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Hobbes to Rousseau:
Inequality, Institutions, and Development

Matteo Cervellati
Piergiuseppe Fortunato
Uwe Sunde

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Matteo Cervellati
University of Bologna

Piergiuseppe Fortunato
University of Bologna

Uwe Sunde
*IZA Bonn
and University of Bonn*

ABSTRACT

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This paper studies the endogenous evolution of economic and political institutions and the interdependencies with the process of economic development. Favorable economic institutions in form of a social contract that ensures a state of law and the absence of societal conflict are not assumed exogenously under certain political systems, but arise in equilibrium. We study the conditions under which a state of law can be implemented under oligarchy, and when democratization is necessary. Economic inequality is the main determinant of economic and political institutions. In turn, institutions shape the income distribution. Simulations illustrate how inequality affects the development process and may lead to overtaking and divergence.

Corresponding author:

Uwe Sunde
IZA Bonn
P.O. Box 7240
53072 Bonn
Germany
Email: sunde@iza.org

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1 Introduction

The importance of institutions for economic development is well recognized. A vast literature studies the economic consequences of the different political institutions regulating the limits of political power and the aggregation of individual preferences.[1] An important finding is that political institutions affect social interactions, the resolution of conflicts of interests, and play an important role in shaping economic outcomes. Another strand of the literature highlights the role of economic, rather then political, institutions, and in particular the role of well functioning legal systems and the existence of a state of law, as a primary determinant of economic development.[2] Also, there exists an increasing awareness that economic and political institutions themselves evolve endogenously and are affected by economic forces and long term development.

In this paper we propose a theory which studies the distinctive roles of economic institutions and political systems in the process of development, and the role of economic inequality and long-term development as both a determinant and a result of institutional change. We address the issue by modelling economic and political institutions as intrinsically different but interacting domains. Formally, we provide a stylized model which relates to the metaphors proposed by Thomas Hobbes (1651) and Jean-Jacques Rousseau (1762) where a favorable environment of economic institutions is interpreted as a 'social contract', or state of law, characterized by limited conflict in society. Conversely, when society falls into a 'state of nature', resources are wasted in economy-wide conflict and universal expropriating activities. In the model we study the conditions under which efficient economies can emerge in equilibrium under different political regimes. In particular, we consider democracy with universal franchise as opposed to limited franchise under oligarchy. In each regime, political power allows the enfranchised population to decide about income redistribution but without having the possibility to *ex-ante* commit over political actions. Conditional on the political system, the social contract, or the absence of it, is the equilibrium outcome of a simple conflict game played between well defined social groups. In particular, we consider a simple conflict game in which groups can decide to invest in "arming" or abstain from it, but where the cost of conflict is given. This conflict model is nested

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[1]This includes, among others, investigations of the effects of the political system (democracy or not), the role of voting systems, of the form of government, or of the form of state to name a few, on various governmental activities and economic performance in general. See e.g. Persson, Roland, and Tabellini (2000) as well as two recent books by Persson and Tabellini (2003) and Alesina and Glaeser (2004) for surveys of theories and empirical evidence.

[2]For example Glaeser and Shleifer (2002) emphasize the crucial role of economic, particularly legal, for economic well-being and also stress the role of the social environment.

in a simple growth model in which economic inequality changes overtime. At each moment in time, the political and economic institutions emerge as subgame perfect Nash equilibrium of the game played among the members of different groups in society. As a result, good economic institutions, i.e. a social contract, can be sustained if and only if no individual has incentives to deviate and invest in arms and conflictual activities.

The model predicts that a social contract can be sustained in equilibrium under different political systems. Inequality in resource endowments and incomes, which is closely linked to the level of development of the economy in our model, is the crucial determinant of political and economic institutions. In particular, we find that if inequality is sufficiently high, the economy can sustain a social contract only under the rule of an oligarchic elite, with all members of society optimally obeying to this system, paralleling Hobbes' Leviathan. In contrast, if inequality is sufficiently low, a social contract can only be supported under democracy. For intermediate levels of inequality a state of nature, characterized by widespread conflict, can represent the unique equilibrium. In this situation no social contract is feasible regardless of the political system in place.

The paper relates to several branches of the literature. The set up allows to investigate the dynamic feedback effects between the endogenous evolution of economic and political institutions and the process of economic development and inequality. Consequently, the model delivers predictions for the development path of an economy together with its institutional and political environment by uncovering the dynamic forces leading to institutional changes and, in turn, the effects of these changes for economic development. The paper therefore contributes to the increasing literature studying the economic forces behind the process of democratization. In their seminal contributions, Acemoglu and Robinson (2000, 2001, 2004) put forward the argument that rich elites may initiate a democratic transition as a commitment device against regressive redistribution to moderate the pressure of social conflict.[3] In our model, as in other contributions including Bourguignon and Verdier (2000), Bertocchi and Spagat (2004), Lizzeri and Persico (2004), and Llavador and Oxoby (2005), the process of endogenous institutional change is related to an efficiency argument for the democratic transition which implies that the extension of the franchise may also be in the own interest of (part of) the oligarchic elite.[4] This feature is also

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[3]In these papers, social conflict is seen as the main force leading to democratic transitions: oligarchic elites facing substantial opposition and a threat of revolution release political power to larger parts of the population in a controlled way. See also the discussion in Acemoglu, *et al.* (2004). Related studies that investigate extensions of the franchise by the elite as an instrument to avoid conflict are Bertocchi and Spagat (2001) and Conley and Temimi (2001).

[4]In these contributions, democratic regimes allow to increase efficiency by facilitating, or giving higher incen-

present in the contribution by Gradstein (2006) who, as does our study, investigates the role of inequality for the endogenous emergence of democracy. In fact, despite the different focus on the endogenous emergence of public property rights protection, our results corroborate and complement Gradstein's findings on the role of initial inequality for the development path and the transition to democracy.

Differently from most of the previous literature, in which democracy is a necessary and sufficient condition to ensure the appropriability of economic efforts through a state of law, we do not assume that democratic regimes are 'intrinsically better' than oligarchies, however. Both political regimes can exhibit statically efficient economic institutions under a social contract, or alternatively widespread wasteful conflict. The economic institutions are the equilibrium outcome of a simple conflict game between two well defined social groups. The features of societal conflict are shared with the contribution of Esteban and Ray (1999). While their aim is to study how the extent of conflict, as measured by its wastefulness, depends on the preferences and relative sizes of groups without considering the role of income inequality, the focus of our paper is on disentangling the distinct roles of income inequality and political institutions in determining conflict resolution and thus economic institutions, and in creating the conditions under which a state of law can be sustained in equilibrium. Moreover, our paper also investigates the resulting dynamic evolution of the economy. The emphasis on disentangling political and economic institutions is shared by Acemoglu (2006), who concentrates on issues like inefficient regulation of economic activities rather than democratization and the role of inequality, however. Our model provides conditions under which different political regimes are expected to lead to efficient outcomes, and delivers a rationale for the historical and contemporaneous empirical observation that even oligarchies can be relatively efficient in preventing wasteful investment in appropriative conflictual activities. In fact, our results are line with the empirical evidence presented by Glaeser et al. (2004), that good economic and political institutions, although causally affecting each other, can, but do not have to, go hand in hand. In the model, while being equally effective in limiting conflict activities, the social contracts emerging in the different regimes tend to be different, however. In particular, democracies are characterized in equilibrium by larger governments, which provide more redistribution and public goods then oligarchies. Therefore the different political regimes may be characterized by different patterns of dynamic efficiency due to the different public policies, and the distortions and externalities associated

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tives for, the accumulation of growth-enhancing human capital, by facilitating the provision of public goods as compared to oligarchies, or by setting limits to rent-seeking and corruption by the elite and granting universal property rights.

with them. Whenever democracies emerge in equilibrium they are statically (and dynamically) efficient in our model. This is not necessarily the case for oligarchies, which may be observed in equilibrium even if they are inefficient. The joint predictions of the model can therefore rationalize the empirical observation that in a long run perspective democracies seem to fare better economically than oligarchies even though democratic institutions do not represent a necessary condition for the emergence of good economic institutions.[5] Also, rather than economic development, inequality constitutes the main determinant of economic and political institutions in our model. This allows to rationalize the findings of Acemoglu *et al.* (2005) that richer countries in terms of higher per capita incomes are not necessarily more likely to be democratic.

The model can be applied to study the importance of natural resources and initial inequality for the realization of uneven development paths. We show that the interplay of political and economic institutions may explain episodes of reversal of fortunes. In particular, countries that are richly endowed with natural resources, but where these resources are unequally distributed among the population, can be overtaken in terms of income and growth by initially poorer but more equal countries. Hence, natural resource abundance may negatively affect development if it leads to poor economic institutions, which is more likely the larger the inequality in the distribution of its ownership. This is in line with the historical discussion of development in the Americas by Engerman and Sokoloff (2001). In this respect the paper also complements the findings of Mehlum, Moene, and Torvik (2006), who show that the quality of economic institutions, i.e. the quality of the state of law and property rights enforcement, is crucial for the occurrence of a resource course. A dynamic simulation is presented to illustrate the analytical findings.

The paper is organized as follows. Section 2 presents a theoretical framework to analyze consequences of the presence or absence of a social contract. The politico-economic equilibria of the model are investigated in section 3. Section 4 studies the endogenous evolution of the politico-economic environment of the economy over time and presents some simulations that illustrate the properties and implications of the model. Section 5 concludes.

2 Theoretical Framework

This section introduces the institutional and economic environment under which the members of a society live and make their decisions, and which they endogenously determine by their actions.

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[5]See e.g. Barro (1999), Tavares and Wacziarg (2001), Papaioannou and Siourouni (2004), and Rodrik, Subramanian, and Trebbi (2004) for evidence that democracies are richer and grow faster than non-democracies.

We first discuss the conceptual properties of political and economic institutions that motivate our model, and then their theoretical implementation.

2.1 Institutional Environment: A Social Contract View

The first component of the institutional environment is the political system. For simplicity, we concentrate on two extreme political systems, oligarchy (or aristocracy) and democracy, both of which differ by the formal allocation of political power. The difference between the two systems is given by the degree of enfranchisement: in democracy, all members of society have the right to vote, while in oligarchy some people are excluded and the constituency is restricted to a leading class of oligarchs, the elite.[6] This implies that the decisive agent for political decisions in the two systems differs as well. Consequently, if the interests of the decisive agents in oligarchy and democracy do not coincide, then different actual policies are implemented in the two systems.

The second component of the institutional environment are the rules governing all economic and social interactions. In this respect, we discriminate between state of nature and state of law established under a social contract, reflecting the views of Thomas Hobbes and Jean-Jacques Rousseau. A universally accepted social contract, or a state of law, is characterized by the existence of universally known, accepted, and enforced rules that govern all social interactions. Alternatively, the absence of a social contract is reflected the state of nature. The state of law is more efficient than the state of nature, because individuals face no uncertainty concerning the appropriability of their investments or permanent threat of being expropriated.

Following the views of Thomas Hobbes, under the state of nature...

> " every man will and may lawfully rely on his own strength and art, for caution against all other men. (...) For being distracted in opinions concerning the best use and application of their strength, they [i.e. all men] do not help, but hinder one another, and reduce their strength by mutuall opposition to nothing: (...) also, when there is no common enemy, they make warre upon each other, for their particular interests."
>
> (T. Hobbes, 1651, Leviathan, Part 2 Ch. XVII, pp.128-129)

Our modelling of the politico-economic environment is in line with this view. Individuals face an allocative problem on how to use their "strength" (i.e. income in our model), in the most beneficial way. They decide whether or not to get involved in costly 'arming', i.e. some sort of

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[6]In our model, there is no need to distinguish between *de jure* and *de facto* political power, since both always coincide, as will become clear below. The restriction to two regimes is made for simplicity. See e.g. Gradstein (2006) for a model that allows for intermediate levels of enfranchisement.

conflictual activities. We consider well defined social groups, elite and people. If both groups engage in conflict, neither one will be successful: their attempts cancel each other leading to a mere destruction of income, they "reduce their strength by mutuall opposition to nothing": this is the source of inefficiency associated with the state of nature.[7]

Alternatively the different groups can adhere to a social contract and implement a state of law by abstaining from getting involved in arming activities. According to Jean-Jacques Rousseau the crucial attribute of a society is whether a state of law, exists, or whether the state of nature rules:

> "I therefore give the name "Republic" to every State that is governed by laws, no matter what the form of its administration may be. (...) I understand by this word [Republic] not merely an aristocracy or a democracy, but generally any government directed by the general will, which is the law."

> (J.J. Rousseau, 1762, The Social Contract, Book 2 Ch. 6, pp.39-40)

In Rousseau's view, a social contract can arise under very different political systems. In the following we investigate the possibility of sustaining a social contract in the different political regimes as well as the efficiency features of these equilibria.

2.2 The Model

We next present a model that operationalizes this institutional environment, in particular the concepts of economic and political institutions, in a parsimonious way.

Individuals. Consider an economy, which is populated by an infinite sequence of overlapping generations of individuals. A given generation consists of a continuum of adult individuals i, representing generation t, and a continuum of young individuals i, who represent the adults of generation $t + 1$. Each individual has a single parent and a single offspring, so the size of the population, which is normalized to one, is constant across generations. We use i to interchangeably denote an individual or the dynasty to which he belongs. The population is divided in two groups. The first group constitutes the minority, making up for a fraction $\gamma < 1/2$

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[7]The model can be extended by also considering within group conflict that has to do with the distributional struggle arising if one group successfully expropriates the other, reflecting that individuals "make warre upon each other, for their particular interests". Such an extension, e.g. along the lines of Olson (1965) with internal conflict being more easily resolved in smaller groups, would leave the qualitative results unaffected.

of the population. This group is called the elite, and denoted by E.[8] The remaining fraction $(1 - \gamma)$ of the old population is called the people P. All members of a particular group are identical, they face the same decision problems, and so we can interchangeably speak about a (representative) member of the group or the entire group.

Agents derive utility only from consumption so that maximization of income is a necessary and sufficient condition for utility maximization. Consumption is financed from the income individuals derive from supplying factors of production to the market. During their youth individuals acquire human capital h_t which is produced using only time.[9] The human capital of a generation $H_t = h_t$, fully depreciates when the generation dies. While childhood is devoted to the acquisition of human capital, income production and consumption take place during adulthood. Every individual is endowed with one unit of labor, which he inelastically supplies during his adult life. Apart from labor and human capital, a fraction γ of individuals, the elite, are endowed with natural resources like land. This land is equally distributed among the members of the elite, each one owning $n^E = N/\gamma$, and it is passed-on from generation to generation. The landless people, $i \in P$, own no land, so $n^P = 0$. Land, contrary to human capital, does not depreciate $N_t = N$. We denote per capita variables by lower case letters, and aggregate variables by upper case letters, i.e. $y_t = Y_t/L$, $h_t = H_t/L$, and $n = N/L$. Individuals derive incomes from supplying their factor endowments and are given by $y_t^i = w_t + r_t h_t + \rho_t n^i$, where wages on labor and human capital, w_t and r_t, respectively, and the rent on land ρ_t are determined in equilibrium. Since only members of the elite own land, individual incomes differ between the two groups, with $y_t^E > y_t^P$.

Production. The economy is fully competitive, and all resources are employed in the production of a single final commodity Y, which is used for consumption. The production technology exhibits constant returns to scale and is of the form

$$Y_t = [A_t H_t + N]^\alpha \, L^{(1-\alpha)} \,. \tag{1}$$

Besides the inputs, production is affected by a productivity index A_t, which reflects the technological level of production and augments human capital.

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[8]For later use we assume that members of this group possess some initial political power, enabling it to constitute an oligarchic regime. For example, this power derives from the possession of particular resources, such as land, or other peculiar attributes, like nobility. Alternatively, we could assume an income or wealth requirement for political participation.

[9]In the following we consider the possibility that the acquired human capital may be affected by the provision of a public good which for simplicity is modelled as an externality.

The technological environment evolves endogenously depending on the total stock of human capital available in the economy. Technological innovations in the form of changes in A arrive with the birth of a new generation and build on the available stock of human capital. As a result, we observe steady technological innovations which improve the production possibilities of the economy,

$$\frac{A_t - A_{t-1}}{A_{t-1}} = f\left(H_{t-1}\right) \tag{2}$$

with $f'\left(\cdot\right) > 0$.[10] Following the endogenous growth literature along Lucas (1988) and Romer (1990), human capital acquired by one generation exerts an externality on productivity of the next generation, and is therefore the engine of growth, while technical progress is biased in favor of augmenting the productivity of human capital.[11] At the same time, these two features imply that the available stock of human capital in a given generation indirectly makes human capital a more important source of income for future generations.

Conflict Game. Conditional on the political system in place, the distribution of disposable income is the result of a conflict game played between the different groups. Each group can decide to either "arm" or "not arm". The strategic form of the game is depicted in Figure 1. Whenever one group arms, a wasteful conflict arises. For simplicity we assume that such a conflict implies that a share $(1 - g)$ of total available income is lost, representing the cost of conflict. If only one group chooses to arm and go to conflict, we observe a transfer of income from the non armed to the armed group. Without loss of generality, we assume that all income in the economy net of the waste implied by conflict is appropriated by the armed group. This is illustrated in the off-diagonal panels of Figure 1. If both groups arm the result is mutual opposition to nothing so that both groups burn a fraction $(1 - g)$ of their own income without being able to appropriate anything in addition.[12] This situation is depicted in the top-left panel

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[10] Any formulation implying a positive relationship between human capital and technological progress is equivalent for the results. This specification reflects the idea that the stock of ideas transfers into the productivity of future generations, see e.g. Jones (2001).

[11] The specification of the production function, which is also used by Acemoglu and Robinson (2003), is formally equivalent to the one with two distinct sectors, one exclusively employing land resources together with labor, and the other exclusively human capital together with labor. Assuming that the productivity of land relative to human capital decreases following technological change is consistent with historical evidence from England that suggests that productivity growth in agriculture was modest if existent at all before and during the Industrial Revolution, see Clark (2001, 2002).

[12] This game can be interpreted as an extreme form of a contest game with a non-convex conflict technology in which a threshold expenditure $(1 - g)$ is needed to make the investment effective, and where the probability of winning the contest is one if only one group arms and is zero if both groups arm. The assumption that the

and essentially constitutes a society living under a state of nature with everybody struggling against everybody while foregoing part of their income. Only if both groups abstain from arming, conflict is avoided and no income is burned. If this is the case the society is characterized by a social contract. A social contract may stipulate redistribution of income which, by not going to conflict, is implicitly agreed across groups. The disposable income of available to the members of the two groups under a social contract is denoted by $\widetilde{y}_t^P$ and $\widetilde{y}_t^E$, respectively. This case is reflected in the lower right panel of the figure. The extent of taxation and income redistribution across groups results from a political process that is studied next.

Insert Figure 1 about here.

Political System and Income Redistribution. Under oligarchy, the political power is in the hand of the elite who have the possibility to offer their preferred social contract ($\widetilde{y}_t^P$ and $\widetilde{y}_t^E$). The group in power cannot commit on any action, however. This implies that the elite could e.g. announce a particular redistribution scheme and *ex post* implement a different one, or announce that they will 'not arm', but eventually do arm in order to expropriate the people. In terms of the game introduced before, this absence of commitment implies a timing in which the elite always moves after the people. In turn, the defining characteristic of a democracy is that that everybody participates in the process of political decision making. In the current setting, the people represent the majority in the society so that the pivotal agent is a member of the people under democracy. In terms of the extensive form of the game, this implies that in oligarchy the elite moves last while the opposite is true in democracy. The political system is therefore represented by the sequence of decisions and, in any regime, the group in power has no possibility to commit over fiscal redistribution or arming behavior.

Fiscal redistribution, implemented under any social contract, mirrors the preferences of the group which has political power. For convenience (and realism) we restrict the policy space in both political systems such that there is a maximum extent of regressivity and progressivity. To be more concrete, we assume that under any political system, the tax system can stipulate at most either no redistribution from rich to poor or full redistribution and equalization of incomes.[13] We denote by G_t the total size of fiscal revenues and reflects the extent of the redistribution scheme. Since the people are poorer than the elite, the equilibrium outcome

cost of conflict is the same if both groups or only one group arms do not affect the qualitative results because the off-diagonals will turn out to be out of equilibrium events.

[13]This assumption is made for simplicity. In fact, to sustain equilibria we need much weaker restrictions on the policy space. In particular, as long as policy space is restricted such that, under any political system, both groups get at least a positive income net of taxes, the equilibria discussed in the next section are feasible.

of a voting over taxation under democracy leads to maximum (progressive) redistribution.[14] This means that the only feasible and credible tax and redistribution scheme under democracy involves a social contract where all members of society receive the same income: $\widetilde{y}_t^E = \widetilde{y}_t^P = y_t$. Under oligarchy, on the other hand, the elite has no incentive to implement a social contract involving progressive redistribution. Therefore, the social contract in an oligarchic republic implies no redistribution $\widetilde{y}_t^E = y_t^E$ and $\widetilde{y}_t^P = y_t^P$. This reflects the conventional view that the social contract exhibits more progressive redistribution in democracies that in oligarchies, which goes back to De Tocqueville (1835).[15] This view is also in line with empirical and historical evidence.[16]

<div align="center">
Insert Figure 2(a) about here.

Insert Figure 2(b) about here.
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Timing of Events. We first investigate the decisions of the members of the different groups under the different systems. Depending on whether the economy is characterized by oligarchy or democracy, the groups therefore play either the game depicted in Figure 2(a) or in Figure 2(b). The timing of events within a generation's lifetime is as follows.

1. Birth and period of youth with human capital acquisition h_t^i;

2. Adulthood, with

    (a) production and income generation, w_t, r_t, ρ_t, y_t^i;

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[14]Notice that, as investigated below, taxation is distortionary in the sense that it may lead to a state of nature by inducing arming. Under a state of law, taxation does not distort income production so that maximum redistribution can induce full equalization of post-tax income.

[15]See also Meltzer and Richard (1981). Voting over linear-progressive tax schedules with distortions could be introduced without changing the main results. This would lead to the 'median voter hypothesis', under which taxation increases with inequality. A similar argument is made in the model by Bourguignon and Verdier (2000), where the poor people cannot commit not to expropriate the rich elite once democracy is established. Also, allowing for regressive redistribution in oligarchies would not change the result. What is crucial for our argument is merely the higher progressivity of the redistribution scheme under the democratic social contract.

[16]In a historical discussion of economic and political development in Britain, Justman and Gradstein (1999) argue that democratization was the prime factor that led to declining inequality in the aftermath of the Industrial Revolution beginning in the second third of the 19th Century. In particular, the extension of the franchise led, according to their discussion, to the replacement of regressive indirect taxes by progressive taxes on incomes, land and inherited wealth following. Analyzing historical episodes and cross-country data, Gradstein and Milanovic (2000) and Gradstein, Milanovic, and Ying (2001) find a robust positive correlation between democratization and income equality.

(b) realization of conflict decisions and equilibrium political regime;

(c) redistribution and realization of disposable incomes;

(d) consumption and death.

A new generation is born when its parent generation enters adulthood, and its grand-parent generation dies. This completes the framework, whose dynamic properties are analyzed in the following section.

3 Intra-generational Equilibria

In this section, we characterize the political environment that arises endogenously as equilibrium. A politico-economic equilibrium is characterized by a political system, a redistribution scheme under this system, the arming behavior of the two groups, and the resulting factor and consumable incomes of all members of society, such that all decisions constitute a subgame perfect Nash equilibrium.

3.1 Factor Price Equilibrium and Individual Income

The economy is competitive and all factors are remunerated according to their marginal products.[17] Equilibrium factor prices in terms of labor wages, wages for human capital and land rents, in the economy are given by

$$w_t = w(h_t, A_t, n) = (1 - \alpha) [A_t h_t + n]^\alpha ; \tag{3}$$

$$r_t = r(h_t, A_t, n) = \alpha [A_t h_t + n]^{\alpha - 1} A_t ; \tag{4}$$

$$\text{and} \quad \rho_t = \rho(h_t, A_t, n) = \alpha [A_t h_t + n]^{\alpha - 1} , \tag{5}$$

While the implied income share of labor is stable, the incomes generated by human capital grow at the expense of the incomes generated by land over the course of development.[18]

For notational convenience, denote the effective stock of human capital available per member of generation t in the economy as $\tilde{h}_t$, with

$$\tilde{h}_t \equiv A_t h_t . \tag{6}$$

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[17]Evidence supports this assumption. Even historically, different sectors were competing for factors and factor prices reflected productivities, even before or at early stages of the industrial revolution, see e.g. Magnac and Postel-Vinay (1997).

[18]This is in line with historical evidence. See also Acemoglu and Robinson (2003).

Using this notation, and substituting with the expressions for equilibrium factor prices given by conditions (3), (4) and (5), income of individual i, $i \in \{E, P\}$, can be expressed as

$$y_t^i = w_t + r_t h_t + \rho_t n^i = \left(\tilde{h}_t + n\right)^\alpha \left[(1 - \alpha) + \frac{\alpha \tilde{h}_t}{\tilde{h}_t + n} + \frac{\alpha n^i}{\tilde{h}_t + n}\right] \text{ with } i \in \{E, P\}. \quad (7)$$

Average per capita income is given by $y_t = \left(\tilde{h}_t + n\right)^\alpha$. Also, denote individual income relative to average per capita income by, $\lambda_t^i \equiv \frac{y_t^i}{y_t}$ with $i \in \{E, P\}$ where incomes of members of the elite and the people differ because of the different land endowments. Denote the income of members of the elite relative to that of people simply as $\lambda_t \equiv \frac{y_t^E}{y_t^P}$.

3.2 The Politico-Economic Equilibrium

The goal of this section is to determine under which economic and political conditions a social contract can be supported as equilibrium. By their own arming decisions, members of the different groups determine whether they live under a state of nature, or adopt a state of law. In this sense, a social contract can only arise with mutual consent of all members of society, which justifies the term.[19] This section focuses on static equilibria, so we suppress generation indices t as long as there is no possibility of confusion. The analysis of the dynamic evolution of the economy and the endogenous emergence of different equilibria is postponed to the next section. Three different types of equilibria can arise. These equilibria are denoted State of Nature, Oligarchic Republic, and Democratic Republic, and we characterize them in the following.

State of Nature. The state of nature is characterized by a situation in which all groups invest in arming. This state arises in equilibrium if at least one group does not have sufficient incentives to adhere to the social contract, and therefore deviates by investing in arming activities. Such an equilibrium can be the outcome of social interactions under any political regime. Recall that, as stated above, we assume that no commitment over arming actions and policies (redistribution) is possible by part of the group in power. This implies that in oligarchy the elite moves last, after having observed the people's arming decision. Likewise, in democracy the people have the last move. Notice also that for the group that is not in power and therefore has the first move, the best option is to arm in case it is anticipated that the group in power will

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[19]Also here, the definition follows Rousseau's description:

" To find a form of association which defends and protects the person and property of each member with the whole force of the community, and where each, while joining with all the rest, still obeys no one but himself, and remains free as before.' This is the fundamental problem to which the social contract provides the answer." (Rousseau, 1762, part 1 ch. 6, pp.14-15).

arm. A direct implication of this observation is that a state of nature materializes in equilibrium whenever the group in power, at the moment of making its move, has incentives to go to conflict and arm. Recall that the absence of commitment over public policies implies that the social contract in democracies (oligarchies) stipulates maximum (minimum) progressive redistribution. Under oligarchy, if the elite arms and the people abstain from doing so, all income in the economy, net of the cost associated to arming and conflict, is appropriated by the ruling class. The elite therefore has an incentive to arm *ex-post* if

$$\frac{yg}{\gamma} > y^E \,. \tag{8}$$

Symmetrically, in a democratic regime a state of nature arises if the people have the incentive to arm *ex post*. This is the case if the people earn a larger income by arming than by adhering to the social contract which would allow them to obtain, at most, full equalization of incomes,

$$y\frac{g}{1-\gamma} > y \,. \tag{9}$$

But even if the people do not have an incentive to deviate from the social contract in democracies, a sufficiently rich elite can find it optimal to arm. This is the case if the cost of redistribution is sufficiently large for the elite to prefer to pay the cost of arming.[20]

$$y^E g > y \,. \tag{10}$$

The economic outcome under state of nature, i.e. in the absence of economic institutions under which individuals optimally abstain from arming and without a social contract, is the same regardless of the political system. Hence we have the following,

Proposition 1 (State of Nature). *The politico-economic equilibrium* state of nature *is characterized by societal conflict with all individuals investing in arms, and* $G_t = 0$. *For any* $\{A_t, N, H_t, \gamma\}$, *the state of nature equilibrium emerges if, and only if, condition* (8) *holds under oligarchy, while under democracy a state of nature arises if either* (9) *or* (10) *holds.*

Proof. Consider the conflict game under oligarchy as depicted in Figure 2(a) in which (8) holds. In this case $G_t = 0$ and no income is taxed. Not to arm is a strictly dominated strategy for the elite. Anticipating this, also the people arm, excluding the possibility for a social contract, proving the first claim. Likewise, consider the conflict game under democracy as depicted in Figure 2(b) in which (9) holds. Anticipating that no arming is a strictly dominated strategy

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[20]Notice that in this case arming can be also interpreted as an investment in private property rights protection since it also serves the role of not be subject to fiscal redistribution.

for the people, the elite will arm regardless of any income condition. If (9) is violated, the elite induces a social contract by choosing not to arm, or a state of nature by choosing to arm. However, if (10) holds, again not to arm is strictly dominated, leading the elite to induce a state of nature equilibrium. □

The emergence of a state of nature depends on the level of inequality prevalent in the economy at each moment in time as well as on the degree of inefficiency associated to arming. Deviations from the social contract are less likely if arming is substantially distorting. In fact, for any degree of economic inequality it is possible to identify an upper bound on the wastefulness of conflict above which the social contract can always be implemented, i.e. the state of nature cannot arise in equilibrium.

Lemma 1. *For any $\{A_{t,}N, H_t, \gamma\}$ there always exists a level $\underline{g}(\gamma) \in (0,1)$ such that for any*

$$g < \underline{g}(\gamma)$$

the state of nature cannot emerge in equilibrium.

Proof. In the appendix. □

A social contract can only emerge if it represents a subgame perfect Nash-equilibrium of the game depicted in Figure 2(a) for the case of oligarchy and in Figure 2(b) for the case of democracy. In order to investigate conditions under which a social contract can emerge in equilibrium in a non-trivial way, for the moment we restrict attention to the case in which a state of nature can actually arise in equilibrium, i.e. $g > \underline{g}(\gamma)$.[21]

Oligarchic Republic. In an oligarchy, political power is restricted to the members of the elite who cannot commit *ex ante* to their actions. Nevertheless, in equilibrium it is possible to sustain a social contract if the elite find it optimal not to arm *ex-post*, provided that the people also refrain from arming. Analogously to condition (8) this is the case if and only if,

$$yg/\gamma < y^E. \tag{11}$$

If this condition holds, oligarchic republic is the elite's strictly preferred regime. Since the people move first under an oligarchic system, they anticipate that if they would arm, they would induce the elite to do the same, leading to a state of nature. Notice also that if condition $g > \underline{g}(\gamma)$ holds, then condition (10) is satisfied and the elite arms under a democracy with full redistribution. In

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[21]In the other parametric configuration the equilibrium is always characterized by a social contract. For expositional convenience we discuss this case in the appendix.

this case, the implementation of a democratic system inevitably leads to a state of nature. But since the income under state of nature is lower for the people than under an oligarchic republic in which there is no arming in equilibrium, oligarchic republic is the strictly preferred choice for the people, too. Hence, under condition (11) a social contract can be sustained in equilibrium. Under these conditions all individuals strictly prefer an oligarchy to a democracy, i.e. all groups agree that leave the power in the hands of the elite is best option. This equilibrium reflects Hobbes' idea of a Leviathan.[22]

Proposition 2 (Oligarchic Republic). *For any* $\{A_t, N, H_t, \gamma\}$ *and* $g > \underline{g}(\gamma)$, *the politico-economic equilibrium is an* oligarchic republic, *characterized by political franchise which is restricted to the elite,* $G_t = 0$, *and no arming, if and only if condition* (11) *holds.*

Proof. Consider the conflict game under oligarchy as depicted in Figure 2(a) under which condition (11) holds. Then the elite strictly prefer not to arm in case the people choose not to arm, but arm if also the people deviate and arm. In this case, however, arming is a strictly dominated strategy for the people, since $g < 1$, and no group rent-seeks in equilibrium. On the other hand, if condition (11) is violated, not to arm is strictly dominated for the elite, inducing both groups to arm in equilibrium. $\qquad\square$

Condition (11) is more likely to be satisfied, ceteris paribus, the richer the elite is compared to the people, and the more wasteful is the conflict. Rearranging, one obtains $\lambda^E > g/\gamma$. The larger the income of the rich group relative to the average, and the larger the cost of conflict (i.e. the smaller g), the more easily this condition is satisfied as the elite has less to gain from arming.[23] This condition requires that, under democracy, arming on the side of the elite is still more attractive than full redistribution. Rewritten as $\lambda^E > g/\gamma$ it becomes clear that for the equilibrium to arise, conflict must not be overly wasteful and inequality must not be too low.

Democratic Republic. We next show under which conditions a social contract in which

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[22]Hobbes' idea of a Leviathan implies that everybody would gain by giving all power in the hands of a small elite, or one person: "The only way to erect such a Common Power, as may be able to defend them (...) from the injuries of one another, and thereby to secure them in such sort as by their owne industrie, and by the fruites of the Earth they may nourish themselves, and live contendedly; is to conferre all their power and strength upon one Man, or upon one Assembly of men (...) and therein to submit their Wills, everyone to his Will and their Judgements to his Judgement." (T. Hobbes, 1651, Leviathan, Part 2 Ch. XVII, p. 131).

[23]Similar to our idea that a social contract can emerge only if it is credible, in the paper by Grossman (2004) constitutions provide an alternative to social conflict only if they are self-enforcing, that is, if no party has a big advantage in a social conflict.

no group gets involved in arming can be sustained under a democratic regime. This democratic republic equilibrium is feasible only if the people are credible in sticking with the social contract, without arming and expropriating the elite. Hence, for a democratic republic to be feasible it must hold that the people have incentives not to arm, i.e. that, symmetrically to condition (9), we must have,

$$y\frac{g}{(1-\gamma)} < y. \tag{12}$$

On the other hand, for this equilibrium to emerge, the elite must obey to the system, and not, by arming in order to protect their incomes, break the social contract,

$$y^E g < y. \tag{13}$$

While being less attractive than an oligarchic republic, from the elite's point of view a democratic system can nevertheless be the best available option. This is the case whenever a social contract can only be implemented under a democracy which in turn is strictly preferred to a state of nature. If $g > \underline{g}(\gamma)$ then condition (8) holds implying that a democracy is the preferred regime by all groups in society and consequently emerges as politico-economic equilibrium.

Proposition 3 (Democratic Republic). *For any $\{A_t, N, H_t, \gamma\}$ and $g > \underline{g}(\gamma)$, the politico-economic equilibrium is a* democratic republic, *characterized by universal franchise, progressive redistribution with $G_t = y_t$, and no arming if, and only if, conditions (12) and (13) hold.*

Proof. Consider the conflict game under oligarchy as depicted in Figure 2(b) under which conditions (12) and (13) hold. Condition (12) implies that the people optimally arm if the elite arm, and forbear from arming if the elite choose not to arm. The latter is only a viable strategy for the elite if (13) is satisfied, otherwise the elite induce a state of nature. On the other hand, if (12) does not hold, arming is a strictly dominant strategy for the people, and therefore also for the elite anticipating the people's decision. □

Under these conditions, the elite prefers a democracy with full redistribution to a wasteful state of nature. Rearranging (13) yields $\lambda^E < 1/g$, implying that inequality must be sufficiently low to make the opportunity cost of redistribution bearable for the elite such that members of this group actually prefer democracy to a deviation to arming. Alternatively, the condition holds if the inefficiency associated with the state of nature is sufficiently large. The people have no incentive to deviate and arm once observing the elite's decision only if (12) holds. Rearranging, one obtains $g < (1-\gamma) \equiv \bar{g}(\gamma)$, which implies that for a democratic republic to arise, the cost of arming must be sufficiently large as to induce the people not to deviate and arm. Therefore we

can establish a lower bound on the wastefulness of conflict which is necessary to make a social contract emerge in a democracy in the absence of the possibility for the people to commit on policies and actions.

Lemma 2. *For any $\{A_t, N, H_t, \gamma\}$ and any degree of income inequality λ_t there always exists a level $\overline{g}(\gamma) \equiv (1 - \gamma)$ such that for any $g > \overline{g}(\gamma)$ a democracy cannot emerge in equilibrium.*

Proof. The claim follows from rearranging (12) and Proposition 3. $\square$

During the life of each generation t the economy is characterized by a unique level of inequality λ_t. By inspection of the conditions for emergence of the different equilibria in Propositions 1, 2 and 3, we have that only one equilibrium can emerge for any given λ_t.

Proposition 4 (Taxonomy of Politico-Economic Equilibria). *For any $\{A_t, N, H_t, \gamma\}$ and given $g \in \left[\underline{g}(\gamma), \overline{g}(\gamma)\right]$, all three types of politico-economic equilibria can arise. For any generation t the politico-economic equilibrium is uniquely determined by the level of inequality λ_t. There exist two thresholds of income inequality $\lambda_{SN} > \lambda_D$ such that:*

(i) *For $\lambda_t^E > \lambda_{SN}$ the equilibrium is Oligarchic Republic;*

(ii) *For $\lambda_t^E \in (\lambda_D, \lambda_{SN})$ the equilibrium is State of Nature;*

(iii) *For $\lambda_t^E < \lambda_D$ the equilibrium is Democratic Republic.*

Proof. Existence of all three types of equilibria follows from condition $g \in [\underline{g}(\gamma), \overline{g}(\gamma)]$ and Lemmata 1 and 2. Inspection of the conditions for emergence of the different equilibria in Propositions 1, 2 and 3 makes clear that only one equilibrium can emerge for any given λ_t. There exists a unique level of income inequality, denoted by $\lambda_{SN} = g/\gamma$ such that condition (8) holds with equality. From Proposition 2, this implies that an Oligarchic Republic can emerge as equilibrium only if $\lambda_t^E > \lambda_{SN}$. Similarly there a unique $\lambda_D = 1/g$ such that condition (10) holds with equality so that by Proposition 3 a democratic republic can be implemented in equilibrium only if $\lambda_t^E < \lambda_D$. Notice that if $g > \underline{g}(\gamma)$ then $\lambda_{SN} > \lambda_D$. In this case if $\lambda_t^E > \lambda_{SN}$ a social contract emerges under oligarchy while if $\lambda_t^E < \lambda_D$ a social contract emerges under democracy. Finally if $\lambda_t^E \in (\lambda_D, \lambda_{SN})$ then the equilibrium is a state of nature. $\square$

The economy can be characterized by three different politico-economic equilibria. All three equilibria can be observed if, on the one hand, the cost of conflict in terms of wasted resources is not too small since otherwise arming would be too attractive, and democracy would not emerge; and if, on the other hand, the cost of conflict is not too large, implying that the state of nature would be prohibitively distortive and therefore never be observed. The proposition

also implies that the politico-economic equilibrium is unique no matter which group chooses the political system as long as $g \in \left[\underline{g}\left(\gamma\right), \overline{g}\left(\gamma\right) \right]$. In fact, among all members of society, regardless to which group they belong, there is unanimity about the political system as long as it serves to implement a social contract. A social contract is feasible under oligarchy for sufficiently high levels of inequality since the condition under which the elite does not arm under oligarchy, condition (8), is satisfied for higher levels of inequality than the condition under which the elite prefers democracy, condition (13).

Before proceeding, consider the intuition behind the condition $g \in \left[\underline{g}\left(\gamma\right), \overline{g}\left(\gamma\right) \right]$. In fact, only one part of the condition can be violated at a time. As indicated by Lemmata 1 and 2, the main implication of a violation is that one type of equilibrium becomes infeasible. If $g > \overline{g}\left(\gamma\right)$, the people have an incentive to deviate from a social contract under democracy, as becomes clear when recalling condition (12). This renders a democratic republic infeasible so that the equilibrium is either an oligarchy or a state of nature. If $g < \underline{g}\left(\gamma\right)$, the state of nature is so inefficient to always induce both groups to subscribe a social contract. Hence, the emergence of the different regimes is crucially related the level of inequality, as is studied in more detail below. In particular, for intermediate levels of inequality a social contract may be feasible under both oligarchy and democracy.[24]

To summarize, the model so far provides conditions under which a society can implement Rousseau's idea of a social contract under the rule of law. As has been shown, this is possible both under oligarchy, reflecting Hobbes' view of a potentially beneficial Leviathan, as well as under a democratic system. Failure to reach universal obeyance to a social contract under either political system, however, inevitably leads to a state of nature. This implies that static efficiency, in the sense of avoiding wasteful conflict, is not confined to a particular political system, that is, democracy is not necessarily inherently 'better' in this respect. The major difference between oligarchy and democracy is the extent of public intervention in the market economy, however. While fiscal revenues are zero under oligarchy, there is taxation and redistribution under democracy. If there exists some externality from a larger public sector then these two regimes may be characterized by different dynamic efficiency features, however, as studied below.

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[24]In particular, under certain conditions multiple equilibria can arise, in the sense that society is characterized by a conflict of interest concerning the political system. In this case, each group strictly prefers the equilibrium which grants them larger political power. As is discussed in the appendix, all qualitative results are unaffected.

4 Dynamic Evolution of the Economy

We now turn to the dynamic analysis of the model and to discuss the conditions under which the political equilibria derived in section 3 arise endogenously.

4.1 Development and Politico-Economic Institutions

We first study the evolution of the key state variables, effective human capital $\tilde{h}_t$, and relative inequality $\lambda_t = \lambda_t^E / \lambda_t^P = y_t^E / y_t^P$. The key parameters are the initial inequality in terms of land resources expressed by γ, the inefficiency of the state of nature, g, the process of technological progress, and the total size of the land resources of the economy, n.

Human capital is acquired by all generations throughout history. Because of the externality of human capital on technology, the effective stock of knowledge reflected in productivity A grows monotonically and unboundedly over the course of generations. This observation is recorded in

Lemma 3. *Productivity A is increasing monotonically overtime and grows unboundedly with* $\lim_{t \to \infty} A_t = \infty$.

Proof. In the appendix. □

As a result of this human capital-driven technological progress land becomes less and less important in the production process and its role as a source of individual income declines. In the limit, human capital is the only relevant factor of production. Since the unequal distribution of natural resources is the only source of inequality in incomes, this observation implies that income inequality between the groups tends to decrease monotonically over the course of generations and vanishes in the limit.[25]

Lemma 4. *Once the economy is sufficiently developed in terms of productivity, income inequality decreases monotonically over the course of generations, and vanishes in the limit,* $\lim_{t \to \infty} \lambda_t^E = \lim_{t \to \infty} \lambda_t = 1$.

Proof. In the appendix. □

We are now in a position to study the development path of the economy, and the role of inequality for the process of politico-economic development. The qualitative features of the following results go through as long as natural resources lose importance and eventually human capital is the main factor of income production, implying that in the limit inequality in factor

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[25]Notice that this asymptotic result concerning the relative incomes of landed elite and landless people does not hinge on the assumption of two groups.

endowment loses importance. The monotonic decline in inequality is not necessary for the main results but facilitates the illustration.[26] For the sake of illustration and without loss of generality, assume that initial conditions imply a high level of inequality λ_0^E such that the conditions for oligarchic republic are met.[27] As becomes clear from the structure of individual incomes as displayed in equation (7), already in the initial period the elite has higher income than the people, simply by the fact that they own the same labor and human capital endowments, but, in addition, land, that is $\lambda_1^P \leq 1 \leq \lambda_1^E$. Note that this is true regardless of which political environment individuals face.

Since oligarchic republic equilibria only vanish with sufficiently low inequality, and since inequality is monotonously decreasing in the level of development, which is reflected in productivity A, it follows from Lemma 4 that there exists a unique level of development $\underline{A}$ for which the economy enters the sequence of state of nature equilibria: $\underline{A} : g/\gamma = \lambda_{t(\underline{A})}^E$. From Lemma 3 we know that there exists a one-to-one relationship between the level of technology and time in terms of generations t. Hence, denote the generation for which the conditions for oligarchic republic and state of nature bind with equality as $\underline{t} = t(\underline{A})$. Likewise, once the economy is sufficiently developed, state of nature equilibria disappear, giving rise to democratic republic equilibria. Again, Lemma 4 allows us to denote this level of development by $\bar{A} : \lambda_{t(\bar{A})}^E = 1/g$, and Lemma 3 allows us to translate this into a point in time for which the economy is at the verge of state of nature turning into a democratic republic, $\bar{t} = t(\bar{A})$.

Given this, we can prove the following

Proposition 5 (Development Path). *For any $\{A_0, N, \gamma\}$ such that condition (8) holds, and given $g \in \left[\underline{g}(\gamma), \overline{g}(\gamma)\right]$ the dynamic path of the economy is characterized by $\underline{t} < \bar{t}$ implying a sequence of oligarchic republic equilibria during early stages of development, followed by state of nature for intermediate levels of development, and eventually a sequence of democratic republic equilibria.*

Proof. Existence of all three types of equilibria follows from Proposition 4. If inequality is sufficiently high in the early stages of development, $\lambda_t^E > g/\gamma = \lambda_{SN}$, and the politico-economic equilibrium is Oligarchic Republic from Proposition 2. From Lemmata 3 and 4 we have that λ^E declines monotonically and converges to 1. Hence, eventually the only equilibrium becomes

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[26]Accounting for features like differential fertility, credit market imperfections affecting educational outcomes, or heterogeneity in the accumulation of human capital could lead to a non-monotonic change in inequality with intermediate periods of increasing inequality before eventually declining, see e.g. Bertocchi and Spagat (2004) and Galor (2005).

[27]In the current context, this is equivalent to assuming a sufficiently low initial level of productivity, A_0.

a State of Nature once $\lambda_{SN} > \lambda_t^E > \lambda_D$, compare Proposition 1. As development continues, λ^E decreases further. Once $\lambda_t^E < 1/g = \lambda_D$ the unique politico-economic equilibrium is a Democratic Republic, see Proposition 3, because $\lim_{t \to \infty} \lambda_t^E = 1 < 1/g$. $\qquad \square$

The condition for which the elite prefers democracy to conflict, condition (13), binds at lower levels of inequality, and thus for later generations, than the condition under which the elite cannot sustain an oligarchic republic by credibly announcing not to arm, condition (11). This implies that a democratic republic eventually emerges in equilibrium.

Finally, consider the cases when $g \in [\underline{g}(\gamma), \overline{g}(\gamma)]$ does not hold. Due to Lemma 2, no democracy can be observed if $g > \overline{g}(\gamma)$. In this case, and without the possibility to commit on public policies, the economy is initially characterized by oligarchic republic equilibria, and eventually ends up in a state of nature.[28] If, on the other hand, $g < \underline{g}(\gamma)$ then $\underline{t} > \overline{t}$, which implies a direct transition from an oligarchy to a democracy along the development path, without a state of nature ever emerging along the development path.

4.2 Inequality, Natural Resource Abundance and Development

Having characterized the overall pattern of development in the economic and political domain, we now turn to the investigation of the properties of the development path in detail. First note that, without loss of generality, we restrict attention to the case in which all three politico-economic equilibria can arise. Recall that $\underline{t}$ and $\overline{t}$ denote the generations for which an oligarchy becomes unsustainable and a democracy becomes sustainable, respectively. We have the following result,

Proposition 6 (Natural Resource Abundance and Institutional Development). *For any $\{A_0\}$ and any $g \in \left[\underline{g}(\gamma), \overline{g}(\gamma)\right]$, a larger natural resource abundance (i.e. a larger N given γ) implies:*
(i) a later transition from oligarchic republic to state of nature (i.e. a larger $\underline{t}$);
(ii) a later transition from state of nature to democracy (i.e. a larger $\overline{t}$).

Proof. In the appendix. $\qquad \square$

This proposition illustrates the crucial role of natural resource abundance in determining the endogenous emergence of politico-economic equilibria. Both types of transition, from oligarchy to state of nature, and from this state of nature to democracy occur later the larger N. The main intuition for the result is that the larger the rents accruing to the elite from the control over natural resources the larger is income inequality over the course of development. This has

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[28]This claim is made formally and proven in the appendix.

two important implications for the dynamic evolution of the economy. In the first place the elite can sustain a social contract longer inside an oligarchy since they face a lower incentive to arm and expropriate the disenfranchised people. On the other hand they face a larger (shadow) cost of redistribution which delays the transition to a democracy. With respect to the level of inequality in resource endowments, we have the following result.

Proposition 7 (Inequality and Institutional Development). *For any* $\{A_0\}$ *and any g* $\in \left[\underline{g}(\gamma), \overline{g}(\gamma)\right]$, *a larger inequality in the ownership of natural resources (i.e. a smaller* γ *given N) implies:*

(i) an earlier transition from oligarchic republic to state of nature (i.e. a smaller $\underline{t}$*);*

(ii) a later transition from state of nature to democracy (i.e. a larger $\overline{t}$*).*

Proof. In the appendix. □

Concerning the effect of inequality on the timing of the transition to a state of nature two effects are at work, implying that the larger inequality in resource endowments, i.e. the smaller γ, the larger the possible range for state of nature equilibria. Larger inequality increases the per capita income of each member of the elite, which makes them more credible in not arming. But at the same the expected returns on arming are higher by decreasing the size of the group that has to share the appropriated incomes. Since the second effect always dominates the first, larger inequality (i.e. smaller γ) implies an earlier transition into state of nature. Larger inequality, on the other hand, implies a larger (shadow) cost of redistribution, delaying the transition to democracy. As illustrated in the simulation below even a relative small difference in natural resources abundance and inequality may have important implications for the development of the economy leading to episodes of growth miracles, overtaking and divergence.

4.3 Political Regimes and Development

The results so far give a characterization of the politico-economic equilibria that can arise along the development path of the economy. From the analysis in the previous section, we also know that both oligarchy and democracy can be effective in avoiding wasteful conflict. The possibility to finance a public good like an education system out of the budget for redistribution, however, allows for an externality that implies a higher growth potential under a democratic republic equilibrium as we now discuss. In the context of the model, the amount of fiscal revenues collected with taxation and used for redistribution, which is denoted by G_t, can alternatively be

interpreted as a publicly provided good (rather than a monetary payment).[29] If this in-kind redistribution is not confined to consumptive payments, but has an externality on the human capital formation, like the provision of a public education system, this provides scope for differences in the dynamic efficiency between the different political regimes. In fact, whenever public good provision positively affects the level of human capital, $h_t = h(G_{t-1})$, democracy is dynamically more efficient than oligarchy. This dynamic externality is consistent with empirical findings that democracies foster growth through improved conditions for human capital accumulation, see e.g. Tavares and Wacziarg (2001) and Wacziarg (2001).[30]

Proposition 8. *If $h_t = h(G_{t-1})$ with $\partial h / \partial G_{t-1} > 0$, then a transition to a democratic republic implies an acceleration in the development of the economy compared any other politico-economic equilibrium.*

Proof. The claim immediately follows from the formulation of improvements in productivity in (2), since $A_t = f(H_{t-1}(G_{t-2}))$. Because of the time structure, the acceleration of technological progress begins in the generation of grand children of the generation experiencing the democratic transition since $G_t = 0$ for every t in an oligarchic republic or state of nature equilibrium. $\square$

This result implies that democracies may provide a better environment for growth than oligarchies, even in the case in which the latter are statically efficient in the sense that a social contract can be implemented. Hence, the sooner a country democratizes the faster it develops.

Finally notice that these results are obtained by neglecting any dynamic inefficiencies of social unrest under the state of nature. It is easy to imagine that societal conflict and widespread arming has long-run effects apart from the static inefficiency because of the resources wasted in conflict. Examples would be negative effects on investment and the accumulation of factors such as physical or human capital. In this case, each period in which resources are wasted in conflict inflicts a permanent effect on the development path of the economy. If the model were extended in this direction, the implication would not only be that earlier democratic transitions are beneficial. As additional prediction, countries would then develop faster the shorter the period of state of nature and social unrest.

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[29]Note that formally, since population size is normalized to 1, there is no distinction between a publicly provided private good and a pure public good.

[30]In principle one could consider the choices of public good provision and redistribution jointly and explicitly, see. e.g. Cervellati, Fortunato, and Sunde (2006). For the purpose of this paper we only want to highlight that in democracy there is larger room for public policies since the poor face a lower marginal cost of taxation, which leads to larger governments. Therefore oligarchies and democracies cannot be expected to be equally efficient in general even in the case in which a social contract can be implemented.

4.4 Illustrative Simulation

We end by presenting simulations of the model to illustrate the main mechanism and the main implications. Without loss of generality, in the simulations we restrict attention to the case in which all three politico-economic equilibria can arise, i.e. when $g \in \left[\underline{g}\left(\gamma\right), \overline{g}\left(\gamma\right)\right]$. In order to be able to simulate the model, we need to make assumptions about the specification of the functions that were left unspecified so far. In particular, following Jones (2001), we specify the function of technological progress (2) as

$$A_t = A_{t-1} \left[1 + \beta H_{t-1}^{\delta}\right] ,$$

with $\beta > 0$ and $0 < \delta < 1$. The externality of the size of the redistributive state on human capital formation in the form of public schooling is specified as

$$H_t = (1 + \phi G_{t-1})^{\rho} ,$$

with $\phi > 0$ and $0 < \rho < 1$.

To show theoretical predictions described in the previous section and to highlight the role of natural resources abundance and inequality in reproducing episodes overtaking, we proceed in steps. Consider first an economy characterized by a relatively low level of initial inequality in land ownership, and a relatively large elite. In particular, let us assume that the total amount of land available in the economy is $N = 20$ and that the group of landlords represents 32% of the population (i.e. $\gamma = 0.32$). The full parametrization used for the simulation is displayed in Table 1.

Insert Table 1 about here.

Figure 3 shows the evolution of income in this economy and compares the actually realized disposable income generation by generation with the potential disposable income that could be realized if an efficient state of law were implemented. As shown in the figure, this economy is characterized by an oligarchy which is able to implement an efficient state of law during the early generations. This is possible since inequality is sufficiently high during the early stages of development in order to make expropriation not attractive for the elite. The elite is therefore credible in offering and respecting the rule of law. As generations pass and income inequality shrinks, the arming on the landless people becomes more and more attractive for the ruling elite. This eventually leads to a situation in which the social contract cannot be sustained under an oligarchic regime. The economy therefore enters a phase in which the state of nature

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characterizes the interactions between the two social groups. Realized disposable income drops substantially below potential income because of the waste associated with conflict. Finally, after a substantial number of generations has lived in this dismal state, the society eventually returns to efficiency by making a democratic transition. The reason for this transition is that the progressive reduction of inequality makes democracy the most attractive solution also for the elite: they are willing to trade-off redistribution against the efficiency gains associated with the state of law. Note that this transition towards a democratic system coincides with the decisive take off of the economy towards a path of more rapid and sustained growth. To sum up, the simulation illustrates the path of development from an oligarchic republic with a social contract despite limited political franchise reflecting Hobbes' idea of a Leviathan, to a Hobbesian state of nature, in which society engages in universal conflict, and eventually to a social contract in the sense of Rousseau, with effective and equal protection of property rights and universal franchise.

Insert Figure 3 about here.

Now, consider how the development process is affected by different distributions of natural resources. Compare two economies that are identical to the one studied before, but that differ in γ. In particular, let us compare Economy 1 (with $\gamma_1 = 0.35$) to a more unequal Economy 2 (with $\gamma_2 = 0.28$). Proposition 6 *(i)* predicts that Economy 1 enters state of nature later and transits to democratic republic earlier than Economy 2. This is shown in Figure 4. Economy 1 in fact experiences a later transition into the inefficient state of nature, and a much shorter duration of this dismal state than Economy 2. Hence, the distribution of natural resources affects the timing of the transitions between the different politico-economic equilibria. However, since the transition to the democratic republic equilibrium happens earlier in the economy with the more equal distribution of natural resources, also the growth-enhancing effects of democratization kicks in earlier, leading to a divergence of incomes at later stages of development.

Insert Figure 4 about here.

Natural resource abundance coupled with inequality may generate patterns of overtaking and divergence across countries. This possibility is explored in more detail by comparing two economies that differ both in the distribution as well as the level of natural resources. Again, consider two economies that are identical in all parameters and initial conditions, but where economy 1 is poorer in natural resources with $N_1 = 17$ while $N_2 = 23$, and where these natural resources are additionally more equally distributed in economy 1 (as before with $\gamma_1 = 0.35$ while $\gamma_2 = 0.28$). The consequences of differences in both natural resource abundance and

distribution for the development paths of the economies are illustrated in Figure 5. Economy 2 initially exhibits higher incomes, because it is richer in terms of natural resources. Due to the higher initial inequality, economy 2 enters the state of nature earlier than economy 1, and remains trapped in the state of nature equilibrium for a larger number of generations. The earlier democratization of economy 1, however, leads to an earlier take-off in growth in that economy. The figure illustrates that, even when entering democracy eventually, economy 2 cannot make up this lost ground, and the two economies diverge. Hence, as generations pass, the initially poorer but more equal society catches up and eventually overtakes the richer one. The reason is that the initially poorer and more equal economy is sooner prepared to reap the benefits of a democratic transition. These dynamics of the model are also in line with the historical discussion by Engerman and Sokoloff (2002, 2004), who provide extensive evidence on the role played by natural resource abundance and institutional development in the process of economic development of the Americas. Focussing on the divergent development patterns of the Americas, they show how the originally richer and more unequal Central and South American countries were unable to implement an efficient institutional system. This eventually led to the overtaking by North American countries, which were able to implement efficient institutions and reaped their benefits.

<div align="center">Insert Figure 5 about here.</div>

The previous simulation also points out that even small differences in natural resource abundance and in their distribution may have important dynamic implications for the development possibilities of a country.[31]

5   Concluding Remarks

This paper provides a theory in which economic and political institutions are interdependent and emerge endogenously in equilibrium. Good economic institutions in the form of a Rousseauvian social contract can arise in equilibrium if and only if no group in society has an incentive to deviate and invest in appropriation activities and conflict. Economic institutions are distinct

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[31]Notice that since we rule out static distortions from inequality on human capital accumulation due to credit market imperfections as discussed in e.g. Banerjee and Newman (1991) or Galor and Zeira (1993), the total production under the oligarchic republic is the same in both economies. Thus, the distribution of natural resources has no effect on the static production possibilities of the economy. The consideration of distortions in the formation of aggregate human capital would reinforce the importance of inequality and natural resource abundance for development.

from political institutions that govern aggregation of preferences regarding redistribution. The politico-economic equilibrium is crucially affected by the level of development and, in particular, economic inequality. At the same time, the political and economic institutions causally determine economic development and inequality. A social contract may be sustained only under the rule of an oligarchic elite when development is low and inequality is very large. This is the case in economies in which the control over factors of production, particularly natural resources, is very unequal. The redistributive pressure that arises from the reallocation of political political power to parts of the population with smaller endowments associated with a democratic transition would, under these conditions, push the newly enfranchised toward excessive fiscal redistribution. The reaction of the rich who try to protect their wealth would lead to a conflictual state of nature equilibrium. On the other hand, a transition to democracy represents the only possibility to sustain a social contract if the control over natural resources is sufficiently equal and inequality is sufficiently small. Under these conditions, the elite cannot credibly refrain from expropriating the other members of society under oligarchy, but at the same time the costs arising from redistribution under democracy are lower for the elite than the costs that would arise from society-wide conflict.

The results imply that a focus on political structures and democratization is neither necessary nor sufficient for making a social contract feasible. Conflictual equilibria may materialize under both regimes as long as there are incentives for some parts of the population to expropriate other groups. In terms of development, the model also predicts that, due to the different public policies implemented in the different regimes, democracies are likely to be dynamically more efficient than oligarchies. These results are in line with empirical findings that democracies are on average richer than oligarchies and that democratic transitions are usually beneficial in terms of efficiency (and even more so in terms of equity), even though democratic institutions do not seem to represent a necessary or sufficient condition for good economic institutions such as a state of law. We show that, in the presence of dynamic externalities, the emergence of the different political regimes, and accordingly the implementation of different public policies, may lead to different patterns of development. In particular the model provides a rationale why naturally rich countries with high inequality often display worse economic records than countries with little natural resources. By providing a simple dynamic simulation we illustrate the analytical results and show that episodes of reversal of fortunes can be the consequence of the endogenous emergence of inferior economic institutions.

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A   Appendix

A.1   Proofs and Supplementary Propositions

Proof of Lemma 1:

Proof. A necessary condition for the emergence of a state of nature is that the elite cannot refrain from arming under oligarchy. In this case the state of nature arises if a social contract under democracy is not feasible that is if either the elite or the people have incentives to arm under democracy. This is the case when (8) holds together with (9) or (10). Conditions (8) and (10) hold simultaneously if

$$yg/\gamma > y^E \wedge gy^E > y \Leftrightarrow g/\gamma > \lambda^E > 1/g$$

which implies $g/\gamma > 1/g \Leftrightarrow 1/\gamma > 1/g^2$.

Hence, (8) and (10) cannot be jointly satisfied if $g < \sqrt{\gamma}$. In this case a state of nature can arise only if the people deviate in democracy, that is, if (9) is not satisfied. This is the case only if $g > 1 - \gamma$. But note that (9) is redundant whenever $g < \sqrt{\gamma}$ if $\sqrt{\gamma} < 1 - \gamma$. On the other hand, (9) is not redundant if $\sqrt{\gamma} > 1 - \gamma$. A state of nature can therefore arise only if $g > (1 - \gamma)$. Hence for any $\{A_t, N, H_t, \gamma\}$ we can identify $\underline{g}(\gamma) = \min\{\sqrt{\gamma}, 1 - \gamma\}$ such that for any $g < \underline{g}(\gamma)$ the state of nature cannot be an equilibrium. □

Proof of Lemma 3:

Proof. The result follows from (2) and $h_t > 0$ $\forall t$, implying that $(A_t - A_{t-1})/A_{t-1} > 0$ $\forall t$. Rearranging condition (2), technological progress is of the form $A_t = (1 + f(H_{t-1})) A_{t-1} = d_{t-1}(H_{t-1})A_{t-1}$ with $d_{t-1}(\cdot) > 1$ $\forall t > 1$ due to the human capital accumulation process. For any $A_0 > 0$, we can rewrite $A_t = \left(\prod_{j=1}^{t} d_{j-1}\right) A_0$, where $\left(\prod_{j=1}^{t} d_{j-1}\right) > 1$ and $\lim_{t \to \infty} \left(\prod_{j=1}^{t} d_{j-1}\right) = \infty$. This means that the process is autoregressive, positive monotonous and non stationary. Hence, A_t is strictly increasing generation after generation, with $\lim_{t \to \infty} A_t = \infty$. □

In the following , we characterize the equilibria for the parametric cases complementary to the one of Proposition 4.

Proposition 4 (Taxonomy of Politico-Economic Equilibria - Alternative Cases). *For any $\{A_t, N, H_t, \gamma\}$,*
  (i) a democratic republic cannot emerge if $g > \overline{g}(\gamma)$. In this case the politico-economic equilibrium is an Oligarchic Republic if $\lambda_t^E > \lambda_{SN}$ or a State of Nature if $\lambda_t^E < \lambda_{SN}$;
  (ii) a state of nature cannot emerge if $g < \underline{g}(\gamma)$, since then $\lambda_D > \lambda_{SN}$. The politico-economic equilibrium in this case is an Oligarchic Republic if $\lambda_t^E > \lambda_D$, a Democratic Republic if $\lambda_t^E < \lambda_{SN}$ and a social contract can be sustained either in an oligarchy or in a democracy if $\lambda_{SN} < \lambda_t^E < \lambda_D$.

Proof. (i) Under oligarchy, for any $\lambda_t^E > \lambda_{SN}$ the elite prefers not to arm as implied by Proposition 2. The people agree with an oligarchic republic and do not deviate to arm because of the associated costs, supporting the oligarchic republic equilibrium. Alternatively, when $\lambda^E < \lambda_{SN}$, the elite is not credible in refraining from arming, triggering arming by the people as best reply. Hence, in this case a state of nature arises under oligarchy. Moreover, from Lemma 2, no democratic republic can arise in equilibrium, so the only equilibrium in this case is state of nature.

(ii) If $g < \underline{g}(\gamma)$ then from Lemma 1 the state of nature never arises in equilibrium. From conditions (8) and (10), $g < \underline{g}(\gamma)$ implies that $\lambda_D = 1/g > \lambda_{SN} = g/\gamma$. In this case for any $\lambda_t^E > \lambda_D > \lambda_{SN}$, the elite chooses to arm under democracy but not under oligarchy. Again, the people do not deviate to arming and hence the equilibrium is an oligarchic republic. For any $\lambda_D > \lambda_{SN} > \lambda_t^E$ the elite arm under oligarchy but not under democracy. Since the people do not deviate either under these conditions, the equilibrium is a democratic republic. Finally, for $\lambda_{SN} < \lambda_t^E < \lambda_D$ both elite and people prefer not to arm under either regime so that a social contract is feasible in both an oligarchy and a democracy. Notice however that in this case the elite would prefer an Oligarchic Republic to a Democratic Republic due to the different redistribution implied by the different social contracts. The opposite is true for the people. Hence in this case the social contract is sustainable under both regimes. $\qquad\square$

Proof of Lemma 4:

Proof. For any $\{N, \gamma\}$, the relative income of the elite λ_t^E is given by,

$$\lambda_t^E = \frac{w(A_t, N) + h_t r(A_t, N) + (n/\gamma)\rho(A_t, N)}{w(A_t, N) + h_t r(A_t, N) + n\rho(A_t, N)} :, \tag{14}$$

where the factor rents are given by the expressions (3), (4) and (5). Computing the derivative with respect to A_t one gets,

$$\frac{\partial \lambda_t^E}{\partial A_t} = \frac{n\left(1 - \frac{1}{\gamma}\right)[w'\rho - w\rho' + r'\rho - r\rho']}{[w(A_t, N) + h_t r(A_t, N) + n\rho(A_t, N)]^2} < 0$$

with primes denoting partial derivatives with respect to A_t. Negativity follows since $w' = \alpha(1-\alpha)[A_t h_t + n]^{\alpha-1}h_t > 0$, $r' = \alpha[A_t h_t + n]^{\alpha-1}\left(1 - \frac{(1-\alpha)}{A_t h_t + n}\right) > 0$ for large A, and $\rho' = \alpha(\alpha-1)[A_t h_t + n]^{\alpha-2} < 0$ and $\gamma > 1/2$. Monotonicity after a certain level of development follows from the change in sign in r' and Lemma 3. From the fact that $\lim_{A\to\infty}\rho_t(A, N) = 0$ and noting the definition of λ_t^E in (14) it follows that $\lambda_\infty^E = 1$. Since $n^P = 0$, similar reasoning yields $\lambda_\infty = 1$. $\qquad\square$

Next, consider the statement of Proposition 5 under the complementary parametric cases:

Proposition 5 (Development Path - Alternative Cases). *For any $\{A_t, N, H_t, \gamma\}$ the dynamics of the economy is characterized by:*
(i) a sequence of oligarchic republic equilibria during early stages of development, followed by a sequence of state of nature equilibria if $g > \bar{g}(\gamma)$;
(ii) a sequence of oligarchic republic equilibria during early stages of development, followed by a sequence of democratic republic equilibria if $g < \underline{g}(\gamma)$.

Proof. (i) A similar reasoning as in the proof to Proposition 5 applies, given that initial inequality is sufficiently high to support an oligarchic republic. But note that it follows from Propositions 3 and 4 that democratic republic is not an equilibrium if $\bar{g}(\gamma) = 1 - \gamma < g$ as the people always have an incentive to deviate and arm in this case. But then, from Lemmata 3 and 4 and condition (9) it follows that the development path is characterized by oligarchic republic in the early stages of development, followed by a sequence of state of nature equilibria in later stages of development.
(ii) Again, a similar reasoning applies, given that initial inequality is sufficiently high to support

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an oligarchic republic. However, note that as direct corollary of Proposition 4, state of nature is not an equilibrium if $g < \underline{g}(\gamma)$ since then $y_t g/\gamma > y_t^E$ and $g y_t^E > y_t$ in condition (8) cannot hold at the same time. Hence, by monotonicity of λ^E, the economy experiences a direct transition from oligarchic to democratic republic. The timing of the transition is undetermined in this case as consequence of the possibility that a social contract can be sustained under both political regimes. If the elite have the power to impose a political system, the democratic transition occurs for lower levels of λ_t^E, and thus during later generations because of Lemma 4, than if the people have the power to impose a political system on the society. All other results concerning the comparative dynamics remain unchanged.

$\square$

Proof of Proposition 6:

Proof. Rewrite the conditions that define $\underline{t}$ and $\bar{t}$ in implicit terms as,

$$\lambda_{\underline{t}}^E \gamma - g = 0 \quad \text{and} \quad \lambda_{\bar{t}}^E - 1/g = 0 \,, \tag{15}$$

respectively. First note that $n = N/L = N/1$ and that

$$\lambda_t^E = \frac{y_t^E}{y_t} = \frac{y_t + n\rho_t\left(1/\gamma - 1\right)}{y_t} = 1 + \frac{n\rho_t}{y_t}\left(1/\gamma - 1\right) \,.$$

Hence, because $\frac{\partial(n\rho_t/y_t)}{\partial n} = \frac{\alpha A_t h_t}{(A_t h_t + n)^2} > 0 \; \forall t$ and monotonicity we know by applying the implicit function theorem that

$$\frac{d\underline{A}}{dn} = -\frac{\partial\left[\lambda_{\underline{t}}^E \gamma\right]/\partial n}{\partial\lambda_{\underline{t}}^E/\partial \underline{A}} > 0 \; \text{ and}$$

$$\frac{d\bar{A}}{dn} = -\frac{\partial(\lambda_{\bar{t}}^E \gamma)/\partial n}{\partial\lambda_{\bar{t}}^E/\partial \bar{A}} > 0 \,,$$

and by monotonicity of A in t we have $sign\left(\frac{d\underline{t}}{dn}\right) = sign\left(\frac{d\underline{A}}{dn}\right)$ and that $sign\left(\frac{d\bar{t}}{dn}\right) = sign\left(\frac{d\bar{A}}{dn}\right)$.

$\square$

A similar reasoning applies for a change of the different timing with respect to inequality γ for a given N.

Proof of Proposition 7:

Proof. Define $\underline{t}$ and $\bar{t}$ in implicit terms as in the proof of Proposition 6 and note that $sign(\partial\lambda_{\bar{t}}^E/\partial\bar{A}) = sign(\partial\lambda_{\underline{t}}^E/\partial\underline{A}) = sign(\partial\lambda_t^E/\partial A_t) < 0$. Also note that $\partial\left[\lambda_{\underline{t}}^E \gamma\right]/\partial\gamma = \left(w_{\underline{t}} + r_{\underline{t}} h_{\underline{t}}\right) > 0$ and $\partial\lambda_{\bar{t}}^E/\partial\gamma = -\left(n/\gamma^2\right)\rho/y < 0$. Moreover, by implicit differentiation we know that
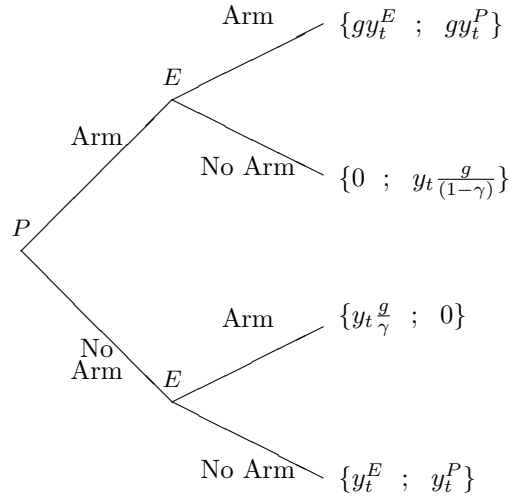
$$\frac{d\underline{A}}{d\gamma} = -\frac{\partial\left[\lambda_{\underline{t}}^E \gamma\right]/\partial\gamma}{\partial\lambda_{\underline{t}}^E/\partial\underline{A}} > 0 \; \text{ and}$$

$$\frac{d\bar{A}}{d\gamma} = -\frac{\partial(\lambda_{\bar{t}}^E \gamma)/\partial\gamma}{\partial\lambda_{\bar{t}}^E/\partial\bar{A}} < 0 \,.$$

Finally, by monotonicity of A in t we have $sign\left(\frac{d\underline{t}}{d\gamma}\right) = sign\left(\frac{d\underline{A}}{d\gamma}\right)$ and that $sign\left(\frac{d\bar{t}}{d\gamma}\right) = sign\left(\frac{d\bar{A}}{d\gamma}\right)$, which proves the claim.

$\square$

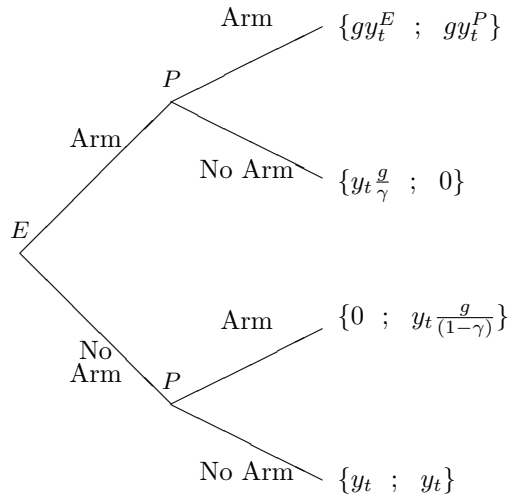## A.2   Figures and Tables

People *Elite*	Arm	Not Arm
Arm	gy_t^E , gy_t^P	$y_t \frac{g}{\gamma}$, 0
Not Arm	0 , $y_t \frac{g}{1-\gamma}$	$\tilde{y}_t^E$, $\tilde{y}_t^P$

Figure 1: The Conflict Game

(a) Under Oligarchic System

P

Arm

E

Arm $\longrightarrow \{gy_t^E \ ; \ gy_t^P\}$

No Arm $\longrightarrow \{0 \ ; \ y_t\frac{g}{(1-\gamma)}\}$

No Arm

E

Arm $\longrightarrow \{y_t\frac{g}{\gamma} \ ; \ 0\}$

No Arm $\longrightarrow \{y_t^E \ ; \ y_t^P\}$

(a) Under Oligarchic System

(b) Under Democratic System

E

Arm

P

Arm $\longrightarrow \{gy_t^E \ ; \ gy_t^P\}$

No Arm $\longrightarrow \{y_t\frac{g}{\gamma} \ ; \ 0\}$

No Arm

P

Arm $\longrightarrow \{0 \ ; \ y_t\frac{g}{(1-\gamma)}\}$

No Arm $\longrightarrow \{y_t \ ; \ y_t\}$

(b) Under Democratic System

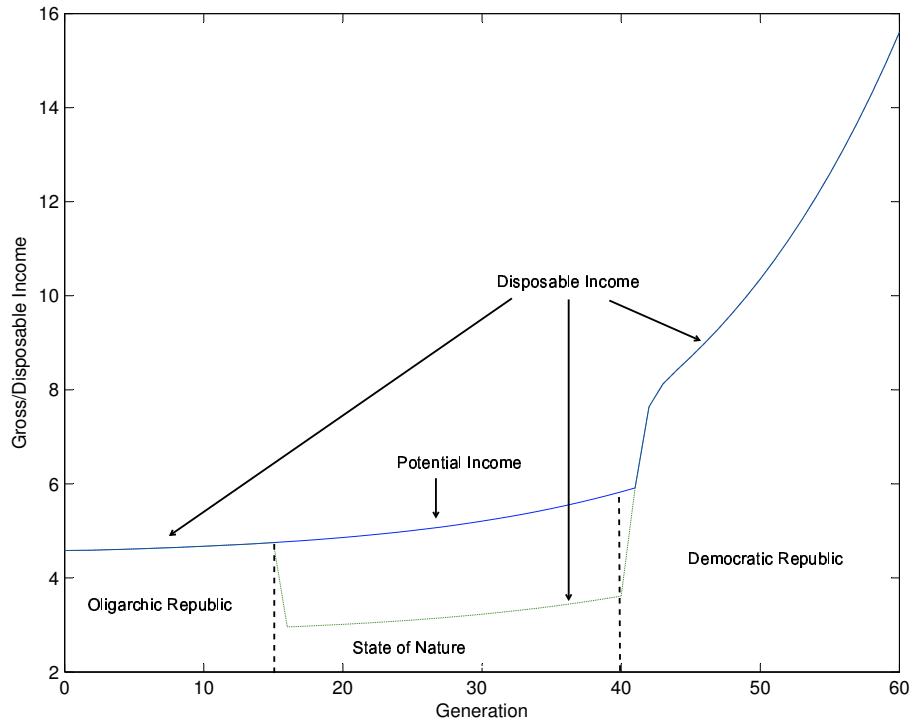Figure 2: Extensive Form of the Conflict Game

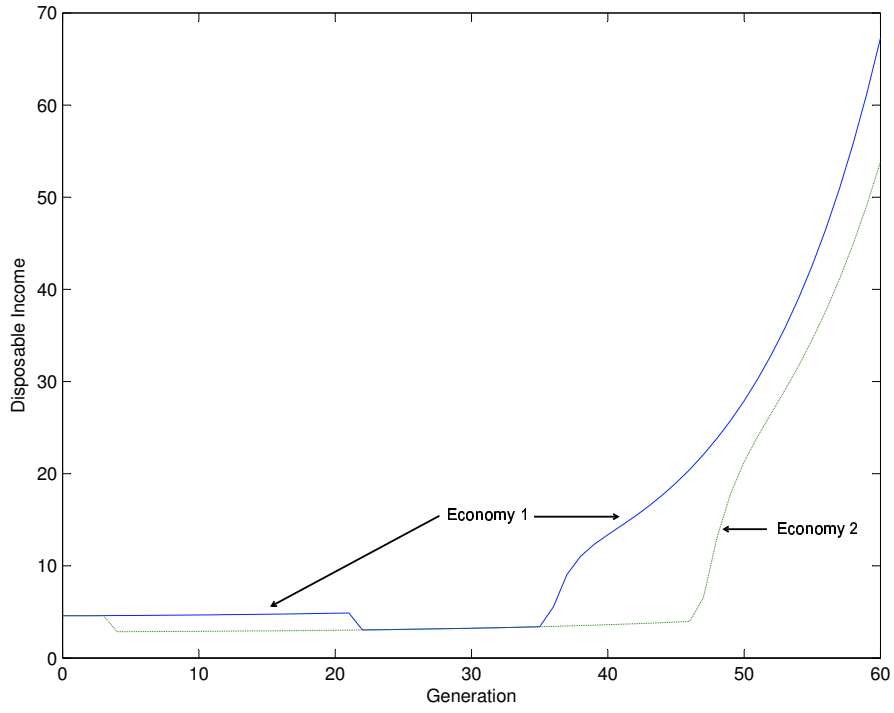Figure 3: A Simulation of the Development Path

Figure 4: Simulation of the Development Path for Countries with Different γ
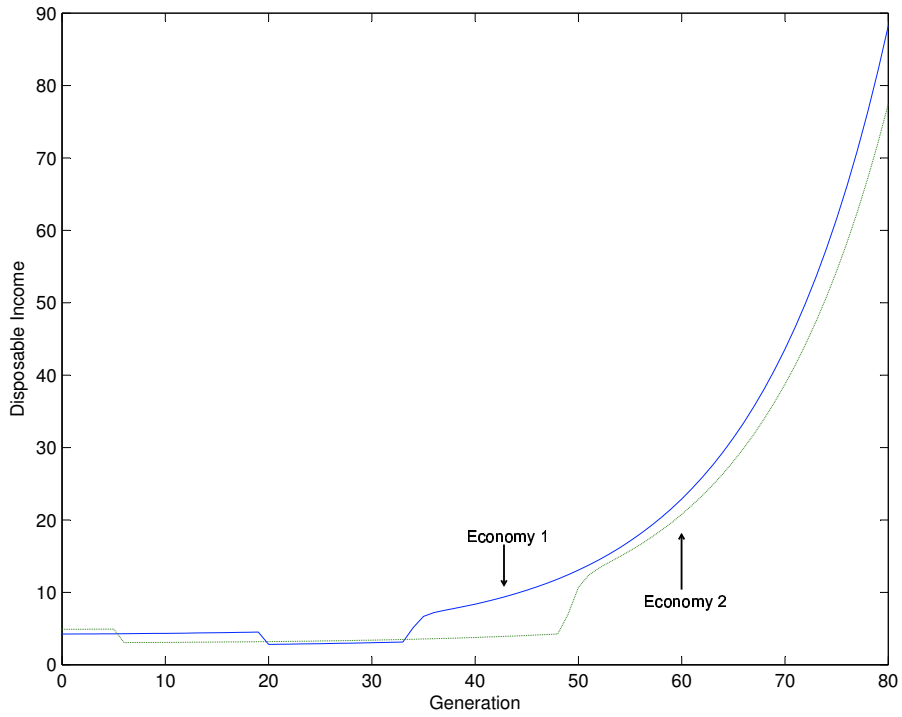

Figure 5: Overtaking and Divergence: Simulation of the Development Path for Countries with Different γ and N

Table 1: Simulation: Parameters Values Used for Simulation

Base-line Specification								
α	$=$	0.5;	β	$=$	0.07;	δ	$=$	0.1;
ρ	$=$	0.5;	ϕ	$=$	0.8;	g	$=$	0.62;
γ	$=$	0.32;	N	$=$	20;	A_0	$=$	1;

Variation in γ								
α	$=$	0.5;	β	$=$	0.07;	δ	$=$	0.1;
ρ	$=$	0.5;	ϕ	$=$	0.8;	g	$=$	0.62;
γ_1	$=$	0.35;	N	$=$	20;	A_0	$=$	1;
γ_2	$=$	0.28;						

Overtaking and Divergence								
α	$=$	0.5;	β	$=$	0.07;	δ	$=$	0.1;
ρ	$=$	0.5;	ϕ	$=$	0.8;	g	$=$	0.62;
γ_1	$=$	0.35;	N_1	$=$	17;	A_0	$=$	1;
γ_2	$=$	0.28;	N_2	$=$	23;			