99 acres, 100–499 acres, 500–999 acres, and greater than 1000 acres). Since the Censuses do not report identical bin sizes for 1880, 1900, and 1920, we aggregate farms into the previously listed six categories that are comparable across years.

To calculate S_{it}, we require information on the actual size of farms within each size category reported by the Census, but this is not directly available in 1880 or 1900. We therefore assume that each farm within a given category is of the average size of that category. For example, each farm in the range 20–49 acres is assumed to be 34·5 acres. For the category of farms greater than 1000 acres, we assume that each farm is exactly 1000 acres. The results are not sensitive to alternate choices. While data on farm size within categories is available for 1920, it does not differ greatly from the assumed average values, and the results are not sensitive to the use of the actual farm size data for 1920.

Initially we calculate a Gini coefficient of farm size distribution. There are N size categories, numbered from 1 to 6 in order of increasing size of farms. Let f_i be the share of all farms that are in category i. Let a_i be the share of all acreage that is in category i. Let $F_i = \sum_{s=1}^{i} f_s$, denotes the share of farms that are of size i or smaller. Similarly, $A_i = \sum_{s=1}^{i} a_s$. By definition, $F_6 = A_6 = 1$. It can be shown that the Gini coefficient, G, can be calculated as follows:

$$G = 1 - \sum_{i=1}^{5} (F_{i+1} - F_i)(A_{i+1} + A_i).$$

To perform our calculations of S_{it}, the land share of the largest landowners, we use a simple parameterization of the Lorenz curve. This is denoted $s_L = s_F^{\beta}$ where s_L is the share of land and s_F is the share of farms. The parameter β is related to the Gini coefficient in the following manner, $\beta = (1+G)/(1-G)$. Thus given the Gini coefficient we can derive the parameter β for each state. Given β, we calculate the minimum number of farms in 1880 that constitute 20% of total farm land as $\text{TopFarms}_{1880} = \text{Farms}_{1880}(1 - (0{\cdot}80)^{1/\beta})$ where Farms_{1880} is the total number of farms in 1880, β is the Lorenz parameter from 1880, and TopFarms_{1880} is the number of large farms constituting 20% of all land. Note that we can utilize other choice of percentage (*i.e.* 5%, 10% etc.) in place of 20%.

We can then track how the share of land held by the largest number of farms evolves over time, where the number of these farms is held constant at TopFarms_{1880}. By construction, this share of land is 20% in 1880. For subsequent years, the share can be calculated as $S_{it} = 1 - (1 - \text{TopFarms}_{i,1880}/\text{Farms}_{it})^{\beta_{it}}$ where Farms_{it} measures the total number of farms in year t, and β_{it} measures the coefficient on the Lorenz curve from year t in state i. One advantage of this calculation is that it is independent of the average farm size between states, which varies incredibly across the U.S. based on geographic conditions rather than differences in inequality.

The current method allows for a smooth distribution of farm sizes over the whole range of farms. However, we could alternately calculate the S_{it} variable by going directly to the size distribution data in the U.S. Census. This would assume that each farm within each size category of farm is of an identical size. Starting from the largest bin size (greater than 1000 acres) in 1880 and working down the bin sizes if necessary, we count how many farms account for 20% of farm land. We can then take this number of top farms in subsequent years and ask how much land is accounted for by this same number of farms, again working from the top of the distribution down. One disadvantage of this method is that it depends on the assumed average size of farms over 1000 acres, which is not reported by the U.S. Census. The parameterization method we utilize is less sensitive to this lack of information.

APPENDIX C. DATA SOURCES

Education Expenditures—This is obtained from the Historical Statistics of the U.S. for 1920 and 1940, and from the U.S. Bureau of Education, Report of the Commissioner of Education for 1900. These expenditures were converted to 1920 dollars using the GDP deflator from Bilke and Gordon (1989).

Expenditure per Child—The number of children in a year is taken from the U.S. Census. Consistent across all states, the available age ranges are 5–20 years in 1900 and 7–20 years in 1920.

Income per Capita—These are estimates Richard Easterlin (1957), Population Redistribution, and Economic Growth: U.S. 1870–1950, edited by Kuznets and Thomas. Details of the construction can be obtained from this source. Income *per capita* is converted to 1920 dollars using the GDP deflator from Bilke and Gordon (1989).

Percentage of Blacks—This is taken from the U.S. Census for the relevant years.

Urban Percentage—From the U.S. Census for the relevant years.

Regions—The Northeast is defined as Connecticut, Massachusetts, New Hampshire, New Jersey, New York, Maine, Pennsylvania, Rhode Island, and Vermont. The Midwest is Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, and Wisconsin. The South is Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Tennessee, Texas, Virginia, and West Virginia. The West includes California, Montana, Oregon, Utah, Washington, and Wyoming.

Excluded States—States that are not included in the sample due to data limitations are: Alaska, Arizona, Colorado, Hawaii, Idaho, Nevada, New Mexico, North Dakota, South Dakota, and Oklahoma.

APPENDIX D. CONSTRUCTION OF INSTRUMENTS

The instrument used to identify the effect of land distribution on education is composed of a geographic element and a relative price element. The geographic element is derived from state level data on temperature, rainfall, and heating requirements obtained from the U.S. Department of Commerce National Climatic Data Center (NCDC) (2007), specifically the U.S. Climate Normals. The Climate Normals provide annual average temperature and rainfall for individual climatic regions within states. Annual heating requirements are derived from the average pattern of temperatures throughout the year and capture the intensity of temperature differences within the year (as opposed to the simple average). The heating requirements are reported by regions within states as well. For each measure, the value reported is the average value over the years 1931 through 2000.

To calculate state level values, the regional data are weighted within each state by the area of the region as reported by the NCDC. Examining the data, the three measures of climate are significantly correlated with each other. The correlation of temperature with heating days is $-0{\cdot}99$, temperature with rainfall is $-0{\cdot}49$, and rainfall with heating days is 0·48. All correlations are significant at less than 1%. Using these three collinear terms together may falsely inflate the significance of the first stage regressions, so to extract the most explanatory power from the climate data while limiting the number of variables, a principal components analysis is used. The first component accounts for 78% of the variation observed in the three variables, with an eigenvalue of 2·35. The loadings on the first component are 0·628 for heating days, $-0{\cdot}630$ for temperature, and 0·457 for annual rainfall. The second component accounts for 21% of total variation, with an eigenvalue of 0·64. The loadings are $-0{\cdot}327$ for heating days, 0·319 for temperature, and 0·890 for annual rainfall. Combined, the two principal components capture 99% of the variation in climatic data, with the first component picking up mainly variation associated with temperature and the second component picking up mainly rainfall.

The two climatic components are state specific, and time invariant. To generate a time-varying instrument, we have combined the climate data with information on the relative price of cotton. As explained in the text, the concept is that increases in cotton prices would induce land concentration, but only in those places, which were geographically suited to cotton production in the first place. The price data comes from the National Bureau of Economic Research (NBER) Macrohistory Database. Historical price levels for cotton are obtained as an average of the monthly wholesale price from New York (NBER series 04006), in cents per pound. These prices are 12·04 cents in 1880, 9·64 in 1900, 33·90 in 1920, and 10·38 in 1940. The price of corn, also an average of monthly wholesale prices from Chicago (NBER series 04005), in dollars per bushel. The specific prices are 0·375 dollars in 1880, 0·383 dollars in 1900, 1·439 in 1920, and 0·670 in 1940.

Acknowledgements. We are grateful to two editors, four referees, and Yona Rubinstien for insightful and detailed comments. We thank Daron Acemoglu, Josh Angrist, Andrew Foster, Eric Gould, Vernon Henderson, Saul Lach, Victor Lavy, Ross Levine, Roger Myerson, Joel Mokyr, Daniele Paserman, Torsten Persson, Kenneth Sokolof, Nancy Stokey, David Weil, Ivo Welch, Joseph Zeira, seminar participants at Brown, Cambridge, Clemson, CEFIR/NES, Chicago, Cyprus, GREQAM, Oxford, Royal Holloway, Tel-Aviv, UCL, York, Warwick, and conference participants at the NBER Summer Institute, 2003, the Economics of Water and Agriculture, 2003, Minerva's conference, 2003, ESSIM, Tarragona, 2004, CEPR Sardinia 2004, The Evolution of Institutions, 2006, Minerva-DEGIT Conference, Jerusalem, 2006, CEPR, Annual Public Policy Symposium, Kiel, 2006, CIFAR, Tel Aviv, 2007, for helpful comments. This research is supported by ISF grant 795/03. Galor's research is supported by NSF Grant SES-0004304.

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