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A Tale of Markets and Jungles in a Simple Model of Growth*

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Abstract

Institutions determine prospects for economic growth and development. This paper collapses potentially complex interactions of different institutions into a simple condition on the primitives that determines whether a society supports spot markets or not. In a dynamic model of an agrarian economy agents are heterogeneous in land holdings, skill, and food endowments. Food holdings serve as a proxy for agents' power to expropriate. The main point of interest is whether land is assigned to the skilled or to the powerful, i.e. by coalitional expropriation or by markets. The model finds two different types of limit behavior: a sequence of stable markets and a limit cycle where markets and expropriation alternate. More equal first period endowment distributions facilitate sustainable markets that, in turn, enhance economic efficiency and decrease macroeconomic fluctuations.

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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, institutions determine prospects for economic growth and development, as has been noted by North (1991) and a corresponding literature. Indeed, there appears to be some empirical support for this hypothesis, see e.g. Acemoglu et al. (2001) and Engerman and Sokoloff (2002). Most of the existing literature on institutions and growth has emphasized on explicitly modeling particular institutions, such as elections, specialists for violence, or contract enforcement. We depart from this approach by collapsing potentially complex interactions of different institutions into a simple stability condition on the primitives that reflects whether a society supports market allocations or not. That is we focus on stability of outcomes rather than modeling specific institutions. This has the virtue that the precise nature of interactions between different institutions of political, social, legal or economic nature has not to be incorporated into the model. Indeed, it is not obvious which is the correct set of institutions to be used in a model since different types of institution may reinforce or cancel each other's effect on the economic allocation. Enforcement of property rights, for instance, has been observed under a variety of political institutions (relative stability of property rights under the dictatorships in South Korea and Chile are cases in point). Looking across countries and over the years 1960-90, Mulligan et al. (2004) do not observe any systematic economic or social policy differences between democracies and (non-communist) non-democracies.

To address these issues we propose a simple dynamical model of an agricultural economy. Agents are heterogeneous in land holdings, food endowments, and skill. Food holdings serve as a proxy for agents' power to expropriate other – weaker – agents. The underlying economic problem consists in whether land is assigned to the skilled or to the powerful. The set of economic outcomes of this assignment problem contains the competitive equilibrium allocation of the market for land, and all conceivable redistributions of land to coalitions of agents, termed coalitional expropriation. To determine the economic outcome a stability property is used: an allocation is said to be stable if there is no other allocation that is strictly preferred by sufficiently powerful agents.

It turns out that among all coalitional expropriations the only one that may be stable assigns the land to the most powerful agents in the economy. This assignment mechanism coincides with versions of some allocations known in the literature, e.g. the jungle equilibrium in Piccione and Rubinstein (2006), the pillage game equilibrium (Jordan, 2006), or the dog bone economy in Sattinger (1993). Moreover, stability of competitive markets in a given period is favored by more equal food endowment distributions and by less mismatch between demand and supply on the market.

In the dynamic setting two distinct pattern of economic growth may emerge. On the one hand, there may emerge sustainable markets, that is, after finite time spot markets for land will be stable in every period. On the other hand, after finite time there may emerge a limit cycle where markets will be unstable in one period but stable in every other. Limit cycles permit both persistent elites and social mobility depending on the distribution of surplus on the market. A more equal endowment distribution of food in the initial period increases the strength of market supporters and facilitates stability of markets that in turn lead to higher output and a less volatile growth path. The model is consistent with the emergence of the landed gentry as described by Rajan and Zingales (2003), and the dependence on initial distributions of power resembles the findings of Engerman and Sokoloff (2005). The main ideas of the model are illustrated using historical examples from Malaysia, South Korea and Philippines (reflecting the example provided by Bénabou (1996)).

This paper is related to the field of institutional development. In this literature institutions are understood typically as the degree of property rights enforcement in conjunction with specific political institutions from a limited feasible set.[1] In contrast to those works our paper abstracts from modeling any specific institution and exclusively relies on stability of economic allocations. More recently it has been emphasized, for instance by Acemoglu and Robinson (2006) and Rajan and Zingales (2006), that institutions determining the economic allocation are not equivalent to political institutions. They focus rather on the persistence of powerful elites governing the economic allocation in order to seize economic rents. Though our model can encompass persistent elites, its focus is quite another: we study the prerequisites for the development of competitive spot markets.

The paper is connected to a second field of literature, on stability of property rights in the presence of rent seeking.[2] This literature tends to emphasize

[1] Some contributions following this approach are for instance Acemoglu (2006); Acemoglu et al. (2004); Besley and Persson (2007); Cervellati et al. (2005); Gradstein (2004, 2006).

[2] See for instance Grossman (1991, 2001, 2004); Hafer (2006); Konrad and Skaperdas

efficiency losses, due to resource destruction or time dedicated to prepare and fight a conflict, that arises when property rights cannot be enforced. We use a different modeling strategy, in which contracts are enforceable when the subsequent allocation is supported by sufficiently powerful agents versus alternative feasible allocations. This stresses allocative distortions generated by an imperfect match between skill and land.

Finally, this work is linked to a panoply of papers that studies the relationship between inequality and growth, in particular to those focusing on an institutional channel.[3] They argue that inequality affects the choice of particular political institutions. These in turn determine economic efficiency and thus prospects for growth. In our model low inequality in initial food endowments directly facilitates the emergence of stable spot markets. This means land is allocated efficiently among agents and, as a result, output and average growth rate are higher. Interestingly, our model identifies also an institutional channel that may explain high macro economic volatility of underdeveloped countries. Under some parametric conditions, the model predicts the existence of an institutional cycle where markets and expropriation alternate. Periods of low growth under expropriation are followed by periods of accelerated growth when markets take place and the previous efficiency losses are partially recovered.

The paper is organized as follows. Section 2 outlines the model framework, section 3 contains the analysis of the static equilibrium. In sections 4 and 5 we present our main results, while section 6 provides a case study in which we compare institutions and economic performance of Korea, Malaysia and the Philippines. Section 7 concludes.

2 Framework

2.1 Agents

In each period t the economy is populated by a continuum of agents I endowed with unit Lebesgue measure. Agents live for one period only. An agent $i \in I$ is fully characterized by their type, that is their productivity θ_i, their holdings of land λ_i, and their holdings of food ω_i. Initial period land and food

(1999); Muthoo (2004); Tornell (1993).

[3] See Alesina and Rodrik (1994); Grossman (1994); Persson and Tabellini (1994); Alesina and Perotti (1996) among others.

holdings are distributed independently. Agent i can be skilled, $\theta_i = \theta_H$, or unskilled, $\theta_i = \theta_L < \theta_H$. In each period a time invariant measure s of agents are drawn randomly according to a uniform distribution and become skilled. The remainder remains unskilled. The skill distribution in period t is thus exogenous and denoted by $(\theta_{i,t})_{i \in I}$. Agent i may hold land, $\lambda_i = 1$, or not, $\lambda_i = 0$. The endowment of land in the economy is time invariant and given by $l \neq s$. Denote the endogenous land distribution in period t by $(\lambda_{i,t})_{i \in I}$. The joint distribution of food and land in period t is denoted by $F_t(\omega, \lambda)$, the initial period marginal distribution function with respect to food is assumed to be differentiable. Lower and upper bounds of the support of the food distribution in period t are denoted by $\underline{\omega}_t$ and $\overline{\omega}_t$. Food endowments serve as a proxy for agents' strengths: well-fed agents are more powerful than poorly fed agents and capable of evicting them from their land. An agent's utility is linear in the consumption good at the end of a period.

2.2 Production

Agents work their land producing food output which depends on their skill and on their food endowments. This gives rise to agents' valuations $v(.)$ for food and land holdings depending on own skill:

$$v(\theta_i, \lambda_i, \omega_i) = r\omega_i + \begin{cases} \theta_i & \text{if } \lambda_i = 1 \\ \sigma & \text{otherwise.} \end{cases}$$

Note that $v(.)$ also gives agent i' income. An agent cannot work more than one unit of land. This is best interpreted as a Leontief production technology or as a constraint on the ability to control ownership of land. Food holdings are productive and earn a rate of return $r > 1$. This can be thought of as a part of the subsistence income that depends on ω_i, for instance a backyard activity requiring physical labor. Given the distributions of land and skill are not perfectly correlated there are gains from trade prior to production: There exist prices to ensure that $(\theta_L, 1, .)$ and $(\theta_H, 0, .)$ agents are willing to exchange land for the consumption good. Hence, agents have an opportunity to trade before production takes place. Alternatively there exists the possibility to earn a subsistence income $\sigma < \theta_L$. For notational convenience, let us normalize subsistence income to zero, i.e. $\sigma = 0$.

2.3 Timing

The timing in each period t 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, agents die and bequeath.

This means that there is no role for debt or rental contracts and expropriation takes place only before production. Allowing the model to have markets and production twice each period is an immediate extension and left for future research. Periods are linked by bequests. To make the dynamics of the model tractable agents are assumed to bequeath a fixed percentage b of their income in the consumption good and their land holdings.[4] Let $br > 1$ to let the economy outgrow the credit market friction.

2.4 Assignment of Land

The main economic interaction in the model is the allocation of land among agents. We consider two versions of assignment mechanism, *market for spot contracts* and *coalitional expropriation*. On the market for spot contracts contracts are written that specify an amount of land and an amount of food that is to be exchanged against each other. An allocation implied by spot markets is the competitive equilibrium allocation of land and food. On the other hand, land may be assigned by coalitional expropriation. Any redistribution of the land endowment among agents can be reached by coalitional expropriation. Only land can be expropriated, food can be hidden or consumed. We consider the case of costless redistribution of land, so that the allocation of food reached by coalitional expropriation coincides with food endowments. Feasible allocations can be summarized as follows.

Definition 1 *Let $(\omega_{i,t}, \lambda_{i,t})_{i \in I}$ be initial endowments of food and land in period t. An allocation $(\omega_i, \lambda_i)_{i \in I}$ is feasible if*

(i) $\int_{i \in I} \lambda_i di = l$ and $\lambda_i \in \{0; 1\}$ for all $i \in I$ (feasibility of the land allocation) and

[4] This is consistent with a standard 'warm glow' bequest motive used in the literature.

(ii) $(\omega_i, \lambda_i)_{i \in I}$ *is either a competitive equilibrium of the market for land and food, i.e. is induced by a market for spot contracts, or* $(\omega_i)_{i \in I} = (\omega_{i,t})_{i \in I}$*, i.e. is induced by coalitional expropriation.*

Definition 1 contains two important assumptions. First, redistribution does not waste resources. Second, only deterministic redistribution is considered. We want to focus on distortions of the economic allocation as a consequence of expropriation rather than on the waste of resources. When admitting stochastic redistribution the question of enforcing the outcome arises.[5] The focus of this paper is on identifying allocations induced by assignment mechanisms that are stable with respect to coalitional deviations to other feasible allocations. Define stability as the following binary relation.

Definition 2 *An allocation* (ω, λ) *is stable with respect to an allocation* (ω', λ')*, if* $\int_{i \in C} \omega_i di \geq \int_{i \in C'} \omega_i di$ *where* $C = \{i \in I : v(\theta_i, \lambda_i, \omega_i) > v(\theta_i, \lambda'_i, \omega'_i)\}$ *and* $C' = \{i \in I : v(\theta_i, \lambda_i, \omega_i) < v(\theta_i, \lambda'_i, \omega'_i)\}$*. An allocation is stable if it is stable with respect to any other feasible allocation.*

Intuitively, a stable allocation must be supported by sufficiently powerful agents versus any alternative allocation. For instance, a spot market allocation is considered stable only if for any alternative feasible allocation agents strictly preferring the market outcome are more powerful than agents strictly preferring the alternative. Strict preference is required since agents attacking or defending the status quo allocation may need to communicate and coordinate.[6] Note that the relation "stable with respect to" does not need to be transitive.

Definition 3 *An equilibrium in period* $t > 0$ *is a feasible allocation* $(\lambda_t^*, \omega_t^*)$ *that is stable with respect to any other stable allocation.*

Trivially, an equilibrium allocation in period t then always exists. A stable allocation may not exist, however, so that multiple allocations may be consistent with equilibrium. In case of multiple equilibria we select an equilibrium allocation $(\lambda_t^*, \omega_t^*)$ that is implied by the assignment mechanism that implied the equilibrium allocation in period $t-1$. For convenience we set the assignment mechanism to coalitional expropriation by the most powerful coalition

[5]However, when credit market frictions are sufficiently severe stochastic expropriation may lead to higher output than assignment by markets. Gall (2007) pursues this point.

[6]This means introducing a strictly positive coordination cost that is sufficiently small does not alter the results.

in period $t = -1$.[7] Hence, a static equilibrium allocation is the allocation implied by the status quo assignment mechanism unless there exists another allocation that is stable with respect to all other allocations.

3 Static Equilibrium

Before determining properties of the static equilibrium it is useful to characterize the price of land on a market for spot contracts.

3.1 Market for Contracts

Markets for spot contracts induce a competitive equilibrium allocation that equates supply and demand for land given by valuations $v(\theta_i, \lambda_i, \omega_i)$ subject to individual liquidity constraints $\omega_{i,t} > p_t$. Land is assigned to those agents who value it most, that is the skilled, and have sufficient food endowment to pay for it, since credit markets are absent from this model.

Proposition 1 (Market for Spot Contracts) *The price for land on a market for spot contracts in period t, p_t, is given by*

$$rp_t = \begin{cases} \theta_L & \text{if } F_t(\frac{\theta_L}{r}|\lambda_i = 0) \geq \frac{s-l}{s(1-l)} \\ F_t(p_t|\lambda_i = 0) = \frac{s-l}{s(1-l)} & \text{if } F_t(\frac{\theta_H}{r}|\lambda_i = 0) > \frac{s-l}{s(1-l)} > F_t(\frac{\theta_L}{r}|\lambda_i = 0) \\ \theta_H & \text{if } F_t(\frac{\theta_H}{r}|\lambda_i = 0) \leq \frac{s-l}{s(1-l)} \end{cases} \quad (1)$$

If $s \leq l$ then $rp_t = \theta_L$ for all t.

Proof: In Appendix.

Suppose for instance that ω follows $U[0, 1]$ and $0 < \theta_L < \theta_H < 1$ and ω and λ are independent. Then an example for the market allocation is given in Figure 1 where the market price is θ_L.

At price $p_t = \theta_L/r$ all unskilled agents are indifferent between holding land and not doing so, and at price $p_t = \theta_H/r$ all skilled agents are indifferent. Hence, there has to be some form of rationing. We assume that all agents who are indifferent between holding land and not doing so are uniformly rationed. This seems a reasonable assumption, since otherwise a skilled agent i with $\omega_{i,t} > p_t$, who is not assigned land, will find it profitable to offer a marginally

[7] Alternatively, assuming an initial period distribution of food with $\hat{\omega}_0 \leq \theta_L/r$ suffices to guarantee that this is the unique equilibrium in the initial period.

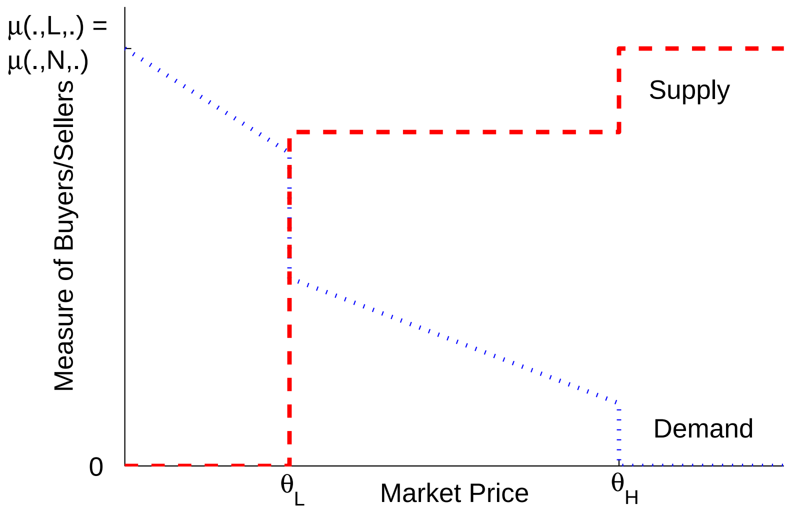

Figure 1: Market for Contracts

higher price and obtain land with certainty. Note that there is no trade if $F_t(\frac{\theta_L}{r}) = 1$ because all agents are too poor to be able to sufficiently compensate an unskilled agent. Moreover, it follows from (1) that for sufficiently low measures of skilled agents the market equilibrium has $rp_t = \theta_L$.[8]

3.2 Coalitional Expropriation: the Jungle Emerges

Characterize the measure l of the most powerful agents by defining a cutoff food endowment $\hat{\omega}_t$ as follows.

$$\hat{\omega}_t : \mu(i \in I : \omega_i > \hat{\omega}) = l,$$

where $\mu(.)$ denotes the measure of agents. The cutoff value is well-defined even if $F_t(\omega)$ has an atom at $\hat{\omega}_t$. Let (ω^E, λ^E) denote a feasible allocation with $\omega_i^E = \omega_{i,t}$ and $\lambda_i^E = 1$ if $\omega_{i,t} \geq \hat{\omega}_t$ and $\lambda_i^E = 1$ if $\omega_{i,t} \geq \hat{\omega}_t$. Then a very useful result follows immediately.

Proposition 2 (Expropriation) *The allocation (ω^E, λ^E) is stable with respect to all feasible allocations (ω', λ') with $\omega_i' = \omega_{i,t}$. If $F_t(\omega)$ is atomless (ω^E, λ^E) is unique a.e. on I.*

[8] If the subsistence income is greater than θ_L unskilled sellers' reservation value drops to 0 and the above equation holds if θ_L is replaced by 0. Note further that p_t induces a cutoff level of food endowment such that agents with $\omega_{i,t} > p_t$ obtain land on the market and agents with $\omega_{i,t} < p_t$ do not.

Proof: Consider a feasible allocation (ω', λ') with $\omega'_i = \omega_{i,t}$ for all $i \in I$. We have that $v(\theta_i, \lambda_i^E, \omega_i^E) > v(\theta_i, \lambda'_i, \omega'_i)$ if and only if $i \in C = \{i \in I : \lambda'_i = 0 \wedge \lambda_i^E = 1\}$, and $v(\theta_i, \lambda_i^E, \omega_i^E) < v(\theta_i, \lambda'_i, \omega'_i)$ if and only if $i \in C' = \{i \in I : \lambda'_i = 1 \wedge \lambda_i^E = 0\}$. Hence, (ω^E, λ^E) is stable with respect to (ω', λ') if

$$\int_{i \in C} \omega_i di \geq \int_{j \in C'} \omega_j dj. \tag{2}$$

Note that $\mu(i \in I : \lambda'_i = 1 \wedge \lambda_i = 0) = \mu(i \in I : \lambda'_i = 0 \wedge \lambda_i = 1)$, i.e. $\mu(i \in C) = \mu(i \in C')$, as both allocations are feasible. Since $\lambda_i^E = 1 \Leftrightarrow \omega_{i,t} \geq \hat{\omega}_t$ and $\lambda_i^E = 0 \Leftrightarrow \omega_{i,t} \leq \hat{\omega}_t$, $\omega_{i,t} \geq \omega_{j,t}$ for all $i \in C$ and $j \in C'$. This implies (2). Uniqueness a.e. follows immediately from the definition of $\hat{\omega}_t$. □

Proposition 2 states that there is a unique distribution of land λ^E implied by coalitional redistribution and stable with respect to coalitional redistribution. This allocation is characterized by expropriation of the weak by the strong, that is the economy becomes a jungle. (ω^E, λ^E) will be referred to as *allocation under expropriation* in the remainder of the paper. There are several reasons for singling out expropriation among a continuum of feasible coalitional expropriations. First, expropriation does not require coordination. Second, it coincides with an assignment of land to agents based on power. Third, it has become a recurrent theme in the literature under various guises.[9] Turn now to stability of expropriation with respect to the market allocation. The stability condition is given by

$$\int_{\underline{\omega}}^{\hat{\omega}} \omega_i dF(\omega_i, \lambda_i{=}1) + (1-s) \int_{\hat{\omega}}^{\overline{\omega}} \omega_i dF(\omega_i, \lambda_i{=}1) < \int_{\hat{\omega}}^{\overline{\omega}} \omega_i dF(\omega_i, \lambda_i{=}0). \tag{3}$$

in case of a high price $rp_t = \theta_H$, by

$$\int_{\underline{\omega}}^{\hat{\omega}} \omega_i dF(\omega_i, \lambda_i{=}1) + s \int_{p}^{\hat{\omega}} \omega_i dF(\omega_i, \lambda_i{=}0) \leq \int_{\hat{\omega}}^{\overline{\omega}} \omega_i dF(\omega_i, \lambda_i{=}0). \tag{4}$$

in case of a low price $rp_t = \theta_L$, and by

$$\begin{aligned} \int_{\underline{\omega}}^{\hat{\omega}} \omega_i dF(\omega_i, \lambda_i &= 1) + (1-s) \int_{\hat{\omega}}^{\overline{\omega}} \omega_i dF(\omega_i, \lambda_i{=}1) + s \int_{p}^{\hat{\omega}} \omega_i dF(\omega_i, \lambda_i{=}0) \\ &< \int_{\hat{\omega}}^{\overline{\omega}} \omega_i dF(\omega_i, \lambda_i{=}0). \end{aligned} \tag{5}$$

[9]For instance the jungle equilibrium in Piccione and Rubinstein (2006), the pillage game equilibrium in (Jordan, 2006), and the dog bone economy in Sattinger (1993).

for intermediate prices of land $\theta_L < rp_t < \theta_H$.

Sufficiently powerful agents ($\omega_{i,t} > \hat{\omega}_t$) not endowed with land always strictly prefer expropriation to markets. Identity of market supporters depends on the equilibrium market price, however. Weak agents ($\omega_{i,t} < \hat{\omega}_t$) holding land always strictly prefer spot markets, since they are expropriated otherwise. For low market prices ($rp_t < \theta_H$), skilled agents that do not hold land and are too weak to expropriate ($p_t \leq \omega_{i,t} < \hat{\omega}_t$) strictly prefer markets. For high market prices ($rp_t > \theta_L$) strong agents ($\omega_{i,t} > \hat{\omega}_t$) who are unskilled and hold land support markets in order to be able to sell land. It is straightforward that intermediate market prices ($\theta_L < rp_t < \theta_H$) do not favor stability of expropriation, since under these market prices surplus is shared quite equally in the economy.

3.3 Stability of Markets

We now check for stability of markets with respect to all other allocations. Define the optimal coalitional expropriation as a distribution of land λ' implied by coalitional expropriation that maximizes the difference between the power of agents strictly preferring λ' and the power of agents who strictly prefer a market. Then stability of markets with respect to the optimal coalitional expropriation is sufficient for stability of markets with respect to all coalitional expropriations.

Lemma 1 (Optimal Coalitional Expropriation) *There exists an optimal coalitional expropriation λ' characterized by*

- $\lambda'_i = 1$ *if* $\omega_{i,t} > \widetilde{\omega}$ *and* $\lambda_{i,t} = 0$ *or* $\lambda_{i,t} = 1$ *and* $\theta_i = \theta_H$ *if* $rp_t = \theta_H$,
- $\lambda'_i = 1$ *if* $\omega_{i,t} > \widetilde{\omega}$ *and* $\lambda_{i,t} = 1$ *or* $\lambda_{i,t} = 0$ *and* $\theta_i = \theta_L$ *or if* $\omega_{i,t} > \max\{\widetilde{\omega}/2; \min\{p_t; \hat{\omega}_t\}\}$ *and* $\lambda_{i,t} = 0$ *and* $\theta_i = \theta_H$ *if* $rp_t = \theta_L$,
- $\lambda'_i = 1$ *if* $\omega_{i,t} > \widetilde{\omega}$ *and* $\lambda_{i,t} = 1$ *and* $\theta_i = \theta_H$, *or if* $\omega_{i,t} > \max\{\widetilde{\omega}/2; \min\{p_t; \hat{\omega}_t\}\}$ *and* $\lambda_{i,t} = 0$ *and* $\theta_i = \theta_H$, *or if* $\omega_{i,t} > \widetilde{\omega}$ *and* $\lambda_{i,t} = 0$ *and* $\theta_i = \theta_L$ *if* $\theta_L < rp_t < \theta_H$,

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

Proof: In Appendix.

Designing an optimal coalitional expropriation to attack markets means deciding on an assignment of land that gives land to agents with the highest

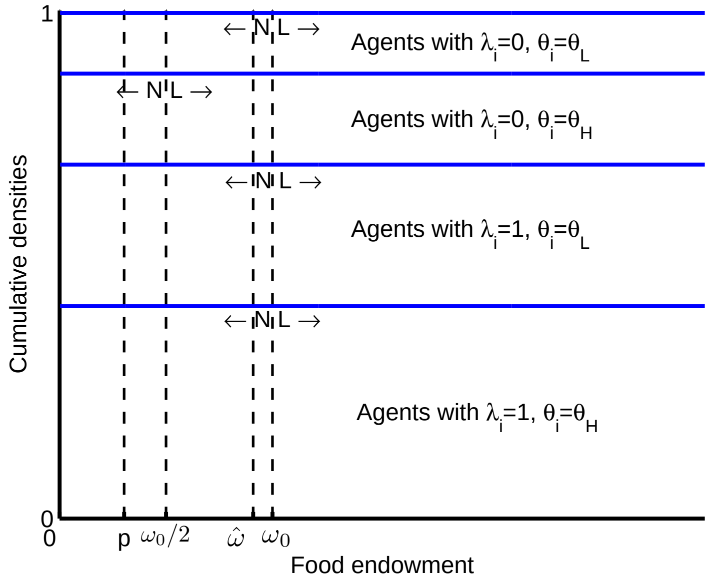

Figure 2: Optimal Coalitional Expropriation

marginal contribution of power to the deviating coalition. An agent contributes with his power, that is his food endowment, in case of a preference switch (e.g. from market supporter to indifference) when given land. Hence, agents switching from supporting markets to supporting coalitional expropriation (well-off, i.e. $\omega_i > p$, skilled landless agents when $rp_t < \theta_H$) are prime recipients of land while agents who cannot be prevented from supporting markets (rich unskilled landholders when $rp_t < \theta_H$) are never given land. This means the optimal coalitional expropriation to attack markets needs not coincide with expropriation. An example for an optimal coalitional expropriation for $rp_t = \theta_L$ is depicted in Figure 2 where the distribution of land is indicated by the letters N and L.

Markets are stable if aggregate power of agents strictly preferring a market to any coalitional expropriation exceeds aggregate power of agents strictly preferring coalitional expropriation to a market. Aggregate power of each group is given by agents' aggregate food holdings in each group. Note that by definition stability with respect to the optimal coalitional expropriation implies stability with respect to any other feasible allocation resulting from coalitional expropriation. The stability condition for markets with respect to optimal coalitional expropriation is given by

$$\int_{\underline{\omega}}^{\widetilde{\omega}} \omega_i dF(\omega_i, \lambda_i = 1) + (1-s) \int_{\widetilde{\omega}}^{\overline{\omega}} \omega_i dF(\omega_i, \lambda_i = 1) > \int_{\widetilde{\omega}}^{\overline{\omega}} \omega_i dF(\omega_i, \lambda_i = 0). \tag{6}$$

in case of a high price $rp_t = \theta_H$, by

$$\begin{aligned} \int_{\underline{\omega}}^{\widetilde{\omega}} \omega_i dF(\omega_i, \lambda_i = 1) + s \int_{p}^{\widetilde{\omega}/2} \omega_i dF(\omega_i, \lambda_i = 0) - s \int_{\widetilde{\omega}/2}^{\widetilde{\omega}} \omega_i dF(\omega_i, \lambda_i = 0) \\ > \int_{\widetilde{\omega}}^{\overline{\omega}} \omega_i dF(\omega_i, \lambda_i = 0). \end{aligned} \tag{7}$$

in case of a low price $rp_t = \theta_L$, and by

$$\begin{aligned} &\int_{\underline{\omega}}^{\widetilde{\omega}} \omega_i dF(\omega_i, \lambda_i = 1) + (1-s) \int_{\widetilde{\omega}}^{\overline{\omega}} \omega_i dF(\omega_i, \lambda_i = 1) \\ &+ s \int_{p}^{\widetilde{\omega}/2} \omega_i dF(\omega_i, \lambda_i = 0) - s \int_{\widetilde{\omega}/2}^{\widetilde{\omega}} \omega_i dF(\omega_i, \lambda_i = 0) \geq \int_{\widetilde{\omega}}^{\overline{\omega}} \omega_i dF(\omega_i, \lambda_i = 0). \end{aligned} \tag{8}$$

if the price for land is intermediate $\theta_L < rp_t < \theta_H$.

In case the events holding land $\lambda_{i,t} = 1$ and belonging to the most powerful agents $\omega_{i,t} > \hat{\omega}_t$ are perfectly correlated the market allocation is stable with respect to any other allocation.

Proposition 3 *Let endowments satisfy $\lambda_{i,t} = 1$ if $\omega_{i,t} > \hat{\omega}_t$ and $\lambda_{i,t} = 0$ if $\omega_{i,t} < \hat{\omega}_t$. Then an allocation implied by markets is stable with respect to all other allocations. If $\hat{\omega}_t \leq \theta_L/r$ allocations under markets and expropriation coincide.*

Proof: In Appendix.

That is, for perfect correlation of land and power the market allocation is always an equilibrium. This is particularly interesting when realizing that an allocation under expropriation induces perfect correlation in next period's land and food endowments. Moreover, Proposition 3 states that for poor economies ($\hat{\omega}_t \leq \theta_L/r$) absence of a credit market prevents any trade on the spot market for land, implying that expropriation and markets yield the same allocation. Moreover, severity of the allocative distortion caused by credit market imperfections interferes with the likelihood of stability of markets. Stability of markets becomes more likely as the measure of agents excluded from the market $\mu(i \in I : \omega_{i,t} < p_t)$ decreases, since slackness of conditions (7) and (8) increases. Additionally, inequality of period t food endowments may prevent stability of markets, as stated in the following proposition. This is because less inequality translates into a reduction of the power of the rich agents without land and an increase in the power of poor agents holding land. The effect of a change in inequality is less pronounced, however, in a high price environment because it also decreases the power of unskilled rich landholders who support markets.

Proposition 4 *(i) Let* $rp_t > \theta_L$*. A redistribution of food from agents with* $\omega_i > \omega'$ *to agents with* $\omega_i < \omega'' < \omega'$ *makes stability of markets more likely if* $rp_t = \theta_L$*, s sufficiently close to* 1*, or correlation between food and land is sufficiently low.*
(ii) Let $rp_t = \theta_L$*. A redistribution of food from agents with* $\omega_i > \omega'$ *to agents with* $\omega_i < \omega'$ *makes stability of markets more likely.*

Proof: In Appendix.

Finally, we are interested in whether equilibrium allocations satisfy a minimum efficiency requirement, namely constrained Pareto efficiency.

Definition 4 *An allocation* (λ^*, ω^*) *is constrained Pareto-efficient if it is feasible and there does not exist another feasible allocation* (λ', ω') *that Pareto-dominates* (λ^*, ω^*)*.*

The use of the qualifier is indeed appropriate since the set of feasible allocation gives rise to a fundamental non-transferability of utility. The following proposition asserts that equilibrium allocations indeed satisfy constrained Pareto efficiency.

Proposition 5 *A static equilibrium allocation is constrained Pareto-efficient.*

Proof: In Appendix.

Note that aggregate output is maximized by an allocation that assigns land to the skilled. Thus there exists always an allocation under coalitional expropriation that is output efficient. Although markets yield always at least as much output as expropriation, they are output efficient only if the economy has grown sufficiently rich, since otherwise some unskilled are assigned land, but not all skilled.

4 Transition Functions

Key to the model's long run dynamics is the transition function that maps period t's joint distribution of land and food into period $t+1$'s joint distribution of land and food. The transition function is well defined since under our selection rule an equilibrium allocation entirely determines next period's endowments through the warm glow bequest motive.

4.1 Allocation under Expropriation

Under expropriation payoffs are either θ_i if $\omega_{i,t} > \hat{\omega}_t$, or 0 otherwise. Food endowments in period $t+1$ are given by

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

Since land goes to the powerful, the land distribution 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 under expropriation $\omega_{i,t} > \hat{\omega}_{i,t}$ implies $\omega_{i,t+1} > \hat{\omega}_{i,t+1}$. Therefore

$$\int_{\hat{\omega}_{t+1}}^{\overline{\omega}_{t+1}} \omega_i dF_{t+1}(\omega_{i,t+1}, \lambda_i{=}0) = 0.$$

This means that, by Proposition 3, an equilibrium with expropriation in period t implies that the market allocation is stable with respect to all other allocations in period $t+1$. That is, the strongest agents obtain land in the jungle in t and thus higher income than expropriated agents. Hence, the strong agents' offspring will be among the strongest agents in $t+1$ as well. Since they already hold land, there is no profit in expropriating again. Moreover, measure $1-s$ of the strong agents' offspring is unskilled in period $t+1$ and may find it profitable to sell their land on a spot market in $t+1$.

4.2 Markets for spot contracts when $rp_t = \theta_L$

In period t unskilled agents earn 0 from land when not endowed with land and θ_L otherwise. Returns from land for skilled agents are $\theta_H - \theta_L$ if they are not endowed with land and $\omega_{i,t} \geq \theta_L/r$, and θ_H if they are endowed with land. Hence, food endowments in period $t+1$ are

$$\omega_{i,t+1} = br\omega_{i,t} + b \begin{cases} \theta_i & \text{if } \lambda_{i,t} = 1 \\ \theta_i - \theta_L & \text{if } \lambda_{i,t} = 0. \end{cases} \tag{9}$$

Deriving the land distribution in period $t+1$ is slightly more involved. Landholders either obtain land on the market if $\omega_{i,t} > p_t$ or inherit it. To have $rp_t = \theta_L$ land supply must exceed demand by skilled agents, that is $\mu(i : \theta_{i,t} = \theta_L, \lambda_{i,t} = 1) \geq \mu(i : \theta_{i,t} = \theta_H, \lambda_{i,t} = 0, \omega_i \geq p_t)$. Then the market allocation is determined by assigning land to all skilled agents with $\omega_{i,t} \geq p_t$ and uniformly rationing the excess supply of land among all unskilled agents i with $\lambda_{i,t} = 1$ or $\omega_{i,t} > p_t$. The probability of such an agent i to be assigned land on the spot market in period t is then given by q_t^L.

$$
\begin{aligned}
q_t^L &= \frac{\mu(i \in I : \theta_{i,t} = \theta_L, \lambda_{i,t} = 1) - \mu(i \in I : \theta_{i,t} = \theta_H, \lambda_{i,t} = 0, \omega_{i,t} \geq p_t)}{\mu(i \in I : \theta_{i,t} = \theta_L, \lambda_{i,t} = 1 \vee \omega_{i,t} \geq p_t)} \\
&= \frac{l - \frac{s}{1-s}\mu(i \in I : \omega_{i,t} \geq p_t, \lambda_{i,t} = 0)}{l + \mu(i \in I : \omega_{i,t} \geq p_t, \lambda_{i,t} = 0)}. \qquad (10)
\end{aligned}
$$

That is, $\lambda_{i,t+1}$ is given by

$$
\lambda_{i,t+1} = \begin{cases} 1 & \text{if } \theta_{i,t} = \theta_H, \lambda_{i,t} = 0 \vee \omega_{i,t} \geq \theta_L/r \\ 0 & \text{if } \lambda_{i,t} = 0, \omega_{i,t} < \theta_L/r \\ \begin{cases} 1 \text{ with prob. } q_t^L \\ 0 \text{ with prob. } 1 - q_t^L \end{cases} & \text{if } \theta_{i,t} = \theta_L, \lambda_{i,t} = 1 \vee \omega_{i,t} \geq \theta_L/r \end{cases} \qquad (11)
$$

Note that uniform rationing implies independence of endowment and land distributions among agents with unskilled parents endowed with land or sufficient food to pay the market price.

4.3 Markets for spot contracts when $rp = \theta_H$

Payoffs from holding land for unskilled agents are either 0 when not endowed with land or θ_H otherwise. Skilled agents earn 0 when not endowed with land or θ_H otherwise. That is, food endowments in period $t+1$ are

$$
\omega_{i,t+1} = br\omega_{i,t} + b \begin{cases} \theta_H & \text{if } \lambda_{i,t} = 1 \\ 0 & \text{if } \lambda_{i,t} = 0 \end{cases} \qquad (12)
$$

The unskilled sell all their land on the market. The skilled are indifferent between holding land or not. To have $rp_t = \theta_H$ we need excess demand, that is $\mu(i \in I : \theta_{i,t} = \theta_L, \lambda_{i,t} = 1) \leq \mu(i : \theta_{i,t} = \theta_H, \lambda_{i,t} = 0, \omega_{i,t} \geq p_t)$. Under uniform rationing the probability of a skilled agent with $\lambda_{i,t} = 1$ or $\omega_{i,t} > p_t$ to bequeath land is given by q_t^H.

$$
\begin{aligned}
q_t^H &= \frac{\mu_t(i : \lambda_{i,t} = 1)}{\mu_t(i : \theta_i = \theta_H, \lambda_i = 1 \vee \omega_i \geq p_t)} \\
&= \frac{l}{s(l + \mu_t(i : \lambda_{i,t} = 0 \wedge \omega_{i,t} \geq p_t))}. \qquad (13)
\end{aligned}
$$

That is, $\lambda_{i,t+1}$ is given by

$$\lambda_{i,t+1} = \begin{cases} 0 & \text{if } \lambda_{i,t} = 0, \omega_{i,t} < \theta_H/r \text{ or } \theta_{i,t} = \theta_L \\ \begin{cases} 1 \text{ with prob. } q_t^H \\ 0 \text{ with prob. } 1 - q_t^H \end{cases} & \text{if } \theta_{i,t} = \theta_H, \lambda_{i,t} = 0 \vee \omega_{i,t} \geq \theta_H/r \end{cases} \tag{14}$$

Note at this point that if demand for land exceeds supply in period t, this will also hold in period $t+1$ since agents' endowments are increasing in time as $br > 1$ thus reducing the measure of wealth constrained agents. That is, the price for land does not decrease in time once the there is sufficient demand for land to sustain the high price in some period.

Lemma 2 *Suppose a market for contracts is stable in period t with market price $p_t = \theta_H/r$. Then $p_{t+1} = p_t$.*

Proof: In Appendix.

5 Long Run Stability of Markets

Observe first that in the long run the market price for land depends only on whether the skilled can be satisfied with the stock of land. This is because the absence of credit markets has no impact on the market for land once the economy has grown sufficiently rich.

Lemma 3 *There exists $T < \infty$ such that for all $t > T$*

(i) $rp_t = \theta_L$ and $q_t^L = \frac{l-s}{1-s}$ if $l > s$, and

(ii) $rp_t = \theta_H$ and $q_t^H = \frac{l}{s}$ if $l < s$.

Proof: Start by noting that there exists $T < \infty$ such that $\underline{\omega}_T > \theta_H/r$, since $br > 1$ and $\underline{\omega}_0 > 0$. This implies $F_T(\overline{\omega}/r|\lambda = 0) = F_T(\theta_L/r|\lambda = 0) = 0$. Applying this to (1) yields $rp_T = \theta_L$ if $l > s$ and (ii) $rp_T = \theta_H$ if $l < s$. By (10), $q_T^L = \frac{l-s}{1-s}$ and by (13) $q_T^H = \frac{l}{s}$. Since $\underline{\omega}_t$ is strictly increasing in t, this must hold for $t > T$ as well. □

We are interested in the long run behavior of the economy depending on primitives and the initial distribution of food and land. In the following we analyze two cases, (i) $l > s$ and (ii) $l < s$.

5.1 Case $l > s$

By Lemma 3 the spot market price for land is given by $rp_t = \theta_L$ for sufficiently high t. Since $l > s$ there will be rationing on the spot market, skilled agents obtain land on the market with probability 1 and unskilled agents obtain land with probability q_t^L. This introduces a convenient independence between next period's distributions of land and food among descendants of unskilled agents. Thus, given stability of spot markets in t, the marginal distribution of food endowments in period $t+1$ is

$$\begin{aligned} F_{t+1}(\omega) &= sF_t\left(\frac{\omega}{br} - \frac{\theta_H}{r}, \lambda{=}1\right) + sF_t\left(\frac{\omega}{br} - \frac{\theta_H - \theta_L}{r}, \lambda{=}0\right) \\ &\quad + (1-s)F_t\left(\frac{\omega}{br} - \frac{\theta_L}{r}, \lambda{=}1\right) + (1-s)F_t\left(\frac{\omega}{br} | \lambda{=}0\right). \end{aligned}$$

This expression can be derived using the transition function (9). Using this intertemporal link between joint distributions we are able to derive bounds on the initial conditions sufficient and necessary for spot market stability.

Proposition 6 *Let $l > s$.*

(i) There exists $T < \infty$ such that markets are stable in every period $t = T + \tau$, $\tau = 1, 2, \ldots$ if

$$g_L^S(E_0(\omega), E_0(\omega|\omega < \hat{\omega}_0), l) < 1,$$

where g_L^S is a function $g_L^S : \mathbb{R}_+^3 \mapsto \mathbb{R}$ that increases in $E_0(\omega)$, decreases in $E_0(\omega|\omega < \hat{\omega}_0)$, and increases in l.

(ii) There exists $T < \infty$ such that markets are stable in every period $t = T + 2\tau - 1$ and markets are unstable in every other period $t = T + 2\tau$, $\tau = 1, 2, \ldots$ if

$$g_L^U(E_0(\omega), E_0(\omega|\omega < \hat{\omega}_0), l) > 1,$$

where g_L^U is a function $g_L^U : \mathbb{R}_+^3 \mapsto \mathbb{R}$ that increases in $E_0(\omega)$, decreases in $E_0(\omega|\omega < \hat{\omega}_0)$, and increases in l.

Proof: In Appendix.

Proposition 6 states that whenever initial period endowments are sufficiently high markets are stable if the initial distribution of food is sufficiently equal.[10] Conversely, there is a limit cycle if the initial endowment distribution is sufficiently unequal. This property carries over from the static equilibrium. Moreover, both the sufficient and the necessary condition tighten in l.

5.2 Case $l < s$

Again, we can state F_{t+1} in terms of F_t. Since $l < s$, a spot market allocates all land by uniform rationing to skilled agents thereby implying independence of next period's land and food endowment distributions. Hence, given stability of spot markets in period t the joint distribution of food and land endowments in period $t+1$ is given by

$$F_{t+1}(\omega) = F_t\left(\frac{\omega}{br} - \frac{\theta_H}{r}, \lambda{=}1\right) + F_t\left(\frac{\omega}{br}, \lambda{=}0\right)$$

Intuitively, markets assign all land randomly and independently from initial land and food endowments as the allocation of land depends only skill and uniform rationing.

Proposition 7 *Let $l < s$.*

(i) There exists $T < \infty$ such that markets are stable in every period $t = T + \tau$, $\tau = 1, 2, ...$ if

$$h_H^S\left(E_0(\omega|\omega > \hat{\omega}_0), E_0(\omega|\omega < \hat{\omega}_0), l\right) > 1,$$

where $h_H^S(.)$ is a function $h_H^S : \mathbb{R}_+^3 \mapsto \mathbb{R}$ that decreases in $E_0(\omega|\omega > \hat{\omega}_0)$, and increases both in $E_0(\omega|\omega < \hat{\omega}_0)$ and in l.

(ii) There exists $T < \infty$ such that markets are stable in every period $t = T + 2\tau - 1$ and markets are unstable in every other period $t = T + 2\tau$, $\tau = 1, 2, ...$ if

$$h_H^U\left(E_0(\omega|\omega > \hat{\omega}_0), E_0(\omega|\omega < \hat{\omega}_0), l\right) < 1,$$

where $h_H^U(.)$ is a function $h_H^U : \mathbb{R}_+^3 \mapsto \mathbb{R}$ that decreases in $E_0(\omega|\omega > \hat{\omega}_0)$, and increases both in $E_0(\omega|\omega < \hat{\omega}_0)$ and in l.

(iii) If $\underline{\omega}_0 > \theta_H/r$, markets are stable every period if for all $t = \tau$, $\tau = 1, 2, ...$

$$h_H\left(E_0(\omega|\omega > \hat{\omega}_0), E_0(\omega|\omega < \hat{\omega}_0), l, t\right) < 1,$$

[10] An increase in inequality corresponds to a decrease in $E_0(\omega|\omega < \hat{\omega}_0)$ keeping constant $E_0(\omega)$.

and a two-period limit cycle emerges if for all $t = 2\tau$, $\tau = 1, 2, ...$

$$h_H\left(E_0(\omega|\omega > \hat{\omega}_0), E_0(\omega|\omega < \hat{\omega}_0), l, t\right) \geq 1,$$

where $h_H^U(.)$ *is a function* $h_H^U : \mathbb{R}_+^3 \times \mathbb{N} \mapsto \mathbb{R}$ *that for each* t *decreases in* $E_0(\omega|\omega > \hat{\omega}_0)$*, and increases both in* $E_0(\omega|\omega < \hat{\omega}_0)$ *and in* l*.*

Proof: In Appendix.

This means that also in case of (asymptotic) scarcity of land sustainability of spot markets depends on the initial distribution of food. A more unequal initial food distribution makes a limit cycle more likely, again a property that is inherited from the static equilibrium. For $l < s$ slackness of both necessary and sufficient conditions for sustainable markets increases in l. Part (iii) of the Proposition gives a necessary and sufficient condition for sustainability of markets in form of a sequence depending on t.

5.3 Land and Inequality

Let us summarize the impact of changes in parameters on sustainability of markets.

Corollary 1 *If period* 0 *initial endowments are both sufficiently great and sufficiently equally distributed, markets are sustainable. If land is abundant, that is* $l > s$*, sustainable markets become more likely as land becomes scarcer. If land is scarce, that is* $l < s$*, sustainable markets become more likely as land becomes more abundant.*

That is, comparative statics from the static equilibrium go through with respect to endowment inequality for the dynamic case as well. Moreover, in our framework, agents on the short market side gain positive rents and support markets. A smaller mismatch on the market increases their measure and thus facilitates sustainable markets.

5.4 Persistent Elites

The presence of a limit cycle in an economy may be compatible with either persistent elites or social mobility. This is stated in the following proposition.

Proposition 8 *Elites are persistent, i.e. for all* $i, j \in I$ $\omega_{i,t} > \hat{\omega}_t > \omega_{j,t}$ *implies* $\omega_{i,t+2} > \hat{\omega}_{t+2} > \omega_{j,t+2}$ *for all* $t > T$*,* T *sufficiently great, if there is a* *limit cycle where markets and expropriation alternate for all t and either (i) $l < s$, or (ii) $l > s$ and $\theta_H < \theta_L/2$.*

Proof: Note first that in a period t when markets are not stable, $\omega_{i,t} > \hat{\omega}_t > \omega_{j,t}$ implies $\omega_{i,t+1} > \hat{\omega}_{t+1} > \omega_{j,t+1}$ for all $i, j \in I$, that is there is almost no social mobility by definition. In $t+1$ under spot markets

$$\begin{aligned} \omega_{i,t+2} &\geq br(\omega_{i,t+1} + p_{t+1}) \text{ and} \\ \omega_{j,t+2} &\leq br(\omega_{j,t+1} - p_{t+1}) + b\theta_H. \end{aligned}$$

Taking the minimum (maximum) with respect to ω over both classes of agents yields a sufficient condition to have $\omega_{i,t+2} > \hat{\omega}_{t+2} > \omega_{j,t+2}$ for all i, j defined as above.[11]

$$br(\hat{\omega}_{t+1} + p_{t+1}) > br(\hat{\omega}_{t+1} - p_{t+1}) + b\theta_H,$$

that is $2p_{t+1} > \theta_H/r$. If $rp_{t+1} = \theta_H$ this always holds, and in case $rp_{t+1} = \theta_L$ it holds whenever $\theta_H < \theta_L/2$. Using Lemma 3 the proposition follows. □

Proposition 8 states that social mobility is precluded when the market allocates the surplus to the landholders, that is when land is scarce. To have social mobility both return on skills must be sufficiently high and skill must be scarce relative to land, so that surplus goes to the skilled on the market. Note that this finding has the flavor of a resource curse when land is interpreted as natural resources.

Intuitively, elites are persistent when buyers of land cannot accumulate sufficient food for their offspring to overtake sellers' offspring. To see this, suppose that in period t expropriation occurs. In $t+1$ the jungle is replaced by spot markets. Sellers of previously expropriated land may earn enough to preserve their rank in the food distribution at the end of period $t+1$. This is the case if sellers get the surplus on the spot market or the productivity difference between skilled and unskilled agents is sufficiently small.

5.5 Long Run Growth Rates

Growth rates in an economy with the possibility of expropriation are linked to stability of markets. The assumption $br > 1$ guarantees that the growth rate

[11] Since skill is drawn independently the condition is also necessary if there exist neighborhoods $\omega \in (\hat{\omega} - \epsilon, \hat{\omega}_{t+1})$ and $\omega \in (\hat{\omega}, \hat{\omega}_{t+1} + \epsilon)$ both endowed with positive measure according to F_{t+1}, that is if $\min_{i \in I: \lambda_{i,t+1}=1} = \hat{\omega}_{t+1}$ and $\max_{i \in I: \lambda_{i,t+1}=0} = \hat{\omega}_{t+1}$.

will be positive and converge to br as t goes out of bounds, since aggregate land endowment remains constant. Since markets allocate land to its most productive use, wealth accumulation can be expected to be faster in economies with stable markets. Denote food holdings in an economy by ω_t^S when markets are sustainable and by ω_t^U if there is a limit cycle.

Corollary 2 *Economies with stable markets accumulate wealth faster than do economies where markets are unstable, that is* $E_{t+\tau}(\omega^S) > E_{t+\tau}(\omega^U)$ *for all* $\tau > 1$ *if* $E_t(\omega^S) \geq E_t(\omega^U)$.

This statement follows directly from $\min\{s;l\}\theta_H + \max\{l-s;0\}\theta_L > l(s\theta_H + (1-s)\theta_L)$. The next result gives growth rates depending on long run stability of markets. If there is a two-period limit cycle periods of very low growth under expropriation are followed by periods of high growth when markets take place and the previous efficiency losses are partially recovered.

Proposition 9 (Growth Rates)

(i) In an economy with sustainable markets the growth rate in period t *is positive and strictly decreasing in* t *and given by*

$$g_t^S = b\left(r + \frac{\min\{s;l\}\theta_H + \max\{l-s;0\}\theta_L}{E_t(\omega)}\right) - 1.$$

(ii) In an economy with a two-period-limit-cycle the growth rate is positive and given by

$$g_t^U = b\left(r + l\frac{s\theta_H + (1-s)\theta_L}{E_t(\omega)}\right) - 1$$

for periods t *when markets not stable and by*

$$g_{t'}^U = b\left(r + \frac{\min\{s;l\}\theta_H + \max\{l-s;0\}\theta_L}{E_{t'}(\omega)}\right) - 1$$

for periods t' *when markets are stable.*

Proof: In Appendix.

In an economy where markets are unstable and there is a limit cycle there is room for non-monotonic behavior of the growth rate: in periods with stable markets the growth rate will exceed the one of the previous period when markets were not stable. This is verified in the following proposition.

Proposition 10 (Fluctuations of the growth rate) *Suppose an economy possesses a two-period limit cycle and* $\min\{s; l\}\theta_H + \max\{l-s; 0\}\theta_L > brl(s\theta_H + (1-s)\theta_L)$*. Then there exists* $t < \infty$ *with stable markets in* t *such that* $g_t^U < g_{t+1}^U$ *and* $g_{t+1}^U > g_{t+2}^U$*.*

Proof: Note that $g_t^U < g_{t+1}^U$ holds if br is sufficiently close to 1 since

$$E_{t+1}(\omega) = brE_t(\omega) + bls\theta_H + bl(1-s)\theta_L.$$

Using the facts that $\underline{\omega}_t > p$ and $E(\omega_t)$ is strictly increasing in t, it must hold that if $\min\{s; l\}\theta_H + \max\{l-s; 0\}\theta_L > brl(s\theta_H + (1-s)\theta_L$ there exists τ sufficiently great such that $g_t^U < g_{t+1}^U$ for all $t > \tau$. □

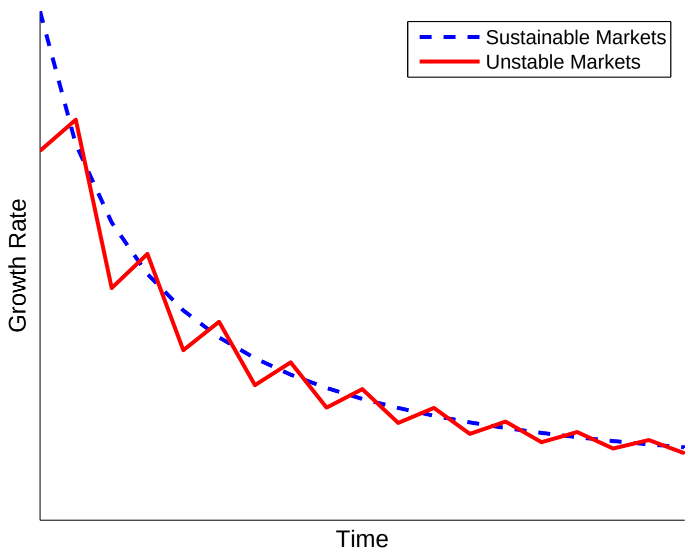

Figure 3: Growth rates depending on stability of spot markets

An example for possible growth paths of two economies that have equal initial period aggregate food endowments but differ in the distribution is depicted in Figure 3.[12]

[12]To generate the figure parameters were chosen such that $s > l$ and $s\theta_H > brl(s\theta_H + (1-s)\theta_L$.

6 Case Study

To illustrate our point further we look at the postwar development of three Asian countries, Korea, Malaysia and the Philippines.[13] In the beginning of the 1960ies all three countries looked reasonably similar in terms of key socio-economic indicators such as per capita GDP, school enrollment, life expectancy, share of urban population. Our observations start shortly after the Korean war, suggesting that Korea was at a disadvantage. The economic growth paths experienced by these countries look, however, remarkable different. Korea's annual growth rate averaged 5.9 % p.a. in the period 1960-2004, Malaysia's 4.6 % p.a. and the Philippines' 1.5 % p.a.

A brief glance at the development of political institutions does not reveal striking differences either. All three countries emerged as sovereign nations only after the Second World War, Korea and Philippines from Japanese occupation and Malaysia from British colonial rule. Each country had its share of authoritative government, the Philippines under the Marcos, Malaysia under the Mahathir, and Korea during the Rhee and Park administrations. In all countries the government assumed an active role and pursued economic policies aimed at promoting industrialization.

A difference did exist in the level of economic inequality in the three countries in the beginning of the 1960ies. Whereas Korea was a remarkably equal country after a land reform in the late 1940ies that created a large class of small landholders, both Malaysia and the Philippines were characterized by high income inequality (as measured by Gini coefficient and quantile ratios). Moreover, Korea had no ethnic fractionalization to speak of unlike both Malaysia and the Philippines.

Indeed a case can be made that economic institutions in the three countries evolved strikingly different. Economic interaction in the Philippines was subject to high corruption, threat of expropriation by the government, and occasional social and religious unrest and conflict for most of the period of observation. In Malaysia positive discrimination in education towards ethnic Malays distorted education choice. As a consequence of the crisis in 1969 positive discrimination was extended, business ownership for non-ethnic Malays was severely restricted and large public companies had to provide Malays with well-paid jobs. In contrast economic activity in Korea took place under secure

[13]The interested reader may not that our choice of countries mirrors the one of Bénabou (1996) adding Malaysia.

property rights. Distortions by the government were mainly due to loan and export subsidization.

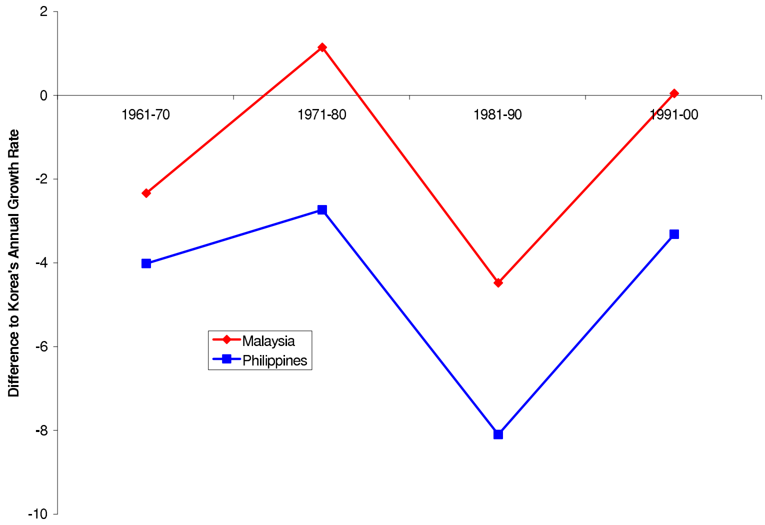

Figure 4: Difference to Korea's average annual per capita growth rate

That is, whereas in Korea markets appear to have been mostly stable in our terminology, markets in Malaysia seemed to operate under a constraint on the distribution of rents, and markets in the Philippines were subject to expropriation in form of corruption and kleptocracy and conflict. Comparing the growth rates of Malaysia and the Philippines with Korea's reveals a cyclical behavior as depicted in Figure 4 and predicted by the model.[14]

7 Summary and Conclusion

We presented a very simple framework where economic outcomes are determined by robustness to coalitional deviations of agents. This restriction serves to capture quality of economic institutions on an abstract level as a condition directly on the primitives of the model. We argue that our choice of modeling approach is instructive since despite its simplicity a rich set of outcomes is possible. A subset of the model's results, such as persistent elites, have already been generated in less abstract frameworks thus indicating that the present approach to embed quality of economic institutions connects well with the existing literature. Moreover, we find that static stability of market allocations

[14]The cyclical behavior in Figure 4 is not limited to the particular choice of period length. Similar patterns appear with different choices of interval lengths.

is favored by more equal endowment distributions and higher correlation of rent and endowment. Long run stability of market allocations becomes more likely both as initial period endowment inequality and the mismatch between market demand and supply decreases.

Of course, the present approach willingly gives up complexity to achieve mathematical tractability. Yet, given the results, a number of directions come to mind that future research may successfully pursue. One natural extension extends the set of feasible contracts to include spot, debt, future and contingent contracts and thus allows for the development of a state of anarchy into full Arrow-Debreu markets. This yields a number of potentially interesting strategic considerations. For instance, stability of debt contracts will be driven by a trade-off in the present period between an increase in demand due to relaxing budget constraints and higher incentives to expropriate due to the existence of a spot market next period.

A second extension that looks fruitful consists in enriching the model by allowing for ethnic groups such that collective action is less costly among agents of the same ethnicity may yield another set of testable predictions linking market outcomes to the degree of ethnic fractionalization.

Another valuable endeavor lies in considering stability of markets within a full-blown endogenous growth model. By introducing an investment decision both its relationship between market stability may be explored and the mismatch between demand and supply on the market becomes endogenous. The latter enables the possibility that only market allocations supporting certain distributions of surplus may be sustainable.

Finally, note that removing endogenous growth (by setting $br < 1$) easily allows for a poverty trap that arises from the interaction of credit market frictions and stability of market outcomes. We conjecture that poverty traps found in such a model need not coincide with traditional individual poverty traps.

A Proofs

Proof of Proposition 1

Net demand for land $D(p_t)$ on a spot market in some period t depends on the market price p_t and is given by

$$D(p_t)=\begin{cases}\mu(i|\lambda_{i,t}=0,\omega_{i,t}\geq p_t) & \text{if } 0<rp_t<\theta_L\\ [\mu(i|\lambda_{i,t}=0,\omega_{i,t}\geq p_t,\theta_{i,t}=\theta_H),\mu(i|\lambda_{i,t}=0,\omega_{i,t}\geq p_t)] & \text{if } rp_t=\theta_L\\ \mu(i|\lambda_{i,t}=0,\omega_{i,t}\geq p_t,\theta_{i,t}=\theta_H) & \text{if } \theta_L<rp_t<\theta_H\\ [0,\mu(i|\lambda_{i,t}=0,\omega_{i,t}\geq p_t,\theta_{i,t}=\theta_H)] & \text{if } rp_t=\theta_H\\ 0 & \text{if } rp_t>\theta_H\end{cases}$$

Supply of land $S(p_t)$ is given analogously by

$$S(p_t)=\begin{cases}0 & \text{if } 0\leq rp_t<\theta_L\\ [0,\mu(i:\lambda_{i,t}=1,\theta_{i,t}=\theta_L)] & \text{if } rp_t=\theta_L\\ \mu(i:\lambda_{i,t}=1,\theta_{i,t}=\theta_L) & \text{if } \theta_L<rp_t<\theta_H\\ [\mu(i:\lambda_{i,t}=1,\theta_{i,t}=\theta_L),\mu(i:\lambda_{i,t}=1)] & \text{if } rp_t=\theta_H\\ \mu(i:\lambda_{i,t}=1) & \text{if } rp_t>\theta_H\end{cases}$$

Equalizing supply and demand yields the expression in the proposition. The second part is immediate from (1) and $0\leq F_t(.|\lambda_{i,t}=0)\leq 1-l$. □

Proof of Lemma 1

Note that $v(\theta_i,\omega_i^M,\lambda_i^M)<v(\theta_i,\lambda_i',\omega_{i,t})$ if $\lambda_i'=1$ and $\lambda_{i,t}=0$. $v(\theta_i,\omega_i^M,\lambda_i^M)>v(\theta_i,\lambda_i',\omega_{i,t})$ if $\lambda_i'=0$ and $\lambda_{i,t}=1$, or if $\lambda_i'=0$ and $\lambda_{i,t}=0$ but $rp_t<\theta_i$ and $p_t<\omega_{i,t}$, or if $\lambda_i'=1$ and $\lambda_{i,t}=1$ but $rp_t>\theta_i$. Define accordingly

$$\begin{aligned}C &= \{i\in I:\lambda_i'<\lambda_{i,t}=1\}\cup\{i\in I:\lambda_i'=\lambda_{i,t}=0\wedge rp_t<\theta_i\wedge p_t<\omega_{i,t}\}\\ &\quad\cup\{i\in I:\lambda_i'=\lambda_{i,t}=1\wedge rp_t>\theta_i\},\\ C' &= \{i\in I:\lambda'>\lambda_{i,t}\}.\end{aligned}$$

Stability of markets with respect to a coalitional expropriation means

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

The optimal coalitional expropriation λ' then solves

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

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

$$\Delta(i) = \begin{cases} 0 & \text{if } i \in C \text{ for } \lambda_i' = 0, \lambda_i' = 1 \\ 0 & \text{if } i \in C' \text{ for } \lambda_i' = 0, \lambda_i' = 1 \\ \omega_{i,t} & \text{if } i \in C \text{ for } \lambda' = 0, i \notin C', i \notin C \text{ for } \lambda_i' = 1 \\ \omega_{i,t} & \text{if } i \notin C, i \notin C' \text{ for } \lambda' = 0, i \in C' \text{ for } \lambda_i' = 1 \\ 2\omega_{i,t} & \text{if } i \in C \text{ for } \lambda' = 0, i \in C' \text{ for } \lambda_i' = 1 \end{cases}$$

All other cases can be excluded. Since the constraint binds with equality for the optimal coalitional expropriation $\lambda_i' = 1$ if $\Delta(i) > \widetilde{\omega}$, with $\widetilde{\omega} : \mu(i \in I : \Delta(i) \geq \widetilde{\omega}) = l \wedge \widetilde{\omega} = 0$. Conditioning on the market price p_t the statement in the lemma follows. □

Proof of Proposition 3

Stability with respect to expropriation follows immediately from the assumption in the proposition since it implies that the RHS of (3), (4), and (5) are all zero, while the LHS are non-negative. Turn now to stability of the market allocation with respect to optimal coalitional redistribution when $rp_t = \theta_H$, that is condition (6) which can be rewritten to yield

$$(1-s)\int_{\hat{\omega}_t}^{\overline{\omega}_t} \omega_i dF(\omega_i, \lambda_i{=}1) \geq \int_{\widetilde{\omega}}^{\hat{\omega}_t} \omega_i dF(\omega_i, \lambda_i{=}0).$$

This condition must hold with strict inequality since $\widetilde{\omega}$ has the property that $\mu(i \in I : \widetilde{\omega} < \omega_{i,t} < \hat{\omega}_t, (\theta_{i,t}, \lambda_{i,t}) \neq (\theta_L, 1)) \leq \mu(i \in I : \omega_{i,t} > \hat{\omega}_t, (\theta_{i,t}, \lambda_{i,t}) = (\theta_L, 1))$ and $\omega_{i,t} \geq \omega_{j,t}$ for all i with $(\theta_{i,t}, \lambda i, t) = (\theta_L, 1)$ and j with $(\theta_{j,t}, \lambda j, t) \neq (\theta_L, 1)$ with strict inequality for some i, j with positive measure whenever $\overline{\omega}_t \neq w_0$.

When $rp_t = \theta_L$ condition (7) can be rewritten to yield

$$\int_{\hat{\omega}_t}^{\widetilde{\omega}} \omega_i dF(\omega_i, \lambda_i{=}1) + s\int_{p}^{\widetilde{\omega}/2} \omega_i dF(\omega_i, \lambda_i{=}0) - s\int_{\widetilde{\omega}/2}^{\hat{\omega}_t} \omega_i dF(\omega_i, \lambda_i{=}0) \geq 0.$$

Again, since $\widetilde{\omega}$ is optimally chosen such that $\mu(i \in I : \widetilde{\omega}/2 \leq \omega_{i,t} \leq \widetilde{\omega}, (\theta_{i,t}, \lambda i, t) = (\theta_H, 0)) = l - \mu(i \in I : \hat{\omega}_t \leq \omega_{i,t} \leq \widetilde{\omega}, (\theta_{i,t}, \lambda i, t) \neq (\theta_H, 0))$, the above condition holds, as $\omega_{i,t} \geq \omega_{j,t}$ for all i with $(\theta_{i,t}, \lambda i, t) \neq (\theta_H, 0)$ and j with $(\theta_{j,t}, \lambda j, t) \neq (\theta_H, 0)$ with strict inequality for some i, j with positive measure whenever $\overline{\omega}_t \neq w_0$. A similar argument applies to the case $\theta_L < rp_t < \theta_H$. For the last statement note that $\hat{\omega}_t \leq \theta_L/r$ implies that $rp_t = \theta_L$ and land is obtained on the market only by agents i with $\omega_{i,t} \geq \hat{\omega}_t$. Since these agents already hold land the market allocation is the endowment allocation which coincides with the allocation under expropriation. $\square$

Proof of Proposition 4

In case $rp_t = \theta_H$ markets are stable if

$$\begin{aligned}&\int_{\underline{\omega}_t}^{\hat{\omega}_t} \omega_i dF_t(\omega_i, \lambda_i = 1) + (1-s) \int_{\hat{\omega}_t}^{\overline{\omega}_t} \omega_i dF_t(\omega_i, \lambda_i = 1) \\ &-s \int_{\widetilde{\omega}}^{\hat{\omega}_t} \omega_i dF_t(\omega_i, \lambda_i = 1) - \int_{\widetilde{\omega}}^{\overline{\omega}_t} \omega_i dF_t(\omega_i, \lambda_i = 0) \geq 0.\end{aligned}$$

Redistributing Δ units of foods by uniformly taking from agents $i \in \{i \in I : \omega_i > \hat{\omega}_t$ and uniformly giving to agents in $i \in \{i \in I : \omega_i < \widetilde{\omega}\}$ yields the following change in the LHS of the above condition

$$\left[\frac{1}{1-l} - \frac{1+(1-l)(1-s)}{l(1-l)} \mu(i \in I : \omega_i > \hat{\omega}_t \wedge \lambda_i = 1)\right] \Delta.$$

This expression is positive if s is sufficiently close to 1 or the correlation between events $\lambda_i = 1$ and $\omega_i > \hat{\omega}_t$ sufficiently low.

In case $rp_t = \theta_L$ markets are stable if

$$\begin{aligned}&\int_{\underline{\omega}}^{\widetilde{\omega}} \omega_i dF(\omega_i, \lambda_i{=}1) + s \int_{p}^{\widetilde{\omega}/2} \omega_i dF(\omega_i, \lambda_i{=}0) \\ &-s \int_{\widetilde{\omega}/2}^{\widetilde{\omega}} \omega_i dF(\omega_i, \lambda_i{=}0) \int_{\widetilde{\omega}}^{\overline{\omega}} \omega_i dF(\omega_i, \lambda_i{=}0) \quad \geq \quad 0.\end{aligned}$$

An adequate redistribution is given by taking Δ units of food uniformly from agents $i \in \{i \in I : \omega_i > \widetilde{\omega}\}$ and giving uniformly to agents $i \in \{i \in I : \omega_i < \widetilde{\omega}\}$. The change in the LHS of the above condition is given by

$$\begin{aligned}&\frac{\mu(i \in I : \omega_{i,t} < \widetilde{\omega}, \lambda_i = 1) - s\mu(i \in I : \omega' < \omega_{i,t} < \widetilde{\omega}, \lambda_i = 0)}{1 - \mu(i \in I : \omega_{i,t} > \widetilde{\omega})} \Delta \\ + \quad &\frac{\mu(i \in I : \omega_{i,t} > \widetilde{\omega}, \lambda_i = 0)}{\mu(i \in I : \omega_{i,t} > \widetilde{\omega})} \Delta\end{aligned}$$

This expression is nonnegative since $\mu(i \in I : \omega_{i,t} < \widetilde{\omega}, \lambda_i = 1) - s\mu(i \in I : \omega' < \omega_{i,t} < \widetilde{\omega}, \lambda_i = 0) = \mu(i \in I : \omega_{i,t} > \widetilde{\omega}) - \mu(i \in I : \omega_{i,t} > 0, \lambda_i = 1)$ by definition of $\widetilde{\omega}, \omega'$. In case $\theta_L < rp_t < \theta_H$ both arguments from above can be exploited. $\square$

Proof of Proposition 5

Let (λ^*, ω^*) denote a static equilibrium allocation. It is to show that there does not exist any feasible allocation $(\lambda', \omega') \neq (\lambda^*, \omega^*)$ with $v(\theta_i, \lambda'_i, \omega'_i) \geq v(\theta_i, \lambda^*_i, \omega^*_i)$ for all $i \in I$ with at least one strict inequality. By Proposition 2 (λ^*, ω^*) is either induced by a market or by expropriation.

Suppose first (λ^*, ω^*) is a spot market allocation. Hence, $v(\theta_i, \lambda^*_i, \omega^*_i) \geq v(\theta_i, \lambda_{i,t}, \omega_{i,t})$ for all $i \in I$. For any coalitional expropriation (λ', ω_t) it must hold that either $v(\theta_i, \lambda_{i,t}, \omega_{i,t}) = v(\theta_i, \lambda', \omega_{i,t})$ for all $i \in I$ or $v(\theta_i, \lambda_{i,t}, \omega_{i,t}) > v(\theta_i, \lambda', \omega_{i,t})$ for some $i \in I$. This implies that equilibrium allocations implied by markets are constrained Pareto efficient.

Suppose now (λ^*, ω^*) is an allocation under expropriation. Consider an allocation (λ^M, ω^M) implied by a spot market. In case $(\lambda^*, \omega^*) = (\lambda^M, \omega^M)$ trivially $v(\theta_i, \lambda^*_i, \omega_{i,t}) = v(\theta_i, \lambda^M_i, \omega^M_i)$ for all $i \in I$. In case $(\lambda^*, \omega^*) \neq (\lambda^M, \omega^M)$ it holds that $v(\theta_i, \lambda^*_i, \omega_{i,t}) > v(\theta_i, \lambda^M_i, \omega^M_i)$ for $i \in I$ with $\lambda^*_i = 1$, $\lambda_{i,t} = 0$ given a strictly positive market price. Suppose there does not exist $i \in I$ with $\lambda^*_i = 1$ and $\lambda_{i,t} = 0$. Then $\lambda^* = \lambda_t$, that is $\lambda_{i,t} = 1$ if $\omega_{i,t} \geq \hat{\omega}_t$ and $\lambda_{i,t} = 1$ if $\omega_{i,t} \geq \hat{\omega}_t$. But this implies that either $\lambda^* = \lambda'$ or, if not, by Proposition 3 that (λ^M, ω^M) is stable with respect to all other feasible allocations and thus that (λ^*, ω^*) is not an equilibrium allocation, a contradiction. Consider now an allocation $(\lambda', \omega') \neq (\lambda^*, \omega^*)$ implied by coalitional expropriation. Then $v(\theta_i, \lambda^*_i, \omega_{i,t}) > v(\theta_i, \lambda'_i, \omega_{i,t})$ for $i \in I$ with $\lambda^*_i = 1$, $\lambda'_i = 0$. Hence, equilibrium allocations implied by expropriation are constrained Pareto efficient. □

Proof of Lemma 2

Note first that $rp_t = \theta_H$ is equivalent to

$$\mu_t(\theta_{i,t} = \theta_L, \lambda_{i,t} = 1) \leq \mu_t(\theta_{i,t} = \theta_H, \lambda_{i,t} = 0, \omega_{i,t} \geq \theta_H/r).$$

Because of independence of θ and λ this is equivalent to

$$(1-s)l \leq s\mu_t(\lambda_{i,t} = 0, \omega_{i,t} \geq \theta_H/r).$$

Given the assumption we can construct the measure

$$\mu_{t+1}\left(i : \lambda_{i,t+1} = 0, \omega_{i,t+1} \geq \frac{\theta_H}{r}\right) = (1 - q_t^H s)\left[\mu_t\left(i : \lambda_{i,t} = 0, \omega_{i,t} \geq \frac{\theta_H}{r}\right) + \mu_t(i : \lambda_{i,t} = 1)\right] + \mu_t\left(i : \lambda_{i,t} = 0, \frac{\theta_H}{r} > \omega_{i,t} \geq \frac{1-b}{b}\right), \tag{15}$$

since $br > 1$ and therefore $\omega_{i,t+1} = br\omega_{i,t} + b\theta_H > \theta_H/r$ if $\lambda_{i,t} = 1$. Because $(1-s)l$ does not vary in time it suffices to show that

$$\mu_{t+1}(i : \lambda_{i,t+1} = 0, \omega_{i,t+1} \geq \theta_H/r) \geq \mu_t(\lambda_{i,t} = 0, \omega_{i,t} \geq \theta_H/r).$$

Using (15) we obtain

$$(1-q_t^H s)l + \mu_t\left(i : \lambda_{i,t}=0, \frac{\theta_H}{r} > \omega_{i,t} \geq \frac{1-b}{b}\right) \geq q_t^H s\mu_t\left(i : \lambda_{i,t}=0, \omega_{i,t} \geq \frac{\theta_H}{r}\right).$$

Using the expression for q_t^H from (13) shows that this condition holds true. Therefore $rp_t = \theta_H$ implies $rp_{t+1} = \theta_H$. □

Proof of Proposition 6

The proof proceeds in steps. First we determine a sufficient condition for stability of markets in any period $t+1$ given stable markets in t for $t, t+1$ such that $\underline{\omega}_t > \theta_L/r$. By Lemma 3 we know that there exists $T < \infty$ such that this is the case for all $t > T$. Then we transform this sufficient condition into a condition on initial period 0 endowments using an appropriate approximation of the growth path in periods $0, ..., t$. Finally, we repeat this exercise with a sufficient condition for unstable markets in period $t+1$ given stable markets in period t. Using the transition functions (9) and (11), and the uniform rationing among the unskilled according to (10) we know that

$$\begin{aligned} F_{t+1}(\omega) &= sF_t\left(\frac{\omega}{br} - \frac{\theta_H}{r}, \lambda=1\right) + sF_t\left(\frac{\omega}{br} - \frac{\theta_H - \theta_L}{r}, \lambda=0\right) \\ &\quad + (1-s)F_t\left(\frac{\omega}{br} - \frac{\theta_L}{r}, \lambda=1\right) + (1-s)F_t\left(\frac{\omega}{br}|\lambda=0\right), \quad (16) \end{aligned}$$

with the marginal distributions

$$\begin{aligned} F_{t+1}(\omega, \lambda=1) &= sF_t\left(\frac{\omega}{br} - \frac{\theta_H}{r}, \lambda=1\right) + sF_t\left(\frac{\omega}{br} - \frac{\theta_H - \theta_L}{r}, \lambda=0\right) \\ &\quad + \frac{l-s}{1-l}F_{t+1}(\omega, \lambda=0), \\ F_{t+1}(\omega, \lambda=0) &= (1-l)F_t\left(\frac{\omega}{br} - \frac{\theta_L}{r}|\lambda=1\right) + (1-l)F_t\left(\frac{\omega}{br}, \lambda=0\right). \end{aligned}$$

(i) Suppose markets were stable in period t. This is without loss of generality since otherwise by Proposition 3 markets will be stable in $t+1$ allowing to simply relabel periods. Markets are stable with respect to expropriation if

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

This is

$$E_{t+1}\left(\omega|\lambda\!=\!0\right)-E_{t+1}\left(\omega|\omega<\hat{\omega}_{t+1}\right)<\frac{s}{1-l}\int_{\underline{\omega}_{t+1}}^{\hat{\omega}_{t+1}}\omega dF_{t+1}\left(\omega,\lambda\!=\!0\right). \quad (17)$$

Since markets were stable in period t with $rp_t=\theta_L$ and land was rationed among the unskilled,

$$E_{t+1}\left(\omega|\lambda\!=\!0\right)=brE_t(\omega)+lb\theta_L. \quad (18)$$

Turn now to the RHS of (17). Note that if markets were unstable in $t-1$,

$$F_{t+1}\left(\hat{\omega}_{t+1},\lambda\!=\!0\right)\geq(1-l)^2=(1-l)(1-s)(1-q^L),$$

since $F_t(\hat{\omega}_t,\lambda\!=\!0)=F_{t-1}(\hat{\omega}_{t-1})=1-l$ in this case. If markets were stable in $t-1$ on the other hand, by the definition of $\hat{\omega}$ and (16)

$$\begin{aligned}F_{t+1}\left(\hat{\omega}\right) &= sF_t\left(\frac{\hat{\omega}_{1+t}}{br}-\frac{\theta_H}{r},\lambda\!=\!1\right)+sF_t\left(\frac{\hat{\omega}_{1+t}}{br}-\frac{\theta_H-\theta_L}{r},\lambda\!=\!0\right)\\ &\quad+(1-s)\left[F_t\left(\frac{\hat{\omega}_{1+t}}{br}-\frac{\theta_L}{r},\lambda\!=\!1\right)+F_t\left(\frac{\hat{\omega}_{1+t}}{br},\lambda\!=\!0\right)\right].\end{aligned}$$

Since $F_{t+1}\left(\hat{\omega}\right)=1-l$ we know that

$$1-l<F_t\left(\frac{\hat{\omega}_{1+t}}{br}-\frac{\theta_L}{r},\lambda\!=\!1\right)+F_t\left(\frac{\hat{\omega}_{1+t}}{br},\lambda\!=\!0\right).$$

But also $F_{t+1}(\hat{\omega}_{t+1},\lambda\!=\!0)\geq(1-l)\left(F_t\left(\frac{\hat{\omega}_{1+t}}{br}-\frac{\theta_L}{r},\lambda\!=\!1\right)+F_t\left(\frac{\hat{\omega}_{1+t}}{br},\lambda\!=\!0\right)\right)$ as all these agents have income $r\omega_i+\lambda_i\theta_L$ and do not bequeath land with probability $(1-l)$. Therefore $F_{t+1}(\hat{\omega}_{t+1},\lambda\!=\!0)\geq(1-l)^2$ in both cases and it follows that

$$\int_{\underline{\omega}_{t+1}}^{\hat{\omega}_{t+1}}\omega dF_{t+1}(\omega|\lambda\!=\!0)\geq(1-l)^2brE_t(\omega|\omega<\hat{\omega}_t). \quad (19)$$

Plugging (18) and (19) into (17) yields a sufficient condition for stability of spot markets in $t+1$:

$$E_t(\omega)+l\frac{\theta_L}{r}<\left(1+(1-l)s\right)E_t(\omega|\omega<\hat{\omega}_t).$$

Independently of whether spot markets are stable or not in any period t, $E_t(\omega)\leq brE_{t-1}(\omega)+b(s\theta_H+(l-s)\theta_L)$ and $E_t(\omega|\omega\leq\hat{\omega}_t)\geq brE_{t-1}(\omega|\omega<$

$\hat{\omega}_{t-1}$). Hence, an upper bound of the ratio of conditional expectations can be derived.

$$\frac{E_t(\omega)+l\frac{\theta_L}{r}}{E_t(\omega|\omega<\hat{\omega}_t)} < \frac{E_0(\omega)+b(s\theta_H+(l-s)\theta_L)\frac{(br)^t-1}{(br-1)(br)^t}+l\frac{\theta_L}{r(br)^t}}{E_0(\omega|\omega<\hat{\omega}_0)}$$
$$< \frac{E_0(\omega)+b(s\theta_H+(l-s)\theta_L)\frac{1}{br-1}+\frac{l\theta_L}{r}}{E_0(\omega|\omega<\hat{\omega}_0)}.$$

The sufficient condition follows

$$\frac{E_0(\omega)+b(s\theta_H+(l-s)\theta_L)\frac{1}{br-1}+\frac{l\theta_L}{r}}{E_0(\omega|\omega<\hat{\omega}_0)} < 1+(1-l)s.$$

Define $h_L^S\left(E_0(\omega),E_0(\omega|\omega<\hat{\omega}_0),l\right) = \frac{E_0(\omega)+b(s\theta_H+(l-s)\theta_L)\frac{1}{br-1}+\frac{l\theta_L}{r}}{E_0(\omega|\omega<\hat{\omega}_0)} - (1-l)s$. Taking the derivatives of $h_L^S(.)$ yields part (i) of the proposition.

(ii) Now turn to a sufficient condition for expropriation in period $t+1$. Suppose again that markets are stable in some period t. This is again without loss of generality. Stability of markets in period t implies

$$E_{t+1}(\omega|\omega<\hat{\omega}_{t+1}) \leq brE_t(\omega|\omega<\hat{\omega}_t)+b(s\theta_H+(1-s)\theta_L).$$

Note that aggregate wealth of all poor agents must exceed aggregate wealth of poor agents without land:

$$\int_{\underline{\omega}_{t+1}}^{\hat{\omega}_{t+1}} \omega dF_{t+1}\left(\omega,\lambda{=}0\right) \leq (1-l)E_{t+1}(\omega|\omega<\hat{\omega}_{t+1}).$$

Using these expressions and (18) on (17) a necessary condition for stability of markets in $t=1$ is

$$brE_t(\omega)+lb\theta_L > (1{+}s)\left(brE_t(\omega|\omega<\hat{\omega}_t)+b(s\theta_H+(1{-}s)\theta_L)\right).$$

Note that $E_t(\omega) \geq brE_{t-1}(\omega)+bl\theta_L$ and $E_t(\omega|\omega<\hat{\omega}_t) \leq brE_{t-1}(\omega|\omega<\hat{\omega}_{t-1})+b(s\theta_H+(1-s)\theta_L)$ for any period independent of stability of markets. That is

$$\frac{E_t(\omega)+l\frac{\theta_L}{r}}{E_t(\omega|\omega{<}\hat{\omega}_t)+\frac{s\theta_H+(1-s)\theta_L}{r}} \geq \frac{E_0(\omega)+\frac{(br)^{t+1}-1}{(br-1)(br)^{t+1}}bl\theta_L}{E_0(\omega|\omega<\hat{\omega}_0)+b(s\theta_H+(1-s)\theta_L)\frac{(br)^{t+1}-1}{(br-1)(br)^{t+1}}}$$
$$> \frac{E_0(\omega)+\frac{l\theta_L}{r}}{E_0(\omega|\omega<\hat{\omega}_0)+b(s\theta_H+(1-s)\theta_L)\frac{1}{br-1}}.$$

Hence, a necessary condition is given by

$$\frac{E_0(\omega) + \frac{l\theta_L}{r}}{E_0(\omega|\omega < \hat{\omega}_0) + b(s\theta_H + (1-s)\theta_L)\frac{1}{br-1}} > 1 + s.$$

Define $h_L^U\left(E_0(\omega), E_0(\omega|\omega < \hat{\omega}_0), l\right) = \frac{E_0(\omega)+\frac{l\theta_L}{r}}{E_0(\omega|\omega<\hat{\omega}_0)+b(s\theta_H+(1-s)\theta_L)\frac{1}{br-1}} - s$. Taking the derivatives of $h_L^U(.)$ then establishes the proposition. □

Proof of Proposition 7

The proof of this proposition is analogous to the proof of Proposition 6. Choose t such that $\underline{\omega}_t \geq \theta_H/r$. This is possible for $t < \infty$ by Lemma 3. Using the transition functions (12) and (14), and the uniform rationing among the unskilled according to (13) we know that

$$\begin{aligned} F_{t+1}(\omega) &= F_t\left(\frac{\omega}{br} - \frac{\theta_H}{r}, \lambda{=}1) + F_t(\frac{\omega}{br}, \lambda{=}0\right) \\ F_{t+1}(\omega, \lambda{=}1) &= lF_t\left(\frac{\omega}{br} - \frac{\theta_H}{r}, \lambda{=}1\right) + lF_t\left(\frac{\omega}{br}, \lambda{=}0\right), \\ F_{t+1}(\omega, \lambda{=}0) &= \frac{1-l}{l} F_{t+1}\left(\omega, \lambda{=}1\right). \end{aligned} \tag{20}$$

(i) Suppose markets are stable in period t without loss of generality. Using (20) on the stability condition (3) for period $t+1$ under high prices yields

$$\int_{\underline{\omega}_{t+1}}^{\hat{\omega}_{t+1}} \omega dF_{t+1}(\omega, \lambda{=}1) > \left(\frac{1-l}{l} - (1-s)\right) \int_{\hat{\omega}_{t+1}}^{\overline{\omega}_{t+1}} \omega dF_{t+1}(\omega, \lambda{=}1).$$

This expression is, since land is distributed independently among skilled agents in period t by uniform rationing, by (20) equivalent to

$$l \int_{\underline{\omega}_{t+1}}^{\hat{\omega}_{t+1}} \omega dF_{t+1}(\omega) > l\left(\frac{1-l}{l} - (1-s)\right) \int_{\hat{\omega}_{t+1}}^{\overline{\omega}_{t+1}} \omega dF_{t+1}(\omega).$$

That is,

$$E_{t+1}(\omega|\omega < \hat{\omega}_{t+1}) > \left(1 - \frac{l(1-s)}{1-l}\right) E_{t+1}(\omega|\omega > \hat{\omega}_{t+1}). \tag{21}$$

Note that, independently of whether markets are stable in any period t or not, $E_{t+1}(\omega|\omega < \hat{\omega}_{t+1}) \geq brE_t(\omega|\omega < \hat{\omega}_t)$. $E_{t+1}(\omega|\omega > \hat{\omega}_{t+1}) \leq brE_t(\omega|\omega > \hat{\omega}_t) + b\theta_H$. Since, regardless of stability of markets or expropriation, not more than a fraction s of the rich in period t may obtain θ_H twice in two consecutive periods, for any period $t > 2$ it must hold that

$$E_t(\omega|\omega > \hat{\omega}_t) \leq (br)^2 E_{t-2}(\omega|\omega > \hat{\omega}_{t-2}) + b\theta_H + b^2 r(s\theta_H + (1-s)\theta_L).$$

Therefore

$$E_{t+1}(\omega|\omega > \hat{\omega}_{t+1}) \leq (br)^{t+1} E_0(\omega|\omega > \hat{\omega}_0) + b(\theta_H + brE[\theta] + (br)^2\theta_H + ...),$$

with $E[\theta] = s\theta_H + (1-s)\theta_L$. That is, a lower bound on the ratio of conditional expectations is given by

$$\begin{aligned}\frac{E_{t+1}(\omega|\omega < \hat{\omega}_{t+1})}{E_{t+1}(\omega|\omega > \hat{\omega}_{t+1})} &\geq \frac{(br)^{t+1} E_0(\omega|\omega < \hat{\omega}_0)}{(br)^{t+1} E_0(\omega|\omega > \hat{\omega}_0) + b(\theta_H + brE[\theta] + (br)^2\theta_H + ...)} \\ &\geq \frac{E_0(\omega|\omega < \hat{\omega}_0)}{E_0(\omega|\omega > \hat{\omega}_0) + b\theta_H \frac{1}{br-1}}.\end{aligned}$$

Hence, a sufficient condition for stable markets independent of t is given by

$$\frac{E_0(\omega|\omega < \hat{\omega}_0)}{E_0(\omega|\omega > \hat{\omega}_0) + b\theta_H \frac{1}{br-1}} > 1 - \frac{l(1-s)}{1-l}. \quad (22)$$

Define now $h_H^S\left(E_0(\omega|\omega > \hat{\omega}_0), E_0(\omega|\omega < \hat{\omega}_0), l\right) = \frac{E_0(\omega|\omega<\hat{\omega}_0)}{E_0(\omega|\omega>\hat{\omega}_0)+b\theta_H \frac{1}{br-1}} + \frac{l(1-s)}{1-l}$. Taking the derivatives of $h_H^S(.)$ establishes part (i) of the proposition.

(ii) Turn now to a sufficient condition for stability of expropriation in $t+1$. Since for all t $E_{t+1}(\omega|\omega < \hat{\omega}_{t+1}) \leq brE_t(\omega|\omega < \hat{\omega}_t) + b\theta_H$ and $E_{t+1}(\omega|\omega > \hat{\omega}_{t+1}) \geq brE_t(\omega|\omega > \hat{\omega}_t)$, an upper bound on the ratio of conditional expectations can be obtained as follows.

$$\begin{aligned}\frac{E_{t+1}(\omega|\omega < \hat{\omega}_{t+1})}{E_{t+1}(\omega|\omega > \hat{\omega}_{t+1})} &\leq \frac{(br)^{t+1} E_0(\omega|\omega < \hat{\omega}_0) + b\theta_H \frac{(br)^{t+1}-1}{br-1}}{(br)^{t+1} E_0(\omega|\omega > \hat{\omega}_0)} \\ &\leq \frac{E_0(\omega|\omega < \hat{\omega}_0) + b\theta_H \frac{1}{br-1}}{E_0(\omega|\omega > \hat{\omega}_0)}.\end{aligned}$$

Then a sufficient condition for unstable markets in periods $t+1$ following a period with stable markets is given by

$$\frac{E_0(\omega|\omega < \hat{\omega}_0) + b\theta_H \frac{1}{br-1}}{E_0(\omega|\omega > \hat{\omega}_0)} \geq 1 - \frac{l(1-s)}{1-l}. \quad (23)$$

Define $h_H^U\left(E_0(\omega|\omega > \hat{\omega}_0), E_0(\omega|\omega < \hat{\omega}_0), l\right) = \frac{E_0(\omega|\omega<\hat{\omega}_0)+b\theta_H \frac{1}{br-1}}{E_0(\omega|\omega>\hat{\omega}_0)} + \frac{l(1-s)}{1-l}$. Taking the derivatives of $h_H^S(.)$ establishes part (ii) of the proposition.

(iii) Suppose $\underline{\omega}_0 > \theta_H/r$. A sufficient condition for a two-period limit cycle starting in period 0 is for any period $t = 2\tau$, $\tau = 1, 2, ...$

$$\frac{(br)^{t+1} E_0(\omega|\omega < \hat{\omega}_0)}{(br)^{t+1} E_0(\omega|\omega > \hat{\omega}_0) + b(\theta_H + brE[\theta] + (br)^2\theta_H + ...)} \geq 1 - \frac{l(1-s)}{1-l}. \quad (24)$$

This is sufficient, since if markets are not stable in periods $t+1$ and $t-1$, $t > 0$, this implies

$$\begin{aligned} E_{t+1}(\omega|\omega < \hat{\omega}_{t+1}) &= brE_t(\omega|\omega < \hat{\omega}_t) = (br)^2 E_{t-1}(\omega|\omega < \hat{\omega}_{t-1}) \text{ and} \\ E_{t+1}(\omega|\omega > \hat{\omega}_{t+1}) &= brE_t(\omega|\omega > \hat{\omega}_t) + b\theta_H \\ &= (br)^2 E_{t-1}(\omega|\omega > \hat{\omega}_{t-1}) + b\theta_H + b^2 r(s\theta_H + (1-s)\theta_L). \end{aligned}$$

Therefore conditional expectations can be calculated:

$$E_{t+1}(\omega|\omega > \hat{\omega}_{t+1}) = (br)^{t+1} E_0(\omega|\omega > \hat{\omega}_0) + b(\theta_H + brE[\theta] + (br)^2\theta_H + ...),$$

Using the set of conditions (24) we can define a time dependent function $h_H\left(E_0(\omega|\omega > \hat{\omega}_0), E_0(\omega|\omega < \hat{\omega}_0), l, t\right) = \frac{E_0(\omega|\omega<\hat{\omega}_0)}{E_0(\omega|\omega>\hat{\omega}_0) + \frac{b(\theta_H + brE[\theta] + (br)^2\theta_H + ...)}{(br)^{t+1}}} + \frac{l(1-s)}{1-l}$. If $h_H(., t) > 1$ for all $t > 0$ then stable markets are sustainable and if $h_H(., t) \leq 1$ for all $t = 2\tau$, $\tau = 1, 2, ...$ a two-period limit cycle emerges. Taking the derivatives of h_H completes the proof of the proposition. □

Proof of Proposition 9

For part (i) suppose the economy reaches sustainable markets, that is for each $t \geq T$ such that $\underline{\omega}_T > p/r$ markets are stable. Then aggregate income in period t is given by $rE_t(\omega) + \min\{s; l\}\theta_H + \max\{l-s; 0\}\theta_L$. Since agents bequeath at a constant rate b,

$$E_{t+1}(\omega) = brE_t(\omega) + b\min\{s; l\}\theta_H + b\max\{l-s; 0\}\theta_L.$$

This means that the growth rate of aggregate wealth in an economy with sustainable spot markets g_t^S is given by

$$g_t^S = b\left(r + \frac{\min\{s; l\}\theta_H + \max\{l-s; 0\}\theta_L}{E_t(\omega)}\right) - 1.$$

It easy to see that g_t^S is strictly positive and therefore also decreasing in time t.

To show part (ii) suppose now that markets are not sustainable and there is two period cycle for $t \geq T$. Let markets be unstable in periods with even t and be stable in every other. When t is even and markets are not stable aggregate income in period t is given by $rE_t(\omega) + ls\theta_H + l(1-s)\theta_L$. Thus the growth rate of aggregate wealth for even periods t, g_t^U, is given by

$$g_t^U = b\left(r + l\frac{s\theta_H + (1-s)\theta_L}{E_t(\omega)}\right) - 1.$$

In odd periods $t+1$, when markets are stable, aggregate income is given by $rE_{t+1}(\omega) + \min\{s; l\}\theta_H + \max\{l-s; 0\}\theta_L$. This gives the growth rate of aggregate wealth in odd periods $t+1$, g_{t+1}^U, as follows.

$$g_{t+1}^U = b\left(r + \frac{\min\{s; l\}\theta_H + \max\{l-s; 0\}\theta_L}{E_{t+1}(\omega)}\right) - 1.$$

Both growth rates are positive and decreasing in t. □

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