# Colonies*

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**Abstract**

In many developing countries, the institutional framework governing economic life has its roots in the colonial period, when the interests of European settlers clashed with those of the native population or imported slaves. We examine the economic implications of this conflict in a framework where institutions are represented by the number of people with property-rights protection, i.e., "gun owners." In the model, gun owners can protect their own property, they can exploit others who do not own guns, and they may decide to extend property rights by handing out guns to previously unarmed people. The theory generates a "reversal of fortune" between colonies with many and few oppressed: income per capita is initially highest in colonies with many oppressed that can be exploited by gun owners, but later on excessive concentration of economic power becomes a hindrance for development.

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# 1 Introduction

A growing historical and empirical literature documents a "reversal in fortune" among former European colonies, i.e., countries that were economically successful initially were overtaken by others (such as the U.S. and Canada) that started out relatively poor (see Sokoloff and Engerman 2000 and Acemoglu, Johnson, and Robinson 2002). Table 1, adapted from Sokoloff and Engerman (2000), displays the basic pattern. In 1700, GDP per capita in economies such as Barbados and Cuba was at least 50 percent larger than in the colonies that were to become the United States. In 1800, both Argentina and Cuba were still ahead of the U.S. in terms of income per capita. Over the next 200 years, however, the initially successful countries fell behind slow starters such as the U.S. and Canada. Today, GDP per capita in the U.S. exceeds the level in Barbados, Cuba, or Argentina by a factor of two or three.

A number of authors argue that this pattern is due to institutions; in particular, institutions that were set up in the initially successful colonies turned out to be a hindrance for development later on. While there is empirical and historical support for this hypothesis, the argument raises a number of important questions for economic theory. First of all, one would like to know why different institutions were set up in different colonies in the first place, even though in many cases the colonizing power was the same European country. Second, one wonders why it was the institutions that were associated with the initially successful colonies that ultimately became a barrier to growth. The third, and arguably most important question is why differences in institutions were so persistent, despite the significant costs that inappropriate institutions imposed in terms of slowing economic growth. Put differently, if bad institutions really were the main culprit for former colonies' failure to develop at the same pace as the leading industrial nations, what prevented these countries from changing their institutions in order to reap enormous growth benefits?

The aim of this paper is to outline possible answers for these questions in a theoretical framework based on endogenous property rights. In our theory, property-rights institutions are represented as a state variable given by the number of peo-

| | 1700 | 1800 | 1900 | 1997 |
|---|---|---|---|---|
| Argentina | – | 102 | 52 | 35 |
| Barbados | 150 | – | – | 51 |
| Brazil | – | 50 | 10 | 22 |
| Chile | – | 46 | 38 | 42 |
| Cuba | 167 | 112 | – | – |
| Mexico | 89 | 50 | 35 | 28 |
| Peru | – | 41 | 20 | 15 |
| | | | | |
| Canada | – | – | 67 | 76 |

Table 1: "Reversal of Fortune" in the Americas: Income per Capita Relative to United States (U.S.=100; Source: Sokoloff and Engerman 2000).

ple with power in a country, i.e., "gun owners." Gun owners can protect their own property, they can trade with other gun owners in a standard market economy, and, crucially, they can exploit and expropriate others who do not own guns. In the words of Piccione and Rubinstein (2003), our economy is ruled by a combination of the "invisible hand of the market" and the "iron hand of the jungle." An important advantage of this framework is that property rights are represented as a continuous variable, given by the fraction of people in a country whose property rights are protected. We can therefore trace out the entire evolution of an economy from something close to a pure dictatorship with a small class of gun owners to a standard market economy with full property rights protection. This would be difficult to accomplish in a theory with a discrete set of distinct institutions.

Based on our representation of property rights institutions, a simple theory of colonization is developed where the colonizing power optimally determines the number of gun-owning settlers to be sent to each colony, where a colony is characterized by its technology and factor endowments, including the number of (unarmed) locals already present. After the initial colonization stage, political control passes to the gun owners in each colony. The key decision collectively taken by the gun owners is emancipation: they can decide to issue guns to some or all of the oppressed locals and slaves, and thereby issue them with property rights. The incentives for doing so stem from the fact that free labor is assumed to be complementary to physical capital, which, in turn, is owned by the existing gun owners.

Optimal colonization leads to an initial outcome where income per capita is highest in the colonies with the highest ratio of the unarmed to gun-owning settlers. Subsequently, capital accumulation leads to a rise of the industrial sector, with an associated increase in the demand for free labor. In the long run, emancipation takes place in all colonies. Emancipation proceeds faster, however, in colonies that start out with relatively few oppressed. Intuitively, there is a complementarity between a large population with property rights protection today and free labor tomorrow. People whose property rights are protected accumulate more capital, which in turn makes it attractive to issue even more property rights in the future in order to raise the return on this capital. The result is a reversal of fortune: Through faster emancipation, the initially poor colonies overtake the richer colonies in terms of income per capita.

The mechanism described here confirms the view of Sokoloff and Engerman (2000) that inequality is the key variable that lends persistence to institutions. When deciding on emancipation, the gun owners face a tradeoff between exploitation and efficiency. Freeing an oppressed worker entails a loss of rents, but also improves the overall efficiency of the economy. In colonies with relatively few gun owners relative to the oppressed population, the rents from exploitation are particularly large, so that substantial efficiency gains may be forgone in order to continue exploitation. Comparing across countries, gun owners in a colony with many oppressed people can be much better off than gun owners in a country with mostly free people, even if income per capita (i.e, income divided by the sum of gun owners and the oppressed) is substantially lower. This observation accounts for the persistence of inequality of property rights despite the apparent ill effects on development as measured by growth in income per capita.

The next section outlines the basic theoretical framework. In Section 4, we analyze outcomes during the initial colonization stage, when colonies are settled with gun owners and, possibly, slaves. Section 5 discusses the further evolution of a colony after political control passes to the local gun owners. Section 6 illustrates the results via simulations for a parameterized model economy, and Section 7 concludes.

## 2 Existing Literature

The empirical literature has put forth several pieces of evidence that property rights institutions are important for growth and financial development. With respect to output and growth, Hall and Jones (1999) find that institutions are important for explaining Solow residuals. Likewise, Parente and Prescott (2000) argue that incumbents erect barriers to entry which deter growth. Addressing the endogeneity concerns in a creative way, Acemoglu, Johnson, and Robinson (2001) use settler mortality as an instrument for institutions and argue that extractive institutions inhibit long run growth. Easterly and Levine (2003) and Rodrik, Subramanian, and Trebbi (2004) argue that the importance of geography is through its affect on institutions. Dollar and Kraay (2003) find that both trade and institutions affect long term growth. Concerning financial development, La Porta, Lopez-de Silanes, Shleifer, and Vishny (1998) examine the relationship between legal rules, quality of enforcement and concentration of ownership, and conclude that ownership concentration is affected by measures of the property rights of investors, or investor protection. Similarly, La Porta, Lopez-de Silanes, Shleifer, and Vishny (1997) show that countries with less investor protection have smaller capital markets, and La Porta, Lopez de Silanes, and Shleifer (1999) show that unless investor protection is very good, ownership is very concentrated. Finally Acemoglu, Johnson, and Robinson (2005) use an instrumental variables approach to provide evidence that protection against exploitation is more important than enforcement of private contracts for long run growth, investment, and financial development.

The idea that institutions are crucial determinants of growth is not uncontroversial, however. For example, Dixit (2004) illustrates how private contracts can substitute for institutions in several contexts. Engerman and Sokoloff (2003) make the related point that very different institutions can offer similar property rights enforcement, and what is important for progress is the adaptability of institutions. Finally, Glaeser, La Porta, Lopez-de-Silanes, and Shleifer (2004) also argue that both dictatorships and democracies alike can secure property rights, and so institutions per se do not influence growth.

Despite, or possibly because of, the debate over role of institutions in growth and financial development there has been considerable recent interest in the evolution of political and economic institutions. Particular focus has been paid to the comparison of democratic vs. oligarchic regimes. Acemoglu (2005) compares oligarchic and democratic institutions and studies how a tradeoff by the elite between barriers to entry and redistribution, which have both positive and negative effects on the wealth of the elite, determines the evolution of the distribution of power. Similarly, Gradstein (2006) highlights the role of democracy in the broad protection of property rights and in wealth redistribution. Cervellati, Fortunato, and Sunde (2006) study a model where democratization is the provision of productive public goods and the redistribution of income and the elite face tradeoffs between oppression and rebellion. In related studies, Acemoglu (2006) considers the negative effects of rent seeking behavior by the elite and the effects of somehow committing to limits on taxation, and Acemoglu and Robinson (2006a) consider the incentives of the elite to accept or block innovations in the spirit of Parente and Prescott (2000). Acemoglu and Robinson (2006b) consider the role of de jure and de facto power in the persistence of institutions, again emphasizing the role of wealth in political power. Acemoglu, Johnson, and Robinson (2005) summarizes and builds on these ideas. Acemoglu and Johnson (2005) argue that trade was important for the gain in power of the merchant class in colonial times, and had a larger positive effect in countries where institutions were more flexible. Rajan and Zingales (2003) and Falkinger and Grossmann (2005) focus on the role of open trade in reducing the returns to barriers to entry by the elite, also in the spirit of Parente and Prescott (2000). Bourguignon and Verdier (2000) study a model where education determines political participation and human capital, and where the elite may gain from educating the non-elite through externalities from education but must redistribute wealth in order to enable such education. Cervellati, Fortunato, and Sunde (2005) also focus on investment in human capital and demonstrate a shift in wealth as human capital increases in importance relative to natural resources. Engerman and Sokoloff (2005) argue that early distributions of voting rights have lasting impacts. Finally, in an example of concentrated power leading to better outcomes, Glaeser and Shleifer (2002) argue that the relative power of the monarchy in England reduced the possibility of coercion and led to the establishment of a legal system where trials by jury were possible.

Our paper builds on the evidence that geography and factor endowments influence growth through their effect on institutions. Specifically, we argue that factor endowments during the colonial era affected the ratio of free to enslaved labor and that this initial distribution of property rights had long run growth implications and drove the observed reversal of fortune in the colonies. Galenson (1996) describes the economies of the North American colonies. Bertocchi and Canova (2002) provide empirical evidence that the colonial experience was important for long run growth in African countries by exploiting within continent variation. Beckford (1971) argues that the plantation technology lead to long run differences in development between the North Atlantic and the third world. He argues that because most countries evolve from agricultural economies, agricultural technologies are crucial determinants of initial institutions. Dunn (1972) also emphasizes the effect of the availability of the plantation technology on variations in the types of societies set up in the colonies. Engerman and Sokoloff (1997) build on these ideas to argue that the roots of inequality are in the initial factor endowments of the colonies, including the quality of the land and the size of the indigenous population. Grossman and Iyigun (1993) study the choice of investment in colonies in order to maximize profits when production technologies and the indigenous threat vary. Engerman and Sokoloff (2003) emphasize the importance of slavery in particular on the distribution of wealth and political power, and note that there are important differences in development within legal systems (such as the northern and southern US) due to variation in the profitability of slavery. The dynamic evolution of labor rights and the economics of slavery is the focus of Lagerlöf (2006), who shows how increases in the productivity of agricultural technologies enables land owners to spend time monitoring slave labor. The interaction between property rights with respect to land and labor is also emphasized by Galor, Moav, and Vollrath (2006), who focus on the adverse effects of an unequal distribution of land rights on human capital accumulation. Interestingly, the interaction between labor and capital rights and the corresponding effect on the long run distribution of capital property rights has not been emphasized thus far in the financial development literature.

Our related focus on the tradeoff between exploitation and productive activities builds on insights by Grossman and Kim (1995), who construct an equilibrium model of the resource allocation decision between productive and appropriative activities. Grossman and Iyigun (1997) use related ideas to study the effect of population on time allocated to subversive vs. productive activities in order to understand the granting of freedom to some African and Southeast Asian colonies. Skaperdas (1992) studies the strategic interaction between players who can engage in productive and coercive activities in an environment absent of any property rights institution. Finally, in a related paper, Muthoo (2004) also studies strategic interaction in an environment without property rights and in particular focuses on the effects of agents' fighting and production skills on the emergence and security of such rights.

Building on this literature, we provide a simple representation of "institutions" as a state variable given by the fraction of people with power: "gun owners". Gun owners' property rights are protected. Others (the "oppressed") can be exploited by these gun owners. The initial state is determined by the colonizing power as a function of factor endowments in each potential colony. After the colonization stage, gun owners can subsequently decide to arm some or all of the oppressed. In making this decision, they face a tradeoff between exploitation and efficiency. Our theory is consistent with several themes emerging from the literature, namely, that the effect geography and factor endowments on growth works through their effect on institutions; that different political institutions and legal systems can lead to similar economic outcomes; and, that slavery appears important for the long run distribution of wealth in the colonies.

# 3 The Model

The model economy consists of a number of different locations or "colonies" which are distinguished by their endowments in terms of land and local population, as well as by characteristics such as climate and soil that determine the productivity of agriculture. There is a single colonizing power that is sending settlers and, possibly, slaves to each of the colonies. The existing local population does not possess modern weaponry; therefore, after colonization the local population is oppressed by the settlers on equal terms with the slaves. In economic terms, the key difference between the settlers and the oppressed in a given colony is property rights protection. Some of the inhabitants of an economy are "gun owners." Gun owners can protect their own property, and participate in standard market exchange with other gun owners under full property-rights protection. In addition, owning a gun enables a gun owner to exploit or expropriate others who do not have guns and consequently do not enjoy property-rights protection. Using the terminology of Piccione and Rubinstein (2003), our economy is ruled by a combination of the "invisible hand of the market" and the "iron hand of the jungle."

During the initial colonization phase, all settlers and none of the locals and slaves (the oppressed) own guns. Later on during the development of a colony, the existing gun owners may choose to issue guns to some or all of the oppressed, and thereby endow them with property rights. People without guns who are exploited by gun owners only receive subsistence consumption $\underline{w}$. Since any surplus wealth above this subsistence level is expropriated, unarmed people have no incentives for savings, investment, or exerting high effort when working. The lack of economic incentives for unarmed people causes an efficiency loss, which in turn provides a potential motive for issuing guns to unarmed people.

A key assumption of the model is that the efficiency loss from a lack of property rights differs across production technologies. There are two modes of production in our economy, agriculture and industry, where agriculture uses manual labor and land and industry used skilled labor and capital. In agriculture, the efficiency loss of from lack of property rights is small. The effective labor input of an oppressed worker (who only receives subsistence consumption) relative to a free worker (who receives the full marginal product of his labor effort) is given by $\phi_A$, where $0 < \phi_A \leq 1$. We denote the total efficiency units of manual labor that are used in agriculture as $N$, and the land input is denoted as $X$. The agricultural production function is given by:

$$Y = N^{\alpha} X^{1-\alpha}.$$

In the industrial technology, in contrast, the efficiency loss from lack of property rights is high. Intuitively, industrial production is a multi-stage production process, in which the contribution of each worker is harder to measure than, say, the amount of crops harvested by each worker on a plantation. This raises monitoring cost and lowers the efficiency of oppressed workers. An alternative interpretation is that industrial production requires additional skills, in which the oppressed have no incentive to invest, since all their surplus is extracted. In the model, the relative efficiency of an oppressed worker in supplying skilled labor to the industrial sector is $\phi_I$, where $0 \leq \phi_I < \phi_A$. The total efficiency units of skilled labor are denoted as $H$, and the supply physical capital is given by $K$. The industrial production technology is:

$$Y = AH^{\theta} K^{1-\theta}.$$

All colonies have access to the same industrial technology. However, because agriculture depends on location-specific conditions such as climate and soil, there may be differences across colonies in terms of the relative efficiency of forced labor in agriculture. At one extreme would be colonies where local conditions are amenable to plantation agriculture. In this system, it is relatively easy to monitor forced labor and to extract information on effort; as a consequence, $\phi_A$ is high. In colonies with less productive soils agriculture has to be less intensive, with workers spread out over comparatively larger areas. This impairs monitoring, and thus lowers the relative productivity $\phi_A$ of forced labor. However, we maintain the assumption that even in these colonies forced labor is relatively more productive in agriculture than in industry, $\phi_A > \phi_I$.

At the beginning of the colonization period, no physical capital is available in any of the colonies, so that only agriculture is used. Subsequently, the colonizers start to save in the form of physical capital, which triggers the introduction of the industrial technology. The oppressed do not save, since any savings would be immediately confiscated by a gun owner. As a consequence, aggregate savings and the scale of the industrial technology are larger if there are many free gun owners.

It is assumed that the productivity of the industrial technology improves over time:

$$A' = (1 + \gamma)A.$$

For simplicity, we assume that there is no productivity growth in agriculture. What matters for the results is that the productivity of industry improves relative to agriculture over time.

In addition to the direct efficiency loss from using forced labor, oppression is also costly in the sense that the gun owners have to use some of their time to monitor the oppressed. The monitoring time for a single gun owner oppressing $o$ workers is given by $\lambda o^{\eta}$, where $\lambda > 0$ and $0 < \eta < 1$. As each gun owner has only one unit of time available, the maximum number of people $\bar{o}$ that a single gun owner can oppress is given by:

$$\bar{o} = \left(\frac{1}{\lambda}\right)^{\frac{1}{\eta}}.$$

If there are $G$ gun owners and $O$ oppressed, there are $O/G$ people to be oppressed by each of the $G$ gun owners. As long as $O/G \leq \bar{o}$, the total time $M$ needed for monitoring the oppressed is given by:

$$M = G\lambda \left(\frac{O}{G}\right)^{\eta} = \lambda G^{1-\eta} O^{\eta}.$$

If $O/G > \bar{o}$, the gun owners will spend all their time on monitoring, and some of the oppressed will escape from oppression. We assume that the monitoring technology is sufficiently productive to ensure that the workers monitored by a single gun owner produce more than the gun owner could himself. That is, we require $\phi_A \bar{o} > 1$ or:

$$\phi_A \left(\frac{1}{\lambda}\right)^{\frac{1}{\eta}} > 1.$$

For simplicity, we assume that the same $\lambda$ applies to monitoring in both agriculture and industry.[1]

People live for a single period (i.e., one generation), and each person has a single child. Preferences are defined over consumption $c$ and a bequest $b$ left to the child:

$$U(c, b) = c^{1-\beta}\, b^{\beta}. \tag{1}$$

While all people would like to leave bequests to their children, only gun owners do so in equilibrium, because any bequests left by an unarmed person would be expropriated by a gun owner.

The evolution of the colonies described so far unfolds in two stages. Initially, a certain number of settlers and, possibly, slaves are sent to each colony, in addition to the unarmed local population already present. The decision of how many settlers and slaves to send to each location is made by the colonizing power, to be described in more detail in the following section. Once each colony is settled, further events unfold under local control. In addition to personal economic decisions, at the political level the gun owners (who are in power) have to decide how many, if any, of the oppressed they want to free (i.e., issue with guns) in any given period. This process is analyzed in Section 5.

# 4 The Colonization Stage

We start our analysis from an initial stage when a set of potential colonies has just been discovered. The colonies differ along two dimensions. First, there may be differences in factor endowments, i.e., the amount of land $X$ and the size of the local population $L$. Second, the relative productivity $\phi_A$ of an oppressed worker

[1] The effect of $\lambda$ varying across sectors is similar to what is now accomplished by having different labor efficiencies $\phi_A$ and $\phi_I$ of the oppressed in the two sectors Similarly, the differences across colonies in terms of $\phi_A$ could be alternatively expressed as differences in $\lambda$, with similar results.

in agriculture may also vary across colonies. We interpret a colony with a high productivity of oppressed labor $\phi_A$ as one where forced labor can be easily monitored; in the real world, this corresponds to colonies where climate and soil are amenable to plantation agriculture.

There is a single colonizing power that sends gun-owning settlers $G$ and, possibly, slaves $S$ to each of the colonies. The motive of the colonizing power is trade: A fraction of the output of each colony is sold overseas. The colonizing country reaps gains from trade, and possibly generates additional revenue from duties on imports that are sent on to other countries. Rather than model the gains of the colonizing power in detail, we assume that a fixed fraction $\tau$ of the output of each colony accrues as revenue to the colonizing power.

Colonization is limited by the cost of sending gun owners and slaves to the colonies. We assume that there is a fixed cost of $g$ for sending each settler to a specific colony, and the fixed cost for each slave is $s$. These costs include transport, the purchase price in the case of slaves, and also indirect costs such as military spending needed to secure shipping lanes and fend off competing colonizers.

We assume that the colonizer aims to maximize the surplus during the initial colonization period. While we could, at the cost of significant complication, also consider the discounted surplus from future periods, the results are likely to be dominated by the initial tradeoffs because a period is interpreted as a generation and thus any future payoffs are heavily discounted.

Conditional on entry being optimal, the colonizer's optimization problem in choosing how many gun owners $G$ and slaves $S$ to send to a given colony is then given by:

$$\max_{G\geq 0, S\geq 0} \left\{\tau N^{\alpha} X^{1-\alpha} - sS - gG\right\} \tag{2}$$

subject to:

$$O = L + S, \tag{3}$$

$$M = \lambda G^{\eta} O^{1-\eta}, \tag{4}$$

$$N = \phi_A O + G - M, \tag{5}$$

$$G \geq M. \tag{6}$$

Thus, the surplus of the colonizer consists of fraction $\tau$ of agricultural output minus the expense of sending $G$ settlers at cost $g$ and $S$ slaves at cost $s$ to the colony. Notice that during this initial stage industrial production is not available, since no industrial capital yet exists in the colony. Constraint (3) states that the total number of oppressed $O$ is composed of the unarmed locals $L$ and slaves $S$; constraint (4) is the monitoring requirement; constraint (5) computes effective labor supply net of monitoring; and constraint (6) states that at least as many settlers have to be shipped as are required to oppress all of the unarmed.

In principle, the colonizer could decide to occupy a colony only partially. In this case the number of settlers sent to the colony is not sufficiently large to oppress the entire population. However, since the locals are spread out over the entire colony, a colonizer oppressing only a share of the locals would also have access to only a share of the land, with the remainder staying under control of the locals who remain free. Consider the situation of a colonizer who has already occupied a fraction of a colony and generated a surplus by doing so. By increasing the number of settlers, the colonizing power could now raise its profit in proportion to the existing surplus, because the surplus per settler is the same in the already occupied and the remaining territory. Thus, we can assume without loss of generality that the colonizer will either occupy a colony in its entirety or not enter at all.

A first useful result is that it is never optimal to have slaves working alongside gun owning settlers; that is, if $S > 0$ all settlers use all their time for monitoring.

**Lemma 1** *The solution of the maximization problem* (2) *features either $S = 0$ and $G \geq M$, or $S > 0$ and $G = 0$.*

As a consequence of the lemma, we can characterize the solution of the optimization problem separately for the cases $S = 0$ and $S > 0$ (of course, we will also have to derive a condition that determines which of these regimes applies). Let us first assume that $S = 0$. In this case, the optimization problem (2) can be written as:

$$\max_{G \geq 0} \left\{ \tau N^{\alpha} X^{1-\alpha} - sS - gG \right\}$$

subject to:

$$\begin{aligned} M &= \lambda G^{\eta} L^{1-\eta}, \\ N &= \phi_A L + G - M, \\ G &\geq M. \end{aligned}$$

If the solution is interior, it is characterized by the following first-order condition:

$$g = \tau\alpha \left(\frac{X}{N}\right)^{1-\alpha} \left(1 - \lambda(1-\eta)\left(\frac{L}{G}\right)^{\eta}\right). \tag{7}$$

Here the left-hand side is the marginal cost of sending one more settler to the colony, while the right-hand side is the marginal benefit accruing to the colonizing power. The term $\tau\alpha(X/N)^{1-\alpha}$ is the marginal product of labor multiplied by the colonizer's share $\tau$. The second term (in brackets) is the fraction of time the marginal settler spends working, as opposed to monitoring and oppressing locals. The colonizing power is interested in the total output of the colony, but does not have a direct gain from the expropriation activities of the gun owners that merely redistribute income within the colony. Hence, oppression of locals lowers the value of an additional settler from the colonizer's perspective.

The condition implies that in the optimum, the marginal product of labor will be highest in the colonies with the highest number of locals relative to the amount of land. Colonies with few or no locals will receive relatively more gun-owning settlers per unit of land. For the colonizer, their lower marginal product is made up for by the fact that in a local-free colony all time is used for production instead of oppression. What this implies for income per capita (i.e., output divided by the sum of gun owners and locals) depends on the locals' agricultural efficiency $\phi_A$. In particular, if the locals' efficiency is similar or identical to that of the gun owners ($\phi_A = 1$), the higher marginal product of labor in local-rich colonies directly translates into higher income per capita.

**Proposition 1 (Income per Capita at Colonization Stage: Case $S = 0$)** *Consider a set of colonies with $S = 0$, i.e., there are no slaves. After the initial colonization is completed, the marginal product of labor $\alpha(X/N)^{1-\alpha}$ is an increasing function of the ratio* *of locals to land $L/X$. If $\phi_A = 1$, income per capita $N^\alpha X^{1-\alpha}/(G+L)$ is an increasing function of $L/X$ as well.*

Our theory is thus able to capture one of the main features in Table 1, namely that colonies with a higher ratio of forced labor to settlers initially had a higher income per capita.

We now turn to the second regime, which is that of a colony that imports slaves. According to Lemma 1, this implies that gun owning settlers use all their time for monitoring, $G = M$. The colonizer's maximization problem in this regime is:

$$\max_{G\geq 0, S\geq 0} \{\tau N^\alpha X^{1-\alpha} - sS - gG\}$$

subject to:

$$\begin{aligned} O &= L + S, \\ M &= \lambda G^\eta O^{1-\eta}, \\ N &= \phi_A O + G - M, \\ G &= M. \end{aligned}$$

Solving for the required number of gun owners as a function of $S$ yields:

$$G = \lambda^{\frac{1}{1-\eta}}(L+S). \tag{8}$$

The maximization problem can therefore be rewritten as:

$$\max_{S\geq 0} \left\{\tau(\phi_A(L+S))^\alpha X^{1-\alpha} - sS - g\lambda^{\frac{1}{1-\eta}}(L+S)\right\}$$

The first-order condition is:

$$\tau\alpha\phi_A^\alpha \left(\frac{X}{L+S}\right)^{1-\alpha} = s + g\lambda^{\frac{1}{1-\eta}}.$$

The left-hand side multiplies the colonizer's share $\tau$ with the marginal product of forced labor, and the right-hand side is the total cost of sending one more slave, including the added cost of monitoring by a gun owner. Solving for $S$ yields:

$$S = \phi_A^{\frac{\alpha}{1-\alpha}} \left( \frac{\tau\alpha}{s + g\lambda^{\frac{1}{1-\eta}}} \right)^{\frac{1}{1-\alpha}} X - L. \tag{9}$$

Let us now consider what this condition implies for income differences across colonies. Using (8) and (9), income per capita can be written as:

$$\begin{aligned}
\frac{(\phi_A(L+S))^\alpha X^{1-\alpha}}{L+S+G} &= \frac{(\phi_A(L+S))^\alpha X^{1-\alpha}}{(1+\lambda^{\frac{1}{1-\eta}})(L+S)} \\
&= \phi_A^\alpha \frac{1}{1+\lambda^{\frac{1}{1-\eta}}} \left( \frac{X}{L+S} \right)^{1-\alpha} \\
&= \frac{s + g\lambda^{\frac{1}{1-\eta}}}{\tau\alpha(1+\lambda^{\frac{1}{1-\eta}})}
\end{aligned}$$

Thus, in this regime income per capita is independent both of factor endowments ($X$ and $L$) and the efficiency of forced labor $\phi_A$. The reason for this outcome is that the total cost of sending an slave is the same for all colonies. The marginal surplus is therefore also equated across colonies, and must be independent of local conditions.

If we now compare colonies with and without forced labor, the key determinant of income per capita is the relative cost of sending slaves and gun owners to each colony. Consider a slave-owning colony with transportation costs $s$ and $g$ for slaves and gun owners and a slave-free colony where the transportation cost is $\tilde{g}$. Assume that in the slave-free colony there is no forced labor at all (thus, all work is done by gun owners, and there is no monitoring). We can then use the first-order condition (7) to derive an expression for income per capita. In particular, given (7) the number of settlers in this colony is:

$$G = \left( \frac{\tau\alpha}{\tilde{g}} \right)^{\frac{1}{1-\alpha}} X,$$

so that income per capita is:

$$\begin{aligned}\frac{G^{\alpha}X^{1-\alpha}}{G} &= \left(\frac{X}{G}\right)^{1-\alpha} \\ &= \frac{\tilde{g}}{\tau\alpha}.\end{aligned}$$

The ratio of the income levels between the colonies with and without slavery is:

$$\frac{Y_{\text{Slavery}}}{Y_{\text{Free}}} = \frac{s + g\lambda^{\frac{1}{1-\eta}}}{\tilde{g}(1+\lambda^{\frac{1}{1-\eta}})}$$

Thus, income per capita will be higher in the colony with slaves if $\tilde{g}$ is sufficiently small relative to $g$, i.e., sending settlers to the colony with slaves is costly). Alternatively, the same result obtains if we have $\tilde{g} = g$ and $s > g$, i.e., slaves are more expensive than gun owners. While this last condition may sound counterintuitive, one needs to keep in mind that $g$ is not necessarily the full cost of sending a settler to a colony, but only the part of the cost that is borne by the colonizing power. Given that gun owners have an own financial interest in colonization, they may well (and often did) pay a significant fraction of the overall cost. This then raises the question of why slaves would be used in the first place if $s > g$. In the model, this would only happen if slaves are more productive than gun owners in production. An empirically relevant case is that of work that is so hazardous that settlers would not voluntarily perform it. On the plantations of the Caribbean sugar islands, for example, mortality rates were extremely high, so that using free settlers for physical labor was simply not an option. For similar reasons, the net cost of sending settlers to monitor these locals (even for the monitoring tasks) may have been high because of unsuitable living conditions for white settlers from temperate climates, as emphasized by Acemoglu, Johnson, and Robinson (2001). The following proposition summarizes these findings.

**Proposition 2 (Income per Capita at Colonization Stage: Case $S > 0$)** *Consider a set of colonies with $S > 0$, i.e., at least some slaves are used for production, and all gun owners engage in monitoring, $G = M$. After the initial colonization is completed, income per capita is independent of factor endowments $L$ and $X$ and the relative efficiency* *of forced labor $\phi_A$. Income per capita is increasing in the transportation costs $s$ and $g$. A slave-owning colony has higher income per capita than a colony with only free labor if either $s > g$ with $g$ identical across colonies, or if the cost of sending settlers $g$ is sufficiently high in the slave-owning colony relative to the free-labor colony.*

To summarize, we identify two reasons why income per capita may have been higher initially in colonies with a more uneven distribution of property rights. First, comparing colonies with slaves to those without, the slave-owning colonies have a higher income per capita if the cost of sending settlers and/or slaves is high relative to colonies with free labor. A potential reason for this pattern is that many slave-owning colonies were in tropical locales where mortality rates were high for both settlers and slaves. Second, comparing colonies without slaves but with different sizes of oppressed local populations, we find that income per capita is high in places where the oppressed population is large, even if the transportation costs are the same across colonies. The reason is that in colonies with many oppressed gun owning settlers use a large fraction of their time for exploitation activities that have no value per se from the colonizers perspective.

An alternative mechanism that would work in a similar fashion would be migration restrictions that are imposed by the settlers themselves, as opposed to the colonizing power. Gun owners in colonies with many oppressed workers derive rents from oppression that they, presumably, would not want to share with newly arriving gun owners. In contrast, in an economy with free labor and an abundance of land, competition for rents between old and new immigrants would be less of an issue. This mechanism has been emphasized by Engerman and Sokoloff (1997), among others.

# 5 Industrialization and Emancipation

After the initial settlement of a colony, political control passes to the local gun owners. The further evolution of economic outcomes is driven by the accumulation of physical capital and the rise of industrial production. Once the industrial sector is introduced, gun owners can freely allocate their labor between the two sectors, implying that wages will be equalized as long as at least some gun owners work in each sector. In addition, gun owners can collectively decide to free (i.e., issue with guns) some or all of the oppressed.

The potential motive for emancipating the oppressed is twofold. First, the accumulation of capital leads to a rising marginal product of labor in the industrial sector. If the return to working in this sector is sufficiently high, gun owners may be willing to forgo the gains derived from exploiting the oppressed in order to supply more of their own time to the market. Thus, one motive is to free up time that otherwise has to be used for monitoring purposes. In addition, the gun owners also gain because they own all the capital in the economy, and capital is complementary to free labor (recall that $\phi_I$ is small). Emancipating some or all of the oppressed thus raises the return on the capital held by the gun owners.

We assume that each generation of gun owners decides on how many oppressed $F$ to free in order to maximize the existing gun owners' total income $Y_G$. We focus for now on the case where $\phi_I$ is sufficiently small for it to never be optimal to use forced labor in production (because the monitoring cost is higher than the additional output). Once the $F$ oppressed are freed, they enjoy full property rights protection, and thus receive the market wage. The freed do not own any capital of their own yet because their parents (who would have wanted to leave them a bequest) were oppressed. However, they will leave a bequest to their own children just as the other gun owners.

We formulate the gun owners' collective planning problem of choosing the number $G_I$ of existing gun owners who should work in the industrial sector, and the number $F$ of oppressed to be armed.[2] This planning problem can be given a political-economic interpretation; in particular, probabilistic voting among the gun owners on $F$ would generate the same result. The maximization problem is:

$$\max_{0 \leq G_I \leq G,\, 0 \leq F \leq O} \left\{ N^\alpha X^{1-\alpha} + AH^\theta K^{1-\theta} - \underline{\mathrm{w}}(O-F) - wF \right\} \equiv Y_G, \tag{10}$$

[2]Equivalently, the decision on $G_I$ could be decentralized through a standard labor market.

where the maximization is subject to the constraints:

$$N = G - G_I - M + O - F, \tag{11}$$

$$H = G_I + F, \tag{12}$$

$$M = \lambda(O - F)^{\eta}(G - G_I)^{1-\eta}, \tag{13}$$

$$G - G_I \geq M, \tag{14}$$

$$w = A\theta \left(\frac{K}{H}\right)^{1-\theta}. \tag{15}$$

The first two terms in (10) are the outputs of the agricultural and industrial sector, respectively. The third term is the subsistence consumption level that is paid to each of the remaining $O - F$ oppressed ($O$ denotes the number of oppressed at the beginning of the period, before $F$ of them are armed). The term $wF$ represents the market wage that has to be paid to each of the free workers. Constraints (11) and (12) give the effective labor supply $N$ in agriculture and $H$ in industry. Since the oppressed are freed precisely so that they can raise the return on capital, the constraints already reflect that all $F$ new gun owners will work in industry. Constraint (13) is the monitoring requirement for the remaining oppressed, constraint (14) states that sufficiently many gun owners have to remain in agriculture to monitor all of the remaining oppressed, and constraint (15) states that the new gun owners have to be paid the market wage, which is the marginal product of labor in industry. The following proposition sums up our main results regarding optimal emancipation.

**Proposition 3 (Emancipation Decision)** *The optimization problem* (10) *has the following properties:*

1. *Emancipation does not occur as long as the monitoring constraint is not binding:*

$$G - G_I > M \implies F = 0.$$

2. *For a given $G$ and $O$, once the monitoring constraint is binding the number of new gun owners $F$ is increasing in capital $K$.*

Intuitively, it is initially more costly from the gun owners' perspective to free an oppressed person rather than move an gun owner from the agricultural to the industrial sector, because freeing an oppressed person leads to the additional cost $w - \bar{w}$ of having to pay market wages instead of subsistence consumption. Thus, as long as additional gun owners are available, no oppressed will be freed. At some point, however, the number of gun owners in agriculture will be reduced so far that all remaining gun owners are using all their time for monitoring the oppressed. From this point on, emancipating the oppressed becomes attractive. Notice that it is never optimal to simply withdraw additional gun owners from agriculture without arming the oppressed which now would go unmonitored: unmonitored oppressed people contribute nothing to the gun owners' income, whereas emancipated oppressed can work in industry and thereby raise the return on the gun owners' capital.

To summarize, emancipation in the colony is ultimately driven by the accumulation of physical capital, which is complementary to free labor. Emancipation starts only after the only gun owners remaining in agriculture are using all their time to monitor the oppressed. The dynamic evolution of the colony is driven by the following laws of motions:

$$G' = G + F, \tag{16}$$

$$O' = O - F, \tag{17}$$

$$K' = \beta(Y_G + wF), \tag{18}$$

$$A' = (1 + g)A. \tag{19}$$

Here $G'$ denotes the number of gun owners in the next generation, and $O'$ is the remaining number of the oppressed. The law of motion for capital (18) follows from the optimal allocation of income between consumption and bequest of capital given the utility function (1), and equation (19) reflects productivity growth at rate $g$ in the industrial sector. Notice that the newly freed oppressed leave bequests as well, thus the term $wF$ in the law of motion for capital ($Y_G$ is the income of the original gun owners, excluding the newly freed).

The evolution of each colony is driven by the complementarities between property rights protection, capital accumulation, and free labor.

**Proposition 4 (Evolution of the Economy)** *Consider a set of colonies that differ in terms of the initial ratio $O/G$ of oppressed to gun owners. The optimization problem* (10) *together with the laws of motion* (16) *to* (19) *leads to the following results:*

1. *Colonies with relatively fewer oppressed accumulate more capital per capita.*
2. *In colonies with relatively fewer oppressed emancipation full emancipation is achieved earlier.*

Since productivity $A$ keeps increasing, ultimately all colonies achieve full emancipation, even those starting out with many oppressed. In addition, the share of industrial production in output will converge to one. In the limit, our model is identical to the Solow model, i.e., a neoclassical growth model with a Cobb-Douglas production function and a constant savings rate. This feature is desirable, because it implies that in the balanced growth path the model is consistent will the stylized facts of economic growth in developed countries. During the transition, the output share of agriculture and the income share of land are slowly decreasing, so that the model also accords with the usual pattern of structural formation in the course of development.

The fact that the limit economy is the neoclassical growth model also implies that an uneven distribution of initial property rights only has transitory effects. Once the last colony has achieved full emancipation, the usual transitional dynamics of the neoclassical growth model take over. Thus, in the limit all colonies converge to the same balanced growth path.

# 6 A Computed Example

In this section we present a simple computed example that illustrates the results obtained so far. The simulation is not meant to closely match empirical features of some real-world country; rather, it is intended to clarify the main qualitative features of the model. We focus on the case $S = 0$. [To be updated with $S > 0$].

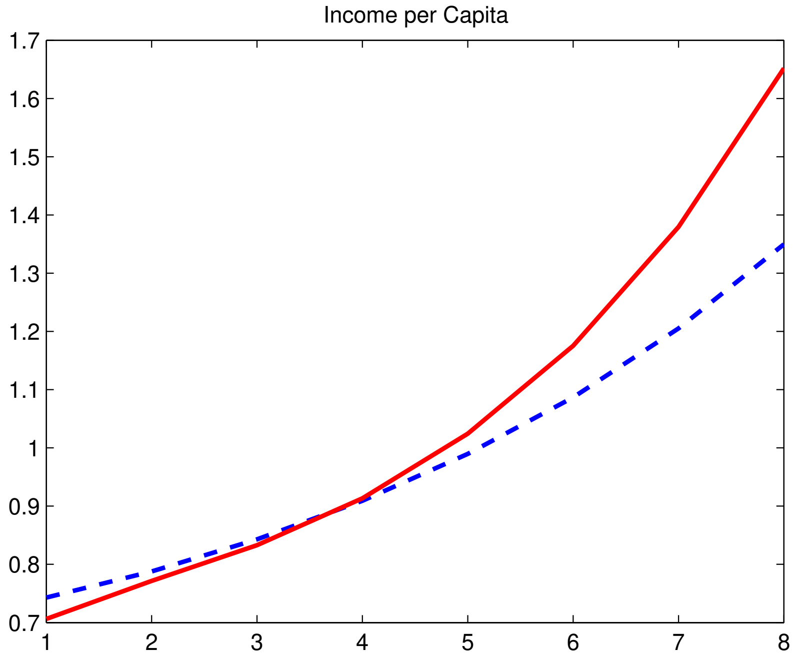


Figure 1: Income per Capita in First Periods. Dashed: $O = 1$, solid: $O = 0$.

The following parameter values were used for the computations:

$$\alpha = \theta = 0.6,$$
$$\lambda = \eta = 0.5,$$
$$\beta = 0.2,$$
$$\underline{\mathrm{w}} = 0,$$
$$g = 0.1,$$
$$\tau = 0.1,$$
$$\gamma = 0.15.$$

Figures 1 to 4 compare outcomes through from the colonization stage on in two colonies which have the same amount of land $X = 1$, but are distinguished by the number of locals. In particular, one colony, "New England," does not have any locals at all, $O = 0$, while in the other colony, "Barbados," we have $O = 1$.

Consistent with Proposition 1, initial income per capita is higher in Barbados. Almost three times as many settlers are sent to New England as to Barbados, resulting in a lower marginal product of labor in New England. However, as described by Proposition 4, the larger number of free people in New England leads to fast capital accumulation, so that after a few generation New England closes the gap to Barbados in terms of income per capita, and ultimately moves ahead (see Figure 1).

The overtaking takes place long before emancipation starts to take hold in Barbados. Given the relatively small number of gun owners, little capital is accumulated, thus the demand for free labor rises only slowly. The gap between New England and Barbados continues to widen for some time, as New England has a much larger industrial sector and thus reaps more benefits from productivity growth in that sector.

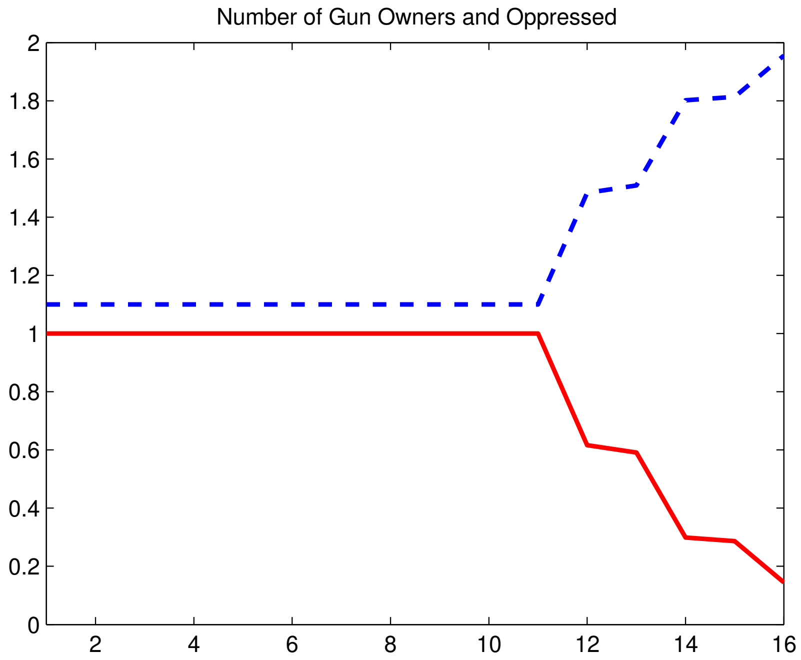


Figure 2: Number of Gun Owners and Oppressed in Barbados. Dashed: $G$, solid: $O$.

Ultimately, productivity growth pushes the marginal product of labor in industry to a level where emancipation in Barbardos begins to take hold. As Figure 2 shows, from period 11 on an increasing number of locals is set free.

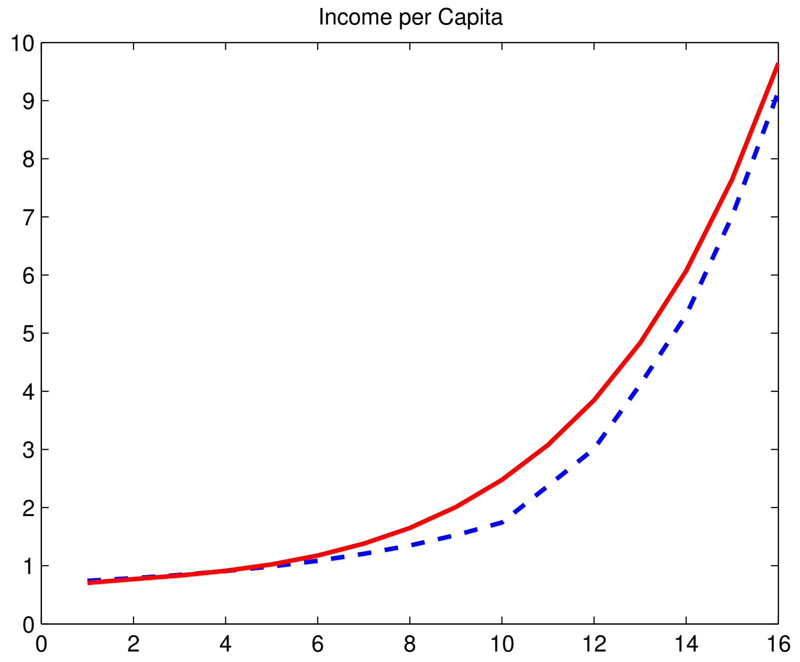


Figure 3: Income per Capita over Longer Term. Dashed: $O = 1$, solid: $O = 0$.

After emancipation takes hold, the two colonies start to resemble each other more closely. The increased extent of property rights protection fosters capital accumulation, which reduces the gap between the two colonies. In the limit, the model behaves like a Solow growth model, and the two colonies converge to the same balanced growth path. However, as Figure 3 shows, convergence is achieved only at a slow pace. Emancipation starts in period 12, but the there is still a sizable gap in income per capita between New England and Barbados four generations later.

So far, we have focused on income per capita, and disregarded the distribution of income within each colony. Political decisions, however, are driven not by a concern for income per capita, but a concern for the gun owners' income. To highlight this dimension, Figure 4 displays income per gun owner in the two colonies over time. Despite falling behind in income per capita from period 4

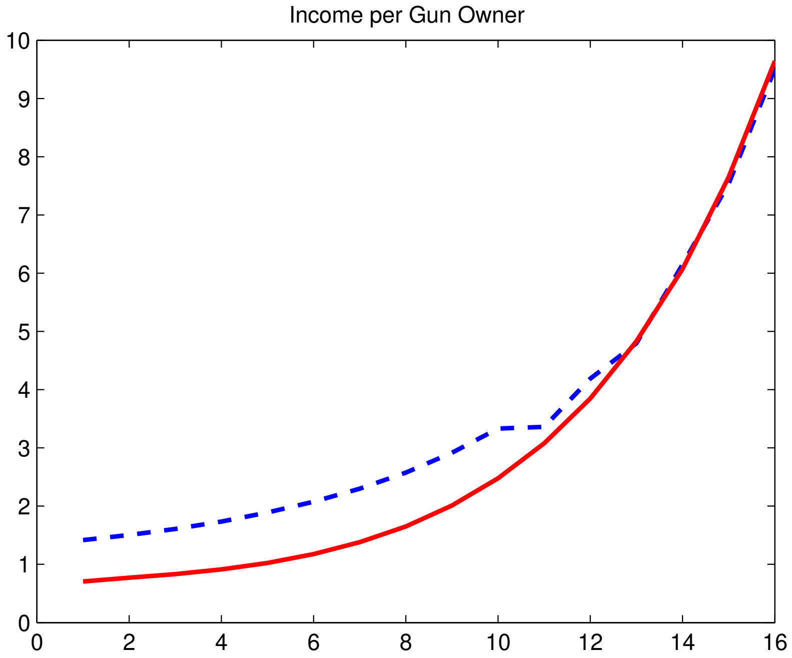


Figure 4: Income per Gun Owner. Dashed: $O = 1$, solid: $O = 0$.

onwards, income per gun owner is higher in Barbardos throughout most of the transition. After the start of emancipation, the figure masks heterogeneity among the gun owners themselves, as the dynasties of the original settlers remain richer than the descendants of freed locals, who start out with zero capital. The upshot is that through the entire transition, a descendant of one of the original Barbardos settlers is better of than a descendant of a New England settler. The cost of delayed development is thus born by the locals, not the gun owners.

## 7 Conclusions

In this paper, we present a simple theory that can rationalize the "Reversal of Fortunes" that can be observed among former European colonies in the Americas. The theory suggests that such a reversal is a fairly natural outcome in a model with an exploitation-efficiency tradeoff. The key feature in our theory generating the reversal of fortune is a complementarity between the size of the free population today and the demand for even more free people in the future. The source of this complementarity is capital accumulation: Free people save more because their property rights are protected; in turn, capital accumulation increases the demand for free people, because forced labor is relatively inefficient in modern production.

In our theory, the reversal of fortune is a transitory (though possibly long lived) phenomenon. Exogenous productivity growth in the industrial sector ensures that ultimately full emancipation is achieved in all colonies. From that time on, all colonies converge to the same balanced growth path. The model could be extended, however, to mechanisms other than capital accumulation where divergence in property rights might be more persistent. In particular, if technology adoption is endogenous, and available technologies differ in the extent to which they can use free and forced labor, permanent differences between colonies with little and wide property-rights protection may arise. We plan to explore this possibility in further research.

From a theoretical perspective, the main innovation of this paper is the modeling of property rights at the level of the individual, rather than the country. This has the advantage that our theory allows for smooth transitions where the extent of property rights protection (i.e., the number of "gun owners") increases gradually over time. This contrasts with much of the existing literature, which has focused on discrete sets of property rights regimes that apply to entire countries. Our preliminary results indicate that the individual-level approach may prove fruitful for addressing the evolution of property rights in the course of development. A limitation of our theory is that it incorporates only two levels of property-rights protection, i.e., full protection for gun owners and the lack of any protection for the oppressed. In the real world, many gradations of property rights can be observed. It might be useful to model this with the introduction of guns with varying levels of effectiveness, so that a particular type of gun can protect against expropriation with some probability, or can fully protect some fraction of property. In future research, we plan to extend the model to multiple levels of property-rights protection.

# A Mathematical Appendix

**Proof of Lemma 1:** The maximization problem is:

$$\max \tau N^{\alpha} X^{1-\alpha} - sS - gG$$

subject to:

$$\begin{aligned}
M =& \lambda G^{\eta} O^{1-\eta}, \\
N =& \phi_A O + G - M, \\
O =& L + S, \\
G \geq & M.
\end{aligned}$$

Let $E$ be the total cost of sending settlers and slaves in the optimum, $E = sS + gG$. Since the colonizer's profits depends only this cost and total labor supply $N$, the allocation of $E$ between slaves and settlers has to maximize $N$. This sub-problem can be written as:

$$\max N$$

subject to:

$$\begin{aligned}
S &= E - \frac{g}{s} G, \\
N &= \phi_A (L + S) + G - \lambda G^{\eta} (L + S)^{1-\eta}.
\end{aligned}$$

or:

$$\max \phi_A (L + E - \frac{g}{s} G) + G - \lambda G^{\eta} (L + E - \frac{g}{s} G)^{1-\eta}.$$

It can be easily verified that the second derivative of the objective function is positive, implying that there is no interior optimum. Thus, the solution is at a corner, implying that either $S = 0$ or $G = M$. □

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