From rent seeking to human capital: a model where resource shocks cause transitions from stagnation to growth*

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*We are grateful for comments from Tasso Adamopoulos, Ahmet Akyol, Paul Klein, Robert Tamura, and two anonymous referees.

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Abstract: We present a growth model where agents divide time between rent seeking in the form of resource competition, and working in a human capital sector. The latter is interpreted as trade or manufacturing. Rent seeking exerts negative externalities on the productivity of human capital. Adding shocks, in the form of fluctuations in the size of the contested resource, the model can replicate a long phase with stagnant incomes and high levels of rent seeking, interrupted by small, failed growth spurts, eventually followed by a permanent transition to a sustained growth path where rent seeking vanishes in the limit. The model also generates a rise and fall of the so-called natural resource curse: before the takeoff, an increase in the size of the contested resource has a positive effect on incomes; shortly after the takeoff, the effect is negative; and on the balanced growth path the growth rate of per-capita income is independent of resource shocks.

1 Introduction

A couple of hundred years ago Europe embarked on what is known as the Industrial Revolution: it started to exhibit sustained growth in per-capita incomes. This came together with many other social transformations. Levels of education started to rise, public school reforms were introduced, democracy started to spread, voting rights were extended, the labor force moved from agriculture to industry and from rural to urban areas, and the so-called Demographic Transition set in: first mortality rates fell, and thereafter fertility rates.

All these transformations have been modelled in an expanding literature on long-run economic development. Here we want to think of the Industrial Revolution in the context of another parallel transition, thus far somewhat neglected in this new long-run growth literature. We argue that industrialization came together with a reallocation of agents' time and efforts, away from rent seeking and into productive activities. In pre-industrial Europe, and (to an even larger extent) in early human civilizations, those classes whose incomes were mainly based on the land they held, or the conquest of new land – that is, the landed aristocracy and the military – had more status, power, wealth, and higher incomes, than the classes who made their living from skills, rather than land. Industrialization resulted in the rise of a new class of skilled and urban agents, specialized in producing resources, rather than appropriating them.

We set up a long-run growth model where agents divide time between rent seeking and productive activities. Rent seeking could be, for example, military competition for land and other resources: that is, a pure zero-sum game. The productive activity is one where agents use their human capital, which could be interpreted as trade or manufacturing.

The model generates an endogenous transition from a situation where per-capita incomes are stagnant and agents spend all their time in rent seeking, to a growth path where per-capita incomes grow at a sustained rate and rent seeking vanishes in the limit, broadly consistent with long-run human history.

There are two important components driving the model. The first is an externality from rent seeking on the productivity of human capital. One way to think of this is that rent seeking can be associated with violence, which adversely affects, for example, trade.

The second component is a stochastic resource shock, which changes the size of the pie that agents compete for when engaging in rent seeking. The distribution from which these shocks are drawn is exogenous and time-invariant, but the economy endogenously alters its response to the shocks over the course of development.

This gives rise to quite rich dynamics. The economy can be stuck for very long in a stagnant trap with low levels of human capital and per-capita incomes, and agents engaging only in rent seeking. In the wake of a negative resource shock agents re-allocate some time away from rent seeking into the human capital sector. This may push the economy onto a sustained growth path, on which, in the limit, rent seeking vanishes altogether, making the economy insulated from resource shocks.

An economy can also go through temporary spurts – phases of declines in rent seeking and rising human capital levels, followed a few periods later by a reversion into a state of full rent seeking and no sustained growth.

The economy's changing response to the resource shocks is broadly consistent with a long-run pattern which we argue can be discerned throughout human history with respect to the so-called natural resource curse. At early stages of development an increase in resources *raises* incomes. Shortly after the growth takeoff an increase in resources *reduces* incomes. On the balanced growth path, resource shocks are neutral.

This paper relates to a literature on takeoffs from stagnation to growth (Goodfriend and McDermott 1995; Tamura 1996, 2002, 2006; Galor and Weil 2000; Jones 2001; Kögel and Prskawetz 2001; Galor and Moav 2002; Hansen and Prescott 2002; Lucas 2002; Lagerlöf 2003a,b, 2006; Doepke and Zilibotti 2005; see Galor 2007 for an overview). In this context, we are the first to examine transitions from rent seeking to productive activities, although this theme relates to models of transitions from agriculture to industry (Kögel and Prskawetz 2001, Hansen and Prescott 2002, and Tamura 2002). Another novel feature here is that transitions are caused by stochastic shocks, the effects of which are altered endogenously in the course of development.[1]

There is also a large literature on rent seeking and conflicts. Some important contributions include Hirshleifer (1988, 1989), Grossman (1991), Murphy et al. (1991, 1993), Skaperdas (1991, 1992, 2003), Acemoglu (1995), Grossman and Kim (1995), Baland and Francois (2000), Torvik (2002), and Anderson and Marcouiller (2005). These papers often use static models; to explain changes over time we need a dynamic model.[2] The particular mechanism through which increases in human capital induce reductions in rent seeking relates to the model of Grossman and Kim (2003), where governments invest in public schooling to induce potential criminals not to steal. Mehlum et al. (2006) present a model where income effects from changes in the size of a contested resource depend on institutional quality, but do not allow resource competition to feed back into institutional quality, as in our model.

The rest of this paper is organized as follows. Section 2 sets up the model and derives some qualitative results, examining in particular how resource shocks can cause transitions, and how the economy's response to resource shocks changes in the course of development. Section 3 illustrates the dynamic features of the model in a couple of simulations. Section 4 discusses how the results relate to the empirical evidence. In Section 5 we discuss some alternative functional forms for rent seeking income. Section 6 concludes.

2 The Model

Agents live in overlapping generations for two periods, as children and adults. Adults consume and invest in their children's human capital. Children consume nothing and are passive, other than receiving human capital investment from their parents.[3]

Adults earn income from two sources: rent seeking, here meaning zero-sum competition for a finite resource (for instance land); or activities where they use their human capital. That is, we assume that human capital cannot be expropriated, or taxed: rent seeking is here defined as competition over resources other than human capital. This could be motivated by human capital being harder to expropriate because it is more mobile.[4]

In any period t, the total size (or value) of the contested resource equals A_t. The adult population is a continuum and its size is denoted P_t. (As described later, A_t and P_t evolve stochastically over time.) Each adult agent has one unit of time to divide between working in the human capital sector and engaging in rent seeking. The income earned from rent seeking is given by a Tullock-type of contest function: an agent who spends $r_t \in [0, 1]$ units of time in rent seeking receives an income from rent seeking proportional to her time engaged in rent seeking, relative to that of the average agent. Let R_t be the average time spent in rent seeking among all P_t agents, and $\gamma_t = A_t/P_t$ denote resources per agent. Then income earned from rent seeking by an agent who invests r_t units of time in the rent seeking process is given by:[5]

$$r_t \gamma_t / R_t. \tag{1}$$

The next component of our model is a negative externality from rent seeking on the productivity of human capital. This externality has several interpretations. First, one can view this as an effect of society-wide violence on trade. For example, sometimes rent seeking may amount to outright warfare. Glick and Taylor (2005) find that inter-state wars reduce trade not only for belligerent nations but also neutrals.

Another (related) interpretation is that the productivity of human capital depends on institutions, and that the quality of institutions depends on the amount of rent seeking (and/or violence). Sala-i-Martin and Subramanian (2003) and Mehlum et al. (2006) present compelling evidence that the negative effects of resource abundance on growth work through institutional quality.

It is well known that institutional quality also depends on historically determined factors, which do not depend on resource competition, e.g. settler mortality rates, pre-colonial development, and the fraction of the population speaking English and European languages (Hall and Jones 1999; Acemoglu 2001, 2002; Sala-i-Martin and Subramanian, 2003).

To capture the joint effects of rent seeking and historical factors, we let the income earned per unit of time spent working in the human capital sector, by an agent endowed with H_t units of human capital, be given by $B(1 - R_t\rho) H_t$. Institutional quality is measured by $(1 - R_t\rho)$, where $\rho \in (0, 1)$ is a measure of historically determined institutional quality. A low ρ implies that the adverse effects on institutional quality stemming from resource competition are relatively mild. (Note that $\rho < 1$ and $R_t \leq 1$ ensures that human capital income is non-negative for all feasible R_t and ρ.) $B > 0$ is a productivity parameter. This specification allows us to derive simple analytical solutions, while still capturing the mechanisms identified by Sala-i-Martin and Subramanian (2003) and Mehlum et al. (2006).[6]

The total income of an atomistic agent is given by the sum of incomes from rent seeking and human capital:

$$Y_t = \frac{r_t \gamma_t}{R_t} + (1 - r_t) B \left(1 - R_t \rho_t\right) H_t. \tag{2}$$

The utility function of the same agent is given by

$$U_t = (1 - \beta) \ln c_t + \beta \ln H_{t+1}, \tag{3}$$

where c_t is the adult's own consumption and H_{t+1} is the human capital invested in the (single) child.[7] Purely for simplicity we assume that one unit of human capital is produced using one unit of the consumption good:

$$c_t = Y_t - H_{t+1}. \tag{4}$$

The agent chooses H_{t+1} and r_t to maximize (3), subject to (2) and (4), and the constraint that $r_t \in [0, 1]$.

The optimality condition for H_{t+1} gives:

$$H_{t+1} = \beta Y_t. \tag{5}$$

Since (2) is linear in r_t, taking as given R_t, each agent is indifferent as to how to set r_t if $\gamma_t / R_t = B \left(1 - R_t \rho\right) H_t$, and prefers $r_t = 1$ ($r_t = 0$) if $\gamma_t / R_t > (<) B \left(1 - R_t \rho\right) H_t$.

2.1 Equilibrium rent seeking

Since all agents are identical, in a symmetric equilibrium they choose the same r_t, that is: $r_t = R_t$. As shown in Section A.1 of the Appendix, the equilibrium time spent in rent seeking is given by:[8]

$$R_t = \begin{cases} 1 & \text{if} \quad H_t \leq \widehat{H}_t, \\ \\ \frac{1}{\rho}\left(\frac{1}{2} - \sqrt{\frac{1}{4} - \frac{\rho\gamma_t}{BH_t}}\right) & \text{if} \quad H_t \geq \widehat{H}_t, \end{cases} \tag{6}$$

where

$$\widehat{H}_t = \frac{\gamma_t}{B(1-\rho)}. \tag{7}$$

In words, $\widehat{H}_t$ is the threshold level that H_t must exceed for agents to allocate any time at all to working in the human capital sector. This threshold is increasing in γ_t, because more resources to compete for makes rent seeking more lucrative, relative to human capital activities. Note also that R_t is decreasing in H_t for $H_t \geq \widehat{H}_t$, and that R_t goes to zero as H_t goes to infinity. That is, accumulation of human capital reduces rent seeking by inducing agents to spend more time in the human capital sector instead.

2.2 Income and dynamics

We can set $R_t = r_t$ in (2) to derive an expression for equilibrium income: $Y_t = \gamma_t + (1 - R_t)B(1 - \rho R_t)H_t$, where R_t is given by in (6). The details of the algebra are messy but Section A.2 of the Appendix shows that:

$$Y_t = \begin{cases} \gamma_t & \text{if} \quad H_t \leq \widehat{H}_t, \\ \\ BH_t\left(\frac{1}{2} + \sqrt{\frac{1}{4} - \frac{\rho\gamma_t}{BH_t}}\right) & \text{if} \quad H_t \geq \widehat{H}_t, \end{cases} \tag{8}$$

where (recall) $\widehat{H}_t$ is defined in (7).

To see the intuition behind (8) it is useful to first close down the rent seeking externality, that is, setting $\rho = 0$. For H_t above $\widehat{H}_t$, income then becomes BH_t, meaning that a marginal increase in H_t raises income by B, independently of how much time is spent in rent seeking. Intuitively, there is a direct effect on income while holding fixed the level of rent seeking, as given by $(1 - R_t)B$. There is also a time reallocation effect, as given by $-(\partial R_t/\partial H_t)BH_t$. The latter effect occurs because rent seeking is a zero-sum activity; therefore, when all agents spend less time in rent seeking everyone's income rises. With the functional forms used here the combined marginal effect of a rise in human capital is the same as if there was no rent seeking at all (that is, B).[9] If $\rho > 0$ an increase in human capital has a third effect, by reducing rent seeking and thus raising productivity in the human capital sector.

Using the expressions for human capital investment in (5) and income in (8) we get a dynamic equation for human capital:

$$H_{t+1} = \begin{cases} \beta\gamma_t & \text{if } H_t \leq \widehat{H}_t, \\ \beta B H_t \left(\frac{1}{2} + \sqrt{\frac{1}{4} - \frac{\rho\gamma_t}{BH_t}} \right) & \text{if } H_t \geq \widehat{H}_t, \end{cases} \tag{9}$$

where (recall again) $\widehat{H}_t$ is defined in (7).

It can also be seen from (9) that sustained growth in H_t requires that $\beta B > 1$, which we hereafter assume holds.[10]

Figure 1 illustrates the dynamics in a 45-degree diagram, where γ takes either one of two values. The function in (9) shifts with γ, but regardless of what value γ takes the economy exhibits multiple steady states: if it starts off with human capital above a critical point it exhibits sustained growth; if it starts off slightly below it jumps (almost) immediately to a steady state with constant human capital. Intuitively, changes in γ have two opposing effects on incomes. On the one hand, a larger pie has a direct positive effect on incomes as all competing agents get more to share; that makes the function shift up. On the other hand, a rise in γ induces more time to be allocated to rent seeking, thus reducing productivity in the human capital sector, leading to lower incomes from human capital, and a higher threshold for agents to spend any time in human capital activities.

As can be seen from Figure 1, an economy which after a number of periods of high γ is hit by a lower γ can transit to sustained growth; once it has reached high enough levels of human capital it does not contract back even if γ reverts back to its higher level. Roughly this is what causes transitions from stagnation to growth in this model.

2.2.1 Changes in γ_t

Before describing the dynamic process for the contested resource, γ_t, we shall examine how changes in γ_t affect R_t and Y_t, at any given level of H_t. Interestingly, the effects of such resource shocks depend on whether, or not, the economy has entered a stage of development where agents spend some time outside of rent seeking. More precisely, from (6) we see that:

$$\frac{\partial R_t}{\partial \gamma_t} \begin{cases} = 0 & \text{if} \quad H_t < \widehat{H}_t, \\ \\ > 0 & \text{if} \quad H_t > \widehat{H}_t, \end{cases} \tag{10}$$

and from (8) that:

$$\frac{\partial Y_t}{\partial \gamma_t} \begin{cases} > 0 & \text{if} \quad H_t < \widehat{H}_t, \\ \\ < 0 & \text{if} \quad H_t > \widehat{H}_t, \end{cases} \tag{11}$$

where (recall once again) $\widehat{H}_t = \gamma_t / [B(1-\rho)]$.

In pre-transitional economies, where H_t falls below $\widehat{H}_t$, agents spend all their time in rent seeking. Therefore, a small increase in γ_t generates no reallocation of time between the different sectors; it only has a positive effect on incomes. When H_t exceeds $\widehat{H}_t$ and agents spend a positive amount of time in the human capital sector, a small increase in γ_t induces agents to allocate more time into rent seeking. The result is lower productivity of human capital, working through the rent seeking externality (ρ), which lowers incomes.

We also note that the effects of resource shocks on rent seeking and growth rates vanish on the balanced growth path:[11]

$$\lim_{H_t \to \infty} \frac{\partial (Y_{t+1}/Y_t)}{\partial \gamma_t} = \lim_{H_t \to \infty} \frac{\partial R_t}{\partial \gamma_t} = 0. \tag{12}$$

Intuitively, on the balanced growth path incomes earned from human capital dwarf those earned from resources.

To sum up, according to this model it is at intermediate stages of development, when the growth takeoff has just set in, that the natural resource curse shows up. In pre-industrial societies incomes increase with the amount of resources, a sort of "natural resource blessing." On the balanced growth path resource shocks have no effect at all on growth.[12] We argue later that this fits with some broad stylized facts from human history.

2.3 Resource shocks and transitions

We now let the size of the resource base (A_t) and population (P_t) evolve stochastically over time. Since only their ratio ($\gamma_t = A_t/P_t$) matters it suffices to specify one single process. We let it take this form:

$$\gamma_{t+1} = D\gamma_t^{\delta}\varepsilon_t, \tag{13}$$

where $\delta \in (0,1)$. We assume that ε_t is uniformly distributed on $[\underline{\varepsilon}, \overline{\varepsilon}]$, where $\underline{\varepsilon}$ and $\overline{\varepsilon}$ are such that $0 < \underline{\varepsilon} < 1 < \overline{\varepsilon}$ and the mean of ε_t is one, that is, $(\underline{\varepsilon} + \overline{\varepsilon})/2 = 1$.

The process in (13) has some interesting interpretations. We can think of a high draw of ε_t as the discovery or conquest of new land, or some new resource, or the invention of a new technology used to harvest the land/resource, or a fall in the population competing for the land/resource. A low draw of ε_t could be due to resource depletion, or a rise in the population competing for the resource.[13]

Since $\delta \in (0, 1)$, the process in (13) exhibits a type of Malthusian mean reversion. That is, if γ_t due to a series of high draws of ε_t grows very large, there is a force pulling it down again. Holding ε_t constant at its mean (one), γ_t converges to $D^{1/(1-\delta)}$.

Consider now an economy where human capital falls below the threshold in some period t, that is, $H_t < \widehat{H}_t = \gamma_t/[B(1-\rho)]$. Since income is then given by the amount of resources per agent, $Y_t = \gamma_t$, in the next period human capital equals $H_{t+1} = \beta\gamma_t$ [recall (5)]. Human capital thus falls below the threshold in period $t+1$ if $H_{t+1} = \beta\gamma_t < \widehat{H}_{t+1} = \gamma_{t+1}/[B(1-\rho)]$; and, vice versa, human capital exceeds the threshold if this inequality is reversed. We can thus write:

$$H_{t+1} \left\{ \begin{array}{c} > \\ = \\ < \end{array} \right\} \widehat{H}_{t+1} \Longleftrightarrow \frac{\gamma_{t+1}}{\gamma_t} \left\{ \begin{array}{c} < \\ = \\ > \end{array} \right\} \beta B(1-\rho). \qquad (14)$$

That is, for agents to start reallocating time away from rent seeking the *change* in resources per agent must be small enough. Put another way, the level of resources per agent in the *present* period must be small enough, thus ensuring that competition for those resources is not too tempting; but resources per agent in the *preceding* period must also be sufficiently high to make human capital investment in that period (and thus human capital levels in the present) high enough to make rent seeking not too tempting today.

Consider an economy where γ_t is at its long-run equilibrium level, $\gamma_t =$

$D^{1/(1-\delta)}$. Then $\gamma_{t+1}/\gamma_t = D\gamma_t^{\delta-1}\varepsilon_t = \varepsilon_t$. We next assume that

$$\underline{\varepsilon} < \beta B(1-\rho) < \overline{\varepsilon}. \tag{15}$$

This ensures that a stagnant economy where γ_t is at its long-run equilibrium, which is hit by the most resource increasing shock ($\overline{\varepsilon}$), remains stuck in the stagnant trap. The same economy being hit by the most resource reducing shock ($\underline{\varepsilon}$) instead transits out of stagnation.

3 A quantitative illustration

This model is highly stylized and it is hardly meaningful to seriously try to calibrate it to data. However, many of the dynamical features of the model are useful to illustrate in a simple simulation. To this end, we first let γ_t follow the process in (13), where we set the upper and lower bounds for ε_t to $\underline{\varepsilon} = 0.68$ and $\overline{\varepsilon} = 1.32$ (implying that ε_t has a mean equal to one). The remaining parameters are set as follows: $\rho = 0.6$, $\beta = 0.346$, $\delta = 0.9$, $B = 5$, $D = 1$.

These values are chosen largely arbitrarily, but we may at least note something about what they imply. The values for β and B generate a growth rate on the balanced growth path of about 2.2% per year, if each period corresponds to 25 years. Also, the value for ρ implies that the return to human capital is 40% lower in a stagnant economy compared to an economy on the balanced growth path. The values also satisfy (15), implying that, for most sequences of realizations of ε_t, the model generates both a stagnant phase and a transition to sustained growth. It can also be shown that when γ_t is at its long-run equilibrium level the probability of a resource shock that pushes the economy out of stagnation (by making $H_t > \widehat{H}_t$) is about 2%.[14] This is small enough to generate long phases of stagnation. (If we, for example, decrease ρ from 0.6 to 0.5 the transition probability rises to 29%, given the values we have chosen for other parameters.)

We let the initial level of resources per agent, γ_0, equal its long-run equilibrium, $D^{1/(1-\delta)}$. Initial human capital, H_0, is set to $\beta\gamma_0$ [cf. (9)].

Figure 2 shows the results from one single run. Panel A shows human capital levels being stagnant for several generations and eventually taking off onto sustained growth.

Panel B shows the time paths for rent seeking and the net growth rate of per-capita income (computed as $Y_{t+1}/Y_t - 1$). Throughout the stagnant phase the economy displays a couple of short growth spurts associated with temporary reductions in rent seeking. These occur when as series of low draws of ε_t are interrupted by a subsequent high draw. This expands the size of the contested pie, leading to a rise in rent seeking, lower incomes, and thus lower human capital in the next period. Human capital levels must be high enough for the economy to be insulated from such shocks.

Note also in Panel B the decline in the volatility of growth rates following the takeoff. On the balanced growth path the resource shocks have no effect on the growth rate, whereas in the stagnant phase incomes fluctuate in levels one-to-one with γ_t, implying big effect on growth rates.

Figure 3 shows the result from a Monte Carlo simulation, where we run the model 500 times; we may think of each run as representing one country. As seen in Panel A, the mean level of human capital takes off earlier than that of the median country; since there is no convergence in the growing club the mean is dominated by the earliest takeoffs. Panel B in Figure 3 shows a decline in rent seeking, and a rise in the net growth rate.

Panel B of Figure 3 also shows the path of the standard deviation in $\ln(Y_t)$ across the 500 countries (scaled down to fit with the other paths). As seen, cross-country income inequality is increasing over time. When all countries are poor income gaps are small; income inequality begins to rise when some countries start to grow while others remain stagnant.

Figure 4 shows the evolution of the distribution of $\ln(H_t)$ across all 500 countries, after 5, 20, and 50 periods. Note that the distribution becomes increasingly skewed over time, as the early countries to take off leave the laggards further and further behind. If we were to allow for convergence within the growing club, similar to Lucas (2002), a more typical bimodular pattern would emerge.

The most interesting observation shows up in Panel C of Figure 3. One path shows the fraction of the countries that are growing ($H_t > \widehat{H}_t$) at any given point in time. This fraction rises from zero to one, as more and more countries take off to sustained growth. The other two paths show the correlation in each period between the gross growth rates of countries (as given by Y_{t+1}/Y_t) and their resource shocks, ε_t: one path refers to all 500 countries, and the other to the subset of countries that are growing ($H_t > \widehat{H}_t$) at a given point in time. As seen, among all countries resource shocks tend to have a positive impact on growth rates, especially in the beginning when most countries are in the stagnant phase. However, among growing countries the effect of a resource shock is negative. Over time the correlation between resource shocks and growth approaches zero. As the share of income earned from human capital increases, total incomes depend less and less on resource shocks. This illustrates the model's prediction of a rise and fall of the natural resource curse.

4 Some empirical support

4.1 Resource, institutions, and growth

As discussed earlier, we may interpret the returns to human capital, $(1 - R_t\rho)$, as a measure of the quality of institutions. Then the model predicts that the negative effects on growth of an increase in resources should work through institutions. More precisely, if $\rho = 0$, so that the quality of institutions is independent of R_t, $\partial Y_t/\partial\gamma_t$ is no longer negative for $H_t > \widehat{H}_t$ [see (8)].

This is consistent with the findings of Sala-i-Martin and Subramanian (2003), Isham et al. (2005) and Mehlum et al. (2006). Looking at cross-country data they find that their measure of resources impacts growth negatively through institutions. Holding the quality of institutions constant, an increase in resources in fact has a positive effect on growth, just like our model predicts.

4.2 Growth paths

The takeoff in growth that this model generates is broadly consistent with the long-run growth experience of Western Europe, where per-capita incomes were stagnant up until about the late 18th, or early 19th, centuries. Over the period 1500-1820 the average per-capita GDP growth rate for 12 Western European countries is estimated to have been a modest 0.14% per year; over the period 1820-70 the growth rate rose to 1.04%, and over the 1870-1913 period to 1.33% (Maddison 2003, Table 8b). A similar pattern can be seen for English real wages, which were roughly constant from 1200 to 1800, and then took off quite suddenly (Clark 2005, Figure 1). This takeoff from stagnation to growth is known as the Industrial Revolution. (See, for example, Galor 2007 for an overview of the facts and sources.)

Also, the type of false starts that our model produces may capture the rise and fall of European city states (De Long and Shleifer 1993, De Long 2000).

The decline in the volatility of growth rates as countries take off to sustained growth is consistent with the well-known cross-country pattern that poor countries have more volatile growth rates (Ramey and Ramey 1994, Olken and Jones 2005).

The rise in the standard deviation in log per-capita income following the takeoff fits with the rise in cross-country income inequality documented by Pritchett (1997) and Lucas (2002). Lucas' (2002, Ch. 4) model (a version of Tamura 1996) also generates a subsequent decline in income dispersion. Our model does not generate such a decline because there is no convergence in growth rates within the growing club.

4.3 The rise and fall of the natural resource curse

One result of our model is that the effects of resource shocks change over the course of development. At the pre-transitional stage, an increase in the size of the contested resource has a positive effect on incomes; after the takeoff to growth the effect is negative; and on the balanced growth path the growth rate of per-capita incomes is independent of resource shocks.

Although humans have obviously relied on different types of resources at different stages of development, some broad historical patterns do seem consistent with this model. The earliest civilizations arose in what was then the Fertile Crescent, and forests and fertile soils have been necessary for their evolvement and survival. The downfall of, for instance, the Maya and Easter Island civilizations followed the depletion of their resource bases (Brander and Taylor 1998, Diamond 2005). In that sense, consistent with our model, natural resources were at that stage of development largely a blessing (and their depletion was the curse).

Resource abundance may have started to become more of a curse concurrent with a number of economic changes beginning in the centuries leading up to the Industrial Revolution. A case in point could be Spain. Initially, the discovery and extraction of silver and gold in the American colonies had a direct positive effect on Spain's incomes, in the sense that it enabled military expansion. However, in the longer run the resulting fiscal expansion created adverse institutional baggage, such as the practice of selling tax exemptions, which in turn delayed Spain's industrialization. This process has been described and modelled by Drelichman (2005); see also Acemoglu et al. (2005). In a sense, Spain's windfall gains thus had opposite effects in the long and short run.

The detrimental effects from resource abundance on growth have been documented in contemporary cross-country data (see, for example, Sachs and Warner 1995; Gylfason et al. 1999; Atay 2001; Sala-i-Martin and Subramanian 2003; Isham et al. 2005, Mehlum et al. 2006). For example, development in Nigeria seems to been hampered by violent struggles over oil (Sala-i-Martin and Subramanian 2003). The East Asian growth miracles occurred in relatively resource sparse environments.

Also consistent with our model, the resource curse does not seem to apply to today's rich and growing countries. Mehlum et al. (2006) find that the resource curse does not apply to countries with good institutions, i.e., rich and growing countries (see also Sala-i-Martin and Subramanian 2003). Some anecdotal and casual empiricism would suggest the same: for example, the income gap between the United States and Europe has little to do with abundance of natural resources on either side of the Atlantic. Resource scarcity has not prevented Luxembourg, Switzerland, or Japan from growing rich; neither has resource abundance (in the form of, for example, oil) been a curse for Norway or Alaska.

5 Alternative functional forms

A more general functional form for the income earned from rent seeking than the one used in (1) is

$$\left(\frac{r_t}{R_t}\right)^{\sigma} \gamma_t H_t^{\eta}, \tag{16}$$

where $\sigma \in (0,1]$ and $\eta \in [0,1)$. Setting $\eta = 0$ and $\sigma = 1$ brings us back to the setting in Section 2.

If $\sigma = 0$, resources are divided equally and agents spend no time in rent seeking. In that sense, a low σ may be interpreted as capturing social norms or institutions which limit rent seeking behavior. We assume $\sigma \leq 1$ to ensure an interior solution for r_t (recall that income from productive activities is linear in r_t).

Assuming that $\eta < 1$ implies that the higher is the level of human capital, the less productive is human capital in rent seeking compared to productive activities. This also rules out sustained growth in human capital absent a reallocation of time away from rent seeking, and into productive activities.

In some complementary notes to this paper (Lagerlöf and Tangerås 2007), it is shown that in this setting the equilibrium time spent in rent seeking becomes:

$$R_t = \begin{cases} 1 & \text{if} \quad H_t \leq \widehat{H}_t, \\ \\ \frac{1}{\rho}\left(\frac{1}{2} - \sqrt{\frac{1}{4} - \frac{\rho\sigma\gamma_t}{BH_t^{1-\eta}}}\right) & \text{if} \quad H_t \geq \widehat{H}_t, \end{cases} \tag{17}$$

where the threshold level is now given by:

$$\widehat{H}_t = \left[\frac{\sigma\gamma_t}{B(1-\rho)}\right]^{\frac{1}{1-\eta}}. \tag{18}$$

Equilibrium income, $Y_t = \gamma_t H_t^\eta + (1 - R_t)B\left(1 - R_t\rho_t\right)H_t$, is given by:

$$Y_t = \begin{cases} \gamma_t H_t^\eta & \text{if} \quad H_t \leq \widehat{H}_t, \\ \\ (1-\sigma)\gamma_t H_t^\eta + BH_t\left(\frac{1}{2} + \sqrt{\frac{1}{4} - \frac{\rho\sigma\gamma_t}{BH_t^{1-\eta}}}\right) & \text{if} \quad H_t \geq \widehat{H}_t. \end{cases} \tag{19}$$

Using (19) and $H_{t+1} = \beta Y_t$ we get a dynamic equation for human capital.

The effects of resource shocks on rent seeking are qualitatively the same as in the previous setting (see Section 2.2.1). Time spent in rent seeking, R_t, increases in response to an increase in γ_t in economies where the productive sector is active (i.e., where R_t is not constrained to unity). However, the effects on income from resource shocks are somewhat different. In particular, for σ small enough income may increase in the wake of a resource shock. Intuitively, when σ is small the rise in income from an increase in γ_t dominates the negative effect on the productivity of human capital caused by the increase in rent seeking.

6 Conclusions

We have presented a growth model where agents divide time between rent seeking and using their human capital. Rent seeking is modelled as competition for a non-growing resource, like land; the human capital activity could be interpreted as trade or manufacturing.

Two elements are central to this model: the first is that rent seeking exerts negative externalities on the productivity of human capital; the second is a shock that changes the size of the resource that agents compete for. Although simple and stylized, the model generates very rich dynamics: an endogenous takeoff from stagnation to growth; several "false starts" preceding the takeoff; a decline in the volatility of growth rates; and a rise in cross-country income gaps.

The results also fit with some long-run facts about the so-called natural resource curse. At early stages of development, when agents spend time only in rent seeking, an increase in resources has only positive effects on incomes. When a growth takeoff has just set in an increase in resources leads to lower per-capita incomes, by inducing a reallocation of time into rent seeking, which lowers the productivity of human capital. On the balanced growth path the detrimental effects of resource shocks vanish, as incomes earned from human capital come to dwarf those earned from resource competition. This three-stage process seems broadly consistent with some historical patterns, but has not yet been replicated in earlier theoretical work.

Several of the mechanisms that here arise by assumption may also arise endogenously in richer frameworks. Most importantly, the negative link from rent seeking to productive activities could be endogenized, for example by endogenizing institutions, which may be positively affected by the amount of trade. For example, in the model of Anderson (2003) trade can induce domestic agents to provide better protection to foreigners, by restricting the scope for bad opportunistic behavior in the market place.

Another element which could be endogenized is the resource shocks. Since these amount to changes in the ratio of total resources over population ($\gamma_t = A_t/P_t$), they could be modeled in a setting where the processes for resources (A_t) and population (P_t) are derived endogenously.

One may also like to use a framework with neoclassical production (rather than the "AK" structure used here) to make a meaningful calibration exercise possible. For example, one could let the rise of the productive sector be driven by exogenous productivity growth, similar to Hansen and Prescott (2002). The very transition phenomenon would then (at least in part) be due to something else than resource shocks, but many interesting features may still be present, like the rise and fall of the natural resource curse.

A Appendix

A.1 Equilibrium rent seeking

First note that $r_t = 0$ is never an optimal choice to the atomistic agent if $R_t = 0$, so $R_t = 0$ cannot be an equilibrium. (An atomistic agent taking $R_t = 0$ as given would get an infinite income by setting r_t arbitrarily small but strictly positive.) We then see from (2) that agents are indifferent as to how to set r_t if $\gamma_t/R_t = B(1 - R_t\rho) H_t$, and prefer $r_t = 1$ ($r_t = 0$) if $\gamma_t/R_t > (<) B(1 - R_t\rho) H_t$. Thus, imposing symmetry ($r_t = R_t$) it is seen that an equilibrium level of R_t on the interval $(0, 1)$ must satisfy

$$\gamma_t/R_t = B(1 - R_t\rho) H_t. \tag{20}$$

Taking into account that $R_t = 1$ if $\gamma_t/R_t > B(1 - R_t\rho) H_t$, we can write:

$$R_t = \min\left\{1, \frac{\gamma_t}{B(1 - R_t\rho) H_t}\right\}. \tag{21}$$

From (21) it can be seen that $R_t = 1$ if $\gamma_t/[BH_t(1 - \rho)] \geq 1$, or

$$H_t \leq \frac{\gamma_t}{B(1 - \rho)} = \widehat{H}_t. \tag{22}$$

This gives the first case in (6). From (21) it is also seen that an equilibrium with $R_t < 1$ must satisfy

$$R_t = \frac{\gamma_t}{B(1 - R_t\rho) H_t} \tag{23}$$

or, after some algebra,

$$R_t^2 - \left(\frac{1}{\rho}\right) R_t + \frac{\gamma_t}{\rho B H_t} = 0 \tag{24}$$

which has solutions:

$$\begin{aligned} R_t &= \tfrac{1}{2\rho} \pm \sqrt{\left(\tfrac{1}{2\rho}\right)^2 - \tfrac{\gamma_t}{\rho B H_t}} \\ &= \tfrac{1}{\rho}\left(\tfrac{1}{2} \pm \sqrt{\tfrac{1}{4} - \tfrac{\rho\gamma_t}{BH_t}}\right). \end{aligned} \tag{25}$$

We choose to disregard the larger root because this equilibrium (if it exists) has many peculiar implications. It implies that R_t is increasing in H_t, so that sustained growth in H_t makes R_t go to one rather than zero. Moreover, for $\rho < 1/2$ it cannot be an equilibrium since that would imply $R_t > 1$.

A.2 Income

Using (6) it easily seen that

$$B(1 - R_t\rho)H_t = BH_t\left(\frac{1}{2} + \sqrt{\frac{1}{4} - \frac{\rho\gamma_t}{BH_t}}\right) \tag{26}$$

for $R_t < 1$. Also, (23) says that

$$B\left(1 - R_t\rho\right)H_tR_t = \gamma_t. \tag{27}$$

Using (26) and (27), together with the expression for income in (2), gives

$$\begin{aligned} Y_t &= \gamma_t + (1 - R_t)B(1 - R_t\rho)H_t \\ &= \gamma_t + B(1 - R_t\rho)H_t - B(1 - R_t\rho)H_tR_t \\ &= \gamma_t + BH_t\left(\tfrac{1}{2} + \sqrt{\tfrac{1}{4} - \tfrac{\rho\gamma_t}{BH_t}}\right) - \gamma_t \\ &= BH_t\left(\tfrac{1}{2} + \sqrt{\tfrac{1}{4} - \tfrac{\rho\gamma_t}{BH_t}}\right), \end{aligned} \tag{28}$$

which is one of the cases in (8).

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Notes

[1]In this respect our paper shares some mechanical features with Lagerlöf (2003a,b), who allows for stochastic shocks to population (epidemics) in a model with endogenous fertility, to explain a transition from stagnation to growth. Likewise, Lagerlöf (2007) allows for war shocks in a model of resource competition and endogenous mortality. Different from these papers, here we endogenize the choice between rent seeking and working in a human capital sector.

[2]Some papers do use dynamic settings, for example Murphy et al. (1991), Tornell and Lane (1999), Grossman and Kim (2000), Gonzales (2007), and Tangerås and Lagerlöf (2007). However, these models are not designed to account for *takeoffs* from stagnation to growth. In that respect, our model relates more closely to the long-run growth literature discussed above.

[3]Since agents are active only in one period of life it may be more correct to call this a non-overlapping generations model.

[4]This is illustrated by the effects of persecution of minorities. As argued by Botticini and Eckstein (2005, Section 7), throughout European history high skill levels facilitated Jewish migration. Human capital accumulation among blacks in the US South facilitated migration to less discriminatory environments, in particular towns (Canaday and Tamura 2006). The idea that the ability to migrate may itself be interpreted as a form of human capital goes back at least to Sjaastad (1962).

[5]For completeness, we could add to (1) that an agent receives the whole pie (and an infinite rent seeking income) if $R_t = 0$, and she herself sets $r_t > 0$. This means that $R_t = 0$ cannot be an equilibrium; see Section A.1 of the Appendix. Note that population is continuous and that each agent has zero measure, so if the whole resource A_t goes to one agent, she receives an infinite rent seeking income.

[6]In Section 5 we present a specification where institutions also affect the marginal productivity of rent-seeking.

[7]Letting the child's human capital directly enter the parent's utility function is the easiest way to create a link from income today to human capital tomorrow. One could alternatively assume that parents care about their children's total income, or welfare. That would greatly complicate the analysis.

[8]The quadratic equation which defines the set of equilibria [see (24)] also has the root

$$R_t = \frac{1}{\rho}\left(\frac{1}{2} + \sqrt{\frac{1}{4} - \frac{\rho\gamma_t}{BH_t}}\right).$$

However, as discussed in Section A.1 of the Appendix, this equilibrium (if it exists) has many peculiar features, so we do not to consider it here.

[9]Using (23) in the Appendix [or applying l'Hôpital's rule to (6)] one can see that $\rho = 0$ gives $R_t = \gamma_t/(BH_t)$. Using (2), setting $r_t = R_t$ and $\rho = 0$, income in equilibrium is seen to equal $Y_t = \gamma_t + (1 - R_t)BH_t$. It is then straightforward to verify that

$$\frac{\partial Y_t}{\partial H_t} = (1 - R_t)B - \left(\frac{\partial R_t}{\partial H_t}\right) BH_t = B.$$

[10]That is, H_{t+1}/H_t goes to βB as H_t goes to infinity, so if $\beta B > 1$ it holds that H_t can grow indefinitely.

[11]Using (8) and (9) we see that Y_{t+1}/Y_t approaches βB, as H_t goes to infinity.

[12]To be precise, on the balanced growth path an increase in γ_t raises the *level* of income. However, the fraction of income earned from resources approroaches zero as human capital income goes to infinity, thus making the growth effect zero in the limit.

[13]Fertility is not modelled here, but population could be thought of as increasing due to immigration.

[14]To see this, recall that $H_{t+1} > \widehat{H}_{t+1}$ when ε_t falls below $\beta B(1-\rho)$. With ε_t uniformly distributed on $[\underline{\varepsilon}, \overline{\varepsilon}]$, this happens with probability

$$\frac{\beta B(1 - \rho) - \underline{\varepsilon}}{\overline{\varepsilon} - \underline{\varepsilon}},$$

which equals 0.01875 if we plug in the numbers above.

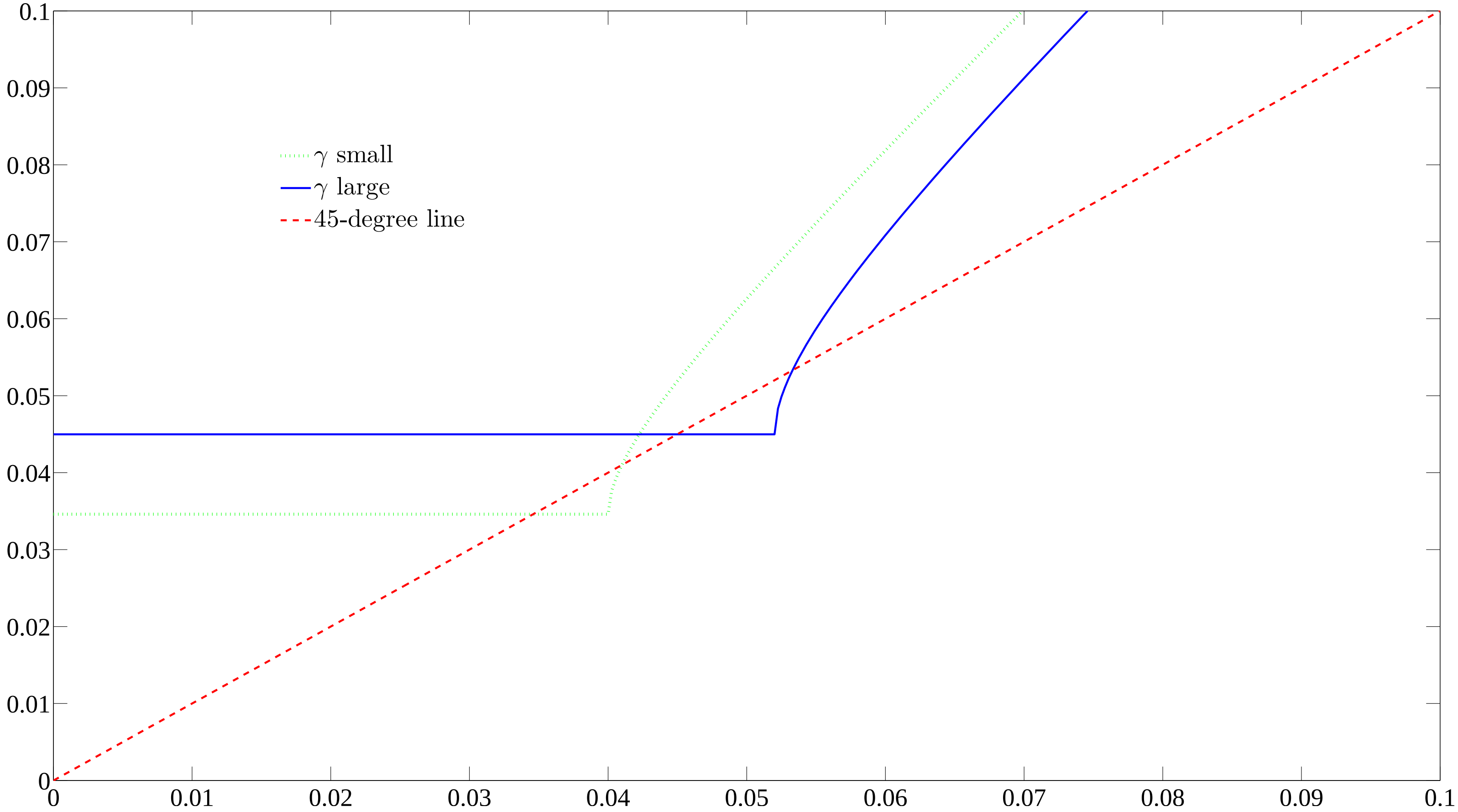

Figure 1: Dynamics for H_t for different constant levels of γ.

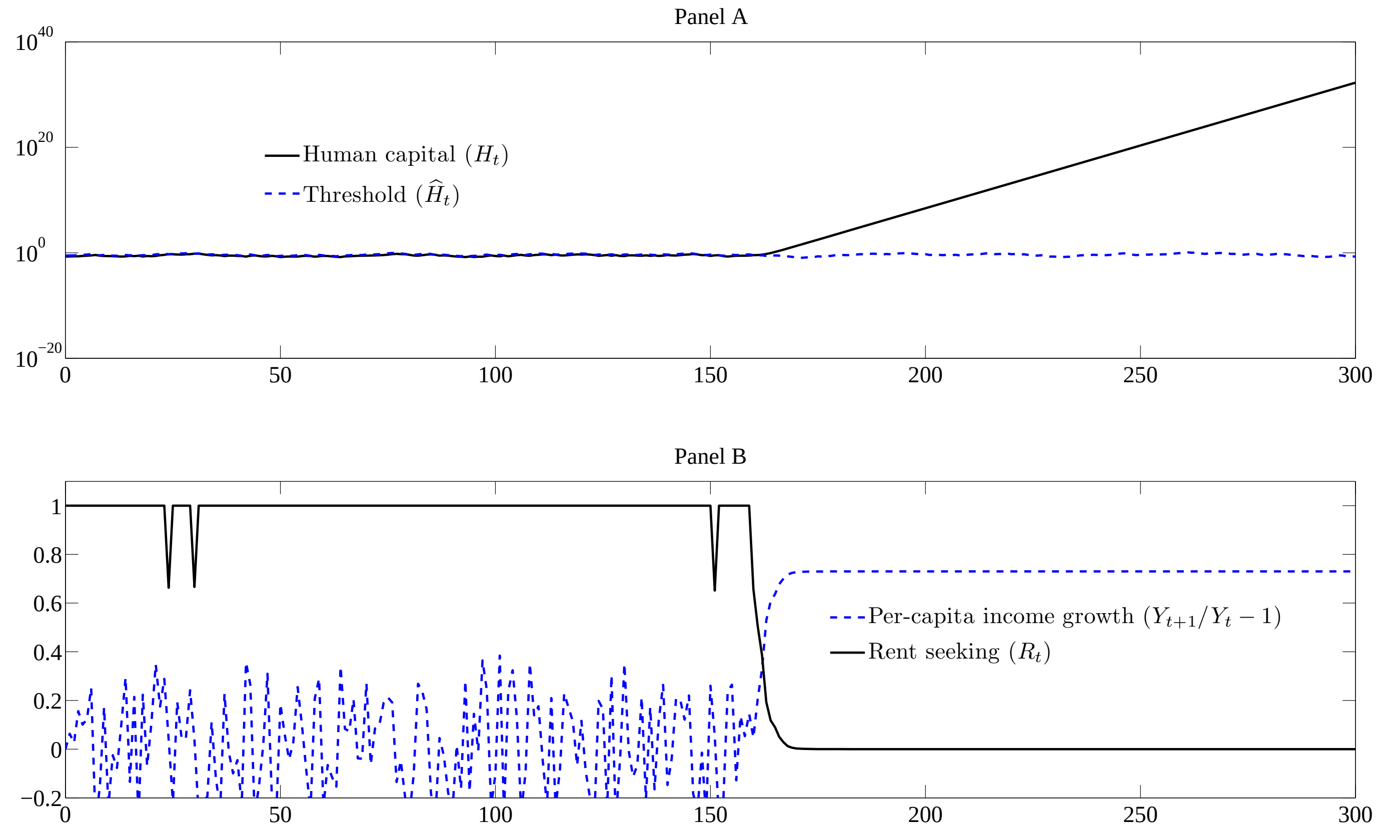

Figure 2: Simulation of one single economy.

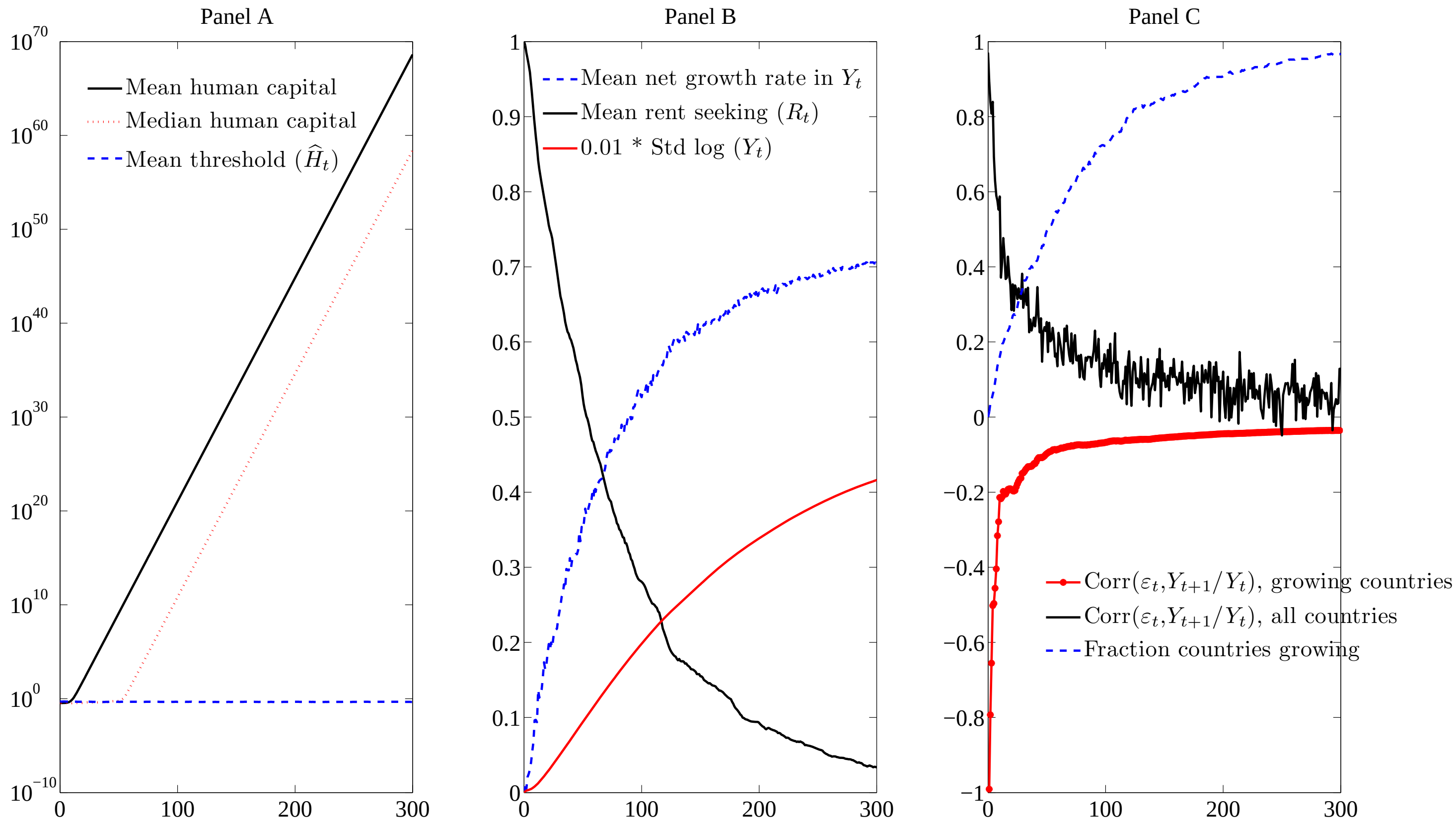

Figure 3: Monte Carlo simulation (500 runs).

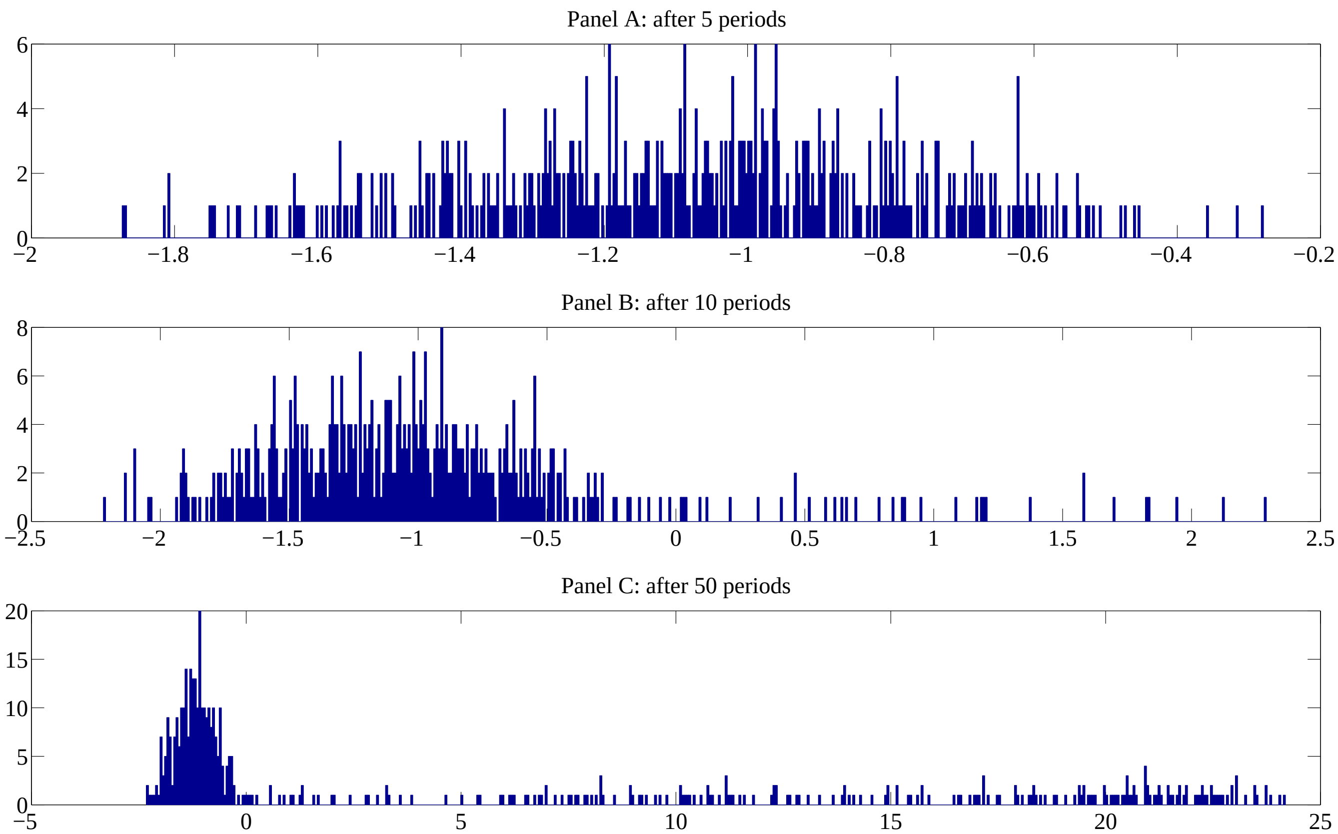

Figure 4: Histograms over $\ln(H_t)$.