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Markets and Jungles*

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Abstract

Economic institutions determine prospects for growth and development. This paper examines necessary conditions for an economy to support institutions that implement markets. Agents differ in land holdings, skill, and power. A competitive market assigns land to the skilled, not necessarily to the powerful. Therefore a market allocation needs to be robust to coalitional expropriation. In a dynamic setting, market payoffs may induce sufficient inequality in next period's endowments for markets to alternate with expropriation in a limit cycle, decreasing efficiency and amplifying macroeconomic fluctuations. Long run stability of markets is favored by higher social mobility, more initial equality, and less mismatch between demand and supply.

Keywords: Expropriation, market institutions, inequality, fluctuations, coalition formation.

JEL: E02, O43, C71.

1 Introduction

The quality of institutions interferes with the ability of markets to successfully assign scarce goods to individuals who can put them to their most productive use. Hence, as has been noted by North (1991) and a corresponding literature, institutions determine prospects for economic growth

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and development, for instance by way of the organization of production. Indeed, there appears to be some empirical support for this hypothesis (see e.g. Acemoglu et al., 2001, Engerman and Sokoloff, 2002, Rodrik et al., 2004).

Institutions typically comprise a host of diverse issues such as the legal and political framework, judicial enforcement, quality of bureaucracy, or social norms. Not only do these affect economic interaction differentially, but also the effects may interlink. The literature so far has focused on modeling particular, mostly political, institutions such as elections and voting on redistribution or public spending, for instance on legal institutions and law enforcement, or state capacity.[1] The correct set of institutions to be included in a model is, however, not obvious. Enforcement of property rights and economic prosperity, for instance, have been observed under a variety of political institutions (see Glaeser et al., 2004); the authoritarian regimes in Chile, Singapore, and South Korea are cases in point. Mulligan et al. (2004) report no systematic economic or social policy differences between democracies and (non-communist) non-democracies across countries over the years 1960-90.[2].

This paper pursues an alternative approach in focusing on whether economic outcomes are implementable, or stable, in a society, remaining agnostic about the particular mix of institutions employed to this end. An outcome is understood to be stable if it is robust to deviations by arbitrary coalitions of agents. Hence, the precise nature of interactions between different institutions of political, social, legal or economic kind need not be modeled. Whether an efficient market allocation can be reached will depend on the distribution of power in a society; more equality or congruence of power and economic resources favor markets. Otherwise a jungle emerges: an outcome that assigns all land to an elite of the most powerful distorting the economic allocation; this is the only cost of expropriation in this model.

Yet the main contribution is to examine the dynamic behavior of such an economy, characterized by the bidirectional feedback between economic outcomes and the distribution of power. This is especially relevant when one seeks to explain macroeconomic phenomena such as output volatility, institutional or election cycles, or poverty traps. Such interaction occurs when individual power depends on parental income in that both the jungle

[1] See among others Acemoglu and Robinson (2000), Acemoglu (2006), Acemoglu et al. (2005), Besley and Persson (2009), Cervellati et al. (2006, 2009), Galor et al. (2009), Gradstein (2004, 2007). It has been emphasized recently, e.g. by Acemoglu and Robinson (2008) and Rajan (2009), that other types of institutions also affect the economic allocation.

[2] On the other hand, Rigobon and Rodrik (2005) find that governance, measured by a rule of law index, is partially explained by a democracy indicator.

and, to a lesser degree, the market concentrate land in the hands of the powerful. Moreover, income inequality of an efficient market allocation affects long run stability: when market payoffs induce sufficient power inequality and thus a jungle in the next period, the market outcome is not a steady state. That is, the market may contain the seed of its own undoing.

To address these issues we use a simple dynamic model of non-overlapping generations. Agents differ in land holdings, skill, and power. Skill is individual productivity with land, and power the extent to which individuals contribute to enforce particular allocations. Power may be thought of as physical power, wealth, or status. Agents are endowed with power; it does not depend on later consumption (as it does in Acemoglu et al., 2008b, 2009), but may depend on parental power and income. The economic problem consists of the organization of production, i.e. in whether land goes to the skilled, which maximizes surplus, or to the powerful. Indeed the presence of land markets that yield a competitive outcome plays an important role in economic development.[3]

Outcomes are given by the land allocation and the price (if any) that is paid for land. This encompasses both the Walrasian market equilibrium allocation and any redistribution of land to coalitions of agents. That is, we consider competitive markets and coalitional expropriation of input factors.[4] As a solution concept we use the largest consistent set (Chwe, 1994). It contains all outcomes that can be supported as a status quo against deviations by farsighted agents, capturing our notion of stability.[5]

An outcome that assigns all land to the most powerful, the jungle, dominates all other forms of coalitional expropriation. Versions of this assignment mechanism appear in the literature: e.g. the equilibrium in the jungle (Piccione and Rubinstein, 2007), the pillage game (Jordan, 2006), or the dog bone economy (Sattinger, 1993). They model expropriation of consumption, not considering a market as an alternative mechanism. Our focus lies

[3]See for instance Deininger and Feder (2001). Rajan and Zingales (2003) discuss extensively the importance of the rise of land markets for the British Economy in the XVI century. Evidence from China reported in Carter et al. (1996), Rozelle et al. (1996), Yao (1996) suggest that higher levels of transfer rights increase investment and improve allocation of labor therefore enhancing the total level of efficiency of the economy.

[4]The essential characteristic of expropriation is a deficit to commit to remunerate agents not among the expropriating coalition. This can also be understood as a failure to make tenants residual claimants, or a lack of commitment not to appropriate profits, both leading to underinvestment (see e.g. Besley and Ghatak, 2009).

[5]Also Acemoglu et al. (2009) use a version of the largest consistent set and give a non-cooperative foundation, not admitting production, power evolution, or Condorcet cycles.

on factor expropriation and distortions of the organization of production.[6] The jungle also shares features with a rent-seeking outcome.

In the long run two distinct patterns may emerge. Allocation by markets can be a stable outcome in every period (similar to the unique limit outcome in Cervellati et al., 2008); that is, markets are sustainable. This is facilitated by more equal initial period power distributions and less mismatch between demand and supply. Otherwise periods when a market allocation is stable alternate with periods when it is not, i.e. there is a limit cycle. This is because a jungle assigns power and economic resources to the elite, removing the elite's motive to expropriate input factors in the next period. Depending on the distribution of market rents, in a limit cycle elites may be persistent as in Acemoglu and Robinson (2008) or they may not.

Whether institutions that permit allocation of resources to reach a market outcome are sustainable in the long run depends on a society's ability to absorb income inequality in a market outcome. Market payoffs play a twofold role in driving power inequality: on the one hand they redistribute power through the skill premium, which is independently drawn, and thus tends to compress the power distribution. On the other hand, they allow power accumulation by sellers of resources through the land price, creating powerful profiteers from a future jungle. Moreover, the way power transmits across generations has a profound effect. If power differentials do not persist over generations, for instance in meritocratic societies, markets are sustainable regardless of other parameters; that is, an ergodicity result holds. If individual power depends on the entire lineage's history, for instance in a caste society, a limit cycle may emerge, causing distortions of the organization of production resulting in lower and more volatile output in the long run than when markets are sustainable. Hence, the model is able to explain long run differences in total factor productivity across countries (cf. Prescott, 1998, Banerjee and Moll, 2010).

The results are consistent with a number of empirical observations. Higher growth rate volatility appears to be linked to inequality (Berg et al., 2008, Breen and García-Peñalosa, 2005), presence of social conflict (Rodrik, 1999), and institutions proxied by settler mortality (Acemoglu et al., 2003). The dependence on initial power distributions resembles the finding in Engerman and Sokoloff (2006), when colonial initial land allocations in European hands can be interpreted as a proxy for the initial distribution of power. Acemoglu et al. (2008a) report that a measure of inequality of

[6]Incorporating both and analyzing possible interdependencies is, though desirable, beyond the scope of the present paper and left to future research.

political power relates negatively to economic development in Colombia.

This paper is related to a field of literature studying equilibrium outcomes in environments of conflict or rent seeking, when market outcomes are precluded.[7] These papers tend to emphasize waste of resources used to prepare and fight conflicts or engage in rent seeking. We abstract from such cost and admit the possibility of economic institutions such as enforceable contracts when sufficiently powerful agents support the resulting allocation.

A second, related strand of literature studies the relationship between inequality and growth. There inequality affects economic organization and efficiency through occupational and, in particular, political choice, determining prospects for growth.[8] We are interested in the underlying conditions enabling a society to support market outcomes regardless of the particular mechanism employed to implement the allocation.

The paper is organized as follows. Section 2 outlines the static framework and section 3 the analysis of its equilibrium. In section 4 we present the dynamic model. Section 5 discusses possible extensions. Section 6 concludes, and all proofs not in the text are in the appendix.

2 Static Framework

2.1 Agents

The economy is populated by a continuum of agents I, which is a compact subset of the real line endowed with unit Lebesgue measure. Agents live for one period only. An agent $i \in I$ is fully characterized by the tuple $(\theta_i, \lambda_i, \omega_i)$, representing productivity, or skill, θ_i, land holding λ_i, and power ω_i. An agent's productivity is high, $\theta_i = H$, with exogenous probability $s \in (0,1)$ and low, $\theta_i = L$, otherwise. Productivities are distributed independently. An agent either holds a unit of land, $\lambda_i = 1$, or not, $\lambda_i = 0$.[9] Aggregate land endowment in the economy is given by $\ell \in (0,1)$. Denote by $G(\omega, \lambda)$ the joint distribution of power and land, and by $F(\omega)$ the marginal distribution with respect to power. We will frequently use $G(\omega, 1)$ ($G(\omega, 0)$), giving the measure of agents weaker than ω who are (not) endowed with land. Let

[7] See for instance Bhagwati (1982), Gonzalez (2007), Grossman (1991, 2001), Hafer (2006), Krueger (1974), Muthoo (2004), Olson (1982), Tornell (1997).

[8] Examples for the former are Banerjee and Newman (1993), Galor and Zeira (1993); see for instance Alesina and Rodrik (1994), Grossman (1994), Persson and Tabellini (1994), Alesina and Perotti (1996) for the latter.

[9] Land can also be interpreted as a capital good that neither depreciates nor accumulates, or, in the short run, as access to occupations or licences.

$F(.)$ be atom-less and bounded below and above by $\underline{\omega}$ and $\overline{\omega}$. Agents derive linear utility from consumption of income y_i, $u(y_i) = y_i$.

2.2 Production

The economy produces a single consumption good. This occurs either using a subsistence technology requiring labor but not land, or using a composite technology that requires both labor and land. To save on notation let $r(\theta_i, \lambda_i)$ denote individual i's revenue from working λ_i units of land given productivity θ_i. Suppose that

$$r(H,1) - r(H,0) > r(L,1) - r(L,0) > 0 \text{ and}$$
$$r(H,1) > r(L,1) \geq r(H,0) \geq r(L,0) \geq 0,$$

so that output using land is always greater than when not using it, and skilled H agents' return from land is higher than that of the unskilled. Output in the economy thus depends on the allocation of land and skill; redistributing land endowments to match the skill distribution, for instance through markets, increases output.

2.3 Timing

The timing of the model is the following:

- at stage 0 agents are born and nature draws types,
- at stage 1 land is assigned to agents,
- at stage 2 production and payoffs take place.[10]

Since individual land holding may change, denote by λ^0 the allocation of land endowments (in stage 0), and by λ the allocation of land after redistribution by some assignment mechanism in stage 1.[11]

2.4 Assignment of Land

The main economic concern in this model is the assignment of land to agents. That is, whether – given an initial endowment distribution of power and land

[10] That is, markets open only once, which precludes debt or rental contracts, and expropriation occurs before production. Letting markets and production open multiple times each period is beyond the present approach.

[11] As a convention we use λ as an abbreviation for $(\lambda_i)_{i \in I}$ to indicate the land allocation, while λ_i denotes individual i's land holding.

– land will be allocated based on a *competitive spot market* or occur through *coalitional expropriation*. In a spot market agents can contract on exchanges of land for labor, so that a competitive equilibrium allocation of land and labor is reached. On the other hand, land may be assigned by coalitional expropriation, reassigning land endowments to members of some coalition.

Competitive Spot Market for Land

The production technology implies that given the initial land allocation there are gains from trade prior to production. Therefore there are prices in units of the consumption good to ensure that both $(H, 0, .)$ agents are willing to buy and $(L, 1, .)$ agents are willing to sell land. Producing the required amount of the consumption good requires the buyer to exert labor effort so that in effect land is exchanged for labor. This is best interpreted as tenants who work the land until they are able to buy out their landlords.[12]

Determine now the competitive market outcome. Agent i's valuation for land is $u(r(\theta_i, 1)) - u(r(\theta_i, 0))$. Given utility function $u(y_i) = y_i$, demand for land at price p is given by agents with $r(\theta_i, 1) - r(\theta_i, 0) \geq p$ and supply by agents with $r(\theta_i, 1) - r(\theta_i, 0) \leq p$. Suppose that $\ell \neq s$ (the case $\ell = s$ is a convex combination of the other two and not particularly enlightening), then the market price for land is

$$p = \begin{cases} r(H,1) - r(H,0) := p^H & \text{if } s > \ell \\ r(L,1) - r(L,0) := p^L & \text{if } s < \ell. \end{cases} \quad [13] \tag{1}$$

In the market equilibrium land allocation $\lambda^M = (\lambda_i^M)_{i \in I}$ all possible matches between high skill and land are realized. Suppose that land is rationed uniformly among indifferent agents. An agent i obtains payoff

$$u(\lambda_i^0, \theta_i, \lambda_i^M, p) = r(\theta_i, \lambda_i^M) - (\lambda_i^M - \lambda_i^0)p,$$

where λ_i^0 denotes land endowment and λ_i^M land in the market outcome. Denote a Walrasian market allocation in this economy by $W(\lambda^0)$. $W(\lambda^0)$ is given by an allocation $((\lambda_i^M)_{i \in I}, p)$ such that

$$\theta_i = H \Rightarrow \lambda_i^M = 1 \text{ if } s < \ell \text{ and } \theta_i = L \Rightarrow \lambda_i^M = 0 \text{ if } s > \ell, \tag{2}$$

[12] Another interpretation is that the buyer pays by installments; this requires enforceability of a relational loan contract between seller and buyer, or access to sufficiently developed capital markets.

[13] Note that in more general setups, e.g. allowing for risk aversion or costly effort provision, typically $p^\theta < r(\theta, 1) - r(\theta, 0)$, $\theta \in \{L; H\}$.

and an associated market price p given by (1). Agents' payoffs are completely determined by the initial land distribution λ^0 and measures s and ℓ. Note that $W(\lambda^0)$ does not pin down a unique land allocation, since agents on the longer market side are indifferent between buying and selling. All allocations in $W(\lambda^0)$ are, however, payoff equivalent.

Coalitional Expropriations

As outlined above any allocation of land that provides measure ℓ of agents with one unit of land can be interpreted as coalitional expropriation, i.e. a coalition of measure ℓ appropriates all land assigning one unit to each member. Denote an allocation resulting from coalitional expropriation by $(\lambda, p) = ((\lambda_i)_{i\in I}, 0)$. Note that the market allocation of land may be reached by coalitional expropriation, although $p = 0$, since land is expropriated and no labor is exchanged for land. This setup remains silent on the exact means of expropriation; it is consistent with violent theft, or discrimination codified in law or laid down in social norms that takes place in actual market places. We abstract from transaction cost so that agents' payoffs are revenues $r(\theta_i, \lambda_i)$.

2.5 Admissible Allocations

We limit our attention to allocations that are induced by a Walrasian market equilibrium or coalitional expropriation. This ignores market allocations with non-Walrasian prices inducing some form of rationing. Define the set of admissible of allocations accordingly as follows.

Definition 1 (Admissible Allocations) *An allocation (λ, p) is admissible if*

(i) $\int_{i\in I} \lambda_i di = \ell$ *and* $\lambda_i \in \{0; 1\}$ *for all* $i \in I$ *(feasibility) and*

(ii) either $p = 0$ *or it is a Walrasian allocation, i.e.* $(\lambda, p) \in W(\lambda^0)$.

Definition 1 contains three important assumptions. First, redistribution does not waste resources. This is because we focus on allocative distortions as a consequence of expropriation rather than on waste. Second, only deterministic redistribution is considered.[14] Third, since labor effort provision

[14] Admitting stochastic redistribution requires commitment to enforce the outcome, see Section 5.1. Moreover, when capital market frictions are severe, stochastic expropriation may yield higher output than assignment by markets (e.g. Gall, 2008, pursues this point).

cannot be forced, for instance due to lack of observability, we consider allocations that result from voluntary exchanges of labor for land on a spot market, but we do not consider allocations requiring gifts or forced labor.

2.6 Solution Concept

Our aim is to identify a resource allocation that is robust to potential coalitional deviations to other admissible allocations. Given such an allocation production takes place, which in turn determines agents' payoffs. Agent i's payoff from an allocation (λ, p) is

$$u(\lambda_i^0, \theta_i, \lambda_i, p) = r(\theta_i, \lambda_i) - (\lambda_i - \lambda_i^0)p.$$

We model coalitional deviations as a move to another admissible allocation enforced by a coalition preferring the new allocation met with opposition by a coalition preferring the status quo. Given an allocation (λ^b, p^b) there is a coalitional deviation to an allocation (λ^a, p^a) if there is a power majority of agents that strictly prefers (λ^a, p^a) to (λ^b, p^b). In the spirit of von Neumann and Morgenstern (1944) we say (λ^a, p^a) *dominates* (λ^b, p^b).

Definition 2 (Dominance) *An allocation (λ^a, p^a) dominates an allocation (λ^b, p^b), that is $(\lambda^a, p^a) \succ (\lambda^b, p^b)$, if $\int_{i\in C} \omega_i di > \int_{i\in C'} \omega_i di$ where $C = \{i \in I : u(\lambda_i^0, \theta_i, \lambda_i^a, p^a) > u(\lambda_i^0, \theta_i, \lambda_i^b, p^b)\}$ and $C' = \{i \in I : u(\lambda_i^0, \theta_i, \lambda_i^a, p^a) < u(\lambda_i^0, \theta_i, \lambda_i^b, p^b)\}$.*

Hence, an allocation a dominates an allocation b, if strict winners under a (coalition C) have greater aggregate power than strict losers under a (coalition C'). C and C' are uniquely determined by the payoffs in the respective allocations. Strict preference is required, since coalition members may need to communicate and coordinate. Introducing a small but positive coordination cost thus does not alter the results, and our setup is consistent with both the use of force to switch allocations and non-violent regime change. To familiarize the reader with the concept suppose $a = W(\lambda^0)$ and $b = (\lambda^0, 0)$. If $W(\lambda^0) \neq (\lambda^0, p)$, the competitive allocation dominates the endowment allocation, that is $a \succ b$. This is because $C' = \emptyset$ as trade is voluntary, and, since θ_i is drawn independently, a positive measure of agents has strict gains from trade, so that $C \neq \emptyset$.

As noted by von Neumann and Morgenstern (1944), transitivity of the relation $\succ$ is not guaranteed. Indeed transitivity may fail in our setup, implying that the core is empty and a stable set does not exist, see the appendix for an example. Therefore we use an appropriate version of the

largest consistent set introduced by Chwe (1994). This requires defining the relation indirect (or farsighted) dominance.

Definition 3 (Indirect Dominance) *Allocation* (λ^a, p^a) *indirectly dominates allocation* (λ^b, p^b)*, that is* $(\lambda^a, p^a) \succcurlyeq (\lambda^b, p^b)$*, if there exist admissible* (λ^1, p^1)*,* (λ^2, p^2)*, ...,* (λ^m, p^m) *(where* $(\lambda^1, p^1) = (\lambda^a, p^a)$ *and* $(\lambda^m, p^m) = (\lambda^b, p^b)$*) such that for every* $j = 2, ..., m$ $(\lambda^{j-1}, p^{j-1}) \succ (\lambda^j, p^j)$ *and* $(\lambda^1, ^1) \not\prec (\lambda^j, p^j)$*.*

That is, for allocation a to indirectly dominate allocation b there must be a sequence of allocations starting at b, such that each element in the sequence (i) directly dominates each predecessor if there is one and (ii) does not dominate the final allocation a.[15] Intuitively, at each step a power majority must be willing to change allocation, while there must not be a power majority preferring the present allocation over the final allocation and thus willing to veto the re-allocation. Define consistent sets accordingly.

Definition 4 (Consistent Set) *A set of admissible allocations* Y *is consistent if* $(\lambda^a, p^a) \in Y$ *if and only if for all admissible* (λ^b, p^b) *with* $(\lambda^b, p^b) \succ (\lambda^a, p^a)$ *there exists* $(\lambda^c, p^c) \in Y$ *where* $(\lambda^c, p^c) \succcurlyeq (\lambda^b, p^b)$ *such that* $(\lambda^a, p^a) \not\prec (\lambda^c, p^c)$*. Define the largest consistent set* $\bar{Y}$ *as a consistent set with* $Y \subseteq \bar{Y}$ *for all consistent* Y*. An allocation* (λ, p) *is said to be* stable *if it is in the largest consistent set,* $(\lambda, p) \in \bar{Y}$*.*

Consistency requires that any deviation from an allocation a in the consistent set to another allocation b dominating a in turn enables a deviation to another allocation c that (indirectly) dominates b and is in the consistent set, but does not dominate a. Intuitively, for any deviation from allocations in the consistent set agents anticipate to return to an allocation in the consistent set not dominating the original allocation. Thus the deviation is deterred. $\bar{Y}$ is then the largest set of admissible allocation that is consistent and therefore encompasses all allocations supportable as stable outcomes.

A particular concern is whether a Walrasian market allocation is in the largest consistent set, since this ensures that when it is the status quo potential deviations can be credibly deterred. A society may attempt to implement a market outcome by way of choosing adequate institutions, for instance a promise to enforce property rights and a free market economy,

[15] In contrast to Chwe (1994) we only require the final allocation to be undominated. Here the dominance relation relies on all winners and losers, and requires relative power majority. Requiring strict dominance of the final allocation thus means that indirect implies direct dominance and a consistent set need not exist, see appendix for an example.

encoded in political or legal institutions such as a constitution. Yet such a promise of enforcement is credible only when the outcome allocation is in the largest consistent set. Otherwise it is vulnerable to coalitional deviations, implying that institutions will necessarily erode.

3 Static Equilibrium

3.1 Coalitional Expropriation: the Jungle Emerges

Although the largest consistent set is non-empty under weak conditions, existence is not straightforward, since our dominance relation only uses relative power majority. This section provides an existence result.

Start by characterizing the economy's elite as measure ℓ of the most powerful agents. That is, if power endowments change over time, so do identities of agents among the elite. An agent i is among the elite of strong agents, if $\omega_i > \hat{\omega}$, with the cutoff power endowment $\hat{\omega}$ defined implicitly by

$$1 - F(\hat{\omega}) = \ell.$$

Let $(\lambda^J, 0)$ denote an admissible allocation that assigns land to the elite, i.e. $\lambda_i^J = 1$ if $\omega_i > \hat{\omega}$ and $\lambda_i^J = 0$ if $\omega_i < \hat{\omega}$. A useful result follows immediately.

Proposition 1 (Expropriation) *The allocation* $(\lambda^J, 0)$ *is unique almost everywhere and undominated by all admissible allocations* $(\lambda', 0)$.

The proof (in the appendix) is straightforward, using that for each allocation $(\lambda, 0) \neq (\lambda^J, 0)$ some members of the elite do not hold land, but are more powerful than some landholders in allocation $(\lambda, 0)$. Hence, there is a unique land allocation λ^J not dominated by any coalitional redistribution. This allocation is characterized by expropriation of the weak by the strong, that is the economy becomes a *jungle*. There are several reasons for singling out the jungle among a continuum of admissible coalitional expropriations. First, no coordination is required. Second, it assigns land only by power (contrary to the market, which assigns land by skill only). Third, it has become a recurrent theme in the literature under various guises.[16]

[16]For instance, it coincides with the jungle equilibrium outcome in Piccione and Rubinstein (2007) and the dog bone economy allocation in Sattinger (1993), and is in the outcome set of a version of the pillage game equilibrium in Jordan (2006).

3.2 Stable Outcomes in the Static Economy

Let us now determine whether a market allocation $(\lambda^M, p) \in W(\lambda^0)$ can be a stable outcome, i.e. be in the largest consistent set. Since by Proposition 1 the jungle dominates all other coalitional expropriation outcomes, $(\lambda^J, 0) \succ (\lambda^M, p)$ implies $\bar{Y} = (\lambda^J, 0)$. That is, if the jungle outcome dominates a market outcome it is the largest consistent set. The opposite, $\bar{Y} = (\lambda^M, p)$ (i.e. the market outcome is the largest consistent set) holds if $(\lambda^M, p) \succ (\lambda, 0)$ for all coalitional expropriations $(\lambda, 0)$ including the jungle. This case is not implied by $(\lambda^M, p) \succ (\lambda^J, 0)$, however, and there may be some coalitional expropriation outcome $(\lambda, 0) \succ (\lambda^M, p)$, while $(\lambda^M, p) \succ (\lambda^J, 0)$, and the relation $\succ$ is not transitive (see appendix for an example). Nevertheless the following proposition states that in this case the market allocation is in the largest consistent set and can therefore be supported as a stable outcome.

Proposition 2 *If $(\lambda^M, p) \succ (\lambda^J, 0)$, where $(\lambda^M, p) \in W(\lambda^0)$, a market for land is stable, $(\lambda^M, p) \in \bar{Y}$. Otherwise only a jungle allocation is stable, $\bar{Y} = (\lambda^J, 0)$.*

The full proof is in the appendix, but a sketch follows. If $\succ$ is not transitive, continuity of the measure of the agent space implies existence of a coalitional expropriation outcome $(\lambda^X, 0)$ with $(\lambda^M, p) \not\succ (\lambda^X, 0)$ and $(\lambda^X, 0) \not\succ (\lambda^M, p)$. Then all three allocations are in the largest consistent set, with the jungle deterring potential deviations from markets, and $(\lambda^X, 0)$ deterring a deviation from the jungle to markets, to enable the jungle as an element in the consistent set to be used as a deterrent.

Hence, whether land markets are stable, that is whether a society can support Walrasian allocations, depends only on the dominance relation between the market and the jungle. $(\lambda^M, p) \succ (\lambda^J, 0)$ implies that all admissible allocations are either directly or indirectly dominated by (λ^M, p). A discussion of conditions implying that (λ^M, p) is the unique stable outcome is postponed to the next section. Determine now conditions for $(\lambda^M, p) \succ (\lambda^J, 0)$ using the definition of $\succ$. Two cases arise depending on the market price for land. Indeed, $(\lambda^M, p) \succ (\lambda^J, 0)$ if and only if

$$\int_{\underline{\omega}}^{\hat{\omega}} \omega dG(\omega, 1) + s \int_{\underline{\omega}}^{\hat{\omega}} \omega dG(\omega, 0) > \int_{\hat{\omega}}^{\overline{\omega}} \omega dG(\omega, 0) \text{ if } p = p^L, \tag{3}$$

$$\int_{\underline{\omega}}^{\hat{\omega}} \omega dG(\omega, 1) + (1-s) \int_{\hat{\omega}}^{\overline{\omega}} \omega dG(\omega, 1) > \int_{\hat{\omega}}^{\overline{\omega}} \omega dG(\omega, 0) \text{ if } p = p^H. \tag{4}$$

That is, a market allocation is stable if the aggregate power of the winners from markets (LHS) exceeds the one of the losers from markets (RHS). Weak agents endowed with land ($\omega_i < \hat{\omega}$ and $\lambda_i^0 = 1$) always support markets, since they are expropriated in the jungle. Moreover, agents who realize gains from trade support markets. Their identity depends on the market price p. When the land price is low, weak skilled buyers ($\theta_i = H$ and $\lambda_i^0 = 0$) obtain rents and support markets, see condition (3). If the market price is high, all unskilled sellers ($\theta_i = L$ and $\lambda_i^0 = 1$) obtain rents on the market and support markets, see condition (4). The RHS of both conditions captures the power of strong agents not endowed with land ($\omega_i > \hat{\omega}$ and $\lambda_i^0 = 0$). They strictly prefer expropriation, since they obtain land for free in the jungle.

3.3 Properties of the Stable Outcome

Some observations are worth mentioning at this point. Whether a market is stable depends on the mismatch between demand and supply in the market and on properties of the joint distribution of land and power such as inequality or correlation. Lower mismatch between demand and supply is associated with more support for market allocations, because the power of either weak skilled buyers or strong unskilled sellers increases.

Moreover, a more equal power distribution favors stability of markets, because more equality decreases the power of strong agents without land and increases the power of weak agents with land. The effect of more equality is less pronounced in a high price environment, since it also decreases the power of unskilled strong landholders who support markets.

Finally, correlation of land and power plays an important role. Suppose for a moment that the most powerful agents hold land (i.e. $\lambda_i^0 = 1 \Leftrightarrow \omega_i > \hat{\omega}$) and thus land and power are perfectly correlated. Then the market allocation is a stable outcome (indeed the only one), as the RHS of the appropriate condition (3) or (4) is zero, while some agents have strict gains from trade, so that the LHS of the respective condition is strictly positive. This is particularly relevant if one is interested in the dynamics, as the jungle assigns land only to the powerful, inducing perfect correlation of end of period power, land holdings, and income.

This reasoning extends to more general cases. Formalize the correlation between land and power by defining binary variables $P(i)$ returning 1 if agent i is member of the power elite (i.e. $\omega_i \geq \hat{\omega}$) and 0 otherwise, and

$L(i) = \lambda_i^0$. The correlation coefficient

$$\rho = \frac{\text{cov}(P, L)}{\sqrt{\text{var}(P)\text{var}(L)}},$$

describes congruence of land and power in the endowment distribution. Indeed sufficient congruence stabilizes markets, as stated in the following summary proposition (details can be found in the appendix).

Proposition 3 *Properties of the stable outcome:*

(i) When $s > \ell$ ($s < \ell$) a decrease (increase) of s favors markets as a stable outcome, i.e. $(\lambda^M, p) \in \bar{Y}$.

(ii) Suppose that $\underline{\omega} < \hat{\omega}$, i.e. the distribution of power is non-degenerate for $\omega \leq \hat{\omega}$, and the jungle is the only stable outcome ($(\lambda^J, 0) \succ (\lambda^M, p)$). Then there is a redistribution of power from the strong ($\omega_i > \hat{\omega}$) to the weak ($\omega_i < \hat{\omega}$) favoring stability of market allocations.

(iii) There is $\epsilon > 0$ such that for all $\rho \geq 1 - \epsilon$ a market allocation is the stable outcome.

4 Dynamic Setting

Consider now a dynamic version of the model outlined above. Each generation of agents lives for a single period. In a period t agents are born and nature draws types, then land is assigned, finally production takes place and output is consumed, as above. Each agent has a single child. Absent investment generations are linked by land bequests and intergenerational spill-overs of power and income. As land does not depreciate, parents leave their land to their offspring. The power of an agent's offspring is potentially determined both by the parent's power *and* income, obeying the rule

$$\omega_{i,t+1} = \alpha\omega_{i,t} + \beta y_{i,t} + \eta, \tag{5}$$

where $\alpha \geq 0$, $\beta \geq 0$ and $\eta \geq 0$. This law of motion merits some explanation. It states that agents' power is an aggregate of their parent's power and income, and an exogenous common component. This allows for a number of interpretations.

First, power may be thought of as *wealth* (measured in units of the consumption good). Suppose that wealth can be invested or stored, yielding return $R \geq 0$, and agents' preferences exhibit some form of warm glow; for instance, let agents' utility from consumption c and bequest b be $u(c, b) =$

$c^{\delta}b^{1-\delta}$. Then utility is linear in the level of wealth accumulated by the agent at the end of a period and in each period t an agent's wealth endowment is given by $\omega_t = \delta(R\omega_{t-1} + y_{t-1})$, that is $\alpha = \delta R$, $\beta = \delta$, and $\eta = 0$.

Power may also be viewed as *social status* of a dynasty acquired through ancestors' income. Individual status could depend on parental economic success, i.e. income, and parents' status. This can be captured by the law of motion (5), with $\eta > 0$. Then the growth rate of power differentials, $\frac{\omega_{i,t}}{\omega_{j,t}} - \frac{\omega_{i,t-1}}{\omega_{j,t-1}}$, decreases in η, and for η large enough the power distribution is compressed over time, so that social stratification diminishes. As η grows out of bounds social status does not play a role; conversely, when $\alpha > 0$ and $\beta = \eta = 0$ the power ranking does not vary over time, which can be thought of as a feudal society. Hence, η is best interpreted as social mobility in this setting.

Finally, power may be interpreted as a *physical characteristic*, such as leadership, cunning or strength. It is then natural to assume that the current generation's phenotypical attribute is given by a common endowment η that is affected by nature (the parent's attribute), and by nurture (e.g. early childhood investment, which correlate with parental income when preference exhibit warm glow as above). In this interpretation $\omega_t = \alpha\omega_{t-1} + \beta y_{t-1} + \eta$, where $\alpha > 0$, $\beta > 0$, and $\eta > 0$.[17]

In all cases α measures the persistence of power, β the impact of contemporaneous income shocks, and η is a mobility component. The case $\beta > 0$ is of particular interest as then economic outcomes affect the future distribution of power and thus future economic institutions.

Proposition 2 ensures that always the jungle or the market is a stable outcome of the static model. As multiple allocations may be in the largest consistent set, select in this case the allocation that is implied by the assignment mechanism generating the previous period's allocation. That is, the status quo assignment mechanism is selected whenever it can be justified as stable. Define a period *equilibrium allocation* by the allocation of the status quo assignment mechanism if it is in the largest consistent set, otherwise by the unique stable allocation. This is well-defined as only expropriation or the market allocation can be unique stable allocations, and both are stable in case of multiple stable allocations. To close the model let the jungle be the status quo in period 0.

[17]Interpreting power as the number of votes an individual is endowed with also yields the same expression. The case where the law of motion, or parameters thereof, is directly chosen by a society is likely to provide interesting future research.

4.1 Transition Functions

Key to the model's long run dynamics is the mapping of period t's joint distribution of land and power into period $t+1$'s joint distribution of land and power. This mapping is well defined since under our selection rule an equilibrium allocation fully determines next period's endowments through the consumption spill-over and the bequest of land.

Income in a jungle outcome is either $r(\theta_i, 1)$ if $\omega_{i,t} \geq \hat{\omega}_t$, or $r(\theta_i, 0)$ otherwise. Power in period $t+1$ is then

$$\omega_{i,t+1} = \alpha\omega_{i,t} + \eta + \beta \begin{cases} r(\theta_i, 1) & \text{if } \omega_{i,t} \geq \hat{\omega}_{i,t} \\ r(\theta_i, 0) & \text{if } \omega_{i,t} < \hat{\omega}_{i,t}. \end{cases}$$

Since land goes to the powerful, the land endowment in period $t+1$ is

$$\lambda_{i,t+1} = \begin{cases} 1 & \text{if } \omega_{i,t} \geq \hat{\omega}_{i,t} \\ 0 & \text{if } \omega_{i,t} < \hat{\omega}_{i,t}. \end{cases}$$

Note that in the jungle $\omega_{i,t} > \hat{\omega}_{i,t}$ implies $\omega_{i,t+1} > \hat{\omega}_{i,t+1}$. Therefore land and power are perfectly correlated in $t+1$.

In a market income is $r(\theta_i, 1)$ if an agent owns land at the beginning and at the end of the period, $r(\theta_i, 0)$ if he never owns land, $r(\theta_i, 1) - p$ if he buys and $r(\theta_i, 0) + p$ if he sells. Hence, power in period $t+1$ is

$$\omega_{i,t+1} = \alpha\omega_{i,t} + \beta(r(\theta_i, \lambda_{i,t}) - (\lambda_{i,t} - \lambda^0_{i,t})p) + \eta.$$

Regarding the land allocation in $t+1$ note that landholders either buy land on the market or inherit it. If $\ell > s$ land supply exceeds demand by skilled agents and the market allocation assigns land at price p^L to all skilled agents and uniformly rations the excess supply to the unskilled. An unskilled agent's probability to obtain land on the market q^L_t is given by

$$q^L_t = \frac{\ell - s}{1 - s}.$$

Since q^L_t does not depend on t we drop the time subscript. $\lambda_{i,t+1}$ is given by

$$\lambda_{i,t+1} = \begin{cases} 1 & \text{if } \theta_{i,t} = H \\ \begin{cases} 1 \text{ with prob. } q^L \\ 0 \text{ with prob. } 1 - q^L \end{cases} & \text{if } \theta_{i,t} = L. \end{cases}$$

Hence, land is distributed randomly among the unskilled.

A similar reasoning applies when $\ell < s$ and thus $p_t = p^H$. All unskilled agents sell their land on the market, while the skilled are indifferent. At

price p^H there is excess demand and land is rationed uniformly to the skilled. Denote a skilled agent's probability to obtain land on the market by q_t^H:

$$q_t^H = \frac{\ell}{s}.$$

Dropping again the time subscript and writing q^H, $\lambda_{i,t+1}$ is given by

$$\lambda_{i,t+1} = \begin{cases} 0 & \text{if } \theta_{i,t} = L \\ \begin{cases} 1 \text{ with prob. } q^H \\ 0 \text{ with prob. } 1 - q^H \end{cases} & \text{if } \theta_{i,t} = H. \end{cases}$$

This means that land is distributed randomly among the skilled.

4.2 Long Run Behavior

The transition functions derived above determine the dynamic pattern of allocations in the model economy. We shall be especially concerned with the question of whether markets are sustainable over time, or whether income inequality generated by a market outcome today will preclude stability of future markets. In the long run two distinct regimes can emerge. The first is sustainable markets, when spot markets for land are stable in every period. The second is a limit cycle, when stable markets alternate with unstable markets in regular intervals. To derive this we need to examine the inter-temporal relation of equilibrium allocations, exploiting independence of both skill draws and uniform rationing.

Note first that a jungle in period t is followed by a market in $t+1$. This is because in a jungle the elite obtains land for free and thus higher income than weak agents. This preserves the power ranking and the offspring of period t's elite forms the elite in $t+1$, implying perfect correlation of land and power. Proposition 3 then ensures that a market is stable, as the elite already holds land and a positive measure of agents gain from trade.

But also a competitive market outcome in period t induces concentration of land among the elite in $t+1$. This is because the event of being assigned land yields a weakly higher income than not being assigned land. Hence, agents who obtain land in a market have weakly higher income and enter the elite in $t+1$ at a rate bounded below by ℓ. A lemma summarizes these findings, see appendix for the full proof.

Lemma 1 (Land Concentration) *In any period $t+1$ the share of agents endowed with land among the weak is less than ℓ, that is, $F_{t+1}(\hat{\omega}_{t+1}|\lambda = 0) > 1 - \ell$. A jungle allocation in period t implies $F_{t+1}(\hat{\omega}_{t+1}|\lambda = 0) = 1$ and stability of markets in period $t+1$.*

Although higher concentration of land favors stable markets (by Proposition 3) in the current period, it increases future power inequality as a market assigns rents to land sellers, which lets agents endowed with land accumulate power even if unskilled. Indeed, to have a stable market in a period $t+1$ following a stable market in t period $t+1$ power endowments, induced by the market outcome in t, need to be sufficiently equal, as stated in the following proposition, see appendix for the proof.

Proposition 4 *Suppose a market is an equilibrium allocation in period t. A market is stable in period $t+1$ if*

$$\alpha E_t(\omega) - \beta\phi_1(s,\ell,r(.),p) \leq \phi_2(s,\ell)\alpha E_t(\omega|\omega < \hat{\omega}_t) + \eta\phi_3(s,\ell),$$

where ϕ_1, ϕ_2, and ϕ_3 are differentiable functions with $\phi_2(s,\ell) > 1$ and $\phi_3(s,\ell) > 0$ that increase (decrease) in ℓ and decrease (increase) in s, ϕ_1 decreases in the market price $p = p^\theta$ and increases in $r(\theta,1) - r(\theta,0)$ with $\theta = H$ ($\theta = L$) if $s > \ell$ ($s < \ell$).

This immediately implies that stable markets spawn stable markets if power is distributed sufficiently equally in t, or if α is sufficiently small while η is sufficiently large. When income affects next period's power ($\beta > 0$), stability in $t+1$ is favored by lower market price p and higher returns from land $r(\theta,1) - r(\theta,0)$.

This is because a market has a twofold effect: on the one hand power is redistributed through randomly drawn rents from skill, on the other hand power is accumulated by agents endowed with land through revenues from sale. Note that, while under our assumptions $p^\theta = r(\theta,1) - r(\theta,0)$, concave utility or costly effort investment may imply that $p^\theta < r(\theta,1) - r(\theta,0)$. If the difference $r(\theta,1) - r(\theta,0) - p^\theta$ is sufficiently high, then $\phi_1(.) > 0$ as a corollary to Proposition 4. This relaxes the condition in Proposition 4 favoring stability of a market outcome, and implies that redistributive effects of land transactions dominate and social mobility increases in β.

If land holdings are concentrated among the elite as stated in Lemma 1, high rents for sellers undermine the market's ability to redistribute power through the skill premium. Indeed a market is followed by a jungle if power is distributed sufficiently unequally, as stated in the following proposition, see appendix for details.

Proposition 5 *Suppose a market is an equilibrium allocation in period t. The jungle is the only stable outcome in period $t+1$ if*

$$\alpha E_t(\omega) - \beta\psi_1(s,\ell,r(.),p) \geq \psi_2(s,\ell)\alpha E_t(\omega|\omega < \hat{\omega}_t) + \eta\psi_3(s,\ell),$$

where ψ_1, ψ_2, and ψ_3 are positive functions that increase in ℓ and decrease (increase) in s if $s > \ell$ ($s < \ell$). ψ_1 increases in $r(\theta, 1)$ and decreases in p.

That is, sufficient inequality of power in t implies that a jungle is stable in $t+1$, when β and η are small enough. Stability of markets in the long run then depends on whether markets induce sufficiently equal power distributions over time. The next proposition gives conditions that ascertain which regime will prevail, the proof can be found in the appendix.

Proposition 6 (Long Run Behavior) *(i) Suppose the condition in Proposition 4 holds in a period t_0. Markets are stable in every period $t > t_0$ if*

$$\kappa_1(s, \ell, r(.), p)\beta + \kappa_2(s, \ell, r(.), p)\alpha\beta + \kappa_3(s, \ell)\eta \leq 0,$$

where κ_1, κ_2, and $\kappa_3(.) < 0$ are differentiable functions. If $s < \ell$ ($s > \ell$), $\kappa_2(.) > 0$, κ_1, κ_2, κ_3 increase (decrease) in ℓ, κ_1 and κ_3 decrease (increase) in s.
(ii) Suppose the condition in Proposition 5 holds and markets are stable in a period t_0. Then the jungle is stable in every period $t_0 + 2\tau - 1$, and a market is stable in every period $t_0 + 2\tau$ for $\tau = 1, 2, ...$ if α is sufficiently great and $\beta > 0$, or if s is sufficiently close to 1 when $s > \ell$ (s and $r(L, 0)$ are sufficiently close to 0 when $s < \ell$).

Proposition 6 contains three important statements. First, as in the static version, sustainable markets become more likely as the initial power distribution becomes more equal and ℓ or s adjust to reduce mismatch of demand and supply of land. Second, an ergodicity result holds: Propositions 4 and 6 imply that markets will be eventually stable forever, independently of the initial power distribution, when social mobility in a society is high, that is α sufficiently small and η sufficiently high. Then the power distribution is compressed over time and eventually markets become sustainable.

Finally, part (ii) of Proposition 6 and Proposition 5 imply that sufficient power inequality in some period may indeed lead to limit cycles, in particular when persistence of power is high, but also when mismatch between demand and supply is sufficiently severe, e.g. when s is sufficiently close to 1 if $s > \ell$. Both impede the market's ability to redistribute power over time by way of rent sharing through prices.

Whether markets are sustainable has important implications for economic mobility as a market allocates resources by productivity, whereas a jungle allocation is based on historic outcomes. Hence, our next concern

is intergenerational earnings mobility. When markets are sustainable, independent draws of skill ensure full social mobility in earnings and rents are distributed equally in the long run. This need not be the case when the economy alternates between markets and jungles. Elites are persistent, that is offspring of agents in the power elite will also be in the elite, if landowners obtain a sufficiently high share of the rents in the market outcome. Otherwise identities of agents in the elite change over time in a limit cycle.

Proposition 7 *Elites are persistent, i.e. for all* $i, j \in I$ $\omega_{i,t} > \hat{\omega}_t > \omega_{j,t}$ *implies* $\omega_{i,t+2} > \hat{\omega}_{t+2} > \omega_{j,t+2}$*, if markets and jungles alternate for all* t *and (i)* $\ell < s$*, or (ii) if* $r(H,1) - r(H,0) - (r(L,1) - r(L,0)) \leq (1+\alpha)(r(L,1) - r(H,0))$ *and* $\ell > s$*.*

Proof: Let t denote a period when markets are unstable. Choose $i, j \in I$ so that $\omega_{i,t} > \hat{\omega}_t > \omega_{j,t}$. A jungle in t implies $\omega_{i,t+1} \geq \alpha\omega_{i,t} + \beta r(L,1) + \eta$ and $\omega_{j,t+1} \leq \alpha\omega_{i,t} + \beta r(H,0)$. In period $t+1$ markets must be stable and

$$\omega_{i,t+2} \geq \alpha\omega_{i,t+1} + \eta + \beta \begin{cases} r(L,0) + p^L & \text{if } s < \ell \\ r(H,0) + p^H & \text{if } s > \ell \end{cases} \quad \text{and}$$

$$\omega_{j,t+2} \leq \alpha\omega_{i,t+1} + \eta + \beta \begin{cases} r(H,1) - p^L & \text{if } s < \ell \\ r(H,1) - p^H & \text{if } s > \ell. \end{cases}$$

Clearly, $\omega_{i,t+2} > \hat{\omega}_{t+2} > \omega_{j,t+2}$ if $\omega_{i,t+2} > \omega_{j,t+2}$ for all $i, j \in I$ with $\omega_{i,t} > \hat{\omega}_t > \omega_{j,t}$. Using the expressions from above, $\omega_{i,t+2} > \omega_{j,t+2}$ if

$$\alpha^2\omega_{i,t} + \beta[\alpha r(L,1) + r(L,0) + p^L] > \alpha^2\omega_{j,t} + \beta[\alpha r(H,0) + r(H,1) - p^L] \text{ if } s < \ell,$$
$$\alpha^2\omega_{i,t} + \beta[\alpha r(L,1) + r(L,0) + p^H] > \alpha^2\omega_{j,t} + \beta[\alpha r(L,0) + r(H,1) - p^H] \text{ if } s > \ell.$$

This and the assumption $r(L,1) \geq r(H,0)$ establish the statement. □

A limit cycle of markets and jungles induces output fluctuations. Aggregate output in a period t when a market is stable is given by

$$y_t^M = \begin{cases} sr(H,1) + (\ell - s)r(L,1) + (1-\ell)r(L,0) & \text{if } s < \ell \\ \ell r(H,1) + (s-\ell)r(s,0) + (1-s)r(L,0) & \text{if } s > \ell. \end{cases}$$

When a jungle is a stable outcome in period t, output is independent of whether land is scarce or not:

$$y_t^J = s[\ell r(H,1) + (1-\ell)r(H,0)] + (1-s)[\ell r(L,1) + (1-\ell)r(L,0)].$$

Clearly, $y_t^M > y_t^J$. Therefore Propositions 4, 5, and 6 link inequality in endowments and income to output efficiency and fluctuations through the land assignment mechanism. When volatility of output in periods $t = t_0 + 1, t_0 + 2, ...$ is measured by $var(y_t - y_{t-1})$ the following corollary emerges.

Corollary 1 (Output Fluctuations) *Lower output volatility and higher average output in periods* $t_0 + 1, t_0 + 2, ...$ *is favored by*
(i) less inequality of power in period t_0*,*
(ii) less mismatch of demand and supply, that is lower (higher) s *and higher (lower)* ℓ *if* $s > \ell$ $(\ell < s)$*,*
(iii) higher social mobility, i.e. lower α *and higher* η*.*

That is, higher initial inequality in power, a wider gap between land demand and supply, and higher persistence of power differentials all tend to accompany more volatile and – on average – lower output. This and higher income inequality in the jungle are consistent with evidence on a negative cross-country relationship between income inequality and macroeconomic stability as measured by the duration of periods with positive growth rates (Berg et al., 2008) and the standard deviation of the output growth rate (Breen and García-Peñalosa, 2005). Several examples follow to illustrate the statements in Corollary 1.

Engerman and Sokoloff (2006) put forward the idea that geographical differences of European colonies affected their institutional development through technology even when colonial heritage is shared. The arrival of European colonists altered the composition of the colony populations and thus affected inequality in the distributions of wealth, human capital, and political power. Inequality in colonies was linked to both soil and climate conditions and to the native and settler population density. British colonies in the Caribbean were suitable for plantations, already populated and home to diseases dangerous to European settlers. This translated into larger plot size, smaller ratio of landholders and European in the population than in temperate colonies, for instance in the northern parts of America. As owners of land, mainly Europeans, were privileged both in terms of social status and their ability to shape political decisions this led to greater initial inequality of land and power in plantation than in temperate farming colonies.[18] Moreover, larger efficient plot size in plantation economies can be viewed in terms of greater mismatch of demand and supply in the land market.[19] The reversal of fortunes of the Caribbean and North America appears thus consistent with our theory as initial conditions in the northern economies

[18] Colonies that were scarcely populated when Europeans first arrived, such as Australia, New Zealand, Canada, or the United States, were characterized by relative equality in wealth, human capital and political influence.

[19] Larger optimal plot sizes imply a smaller fraction of landowners, i.e. smaller ℓ in plantation economies compared to farming economies. This corresponds to greater mismatch of demand and supply in the land market, measured by the difference between s and ℓ.

appear conducive to stable markets in the long run, though not necessarily in the short run, while the opposite holds for the Caribbean colonies.[20]

Colonial legacy, mechanisms of land assignment and the power distribution seem to be important in India as well. Banerjee and Iyer (2005) find that property rights implicitly established by land revenue institutions set up by the British have a significant impact on later agricultural investment and productivity. Districts in India where landlords had the right to collect revenues from cultivators (thus holding de facto property rights) systematically under-perform districts where revenue collection was in the hands of cultivators. They argue that the choice of the land revenue institutions by the British was highly correlated with the economic and political power hold by the local elites. Choice of the revenue system was affected by pre-existing degrees of power of the landlord class, particularly in Bengal, and to some extent by exogenous reasons such as the ideology of the local British administrators. Moreover, the land assignment institution established by the British had a permanent effect on the distribution of economic and political power within Indian districts.

A possible negative association between inequality of political power and economic outcomes is also supported by the micro evidence provided by Acemoglu et al. (2008a). Data on political office holding in the state of Cundinamarca, Colombia, suggest that concentration of power in the hands of a small group of individuals is detrimental for economic development, while economic inequality had little effect.

Revisiting the Lucas and Benabou Sample

When power is interpreted as wealth, initial wealth inequality is linked to long run macroeconomic performance in line with the observations on South Korea and the Philippines put forward by Bénabou (1996) and Lucas (1993). Adding Malaysia to the sample illustrates how a jungle outcome may be reached though flawed market institutions. All three economies emerged from Japanese occupation at the end of World War II, which can be interpreted as a substantial institutional shock, and shared similar socio-economic conditions in the 1950s and a similar development of political institutions with autocratic regimes in power for decades. Long run economic outcomes in the three countries differ considerably, however: South Korea

[20] Following this line of investigation Henry and Miller (2008) remark that despite sharing colonial heritage and geographic conditions, after independence Barbados experienced more sustained and less volatile growth than Jamaica. Barbados had a more equal initial distribution of resources, however (data from Deininger and Squire, 1996).

experience more stable and on average higher growth rates than Malaysia, which in turn substantially outgrew the Philippines. This is despite the fact that the Philippines had a superior starting point in the early postwar years.

The three countries also differed considerably in initial wealth inequality, with South Korea having a remarkably equal distribution. This was the result of land reforms in 1948 and 1950, as a result of U.S. pressure. These land reforms and the Korean war (1950-53) eroded and leveled the social hierarchy considerably (see the survey by Dorner and Thiesenhusen, 1990, and the references therein). This is consistent with initial wealth inequality at independence interpretable as initial inequality of power. In light of our theory this favors sustainability of institutions associated to competitive market outcomes; indeed many of the export stimulating policies took the form of tournaments and turned out to appropriately incentivize the productive organization of the manufacturing sector. It is possible, of course, that the associated income inequality is beginning to affect the distribution of power ultimately eroding market preserving institutions in the future.

Both Malaysia and the Philippines lacked such large scale reforms. In Malaysia, a type of land reform occurred under British administration between 1948 and 1951, granting land rights to approximately 500.000 Chinese citizens with the aim of placating potential supporters of a communist insurgency (see Hack, 1999, for a discussion of the historical literature on the Malayan emergency). British attempts to grant race equality to Chinese and Indian minorities faced ethnic Malayan opposition and were given up by 1948, appeasing most of the ethnic Malay population. Though the constitution in place after the end of the emergency 1957 granted equal citizenship to Chinese and Indian minorities, colonial political structures were retained, entrenching an ethnic Malayan elite in political power and preserving ethnic Malay privileges. Economic power shifted to the Chinese, however, who were more willing to take emerging business opportunities than ethnic Malays, see e.g. Jomo and Gomez (2000) for details. In 1969 race riots led to a state of emergency, expropriation of Chinese businesses, and constitutional changes that limited non-Malay ownership of companies and access to university education, creating a barrier to holding physical and human capital for the Chinese minority (see e.g. Jomo, 1990). That is, Malaysia implemented a system of factor expropriation encoded in law, reducing the need for wasteful rent-seeking activities.

In the Philippines social structure remained largely intact both through Japanese and U.S. occupation and a U.S. proposal for land reform was

blocked.[21] Political reform extended the size of the electorate rapidly in the 1950ies. This was accompanied by the emergence of a clientele system, in which large landholders controlled the votes and, to some extent, coercive power of their economically or socially dependents (Landé, 1965, Sidel, 1999), concentrating political power. This elite dominance provided "a convenient system by which the power can be rotated at the top without effective participation of those below." (Hutchcroft and Rocamora, 2003) In 1972 the Marcos regime began, whose activities have coined the term "crony capitalism". Hutchcroft (2000) concludes that economic development has been hampered by obstructive corruption through extensive wasteful rent-seeking activities and coercion.[22]

Meiji Restoration in Japan

Concerning the link between persistence of power differentials and sustainability of markets, Temple and Johnson (1998) report that higher social mobility in an economy is associated to higher subsequent growth. In a similar vein Inglehart and Baker (2000) find that economic development is associated to more rational, tolerant, trusting, and participatory cultural values. For a more elaborate case consider Japan's transition from feudalism under the Tokugawa shogunate to an industrial economy in the second half 19th century. This transition is commonly referred to as the Meiji Restoration and credited with substantial institutional change toward a capitalist society aiming to compete economically and militarily with the Western powers.[23] Of course, not all important social, economic and institutional change can be attributed to a single event; there had been reforms before the Meiji Restoration, in particular in the Tempo period (1830-44), but these fell short of the substantial transformation that occurred after 1868.

In the middle of the 19th century exogenous events in form of mounting

[21] The Philippines did have a land reform, although only in 1972. Redistribution was implemented chiefly where the breakup of large holdings could generate gains from trade through innovations in e.g. crop choice by cultivators. Moreover, landowners' compensations were close to market rates (at about three times the annual revenue), so that the land reform did not substantially affect inequality and, more importantly, it did not alter social hierarchy, see Otsuka (1991) for a detailed account. In the 1960ies this evolved into an oligarchy of powerful families owning large conglomerates.

[22] "The particular configuration of political power in t/he Philippines, I will conclude, has quite consistently nurtured a "politics of privilege" generally obstructive to sustained economic development.", page 209

[23] See e.g. Beasley (2000), Jansen (1995) for thorough explorations of the Meiji period in Japanese history.

Western pressure on Japan to open up to trade (e.g. the bombardment of Edo in 1853) exposed the allocative cost of isolation and a feudal system where agricultural rents were appropriated by samurai (warriors who had become a hereditary bureaucratic elite) and daimyo (feudal lords). The Tempo crisis in 1833-38 (a great famine followed by a number of suppressed revolts) had already led to a widespread belief that the political and economic organization was inadequate and, when Western navies engaged, Japan's technological and military backwardness became very visible. This, and the sudden availability of Western military technology to all factions able to pay for it, weakened the shogunate's position considerable. After years of political turmoil, loss in military conflict (the second choshu expedition) effectively ended the Tokugawa shogunate in 1867. The resulting power vacuum was filled by restoring the imperial authority in 1868 (the formal Meiji restoration), primarily reflecting a loss of power of feudal lords and high-ranking samurai. Dramatic institutional change ensued: in 1871 feudal privileges were abolished (samurai lost their stipends and daimyo much of their land holdings), as was the division of the Japanese society into classes of social status linked to occupational choice.[24] However, as e.g. Norman (1940) emphasizes, the restoration was by no means a people's revolution, but rather a shift in power from the nobility to low-ranking samurai, smaller landholders, and merchants; in fact, the bureaucracy in the Meiji period relied substantially on former samurai. In 1872 compulsory education was introduced (before access to education was mainly limited to samurai), land expropriation by landlords was prohibited, and the sale of private land holdings was legalized. Land titles were issued, with an aim to create an administrative base for raising land taxes. This further eroded the position of the old feudal elite and was met with opposition (most fiercely during the Satsuma revolution in 1877), but supporters of the new regime prevailed. The Meiji constitution was put in place in 1889, granting the rule of law, independent judiciary, property rights, freedom of occupational choice, and moderate provisions for free speech. As for social change Howland (2001) notes that in Tokugawa Japan "most positions of leadership and responsibility were, in fact, filled on a hereditary basis and justified in terms of loyalty". Bendix (1966) puts forward the idea that by contrast in the Meiji period the samurai warrior code, traditionally emphasizing concepts such as loyalty, evolved to place more weight on competitiveness and achievements.

[24]The hereditary status classes were, from highest to lowest, samurai, peasants, artisans, and merchants. See e.g. the review article by Howland (2001) for details on social class and status in Tokugawa Japan.

In light of our model abolishing feudal status classes and introducing universal access to education and positions in the bureaucracy can be seen as an increase in social mobility, facilitating the sustainability of market supported institutions introduced at the same time. Indeed the beginning of Japan's emergence as an industrial economy and its modern growth is commonly placed in the Meiji period (see among others Maddison, 2006).

5 Discussion and Extensions

5.1 Discussion

Technology

The production technology requires exactly one unit of land to be held in order to use land productively. In essence, this is implied by the revenue from land attaining a maximum at a finite plot size, that is a capacity constraint. This guarantees that in a jungle not all land is held by a measure zero of agents. The assumption that the finite bounds on profitable land holdings are constant across agents primarily serves the ease of exposition. It can be dropped, albeit at the expense of considerable notational inconvenience. Constant plot sizes imply that the measure of landholders equates the measure of land endowment ℓ in all allocations. This seemingly excludes coalitions in which land is distributed in smaller plot sizes. Note that such coalitions are always dominated by a coalitional expropriation that gives land to measure ℓ of the most powerful agents in the original coalition. The production function itself requires that the returns from holding land are positive and strictly increase in skill, and that the return from skill is strictly positive for when holding land. More specific frameworks can be accommodated, in particular those that induce a wedge between utility and output gain from land or productivity. Examples include concave utility functions or effort investment at a convex utility cost, which may also be interpreted as investment in education.

Law of Motion

A stochastic version of the law of motion (5) can be incorporated, assuming for instance that the mobility component η is independently and identically distributed across agents. Then properties of its distribution, such as ratios of mean (mean of the median quantile) to upper and lower bounds of the supports (to the means of top and bottom quantiles) affect the sufficient and necessary conditions for sustainable markets. Theses properties will

affect the dynamics via the degree of social mobility and power inequality. The law of motion also assumes absence of interaction between the different factors determining the transition of power, persistence of power, sensitivity of power to income, and the mobility component. Such complementarities may arise in certain specific applications of the model; their study is left for future research.

Uniqueness

Since the set of stable outcomes may not be a singleton, it is of interest which circumstances imply that markets are not only a stable outcome but also the only one. This occurs if the market allocation dominates all other admissible allocations. This in turn is true if and only if – given parameters – markets dominate the optimal coalitional expropriation to attack markets. Such an optimal coalitional expropriation exists and is well-defined: an admissible distribution of land λ' that maximizes the difference between the power of agents strictly preferring $(\lambda', 0)$ and the power of those strictly preferring a market allocation. Then, if markets dominate $(\lambda', 0)$, markets also dominate any other coalitional expropriation.

Intuitively, the optimal coalition to attack markets assigns land to the agents with the highest marginal contribution to that coalition's power against market supporters. Hence, agents who switch strict preference for markets to coalitional expropriation when assigned land carry double the weight of agents who switch to or from indifference only. Agents whose preferences do not depend on whether they obtain land are never assigned land, see appendix for an example. Proposition 3 can be generalized to state that a market allocation is the unique stable outcome if the mismatch between demand and supply is low and the correlation of land and power is sufficiently strong. Although a more elaborate redistribution is needed, part (ii) of Proposition 3 generalizes in case $\ell > s$, for $\ell < s$ an additional qualifier has to require that s is sufficiently high.[25]

Set of Admissible Allocations

A discussion of other conceptual frameworks to model factor allocation and expropriation is in order. For instance, an outcome where some agents expropriate others, while the remaining land is traded on the market could be reached by randomly matching buyers and sellers (the jungle outcome

[25]See Appendix for a formal analysis deriving the optimal coalitional expropriation to attack markets and conditions for the market allocation as the unique stable outcome.

corresponds to a framework where matching is directed in terms of power). Such a framework remains silent on institutions that determine economic outcomes, and one would need to define institutions ad hoc, for instance by postulating a punishment probability. But probability and extent of the punishment should be chosen by someone, and enforcers need to be properly incentivized. Absent such construct, a competitive market outcome is secured in such a frame if and only if land is distributed to the most powerful, which essentially means that property rights are interpreted as an equilibrium where all agents refrain from expropriating (as in Hafer, 2006).

Considering market allocations with non-Walrasian prices mainly adds the possibility for sellers to extract market rents from buyers. This would have no effect when $\ell < s$ as sellers obtain the entire rent anyway. If $\ell > s$ this facilitates the emergence of limit cycles, since less powerful buyers do not receive rents, which makes elites persistent, see Proposition 7.

5.2 Endogenous Growth

In our framework aggregate inputs of production, land and skill, remain constant over time, which rules out persistent growth of the economy. This subsection discusses possible approaches to endogenize skill levels and enrich the dynamics of the model enabling endogenous growth.

A first approach is introducing individual human capital investment at a cost related to ability θ. Suppose after land is assigned agents can invest e_i in human capital, or education, at cost $e_i^2/(2\theta_i)$ and agents' income is $\sqrt{W}e_i$ if using land, and $\sqrt{w}e_i$ otherwise, with $W > w > 0$ denoting labor productivity. Suppose also that there are aggregate spill-overs in human capital investment that increase labor productivity. Specifically let productivity depend on past aggregate human capital investment $e_{t-1} = \int_{i\in I} e_{i,t-1}di$:

$$W_t = \rho(e_{t-1})W_{t-1} \text{ and } w_t = \rho(e_{t-1})w_{t-1},$$

where ρ is an increasing function. It can be verified that a limit cycle induces lower and more volatile long run growth rates than persistent markets.[26]

Another issue arises when spill-overs from human capital investments do not affect productivity, but the probability of being skilled s. Suppose for instance that the probability of $\theta_i = H$ is a time variant function depending on aggregate investment in the last period:

$$s_t = \nu(e_{t-1}, s_{t-1}).$$

[26]Parente and Prescott (1999) illustrate how such market distortions, in their case factor monopolies, generate sizable losses in long run growth compared to a free market economy.

Suppose $\nu(.)$ is bounded above by 1. Since aggregate output depends on s_t the results above carry over: jungles generate less investment and income than markets, aggregate income increases in the measure of skilled agents, and a limit cycle is associated with a lower growth path than sustainable markets.[27] This setting allows also for institutional poverty traps, as a limit cycle may prevent enough human capital accumulation for s_t sufficiently high to guarantee a sustainable markets regime.

Finally, individual investments may affect children's probability to become skilled, that is skills are no longer distributed independently. When individual probability to become skilled depends on parents' income, and possibly power, effects are ambiguous: positive autocorrelation of skill makes both accumulation and redistribution of power by markets more effective as being skilled also raises expected income of one's offspring independently of land ownership. Furthermore, autocorrelation of skill reduces the number of agents who gain from trade, to the detriment of market stability. A thorough treatment of this case is left to future research.

5.3 Implications

Our theory offers some insights that can possibly be exploited in new empirical work. On an abstract level it implies that both (i) initial power inequality and (ii) intergenerational transition of power inducing high persistence of the power ranking, possibly via an unequal distribution of market rents, are linked to less stable market institutions and inferior long run economic outcomes. To be more specific the abstract concept of power has to be suitably interpreted.

As argued above power may be interpreted as wealth. Then our model links initial wealth inequality to macroeconomic volatility through an institutional channel and predicts that endowment inequality favors output fluctuations and instability of institutions associated to competitive market outcomes. Other explanations linking wealth inequality and macroeconomic volatility rest for instance on imperfect access to capital markets (Aghion et al., 1999) and preference heterogeneity (Ghiglino and Venditti, 2007). Evidence on the relation of institutions and macroeconomic fluctuations is reported e.g. in Acemoglu et al. (2003) emphasizing the role of institutions in the choice of fiscal and monetary policies.[28] Perhaps most closely related,

[27] Note also the possibility that a land abundant economy ($\ell > s_t$) may become skill abundant ($s_t > \ell$), which may trigger a regime switch of the long run behavior.

[28] Rodrik (2002) shows that countries with democratic institutions experience less volatility than nondemocratic regimes, though Mulligan et al. (2004) conclude that democ-

Rodrik (1999) argues that economies with more divisive societies and weak institutions of conflict resolution are prone to social conflict and therefore less able to mitigate adverse shocks.

The intergenerational transmission of power and the degree of rank preservation of dynasties in the power distribution, corresponding to persistence and mobility parameters α and η, corresponds best to measures of social mobility. Social mobility is partly determined by the ability of institutions to uphold a market outcome, endogenous in our model, but also by social norms and cultural values that remain constant over time. A textbook example for low social mobility in this sense is India's caste system. Regardless of the interpretation of power, social norms inducing redistribution of power through market outcomes favor long run sustainability of markets. Hence, our model implies that values and norms that support social mobility are associated to superior long run development.

Interpreting power as social status a direct implication emerges for system of cultural values and social norms: societies that employ value systems that assign social status on a meritocratic basis, i.e. individual social status does not depend on parental status, correspond in light of model to economies with low power inequality, which facilitates the stability of competitive market outcomes both in the short and the long run.[29] Possible effects of norms and values on certain economic outcomes have been documented: income per capita and growth rate (Tabellini, 2010), financial decisions (Guiso et al., 2004) and labor market outcomes (Brügger et al., 2009). Our theory implies that societies that are more leveled in terms of social status tend to sustain institutions associated to competitive market outcomes and achieve better *and less volatile* long run outcomes.

6 Conclusion

This paper presented a tractable framework where economic outcomes are required to be robust to coalitional deviations of agents. This serves to focus attention on properties of economic outcomes necessary for adequate institutions that implement markets to emerge, without the need to explicitly state the mix of institutions employed to this end. We find that unstable

racies and non-democracies do not differ in the choice of public policies.

[29] E.g. Di Tella et al. (2007) measure meritocratic and market beliefs using survey questions like "Do you believe that it is possible to be successful on your own or a large group that supports each other is necessary?" or "In general, people who put effort working end up much better, better, worse, or much worse than those that do not put an effort?".

markets may be persistent, in the form of limit cycles where markets and jungles alternate. Identity of ruling elites may change over time. When the transmission of power across generations generates sufficient social mobility, markets become sustainable for any initial power distribution. Sustainability of markets in economies is favored by less initial power inequality and less mismatch between supply and demand on the land market.

The choice of modeling approach seems instructive as it generates a rich set of outcomes. A subset of our results, such as persistent elites, have already been generated in less abstract frameworks, indicating that our approach to embed institutional quality connects well to existing literature. While our framework willingly gives up complexity to achieve a modicum of tractability, the results look encouraging, not least since they highlight a number of issues that future research may successfully pursue.

As the transition of power may exert considerable influence on long run institutional outcomes, further examination of the determinants of its law of motion appears of interest. Some of these may be to a degree subject to choice, for instance legislation, income taxation or public spending. When evaluating the relative merits of such institutions a substantial concern should be whether they are dynamically self-enforcing.

Finally, further work may profitably examine settings where agents' behavior is forward-looking. This yields some potentially interesting strategic considerations. For instance, desirability of expropriation today will depend on the continuation valuation of land holdings, which in turn will depend on whether markets will be stable tomorrow. Adding uncertainty will further enrich the set of contracts usable in a market and may allow to determine the necessary conditions for a full set of Arrow-Debreu markets to emerge in the shadow of coalitional expropriation.

A Mathematical Appendix

Example: Emptiness of the core, non-existence of a stable set, and the largest consistent set

In the following numerical example the binary relation $\succ$ is not transitive. This in turn will lead to emptiness of the core and non-existence of a von Neumann-Morgenstern stable set.

Core and stable sets

Suppose that measure $1/2$ of agents are *weak* having power $\omega_i = 2/3$, while the remaining agents are *strong* with power $\omega_i = 1$. Let agents become skilled with probability $s = 1/3$ independently of land holdings and power. Suppose $\ell = 1/2$, i.e. land is abundant. The distribution of land is as follows. Measure $\epsilon \in (0, 1/2)$ of weak agents hold land, and so do measure $1/2 - \epsilon$ of strong agents.

A Walrasian allocation (W) assigns land to all the skilled and makes unskilled agents indifferent between holding and not holding land, as there is more land than skilled agents. Compare now a Walrasian allocation to an allocation that assigns all land to the most powerful, i.e. to the strong agents, the jungle (J). Measure ϵ of strong agents strictly prefer J, while measure $\epsilon + (1/2 - \epsilon)/3$ of weak agents strictly prefer W as they are not expropriated or able to obtain a rent buying land in the market. Hence,

$$W \succ J \Leftrightarrow \frac{2}{3}\epsilon + \frac{2}{3}\left(\frac{1}{2} - \epsilon\right)\frac{1}{3} > \epsilon \Leftrightarrow \epsilon < 1/3.$$

Consider now an allocation that assigns land to all *skilled* strong agents, and to measure $2\epsilon/3 + \gamma$ of *skilled* weak agents, with $\gamma \geq 0$, and to measure $2(1/2 - \epsilon)/3 - \gamma$ of *unskilled* strong agents, but not to *unskilled* weak agents. That is, unskilled weak and measure γ of unskilled strong landholders are expropriated. The land is given to the skilled, giving strong agents priority. Call this allocation an expropriation $X(\gamma)$. Clearly, $J \succ X(\gamma)$. Expropriation $X(\gamma)$ in turn dominates the Walrasian allocation if

$$\frac{\epsilon}{3} + \left(\frac{\epsilon}{3} + \gamma\right)\frac{2}{3} > \frac{2\epsilon}{3}\frac{2}{3} + \gamma + \left(\left(\frac{1}{2} - \epsilon\right)\frac{1}{3} - \frac{\epsilon}{3} - \gamma\right)\frac{2}{3}. \tag{6}$$

That is, if $\epsilon + 3\gamma/5 > 1/5$. Suppose for the following that $\epsilon = 1/5$, and therefore (6) holds with equality for $\gamma = 0$. Then

$$W \succ J \succ X(\gamma) \succ W \text{ for } \gamma \in (0, 1/5].$$

None of these allocations are in the core of an appropriately defined cooperative game under nontransferable utility (where a core allocation has to be stable with respect to coalitional deviations, such that deviators are strictly better off and their power exceeds that of strict supporters of the core allocation). Since J dominates all other non-Walrasian allocations as $1 > 2/3$, such a core must be empty.

Likewise a von Neumann-Morgenstern stable set fails to exist. To see this suppose that J is not in a stable set. Then the stable set consists only of

Walrasian allocations, because J dominates non-Walrasian allocations. This contradicts external stability as $X(\gamma) \succ W$ for $\gamma > 0$. Suppose therefore that J is in a stable set. Internal stability then requires J to be the only element in the stable set. But this contradicts external stability as $W \succ J$.

Indirect dominance and the largest consistent set

Turn now to the indirect dominance relation as defined by Chwe (1994):

> An allocation a is indirectly dominated by allocation b if there exist allocations $a_0, a_1, a_2, ..., a_m$ (where $a_0 = a$ and $a_m = b$) and coalitions $S_0, S_1, S_2, ..., S_{m-1}$, such that $a_i \rightarrow_{S_i} a_{i+1}$ and $a_i \prec_{S_i} b$ for $i = 0, 1, 2, ..., m-1$.

Here $a_i \rightarrow_{S_i} a_{i+1}$ indicates that coalition S_i can replace a_i by a_{i+1}. This corresponds to the strict winners S_i being a power majority when comparing a_i to a_{i+1}, i.e. $a_{i+1} \succ a_i$.

Indirect dominance $b \gtrdot a$ via a_i in the sense of Chwe (1994) requires a power majority for both the move from a to a_i and the move from a_i to b. At each move a power majority has to strictly prefer the final allocation b to the status quo. But this implies that $b \succ a$, i.e. b directly dominates a. Hence, indirect dominance implies direct dominance and an allocation b only indirectly dominates an allocation a via a_i if both $b \succ a$ and $b \succ a_i$.

If in contrast to Chwe (1994) indirect dominance of b over a via a_i only requires that $a_i \succ a$ and $b \not\prec a_i$, indirect dominance becomes meaningful in our setup. In particular, there is an allocation a, such that $W \gtrdot a$ via J but $W \not\prec a$. An example of such an allocation is $X(0)$, as by (6) for $\gamma = 0$ aggregate power of winners and losers from a move to W are equal for $\epsilon = 1/5$. As $J \succ X(0)$ indeed $W \gtrdot X(0)$ via J. Moreover, $X(\gamma) \succ X(\gamma')$ whenever $\gamma < \gamma'$, since land is redistributed from measure $\gamma' - \gamma$ of strong to weak agents.

Indeed the set $\{W, J, X(0)\}$ is consistent, since any allocation dominating W, i.e. $X(\gamma) \prec X(0) \in Y$ (for $\gamma > 0$), any allocation dominating J, i.e. $W \lessdot X(0) \in Y$ via any $X(\gamma)$ (with $\gamma > 0$), and any allocation dominating $X(0)$ is directly dominated by $W \in Y$, but $X(0) \not\prec W$. Moreover, for any admissible $Z \notin Y$, $Z \prec J$. But either $Z \not\succ W$, in which case J cannot be deterred by W, or $Z \succ W$ (in which case J can be deterred). Yet as $Z \neq X(0)$ and $Z \succ W$ implies $Z \prec X(0)$, in this last case there is $X(\gamma)$, $\gamma > 0$, with $X(\gamma) \succ Z$ and $X(\gamma) \succ W$. $X(\gamma)$ cannot be deterred by J or $X(0)$ as $J \succ Z$ and $X(0) \succ Z$. As $Y \subset \bar{Y}$, so are W, J, and $X(0)$.

Proof of Proposition 1

Consider admissible allocation $(\lambda', 0)$. $u(\lambda_i^0, \theta_i, \lambda_i^J, 0) > u(\lambda_i^0, \theta_i, \lambda_i', 0)$ iff $i \in C = \{i \in I : \lambda_i' = 0 \wedge \lambda_i^J = 1\}$, and $u(\lambda_i^0, \theta_i, \lambda_i^J, 0) < u(\lambda_0, \theta_i, \lambda_i', 0)$ iff $i \in C' = \{i \in I : \lambda_i' = 1 \wedge \lambda_i^J = 0\}$. Hence, $(\lambda^J, 0) \not\succ (\lambda', 0)$ if

$$\int_{i \in C} \omega_i di \geq \int_{j \in C'} \omega_j dj. \tag{7}$$

Denoting by μ the Lebesgue measure of agents, $\mu(i \in I : \lambda_i' = 1 \wedge \lambda_i^J = 0) = \mu(i \in I : \lambda_i' = 0 \wedge \lambda_i^J = 1)$ as both allocations are admissible. Therefore $\mu(i \in C) = \mu(i \in C')$. Since $\lambda_i^J = 1 \Leftrightarrow \omega_i \geq \hat{\omega}$ and $\lambda_i^J = 0 \Leftrightarrow \omega_i \leq \hat{\omega}$, $\omega_i \geq \omega_j$ for all $i \in C$ and $j \in C'$. This implies (7). Uniqueness a.e. follows from the definition of $\hat{\omega}$ and the assumption that $F(\omega)$ is atom-less.

Proof of Proposition 2

The proof proceeds in four steps.

Step 1. Since all elements in $W(\lambda^0)$ are payoff equivalent, it suffices to consider a typical element $(\lambda^M, p) \in W(\lambda^0)$. As noted in the text three regimes may emerge.

(a) Let $(\lambda^J, 0) \succ (\lambda^M, p)$. Then $\bar{Y} = (\lambda^J, 0)$.

(b) Let $(\lambda^M, p) \succ (\lambda, 0)$ for all admissible $(\lambda, 0)$. Then $\bar{Y} = W(\lambda^0)$.

(c) Let $(\lambda^M, p) \succ (\lambda^J, 0)$ and suppose there is an admissible $(\lambda', 0)$ with $(\lambda', 0) \succ (\lambda^M, p)$. By Proposition 1 $(\lambda^J, 0) \succ (\lambda', 0)$ and there is a cycle. Denote by $X = \{(\lambda, 0) : (\lambda, 0) \text{ admissible}, (\lambda, 0) \succ (\lambda^M, p)\}$ the set of expropriations that dominate the Walrasian allocation.

Step 2. Let case (c) hold. There is always an admissible allocation $(\lambda^X, 0) \not\succ (\lambda^M, p)$ such that $(\lambda, 0) \succ (\lambda^X, 0)$ implies $(\lambda^M, p) \succ (\lambda, 0)$. This is because $\int_{i \in C(\lambda)} \omega_i di - \int_{j \in C'(\lambda)} \omega_j dj$ is continuous in $(\lambda_i)_{i \in I}$ when $C(\lambda) = \{i \in I : u(\lambda_i^0, \theta_i, \lambda_i, 0) > u(\lambda_i^0, \theta_i, \lambda_i^M, p)\}$ and $C'(\lambda) = \{i \in I : u(\lambda_i^0, \theta_i, \lambda_i, 0) < u(\lambda_i^0, \theta_i, \lambda_i^M, p)\}$. By the intermediate value theorem the assumption $(\lambda', 0) \succ (\lambda^M, p) \succ (\lambda^J, 0)$ implies there is a non-empty set K of admissible allocations with $\int_{i \in C(\lambda^K)} \omega_i di - \int_{j \in C'(\lambda^K)} \omega_j dj = 0$ for all $(\lambda^K, 0) \in K$.

For any $(\lambda', 0) \in X$ define the measure of landowners' power by $P_L(\lambda) = \int_{i \in I : \lambda_i = 1} \omega_i di$. Note that $P_L(\lambda) > P_L(\lambda')$ implies $(\lambda, 0) \succ (\lambda', 0)$. Define an allocation $(\lambda^X, 0) = \arg\max_{(\lambda, 0) \in K} P_L(\lambda)$. Since $F(\omega)$ is atom-less, a revealed preference argument validates that $P_L(\lambda^X) > P_L(\lambda')$ for all $(\lambda', 0) \in X$ since the constraint induced by $(\lambda', 0) \succ (\lambda^M, p)$ must be binding as

$(\lambda^M, p) \succ (\lambda^J, 0)$ (implying that in all allocations in X some weak agents are assigned land) holds.
Step 3. To show that $Y = (\lambda^J, 0) \cup W(\lambda^0) \cup (\lambda^X, 0)$ is consistent note that

(a) for all allocations that dominate $(\lambda^J, 0)$ (i.e. $W(\lambda^0)$) the allocation $(\lambda^X, 0) \subset Y$ (in)directly dominates (λ^M, p) via some $(\lambda', 0) \in X$, but $(\lambda^J, 0) \succ (\lambda, 0)$ for all admissible allocations $(\lambda, 0)$.

(b) For all allocations that dominate (λ^M, p), that is all $(\lambda', 0) \in X$, there is $(\lambda^J, 0) \in Y$ with $(\lambda^J, 0) \succcurlyeq (\lambda', 0)$, but $(\lambda^M, p) \succ (\lambda^J, 0)$.

(c) For all allocations that dominate $(\lambda^X, 0)$, that is all $(\lambda', 0) \succ (\lambda^X, 0)$, $(\lambda^M, p) \succ (\lambda', 0)$, as shown in Step 2 above. But $(\lambda^X, 0) \not\prec (\lambda^M, p)$.

(d) For all $(\lambda', 0) \notin Y$ with $(\lambda^M, p) \succ (\lambda', 0)$, $(\lambda^J, 0) \succ (\lambda', 0)$. This deviation cannot be deterred by a market outcome. For all $(\lambda', 0) \notin Y$ with $(\lambda^M, p) \prec (\lambda', 0)$ there is always an allocation $(\lambda'', 0)$ such that $(\lambda'', 0) \succ (\lambda', 0)$ and $(\lambda'', 0) \succ (\lambda^M, p)$. Although $(\lambda'', 0) \prec (\lambda^X, 0)$ and $(\lambda'', 0) \prec (\lambda^J, 0)$, $(\lambda'', 0)$ cannot be deterred by either, since $(\lambda', 0) \prec (\lambda^X, 0)$ and $(\lambda', 0) \prec (\lambda^J, 0)$. So $(\lambda', 0)$ cannot be in the consistent set.

Step 4. Since Y is consistent, whenever $W(\lambda^0) \in Y$, market allocations are in also in the largest consistent set, that is $W(\lambda^0) \subset \bar{Y}$.

Proof of Proposition 3

(i) Evident from (3) and (4).
(ii) The proof constructs a power redistribution that decreases the difference RHS - LHS of the relevant condition in (3), (4). Choose $\tau > 0$ and denote the power distribution after redistributing by ω'. Set $\omega_i' = (1-\tau)\omega_i$ if $\omega_i \geq \hat{\omega}$, and set ω_j' for $j \in I : \omega_j < \hat{\omega}$ such that $\omega_j' \leq (1-\tau)\hat{\omega}$ and

$$\int_{j \in I : \omega_j < \hat{\omega}} \omega_j' dj = \int_{j \in I : \omega_j < \hat{\omega}} \omega_j dj + \tau \int_{j \in I : \omega_j > \hat{\omega}} \omega_j dj. \tag{8}$$

Since $\mu(j \in I : \omega_j < \hat{\omega}) > 0$ by assumption, there is τ sufficiently small to satisfy (8). This decreases all agents' power at rate τ and redistributes the proceeds τ among the weakest, and preserves agents' relative position with respect to $\hat{\omega}$ (a redistribution with $\omega_i' = (1-\tau)\omega_i + T$ and $T = \tau \int_{\underline{\omega}}^{\overline{\omega}} \omega dF(\omega)$ can also be used). The change in the RHS of (3), (4) is then

$$\Delta RHS = -\tau \int_{\hat{\omega}}^{\overline{\omega}} \omega dG(\omega, \lambda^0 = 0),$$

which is negative. The change of the LHS depends on p.

Let first $p = p^L$. Then the change in the LHS of (3) is positive, $\Delta LHS > 0$, since θ is independent of ω and λ. Hence, $\Delta LHS - \Delta RHS > 0$.

In case $p = p^H$ the change of the LHS of (4) satisfies

$$\Delta LHS \geq -\tau(1-s)\int_{\hat{\omega}}^{\overline{\omega}} \omega dG(\omega, 1).$$

Since $(\lambda^J, 0) \succ (\lambda^M, p)$,

$$(1-s)\int_{\hat{\omega}}^{\overline{\omega}} \omega dG(\omega, 1) < \int_{\hat{\omega}}^{\overline{\omega}} \omega dG(\omega, 0),$$

so that $\Delta LHS - \Delta RHS > 0$.

(iii) As $(I, \mathcal{B}(I), \mu)$, where $\mathcal{B}(I)$ denotes the Borel sigma algebra on I and μ the Lebesgue measure, is a measure space, and P and L are measurable functions mapping I into $\{0; 1\}$, P and L are well-defined, with distributions $G_P(P = X) = \mu(i \in I : P(i) = X)$ and $G_L(L = X) = \mu(i \in I : \lambda_i^0 = X)$

Let $\epsilon > 0$ and set $\rho = 1 - \epsilon$. By definition $\text{var}(P) = \text{var}(L) = \ell(1-\ell)$. Thus $E[PL] = (1-\epsilon)\ell(1-\ell) + \ell^2 = \ell(1-\epsilon(1-\ell))$. Then $P \in \{0; 1\}$ and $L \in \{0; 1\}$ implies $Prob(P = L = 1) = \ell(1-\epsilon(1-\ell))$. Define $\delta := \ell(1-\ell)\epsilon$. Now measure $\delta > 0$ of agents have $P = 1$ and $L = 0$, and oppose markets. Hence, the RHS of (3), (4) is

$$0 < \int_{\hat{\omega}}^{\overline{\omega}} \omega dG(\omega, 0) \leq \delta\overline{\omega}.$$

Likewise, measure δ of agents (with $P = 0$ and $L = 1$) prefer markets. If $p = p_L$ also agents with $P = 0$ and $L = 0$ prefer markets. The LHS of (3) is

$$\int_{\underline{\omega}}^{\hat{\omega}} \omega dG(\omega, 1) + s\int_{\underline{\omega}}^{\hat{\omega}} \omega dG(\omega, 0) \geq \delta\underline{\omega} + s(1-\ell-\delta)\underline{\omega}.$$

Thus a sufficient condition for (3), implying the statement for $p = p^L$, is

$$\delta < \frac{s(1-\ell)}{\overline{\omega} - (1-s)\underline{\omega}}.$$

Let now $p = p^H$. Then unskilled agents with $P = 1$ and $L = 1$ prefer markets. The LHS of (3) is thus

$$\int_{\underline{\omega}}^{\hat{\omega}} \omega dG(\omega, 1) + (1-s)\int_{\hat{\omega}}^{\overline{\omega}} \omega dG(\omega, 1) \geq \delta\underline{\omega} + (1-s)(\ell - \delta)\hat{\omega}.$$

A sufficient condition for (4), implying the statement for $p = p^H$, is then

$$\delta < \frac{(1-s)\ell}{\overline{\omega} + (1-s)\hat{\omega} - \underline{\omega}}.$$

Proof of Lemma 1

As mentioned in the text, a jungle in t implies $G_{t+1}(\hat{\omega}_{t+1}, 0) = 1 - \ell$, as $r(L,1) \geq r(H,0)$, which ensures that in t agents in the elite have higher income than all other agents, placing their offspring among the elite in $t+1$.

Suppose instead markets are stable in t. In case of a jungle in $t-1$, $G_t(\hat{\omega}_t, 0) = 1 - \ell$ and uniform rationing implies that $G_{t+1}(\hat{\omega}_{t+1}, 0) \geq (1 - \ell)^2 = (1 - \ell)(1 - s)(1 - q^L)$ if $\ell > s$ and $G_{t+1}(\hat{\omega}_{t+1}, 0) \geq (1 - \ell)^2 = (1 - \ell)(1 - s + s(1 - q^H))$ if $\ell < s$. Suppose instead markets were stable in $t-1$.

Let $\ell > s$ first. By the definition of $\hat{\omega}$ and the transition function rationing land with probability $q^\ell = (\ell - s)/(1 - s)$,

$$\begin{aligned} F_{t+1}(\omega) = s&\left[G_t\left(\frac{\omega-\beta r(H,1)-\eta}{\alpha},1\right)+G_t\left(\frac{\omega-\beta(r(H,1)-p^L)-\eta}{\alpha},0\right)\right] \\ &+(\ell-s)\left[G_t\left(\frac{\omega-\beta r(L,1)-\eta}{\alpha},1\right)+G_t\left(\frac{\omega-\beta(r(L,1)-p^L)-\eta}{\alpha},0\right)\right] \\ &+(1-\ell)\left[G_t\left(\frac{\omega-\beta(r(L,0)+p^L)-\eta}{\alpha},1\right)+G_t\left(\frac{\omega-\beta r(L,0)-\eta}{\alpha},0\right)\right]. \end{aligned}$$

Since $F_{t+1}(\hat{\omega}) = 1 - \ell$, and agents who obtain land in t have highest income in the set of agents with same initial land holdings in t, it must hold that

$$1-\ell < G_t\left(\frac{\hat{\omega}_{t+1}-\beta(r(L,0)+p^L)-\eta}{\alpha},1\right)+G_t\left(\frac{\hat{\omega}_{t+1}-\beta r(L,0)-\eta}{\alpha},0\right).$$

But also

$$\frac{G_{t+1}(\hat{\omega}_{t+1},0)}{1-\ell} \geq G_t\left(\frac{\hat{\omega}_{t+1}-\beta(r(L,0)+p^L)-\eta}{\alpha},1\right)+G_t\left(\frac{\hat{\omega}_{t+1}-\beta r(L,0)-\eta}{\alpha},0\right),$$

as all the agents summed up on the RHS do not bequeath land with probability $(1 - \ell)$ and have income $r(L,0)$ or $r(L,0) + p^L$ ensuring that they end up with $\omega_{t+1} \leq \hat{\omega}_{t+1}$. Therefore

$$G_{t+1}(\hat{\omega}_{t+1}, 0) > (1-\ell)^2,$$

independent of stability of markets in t. Since $F_{t+1}(\hat{\omega}_{t+1}) = 1 - \ell$ and the measure of agents without land is $1 - \ell$, this implies $G_{t+1}(\hat{\omega}_{t+1}, 1) \leq (1-\ell)\ell$.

Let $s > \ell$. Because of uniform rationing of land with probability $q^H = \ell/s$ and independence of skill, and land and power, respectively,

$$\begin{aligned} G_{t+1}(\omega,1) =& \ell\left[G_t\left(\frac{\omega-\beta(r(H,1)-p^H)-\eta}{\alpha},0\right)+G_t\left(\frac{\omega-\beta r(H,1)-\eta}{\alpha},1\right)\right], \\ G_{t+1}(\omega,0) =& (s-\ell)\left[G_t\left(\frac{\omega-\beta r(H,0)-\eta}{\alpha},0\right)+G_t\left(\frac{\omega-\beta(p^H+r(H,0))-\eta}{\alpha},1\right)\right] \\ &+(1-s)\left[G_t\left(\frac{\omega-\beta r(L,0)-\eta}{\alpha},0\right)+G_t\left(\frac{\omega-\beta(p^H+r(L,0))-\eta}{\alpha},1\right)\right]. \end{aligned}$$

Using an argument analogous to the one above, exploiting that agents who obtain land in t have higher income in t than those who did not among agents with the same initial land endowments in t, yields

$$1-\ell > G_t\left(\frac{\hat{\omega}_{1+t}-\beta(r(H,1)-p^H)-\eta}{\alpha},0\right)+G_t\left(\frac{\hat{\omega}_{1+t}-\beta r(H,1)-\eta}{\alpha},1\right).$$

Since the mass on the RHS characterizes all agents who would end up with land in $t+1$ and have $\omega_{i,t+1} < \hat{\omega}_{t+1}$, and land is allocated randomly and independently with probability $\ell = sq^H$, the proportion of landholders among the weak in $t+1$ is bounded above by ℓ:

$$\ell(1-\ell) > G_{t+1}(\hat{\omega}_{t+1},1),$$

or, equivalently, $G_{t+1}(\hat{\omega}_{t+1},0) < (1-\ell)^2$.

Proof of Proposition 4

(i) Let $\ell > s$, then $p = p^L$, unskilled agents obtain land with probability q^L, and skilled agents with certainty. Using the market stability condition (3), $(\lambda^M, p) \succ (\lambda^J, 0)$ holds in $t+1$ if and only if

$$(1-\ell)E_{t+1}(\omega|\omega<\hat{\omega}_{t+1}) > (1-\ell)E_{t+1}(\omega|\lambda=0) - s\int_{\underline{\omega}_{t+1}}^{\hat{\omega}_{t+1}} \omega dG_{t+1}(\omega,0). \quad (9)$$

A market allocation in t rations land uniformly to the unskilled, so that

$$E_{t+1}(\omega|\lambda=0) = \alpha E_t(\omega) + \beta\left(r(L,0)+\ell p^L\right)+\eta. \quad (10)$$

Turn now to the second term on the RHS of (9). By Lemma 1

$$G_{t+1}(\hat{\omega}_{t+1},0) \geq (1-\ell)^2, \quad (11)$$

independent of stability of markets in t. Using (10) and (11) on (9), a sufficient condition for stable markets in $t+1$ given that markets were stable in period t is

$$\begin{aligned}\alpha E_t(\omega) + \beta\left[r(L,0)+\ell p^L\right]+\eta \leq & E_{t+1}(\omega|\omega<\hat{\omega}_{t+1}) \\ & + s(1-\ell)E_{t+1}(\omega|\omega<\hat{\omega}_{t+1},\lambda=0).\end{aligned}$$

Since land is allocated by independent draws via a market in t,

$$\begin{aligned}&E_{t+1}(\omega|\omega<\hat{\omega}_{t+1},\lambda=0) \geq \alpha E_t(\omega|\omega<\hat{\omega}_t)+\beta r(L,0)+\eta \text{ and}\\ &E_{t+1}(\omega|\omega<\hat{\omega}_{t+1}) \geq \alpha E_t(\omega|\omega<\hat{\omega}_t)+\beta[r(L,0)+\ell(r(L,1)-r(L,0)-p^L)+\eta,\end{aligned}$$

where the first line uses that $r(L,0)$ is a general lower bound on income. The second inequality follows as aggregate power of the weak in $t+1$ weakly exceeds aggregate power of the weak in t plus the lower bound of the expected income of an agent without land endowment in t who obtains land with probability ℓ. Combining the above expressions yields

$$\begin{aligned}\alpha E_t(\omega) - \beta[s(1-\ell)r(L,0) + \ell(r(L,1) - r(L,0) - 2p^L)] \\ \leq (1 + s(1-\ell))\alpha E_t(\omega|\omega<\hat{\omega}_t) + s(1-\ell)\eta. \qquad (12)\end{aligned}$$

(ii) Suppose now that $\ell < s$, then $p = p^H$ and skilled agents obtain land with probability q^H, while the unskilled do not obtain land. Using the market stability condition (4), $(\lambda^M, p) \succ (\lambda^J, 0)$ holds in $t+1$ if and only if

$$\ell E_{t+1}(\omega|\lambda{=}1) > \ell E_{t+1}(\omega|\omega>\hat{\omega}_{t+1}) - (1-s)\int_{\hat{\omega}_{t+1}}^{\overline{\omega}_{t+1}} \omega dG_{t+1}(\omega,1). \qquad (13)$$

By Lemma 1 the share of landholders among the weak in $t+1$ is bounded above by ℓ:

$$\ell - G_{t+1}(\hat{\omega}_{t+1}, 1) > \ell^2. \qquad (14)$$

Hence,

$$\int_{\hat{\omega}_{t+1}}^{\overline{\omega}_{t+1}} \omega dG_{t+1}(\omega,1) > \ell^2 E_{t+1}(\omega|\omega > \hat{\omega}_{t+1}, \lambda{=}1).$$

Using this on (13) a sufficient condition for stable markets in $t+1$ is

$$E_{t+1}(\omega|\lambda{=}1) > E_{t+1}(\omega|\omega>\hat{\omega}_{t+1}) - (1-s)\ell E_{t+1}(\omega|\omega>\hat{\omega}_{t+1}, \lambda{=}1). \qquad (15)$$

By independence of skill, and land and power, due to uniform rationing,

$$E_{t+1}(\omega|\lambda{=}1) = \alpha E_t(\omega) + \beta\left(r(H,1) - (1-\ell)p^H\right) + \eta. \qquad (16)$$

Turning to the RHS of (15), as landed agents have highest income

$$\begin{aligned}E_{t+1}(\omega|\omega>\hat{\omega}_{t+1}) <& \alpha E_t(\omega|\omega>\hat{\omega}_t) + \eta \\ &+ \beta[\ell r(H,1) + (s-\ell)r(H,0) + (1-s)r(L,0) + (1-\ell)p^H].\end{aligned}$$

Moreover, the strong landed in $t+1$ must have had at least average expected income of any agent who was landless in t:

$$\begin{aligned}E_{t+1}(\omega|\omega>\hat{\omega}_{t+1}, \lambda{=}1) >& \alpha E_t(\omega|\omega>\hat{\omega}_t) + \eta \\ &+ \beta(\ell(r(H,1) - p^H) + (s-\ell)r(H,0) + (1-s)r(L,0)).\end{aligned}$$

Using these inequalities on (15), markets are stable in $t+1$ if they are stable in t and

$$\begin{aligned}&\alpha E_t(\omega) + \beta[(1-\ell+(1-s)\ell^2)(r(H,1)-r(H,0)) - (2(1-\ell)+(1-s)\ell^2)p^H] \\ &+ \beta(1-s)[(1+s\ell)(r(H,0)-r(L,0)) + \ell r(L,0)] \\ &\geq (1-(1-s)\ell)\alpha E_t(\omega|\omega>\hat{\omega}_t) - (1-s)\ell\eta. \qquad (17)\end{aligned}$$

Noting that $\ell E_t(\omega|\omega>\hat{\omega}_t) + (1-\ell)E_t(\omega|\omega<\hat{\omega}_t) = E_t(\omega)$, (17) becomes

$$\begin{aligned}&\alpha E_t(\omega) - \frac{\beta[(1-\ell+(1-s)\ell^2)(r(H,1)-r(H,0)) - (2(1-\ell)+(1-s)\ell^2)p^H]}{1/\ell-(2-s)} \\ &- \frac{\beta(1-s)[(1+s\ell)(r(H,0)-r(L,0)) + \ell r(L,0)]}{1/\ell-(2-s)} \\ &\leq \frac{(1-\ell)(1/\ell-(1-s))\alpha E_t(\omega|\omega<\hat{\omega}_t) + (1-s)\ell\eta}{1/\ell-(2-s)}.\end{aligned}$$

Proof of Proposition 5

This proof proceeds similarly to the one of Proposition 4.
(i) Start with the case $s < \ell$, then $p = p^L$ and the market assigns land to all skilled agents, and to unskilled agents with probability q^L. Since aggregate power of all agents without land must weakly exceed aggregate power of weak agents without land, an inclusion argument holds:

$$\int_{\underline{\omega}_{t+1}}^{\hat{\omega}_{t+1}} \omega dG_{t+1}(\omega,0) \leq (1-\ell)E_{t+1}(\omega|\lambda=0). \qquad (18)$$

Using (10) and (18) on (9), a sufficient condition for the jungle to be the only stable outcome in period $t+1$ is

$$E_{t+1}(\omega|\omega<\hat{\omega}_{t+1}) \leq (1-s)\alpha E_t(\omega) + \beta(1-s)(r(L,0)+\ell p^L) + (1-s)\eta. \quad (19)$$

By assumption markets were stable in period t, so that

$$\begin{aligned}E_{t+1}(\omega|\omega<\hat{\omega}_{t+1}) \leq &\alpha E_t(\omega|\omega<\hat{\omega}_t) + \eta \\ &+\beta(sr(H,1) + (\ell-s)r(L,1) + (1-s)r(L,0)). \qquad (20)\end{aligned}$$

This upper bound is obtained by calculating the expected income of the weak in t. Note that by (11) at most fraction ℓ of agents with $\omega_t < \hat{\omega}_t$ have land in t. Combining (19) and (20) yields a sufficient condition for a jungle in equilibrium in $t+1$:

$$\alpha E_t(\omega) - \beta\left[\frac{sr(H,1)+(\ell-s)r(L,1)}{1-s} - \ell p^L\right] \geq \frac{\alpha E_t(\omega|\omega<\hat{\omega}_t)}{1-s} + \frac{s\eta}{1-s}. \quad (21)$$

(ii) Let now $s > \ell$, then $p = p^H$ and the market assigns land only to skilled, with probability q^H. By an inclusion argument as above

$$\int_{\hat{\omega}_{t+1}}^{\overline{\omega}_{t+1}} \omega dG_{t+1}(\omega, 1) < \int_{\hat{\omega}_{t+1}}^{\overline{\omega}_{t+1}} \omega dF_{t+1}(\omega) = \ell E_{t+1}(\omega|\omega > \hat{\omega}_{t+1}).$$

Hence, to have a jungle as the only stable outcome in $t+1$ it is sufficient that

$$E_{t+1}(\omega|\lambda = 1) < sE_{t+1}(\omega|\omega > \hat{\omega}_{t+1}). \tag{22}$$

By assumption markets were stable in t, so that

$$\begin{aligned} E_{t+1}(\omega|\omega > \hat{\omega}_{t+1}) > & \alpha E_t(\omega|\omega > \hat{\omega}_t) \\ & + \beta\left(\ell r(H,1) + (s-\ell)r(H,0) + (1-s)r(L,0)\right) + \eta. \end{aligned}$$

This lower bound is obtained by calculating the expected income of the strong in t. By (14) at least fraction ℓ of agents with $\omega_t > \hat{\omega}_t$ have land in t. Hence, using (16) a sufficient condition for a jungle as the only stable outcome in $t+1$ (given that market was an equilibrium in t) is

$$\begin{aligned} & \alpha E_t(\omega) + \beta[(1-s\ell)(r(H,1) - r(H,0)) - (1-\ell)p^H \\ & \quad + (1-s^2)r(H,0) - s(1-s)ry(L,0)] + (1-s)\eta \leq s\alpha E_t(\omega|\omega > \hat{\omega}_t). \end{aligned} \tag{23}$$

Using that $\ell E_t(\omega|\omega > \hat{\omega}_t) + (1-\ell)E_t(\omega|\omega < \hat{\omega}_t) = E_t(\omega)$ again, this becomes

$$\begin{aligned} & \alpha E_t(\omega) - \frac{\ell\beta[(1-s\ell)(r(H,1) - r(H,0)) - (1-\ell)p^H + (1+s)r(H,0) - sr(L,0)]}{s-\ell} \\ & \geq s\frac{1-\ell}{s-\ell}\alpha E_t(\omega|\omega < \hat{\omega}_t) + \eta\frac{(1-s)\ell}{s-\ell}. \end{aligned}$$

Differentiation yields the comparative statics.

Proof of Proposition 6

To simplify notation of this proof we use the abbreviation $\Delta r(\theta) := r(\theta, 1) - r(\theta, 0)$. Assume that in a period t a market is stable.

Part 1. For the first part suppose a market is stable also in $t+1$, i.e. the appropriate condition of (12) and (17) holds.

(i) Let again first $\ell > s$. Suppose condition (12) holds and markets are indeed stable in period t. Then

$$\begin{aligned} & E_{t+1}(\omega) = \alpha E_t(\omega) + \beta(sr(H,1) + (\ell - s)r(L,1) + (1-\ell)r(L,0)) + \eta \text{ and} \\ & E_{t+1}(\omega|\omega < \hat{\omega}_{t+1}) \geq \alpha E_t(\omega|\omega < \hat{\omega}_t) + \beta((1-\ell)r(L,0) + \ell(r(L,1) - p^L)) + \eta. \end{aligned}$$

The second line uses that the landless unskilled have lowest income in a market. By (12)

$$\begin{aligned}&(1+s(1-\ell))\alpha E_t(\omega|\omega<\hat{\omega}_t)+s(1-\ell)\eta\\ \geq&\alpha E_t(\omega)-\beta[s(1-\ell)r(L,0)+\ell(\Delta r(L)-2p^L)].\end{aligned}\tag{24}$$

Applying (12) once more, markets in $t+2$ are stable if

$$\begin{aligned}&\alpha E_{t+1}(\omega)-\beta[s(1-\ell)r(L,0)+\ell(\Delta r(L)-2p^L)]\\ \leq&(1+s(1-\ell))\alpha E_{t+1}(\omega|\omega<\hat{\omega}_{t+1})+s(1-\ell)\eta.\end{aligned}$$

This, using (24) and the expressions above, is implied by

$$\begin{aligned}&\alpha\beta\left[s(r(H,1)-r(L,1))+\ell(1-s(1-\ell))(\Delta r(L)-p^L)\right]\\ \leq&\beta[s(1-\ell)r(L,0)+\ell(\Delta r(L)-2p^L)]+s(1-\ell)\eta.\end{aligned}$$

(ii) Consider now $\ell<s$. Suppose condition (17) holds and markets are indeed stable in t. Then

$$\begin{aligned}&E_{t+1}(\omega)=\alpha E_t(\omega)+\beta(\ell r(H,1)+(s-\ell)r(H,0)+(1-s)r(L,0))+\eta \text{ and}\\ &E_{t+1}(\omega|\omega>\hat{\omega}_{t+1})\leq\alpha E_t(\omega|\omega>\hat{\omega}_t)+\eta\\ &\quad+\beta(\ell r(H,1)+(s-\ell)r(H,0)+(1-s)r(L,0)+(1-\ell)p^H).\end{aligned}$$

The second line follows since landholders have highest incomes in markets. Recall (17), which was given by

$$\begin{aligned}&(1-(1-s)\ell)\alpha E_t(\omega|\omega>\hat{\omega}_t)-(1-s)\ell\eta\\ \leq&\alpha E_t(\omega)+\beta[(1-\ell+(1-s)\ell^2)\Delta r(H)-(2(1-\ell)+(1-s)\ell^2)p^H]\\ &+\beta(1-s)[(1+s\ell)(r(H,0)-y(L,0))+\ell r(L,0)].\end{aligned}$$

Invoking (17) again, a market is stable in $t+2$ if

$$\begin{aligned}&\alpha E_{t+1}(\omega)+\beta[(1-\ell+(1-s)\ell^2)\Delta r(H)-(2(1-\ell)+(1-s)\ell^2)p^H]\\ &+\beta(1-s)[(1+s\ell)(r(H,0)-r(L,0))+\ell r(L,0)]\\ &\geq(1-(1-s)\ell)\alpha E_{t+1}(\omega|\omega>\hat{\omega}_{t+1})-(1-s)\ell\eta.\end{aligned}$$

This, using (17) and the expressions above, is implied by

$$\begin{aligned}&\alpha\beta[(1-\ell)(\Delta r(H)-p^H)+(1-s)(r(H,0)-r(L,0)-\ell p^H)]-\ell(1-s)\eta\\ &\leq\beta[(1-\ell+(1-s)\ell^2)\Delta r(H)-p^H)-(1-\ell)p^H]\\ &+\beta(1-s)[(1+s\ell)(r(H,0)-r(L,0))+\ell r(L,0)].\end{aligned}$$

Note that $\ell p^H \leq r(H,0) - r(L,0)$ is guaranteed when $\ell(r(H,1) - r(H,0)) \leq r(H,0) - r(L,0)$.

Part 2. For the second part suppose the appropriate condition of (21) and (23) holds, i.e. a jungle is stable in $t+1$.

(i) Consider $\ell > s$. Let condition (21) hold. Then a jungle is stable in $t+1$, which in turn implies that a market is stable in $t+2$. By (21) a jungle is stable in period $t+3$ again if

$$\alpha E_{t+2}(\omega) - \beta\left[\frac{sr(H,1)+(\ell-s)r(L,1)}{1-s} - \ell p^L\right] \geq \frac{\alpha E_{t+2}(\omega|\omega<\hat{\omega}_{t+2})+s\eta}{1-s}. \quad (25)$$

That a jungle is stable in $t+1$ implies that

$$\begin{aligned} E_{t+2}(\omega) &= \alpha E_{t+1}(\omega) + \eta \\ &\quad + \beta(\ell[sr(H,1)+(1-s)r(L,1)] + (1-\ell)[sr(H,0)+(1-s)r(L,0)]), \text{ and} \\ E_{t+2}(\omega|\omega<\hat{\omega}_{t+2}) &= \alpha E_{t+1}(\omega<\hat{\omega}_{t+1}) + \beta(sr(H,0) + (1-s)r(L,0)) + \eta. \end{aligned}$$

By assumption markets are stable in t, which implies as above that

$$\begin{aligned} E_{t+1}(\omega) &= \alpha E_t(\omega) + \beta(sr(H,1)+ (\ell-s)r(L,1) + (1-\ell)r(L,0)) + \eta \text{ and} \\ E_{t+1}(\omega|\omega<\hat{\omega}_{t+1}) &\leq \alpha E_t(\omega|\omega<\hat{\omega}_t) + \eta \\ &\quad + \beta(sr(H,1)+(\ell-s)(r(L,1)+(1-\ell)r(L,0)). \end{aligned}$$

Moreover, by assumption condition (21) holds:

$$\alpha E_t(\omega|\omega<\hat{\omega}_t)+s\eta \leq (1-s)\alpha E_t(\omega) - \beta\left[sr(H,1)+(\ell-s)r(L,1)-(1-s)\ell p^L\right].$$

Using these expressions on (25), a jungle is stable in $t+3$ if

$$\begin{aligned} &\alpha\beta[\ell(1-s)(s\Delta r(H)+(1-s)\Delta r(L)) - s(sr(H,0)+(1-s)r(L,0)] \\ &+\alpha^2\beta\left[(1-s)s\Delta r(H)+\ell(\Delta r(L)-p^L)) + (\ell-s)r(L,0)\right] \\ &\geq \beta\left[s\Delta r(H,.) + \ell(\Delta r(L) - (1-s)p^L) + \ell r(L,0)\right] + (1+\alpha)s\eta. \end{aligned} \quad (26)$$

This condition holds for instance when α is sufficiently large, or if both s and $r(L,0)$ are sufficiently close to 0.

(ii) Suppose now $\ell < s$ and that condition (23) holds, so that

$$\begin{aligned} &\alpha E_t(\omega) + \beta[(1-s\ell)(r(H,1) - r(H,0)) - (1-\ell)p^H \\ &\qquad +(1-s^2)r(H,0) - s(1-s)r(L,0)] + (1-s)\eta \leq s\alpha E_t(\omega|\omega>\hat{\omega}_t). \end{aligned} \quad (27)$$

Using (16) and (22), a jungle is stable in period $t+3$ if

$$\alpha E_{t+2}(\omega) + \beta\left(r(H,1) - (1-\ell)p^H\right) + \eta < sE_{t+3}(\omega|\omega>\hat{\omega}_{t+3}). \quad (28)$$

Note here that the identity of the strong ($\omega_i > \hat{\omega}$) agents does not change over time, i.e. $\omega_{i,t+1} > \hat{\omega}_{t+1}$ implies $\omega_{i,t+j} > \hat{\omega}_{t+j}$, $j = 2, 3$ since all the rent goes to the sellers on a market, see Proposition 7. Therefore

$$\begin{aligned} E_{t+3}(\omega|\omega>\hat{\omega}_{t+3}) =& \alpha E_{t+2}(\omega|\omega>\hat{\omega}_{t+2}) + \eta \\ &+ \beta(\ell r(H,1) + (s-\ell)r(H,0) + (1-s)r(L,0) + (1-\ell)p^H). \end{aligned}$$

A jungle as a stable outcome in $t+1$ implies that

$$\begin{aligned} &E_{t+2}(\omega) = \alpha E_{t+1}(\omega) + \eta \\ &\quad + \beta(\ell[sr(H,1) + (1-s)r(L,1)] + (1-\ell)[sr(H,1) + (1-s)r(L,1)]), \text{ and} \\ &E_{t+2}(\omega|\omega>\hat{\omega}_{t+2}) = \alpha E_{t+1}(\omega|\omega>\hat{\omega}_{t+1}) + \beta(sr(H,1) + (1-s)r(L,1)) + \eta. \end{aligned}$$

As above assuming markets are stable in t implies that

$$\begin{aligned} &E_{t+1}(\omega) = \alpha E_t(\omega) + \beta(\ell r(H,1) + (s-\ell)r(H,0) + (1-s)r(L,0)) + \eta \text{ and} \\ &E_{t+1}(\omega|\omega>\hat{\omega}_{t+1}) \geq \alpha E_t(\omega|\omega>\hat{\omega}_t)' + \eta \\ &\quad + \beta(\ell r(H,1) + (s-\ell)r(H,0) + (1-s)r(L,0)). \end{aligned}$$

Using these expressions and (27) on (28), a sufficient condition for a jungle in $t+3$ is

$$\begin{aligned} &\alpha\beta\left((1-\ell)[sr(H,0) + (1-s)r(L,0)] - (s-\ell)[sr(H,1) + (1-s)r(L,1)]\right) \\ <&\beta\left(s(s-\ell)r(H,0) + s(1-s)r(L,0) - (1-s\ell)r(H,1) + (1+s)(1-\ell)p^H\right) \\ &+\alpha^2\beta\big((1-\ell)(r(H,1)-p^H) + (s-\ell)r(H,0) + (1-s)r(L,0)\big) - (1-s)(1+\alpha)\eta. \end{aligned}$$

This condition holds for α sufficiently great or s sufficiently close to 1.

Optimal Coalitional Expropriation

The following lemma characterizes the optimal coalitional expropriation to attack markets:

Lemma 2 (Optimal Coalitional Expropriation) *There is an optimal coalitional expropriation $(\lambda', 0)$ characterized by*

- *if $\ell < s$: $\lambda_i' = 1$ if $\omega_i > \widetilde{\omega}$ and $\lambda_i^0 = 0$ or $\lambda_i^0 = 1$ and $\theta_i = H$,*
- *if $\ell > s$: $\lambda_i' = 1$ if $\omega_i > \widetilde{\omega}$ and $\lambda_i^0 = 1$ or $\lambda_i^0 = 0$ and $\theta_i = L$, or if $\omega_i > \widetilde{\omega}/2$ and $\lambda_i = 0$ and $\theta_i = H$,*

with $\widetilde{\omega}$ implicitly defined by $\mu(i \in I : \lambda_i' = 1) = l \vee \widetilde{\omega} = 0$.

Proof: Note that $u(\lambda_i^0, \theta_i, \lambda_i^M, p) < u(\lambda_i^0, \theta_i, \lambda_i', 0)$ if and only if $\lambda_i' = 1$ and $\lambda_i^0 = 0$. $u(\lambda_i^0, \theta_i, \lambda_i^M, p) > u(\lambda_i^0, \theta_i, \lambda_i', 0)$ if and only if $\lambda_i' = 0$ and $\lambda_i^0 = 1$, or $\lambda_i' = 0$ and $\lambda_i^0 = 0$, but $p < r(\theta_i, 1)$, or $\lambda_i' = 1$ and $\lambda_i^0 = 1$, but $p > r(\theta_i, 1)$. Define accordingly the coalitions of winners and losers

$$\begin{aligned} C =& \{i \in I : \lambda_i' < \lambda_i^0 = 1\} \cup \{i \in I : \lambda_i' = \lambda_i^0 = 0 \wedge p < r(\theta_i, 1)\} \\ & \cup \{i \in I : \lambda_i' = \lambda_i^0 = 1 \wedge p > r(\theta_i, 1)\}, \\ C' =& \{i \in I : \lambda' > \lambda_i^0\}. \end{aligned}$$

Markets dominate a coalitional expropriation $(\lambda', 0)$ if and only if

$$\int_{i \in C} \omega_i di \geq \int_{i \in C'} \omega_i di.$$

The optimal coalitional expropriation λ' then solves

$$\max_{\lambda' : \lambda_i \in \{0;1\}} \left(\int_{i \in C'} \omega_i di - \int_{i \in C} \omega_i di \right) \text{ s.t. } \int_{i \in I} \lambda_i' di = \ell.$$

Agent i's marginal contribution to the objective function $\Delta(i)$ of receiving land $\lambda_i' = 1$ (as opposed to $\lambda_i' = 0$) is

$$\Delta(i) = \begin{cases} 0 & \text{if } i \in C \text{ for } \lambda_i' = 0, \lambda_i' = 1 \\ 0 & \text{if } i \in C' \text{ for } \lambda_i' = 0, \lambda_i' = 1 \\ \omega_i & \text{if } i \in C \text{ for } \lambda_i' = 0, i \notin C', i \notin C \text{ for } \lambda_i' = 1 \\ \omega_i & \text{if } i \notin C, i \notin C' \text{ for } \lambda_i' = 0, i \in C' \text{ for } \lambda_i' = 1 \\ 2\omega_i & \text{if } i \in C \text{ for } \lambda_i' = 0, i \in C' \text{ for } \lambda_i' = 1. \end{cases}$$

All other cases can be excluded. Since the constraint binds with equality, in the optimal coalitional expropriation $\lambda_i' = 1$ if $\Delta(i) > \widetilde{\omega}$, with $\widetilde{\omega} : \mu(i \in I : \Delta(i) \geq \widetilde{\omega}) = \ell \vee \widetilde{\omega} = 0$. Conditioning on scarcity of land the statement in the lemma follows.

Figure 1 shows the optimal expropriation for $\ell > s$ where λ' is the land distribution under expropriation.

A market allocation is the unique stable outcome if the market dominates optimal coalitional expropriation, that is if

$$\int_{\underline{\omega}}^{\widetilde{\omega}} \omega dG(\omega, 1) + s \int_{\underline{\omega}}^{\widetilde{\omega}/2} \omega dG(\omega, 0) > \int_{\widetilde{\omega}}^{\overline{\omega}} \omega dG(\omega, 0) + s \int_{\widetilde{\omega}/2}^{\widetilde{\omega}} \omega dG(\omega, 0), \tag{29}$$

in case $\ell > s$ and therefore $p = p^L$. Otherwise, if $\ell < s$ the condition is

$$\int_{\underline{\omega}}^{\widetilde{\omega}} \omega dG(\omega, 1) + (1 - s) \int_{\widetilde{\omega}}^{\overline{\omega}} \omega dG(\omega, 1) > \int_{\widetilde{\omega}}^{\overline{\omega}} \omega dG(\omega, 0). \tag{30}$$

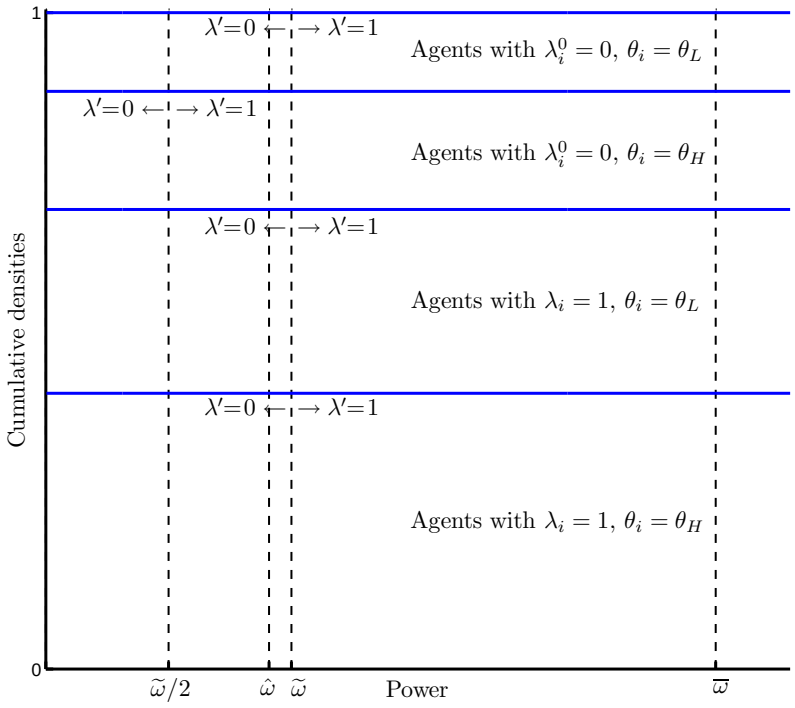

Figure 1: Optimal coalitional expropriation when $\ell > s$.

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