Workers, Warriors, and Criminals: Social Conflict in General Equilibrium

Ernesto Dal Bó
Stanford University and NBER

Pedro Dal Bó*
Brown University

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Abstract

We incorporate appropriation activities ("social conflict") into canonical models of trade and study how economic shocks and policies affect the intensity of conflict. We show that not all shocks that could make society richer reduce conflict: positive shocks to labor intensive industries diminish conflict, while positive shocks to capital intensive industries increase it. The key requirement is that conflict activities be more labor intensive than the economy. Our theory is consistent with observed patterns of conflict, such as the positive association between crime and inequality, and the curse of natural resources. Incorporating appropriation into a canonic general equilibrium model affects what policies may be deemed desirable: in order to reduce conflict and generate Pareto-improvements policy must be distortionary, while reforms that appear efficiency-enhancing under the unrealistic assumption of perfect property rights may backfire. This offers one explanation for why reforms based on traditional models without appropriation may be delayed and become unpopular when implemented, and why societies may sympathize with seemingly inefficient redistribution.

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1 Introduction

One enduring aspect of social life is the conflict over the distribution of resources. This conflict takes many forms, including the forceful appropriation of resources. Agents engaged in forceful appropriation include individual criminals as well as large "political" guerrillas fueled by their ability to recruit members and appropriate resources. The action of such agents is evidence that the division of wealth among individuals is not solely determined by a price system operating on the basis of well defined and perfectly enforced property rights.[1]

We introduce social conflict defined as appropriative activities in two canonical models of trade in a small open economy: the Heckscher-Ohlin and the Ricardo-Viner models. These models have played an important role shaping both the profession's economic intuition and its policy advice. We extend these two classic models to incorporate imperfect property rights. This allows us to, first, study how economic shocks and policies affect the intensity of appropriation activities underlying social conflict and, second, show that appropriation affects what policies may be deemed desirable.

The economy we consider has two productive sectors using two factors, and a third, unproductive sector that we call "appropriation." This last sector appropriates a fraction of what is created in the two productive sectors. The equilibrium size of this appropriation sector yields a measure of the intensity of social conflict over the distribution of resources, and it indicates the degree to which property rights are violated in equilibrium. When this appropriation sector is labor intensive relative to the economy, favorable shocks to the price or technology of the capital intensive industry increase appropriation activities in equilibrium. Even when the shocks are potentially wealth-increasing, the social backlash in the form of increased appropriation may be so strong as to make everyone worse-off. The intuition is that shocks that favor the capital intensive industry (or hurt the labor intensive one) cause the capital intensive industry to expand, the labor intensive industry to contract, and make labor relatively more abundant. This lowers wages (the main opportunity cost of appropriation activities) relative to the value of appropriable resources, fostering more appropriation. The comparative statics hold for any industrial organization of appropriation, from the case of atomistic, competing agents to a monopoly (i.e., from car-stereo thieves to a guerrilla that imposes a tax over a given territory).

One implication of this model is that distortion-free policies that are optimal under perfectly secure property rights may be counterproductive in the more realistic model with

[1] Even in highly developed countries property rights are not perfectly enforced. In the US for example, the total value of appropriated wealth in a year is beyond 5% of GDP and the total burden of crime is beyond 15% of GDP (Anderson, 1999). In less developed countries social conflict phenomena linked to forms of forced redistribution can also be very costly. During the typical civil war in Africa, "the total income loss cumulates to around 60 percent of a year's GDP." (Collier et al. 2003, p.21).

appropriation. Firms do not internalize the appropriation-reducing effects of their hiring relatively more labor, and appropriators do not internalize the consequences of their not producing. Thus, interventions must distort the prices perceived by agents in order to reduce appropriation; non distortionary lump sum redistribution serves no purpose in this economy. This can explain why we observe distortionary policies in reality: they buy social peace.[2] Examples of policies that can reduce appropriation are subsidies to productive labor financed with a tax on capital, trade interventions that lower the protection of capital intensive industries relative to labor intensive ones, and interventions that distort the pattern of technical progress in favor of labor intensive industries. Our model also suggests that international trade policy and peace-keeping initiatives should be considered in unison: to reduce conflict in less developed nations, international trade agreements should consider reducing trade barriers on labor intensive exports from those nations.

The problem of the efficiency of endogenous policy choice is of continuing importance at a time when the profession seeks to explain the uneven performance of the Washington Consensus reforms.[3] The protection of property rights was part of the Washington Consensus agenda but not its top priority (it was the last of the ten priorities, see Williamson, 1990). Our model suggests it should have been given a higher priority, especially if the reforms that were undertaken had the potential to generate higher levels of appropriation.

Why should we pay attention to the policy implications of our model? After all, once a model contains a distortion, many distortionary policies could make sense because of a second best rationale (Lipsey and Lancaster 1956). The answer is that our point of departure is not arbitrary, but two well understood, classic models that have shaped mainstream policy advice; and the distortion we add to those models, namely the existence of appropriation activities, is both real and economically large.

The main point of our paper is conceptual and regards the modification of basic economic intuitions in the face of appropriation activities. However, our simple model provides a rich empirical profile concerning two forms of conflict connected to appropriation activities: crime and civil war. In this way our model yields the first unified explanation for a variety of empirical regularities. First, shocks to income appear to have different effects on conflict depending on what activities they affect. For instance, negative shocks to agriculture foster conflict where agriculture is labor intensive, as in Subsaharan Africa (see Miguel, Satyanath

[2] An important literature in economics has sought to explain why public policy often takes inefficient forms (see for example Coate and Morris, 1995; and Dixit and Londregan 1995).

[3] For example, the market-friendly reforms introduced in some Latin American countries have been followed by a rise in crime (reports of increased victimization rates can be found for instance in Alvazzi del Frate 1998). Di Tella and MacCulloch (2005) show that the perception of increased levels of crime leads people to disapprove of market reforms, and Lora and Olivera (2005) show that reformist governments do not appear to have been rewarded at the polls.

and Sergenti 2004 for evidence). But conflict also appears to increase when positive shocks occur in connection with natural resources, where capital intensive industries are common (on the natural resource curse, see inter alia Collier and Hoeffler 1998, and Ross 2003). There are examples of this divergent effect of shocks even within a single country. In a recent paper, Dube and Vargas (2006) take to the data a modified version of our model to study the determinants of conflict in Colombia and find supportive evidence for the idea that factor intensities matter. They find that conflict increased following both a fall in the price of coffee (a relatively labor intensive product) and an increase in the price of oil (a relatively capital intensive product). A second regularity is the cross-country evidence on the positive association between inequality and crime (see Fajnzylber, Lederman and Loayza 2002). Our model can rationalize this second regularity through its prediction that shocks that increase inequality in favor of capital and against labor (or in favor of high-skilled labor relative to low-skilled labor) increase appropriation.

Theoretical models and empirical evidence suggest that, all else equal, a lower opportunity cost in terms of wages should increase individual propensities toward rebellion or crime.[4] Yet, shocks affecting the opportunity costs of appropriation (e.g., wages) also tend to affect the returns to appropriation by enhancing the amount of appropriable wealth. Therefore, partial equilibrium approaches keeping one of those elements as exogenous cannot make meaningful aggregate predictions. Our general equilibrium approach offers an integrated view of how the costs and benefits of appropriation move in response to economic shocks and policy.[5] When a shock increases wages, what happens to appropriation levels depends on whether appropriable wealth goes up by more or less than wages. This is shown to depend on the factor intensity of productive industries.

Our model also contributes to the literature linking conflict and appropriation. Most of the existing work does not incorporate trade,[6] with two exceptions. Skaperdas and Syropou-

[4] Classic references in the literature on crime are Becker (1968) and Ehrlich (1973). Empirical studies on the relationship between wages and crime suggest that higher wages deter participation in criminal activities (see Grogger, 1998, and Gould, Weinberg and Mustard, 2002). On the related topic of revolts, MacCulloch (2001) finds that higher household income diminishes the propensity to express support for a revolt; see Fearon and Laitin (2003) on the connection between income and civil war.

[5] Other general equilibrium models of crime (which abstract from the trade dimension) include Ehrlich (1981), Burdett et al. (2003) and Imrohoroğlu et al. (2000 and 2004).

[6] See Garfinkel (1990), Grossman (1991), Skaperdas (1992), Powell (1993), Hirshleifer (1995), Grossman and Kim (1995), Esteban and Ray (1999), Acemoglu and Robinson (2001) and Hafer (2006) for other models where parties can attack each other. For conflict in growth models see Benhabib and Rustichini (1996) and González (2005). Ross (2003) lists various connections between natural resources and conflict. See Tornell and Velasco (1992), Tornell and Lane (1996), and Torvik (2002) on resource abundance and rent seeking. Natural resources may affect conflict by generating rents, corruption, and weaker institutions. For the connection between rents and corruption see Ades and Di Tella (1999); on institutions see Acemoglu, Johnson

los (1996) study the incentives of countries to arm themselves and dispute a resource in the face of posterior opportunities for exchange and, in a recent paper, Garfinkel, Skaperdas and Syropoulos (2004) analyze the effects of trade opening when factions can arm themselves to dispute a resource stock. Their focus is different because in their theories the key driver of conflict is the price of a contested stock relative to that of a produced good. The existence of an appropriable stock is also key in papers studying how trade affects the exploitation of natural resources (see, for instance, Chichilnisky 1994, and Hotte, Van Long and Tian 2000).

There is also a related literature on rent-seeking. The appropriation sector may be thought to capture rent-seeking efforts under exogenous tariffs (see Krueger, 1974, and Bhagwati and Srinivasan, 1980).[7] Besides differences in focus and modeling choices, the theory we develop differs significantly from rent-seeking models in that it yields comparative statics that are driven by the relative use of factors across industries.

The plan for the paper is as follows. Section 2 presents the model. Section 3 characterizes the equilibrium after proving its existence and compares it with the equilibrium in a conflict-free society. Section 4 studies how economic shocks affect the extent of social conflict. Section 5 discusses policy-making under the social constraint imposed by appropriation activities. Section 6 extends the basic model to the case of industry-specific factors and Section 7 concludes.

2 The Model

Consider an economy comprising two productive sectors along the lines of the canonical 2x2 international economics model.[8] The productive sectors involve many firms which maximize profits and use technologies characterized by constant returns to scale. The two productive sectors or industries are labeled 1 and 2, and they use two inputs which we call capital and labor, respectively labeled K and L. Factors can move freely across industries. All firms in each industry share the same production function with the property that industry 1 is more capital intensive than industry 2. We denote with r and w the respective rental prices of capital and labor. The given primitives of the model are: the factor endowments available in fixed amounts $\overline{K}$ and $\overline{L}$, the technologies, and the prices of output, which are internationally determined and are labeled p_1 for industry 1, and $p_2 = 1$ for industry 2 (good 2 is the numeraire).

In addition to the productive sectors, there exists an appropriation sector. This sector

and Robinson (2001). On institutions and trade, see Anderson and Marcouiller (2002) and Levchenko (2004).

[7] On the more distant case of endogenous tariffs, see Findlay and Wellisz (1982), and Magee, Brock and Young (1989).

[8] See Stolper and Samuelson (1941) and Jones (1965).

only uses labor (L_A) and produces a redistribution of output from the productive industries towards the appropriation sector.[9] The key assumption in the paper is that appropriation in the economy is increasing in the amount of labor devoted to such activity and that congestion effects in appropriation eventually decrease its average yields. Thus, appropriation is given by the continuous and strictly concave function $A(L_A)$, with $A(0) \geq 0$ and $A\left(\overline{L}\right) \leq 1$. The function $A(L_A)$ specifies the fraction of the total value of production that is appropriated when L_A units of labor are devoted to appropriation activities. The concavity assumption reflects congestion effects in appropriation. The assumption of strict concavity is for convenience only–similar results can be obtained with a linear technology featuring a positive intercept. Given production levels q_1 and q_2 in the two industries, and L_A units of labor devoted to appropriation, the amount appropriated is $A(L_A)[p_1 q_1 + q_2]$. Given that under constant returns to scale payments to factors exhaust the value of production, the appropriated amount can be written as $A(L_A)\left[r\overline{K} + w(\overline{L} - L_A)\right]$. For simplicity and without loss of generality we assume that appropriators target factor owners and steal a fraction of their returns.[10] The terms r and w represent the gross (before appropriation) rental prices of capital and labor in the productive sectors.

Workers decide whether to enter the productive sectors or the appropriation sector. The returns to a unit of labor in a productive sector is the wage net of appropriation. The returns to a unit of labor in the appropriation sector are $\frac{A(L_A)}{L_A}\left[r\overline{K} + w(\overline{L} - L_A)\right]$, whereby each unit of labor applied to appropriation gets an even share of the appropriated wealth. We assume that each worker is infinitesimally small and the there is free entry into the appropriation sector. Therefore, the amount of labor in this sector is determined by the equality of the return to labor in the productive sectors and the appropriation sector. In this model, appropriators are seen as noncooperatively exploiting a common resource, much as fishermen do when fishing in a common pool, and our equilibrium condition coincides with the standard equilibrium condition in models of exploitation of common natural resources with free entry -see Dasgupta and Heal (1979).

In real life, whether the fight for resources takes the form of atomistic criminals or large, politically organized factions will depend on many factors shaping the industrial organization of social conflict. In the appendix we let the industrial organization of appropriation vary between monopoly and perfect competition. When the number of appropriators goes

[9] The extreme assumption that the appropriation sector uses no capital is made for simplicity only. The necessary and sufficient condition for our results to emerge is that the appropriation sector be more labor intensive than the overall economy. This allows for appropriation being less labor intensive than the labor intensive industry. See the appendix for a demonstration.

[10] As we discuss later, the equilibrium conditions and the results do not change if we assume instead that a fraction of their endowments is stolen or that appropriators target the output or revenues of firms.

to infinity, and appropriation becomes perfectly competitive, the equilibrium condition for appropriation converges to the one considered above. In the main model we focus on perfectly competitive appropriation for simplicity and to keep market structure constant across all sectors. However, we show in the appendix that the comparative statics obtained for the competitive case hold for any other market structure in the appropriation business. Similarly, for simplicity we do not consider in the main model the possibility that the public enforcement of the law may respond to changes in the environment. We show in the appendix that the existence of endogenous enforcement does not affect the results. Finally, the model also abstracts from losses that appropriation activities may cause by way of destruction of life and property. Incorporating those is straightforward and would not affect the results either.

3 The Equilibrium

This section characterizes the conditions for existence of an equilibrium with appropriation in our economy. We then describe this equilibrium and compare it to that in an economy where social conflict is absent.

For most of the analysis it is useful to define the minimum unit-cost requirements of inputs in each industry: a_{ij} is the amount of input j used to produce one unit of output i at minimum cost given the technology and factor prices (r and w). To simplify notation we omit expressing these coefficients as functions of r and w.

As is standard, we focus on equilibria without productive specialization (i.e. both q_1 and q_2 are positive). Given the technology, output prices (p_1) and factor endowments ($\overline{K}$ and $\overline{L}$), the equilibrium of the model determines the rental price of factors (r and w), the output production levels (q_1 and q_2), and the utilization of factors in each sector (K_1, K_2, L_1, L_2 and L_A).

Three sets of conditions must be satisfied in a competitive equilibrium. First, firms in the productive industries must earn zero profits:

$$ra_{1K} + wa_{1L} = p_1 \quad (1)$$

$$ra_{2K} + wa_{2L} = 1. \quad (2)$$

Second, the market for factors must clear:

$$q_1 a_{1K} + q_2 a_{2K} = \overline{K} \quad (3)$$

$$q_1 a_{1L} + q_2 a_{2L} = \overline{L} - L_A. \quad (4)$$

Third, a no arbitrage condition must hold, in the sense that labor must obtain similar returns when engaging in appropriation as when it is employed by the productive industries:

$$\frac{A\left(L_A\right)}{L_A}\left[r\overline{K}+w(\overline{L}-L_A)\right]=[1-A\left(L_A\right)]w. \tag{5}$$

This last condition merely says that the individual payoff from appropriation in the left hand side of equation (5), the value of appropriated goods per unit of labor deployed to expropriation, must equal the returns from work net of appropriation losses in the right hand side. This expression is straightforward in the case that appropriation targets factor owners, but also applies to any of the other interpretations given before.[11]

3.1 Existence

Proposition 1 *If there exists an equilibrium without specialization for the economy without appropriation, $A(\overline{L})$ is sufficiently small and $A'(0)$ is sufficiently large, then in the economy with appropriation there is an equilibrium with no specialization and positive levels of conflict.*

Proof. Note that L_A does not appear in equations (1) and (2). Thus, the existence of an appropriation sector does not affect the gross rental price of factors unless it results in specialization. The condition for no specialization in an economy without appropriation is $\frac{a_{2K}}{a_{2L}}<\frac{\overline{K}}{\overline{L}}<\frac{a_{1K}}{a_{1L}}$, while that in the economy with appropriation is $\frac{a_{2K}}{a_{2L}}<\frac{\overline{K}}{\overline{L}-L_A}<\frac{a_{1K}}{a_{1L}}$. In other words, the amount of L_A that solves equation (5) should be small enough (say L_A is below some level we label $\widehat{L}$). Simplifying equation (5) we have that $A\left(L_A\right)=\frac{w}{r\overline{K}+w\overline{L}}L_A$. If $A\left(0\right)=0$ and $A'\left(0\right)>\frac{w}{r\overline{K}+w\overline{L}}$ there is an equilibrium with positive L_A determined by the intersection of $A\left(L_A\right)$ with $\frac{w}{r\overline{K}+w\overline{L}}L_A$. If $A\left(0\right)>0$ equilibrium is unique and L_A is positive. If $A(\overline{L})$ is sufficiently small the interior solution satisfies $L_A<\widehat{L}$, given that $A\left(L_A\right)$ is increasing, and the economy does not specialize. ■

In the remainder of the paper we restrict attention to economies with an active appropriation sector.

[11] In the case when it is the output of firms that is targeted, the value of production available for repaying factors will be affected by the same coefficient in both sectors. The reader might wonder whether the existence of appropriation should affect the first two equations in the system, which appear exactly as in the canonic model without appropriation. Firms would obtain net prices affected by a factor $1-A(.)$ in the right hand side, and we would get net equilibrium factor prices $\hat{w},\hat{r}$. Now note that the unitary input requirement coefficients are homogeneous of degree zero in factor prices. Then, because the system (1)-(2) has a unique solution, we must have $\hat{w}=(1-A)w$ and $\hat{r}=(1-A)r$. All factors $1-A$ disappear, and we are left with the same first pair of equations.

3.2 Comparison of Economies with and without Conflict

In the case of no specialization that we focus on, the existence of an appropriation sector does not affect the absolute gross rental prices of factors. These are solely determined by the characteristics of productive technologies, and the amount of labor engaging in appropriation is residually determined in equations (3) to (5) so that the market for factors will clear and no one will gain by reallocating labor units across activities.

The presence of appropriation activities, however, does affect the rental prices net of appropriation that factor owners actually receive. In fact, the existence of an appropriation sector hurts all agents, including those who go into the appropriation sector.

Proposition 2 *The existence of the appropriation sector makes the owners of capital and labor worse off.*

Proof. If there is no specialization, the rental price of factors are the values of r and w that solve equations (1) and (2). Then, total incomes to capital and labor without an appropriation sector are $r\overline{K}$ and $w\overline{L}$, respectively. With appropriation without specialization, the gross rental prices of factors do not change but the net rental prices are respectively $(1 - A(L_A))\, r$ and $(1 - A(L_A))\, w$. Therefore, total incomes to capital and labor with an appropriation sector are $(1 - A(L_A))\, r\overline{K}$ and $(1 - A(L_A))\, w\overline{L}$, respectively. ■

The possibility that workers may become criminals or warriors poses a paradox, in that they will end up worse off than if they could commit not to leave productive activities. The reason is that workers in the appropriation sector impose a negative externality on the rest of the economy.[12]

In addition, appropriation affects the relative importance of the productive sectors in the economy.

Proposition 3 *The existence of the appropriation sector increases the production of the capital intensive good and reduces the production of the labor intensive good.*

Proof. If there is no specialization, the rental price of factors are the values of r and w that solve equations (1) and (2). These factor prices determine the values of a_{1K}, a_{2K}, a_{1L} and a_{2L} which enter in equations (3) and (4). Given the amount of factors available for production ($\overline{K}$ and $\overline{L} - L_A$) these equations determine the levels of production in the two

[12] Of course, with productive specialization, the existence of an appropriation sector would result in an increase in the wages paid by firms. If this increase is greater than the "appropriation tax," workers would be better-off with the existence of the appropriation sector.

productive industries. It can be easily shown that:

$$\begin{aligned} q_1 &= \frac{a_{2L}\overline{K} - a_{2K}\left(\overline{L} - L_A\right)}{a_{1K}a_{2L} - a_{1L}a_{2K}} \\ q_2 &= \frac{a_{1K}\left(\overline{L} - L_A\right) - a_{1L}\overline{K}}{a_{1K}a_{2L} - a_{1L}a_{2K}}, \end{aligned}$$

so increases in L_A must increase q_1 and reduce q_2 when $\frac{a_{2K}}{a_{2L}} < \frac{a_{1K}}{a_{1L}}$. ■

This proposition is an application of Rybczynski's (1955) theorem, and it shows that the presence of conflict enlarges the capital intensive sector. This has implications for the empirical study of the connection between conflict and natural resources. In countries where extractive industries are relatively capital intensive, they could account for a larger share of economic activity as a consequence–and not a cause–of conflict. As will be shown below, our theory also predicts a causality effect going in the opposite direction: shocks that favor and enlarge extractive, capital intensive activities will increase conflict. This two-way causation poses a challenge to empirical work trying to estimate the impact of natural resource availability on conflict.

This proposition also has implications for understanding the connection between conflict and patterns of trade. Conflict will affect trade by biasing domestic production towards the capital intensive sector. In fact, the effect of conflict may be large enough to reverse the pattern of trade of a country. The reason is that an originally relatively labor abundant country, which would export the labor intensive good in the absence of conflict, may become relatively capital abundant once a share of labor leaves the productive sector to join the appropriation sector and, hence, end up exporting the capital intensive good.

4 Shocks and the Intensity of Social Conflict

We study now how changes in the parameters of the model affect the level of conflict. We first study changes in output prices.

4.1 Changes in the Terms of Trade

Changes in the price of commodities affect the rental price of factors. In an economy with an appropriation sector, this effect is the same as in an economy without an appropriation sector.

Lemma 1 *(Stolper and Samuelson) An increase of the price of the capital intensive output results in an increase in the rental price of capital and a decrease in the rental price of labor* $\left(\frac{dr}{dp_1} > 0 \text{ and } \frac{dw}{dp_1} < 0\right)$.

Proof. Differentiating equations 1 and 2 and using the envelope theorem it is straightforward to show that: $\frac{dr}{dp_1} = \frac{a_{2L}}{a_{1K}a_{2L} - a_{1L}a_{2K}} > 0$, $\frac{dw}{dp_1} = \frac{-a_{2K}}{a_{1K}a_{2L} - a_{1L}a_{2K}} < 0$. ■

This fundamental result of international economics is key to two of the central results of this paper, captured in propositions 4 and 5.

Proposition 4 *An increase in the price of the capital intensive output results in an increase in conflict* $\left(\frac{dL_A}{dp_1} \geq 0\right)$.

Proof. The equilibrium condition for the appropriation sector can be written as $A(L_A) = \frac{1}{\frac{r}{w}\overline{K}+\overline{L}} L_A$. The conditions for the implicit function theorem are satisfied, so we can write L_A as a function of p_1. Differentiating the previous equality with respect to p_1 we obtain: $\frac{dL_A}{dp_1} = -\frac{\frac{\overline{K}L_A}{(\frac{r}{w}\overline{K}+\overline{L})^2}\frac{d(\frac{r}{w})}{dp_1}}{[A' - \frac{1}{\frac{r}{w}\overline{K}+\overline{L}}]}$.

The denominator is negative from the assumptions on $A(L_A)$ (namely, $A(0) \geq 0$ and concavity) and the equilibrium condition in the appropriation sector. Then, $\frac{dL_A}{dp_1}$ has the sign of $\frac{d(\frac{r}{w})}{dp_1}$, which is positive by Lemma 1 (Stolper-Samuelson). ■

The intuition for this result is as follows. In our model the level of conflict responds to a balance between the opportunity cost of appropriation activities and the value of potentially appropriable resources (as captured in the right and left hand sides of equation (5), respectively). An increase in the price of the capital intensive good expands the capital intensive sector while the labor intensive sector contracts. The latter sector releases more labor per unit of capital than the former sector can absorb at the initial factor prices. This availability of labor lowers wages and with them the opportunity cost of the appropriation activity compared with the size of disputable wealth. The consequence is more conflict.

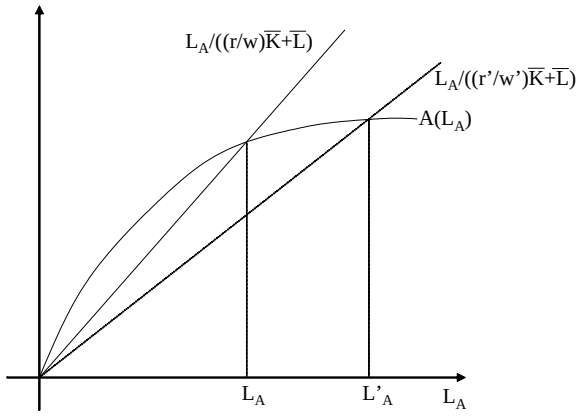

Figure 1: Prices and conflict

The way this result arises from the model can be easily explained by means of Figure 1. A simple manipulation of equation (5) shows that the amount of labor in the appropriation sector is determined by the intersection of the concave function $A(L_A)$ with the linear function $\frac{1}{\frac{r}{w}\overline{K}+\overline{L}}L_A$. By Lemma 1, an increase of p_1 results in an increase of r and a decrease of w. This, in turn, leads to a decrease in the slope of the linear function, resulting in an increase in L_A.

4.2 Changes in Technology

Technical progress unambiguously increases society's ability to create wealth. However, there are instances in which technical change will increase conflict. In what follows we call technical progress in an industry *neutral* if it does not affect the industry's ratio of marginal productivities given its capital to labor ratio - see Hicks (1932).

Proposition 5 *Neutral technical progress in the capital intensive sector results in an increase in conflict.*

Proof. Consider a neutral technical innovation that makes the capital intensive sector $1+\theta$ times more productive ($\theta > 0$). This implies that the zero profit condition in that sector can now be written as: $ra_{1K} + wa_{1L} = (1+\theta)\,p_1$. Therefore, technological progress in the capital intensive sector has the same effect on r and w as an increase of the price of the capital intensive good. The result then follows from Proposition 4. ■

Likewise, neutral technical progress in the labor intensive sector results in a decrease in social conflict. Note that the result that technical change will increase conflict does not rely on such change being of a labor-saving kind, which would of course yield the result more easily. Innovations can lead to more conflict even when being factor-neutral.

5 Policy Analysis with a Social Constraint

In this section we study how the existence of conflict introduces a "social constraint" to policy analysis, altering what we may deem as desirable policy. Policies that are optimal under the unrealistic assumption of perfect property rights may be undesirable in reality because of their impact on social conflict. We first study in Section 5.1 how subsidies to workers in the productive sectors, financed with taxes to capitalists, can reduce the level of social conflict and enlarge the total value of production in the economy. In Section 5.2 we examine a rationale for trade policy intervention both from a domestic and an international perspective. Finally, in Section 5.3 we study the policy implications of our proposition that

technical progress in the capital intensive industry will increase conflict. We show that this increase in conflict can be as large as to make everybody worse off, so policies affecting the adoption of technical innovations might be justified. The results of this section help explain how certain policy reforms that appear Pareto-improving in a frictionless model may be rendered inefficient by the social backlash to policy in a conflictive world. Once appropriation is taken into account, policies that seem inefficient may instead be Pareto-improving. This is of course an instance of the theorem of the second best: in the presence of a distortion, another distortion may improve matters (see Lipsey and Lancaster, 1956). In our model, the original distortion is given by the presence of appropriation activities. Some of the policies rationalized in this section fit the populist stereotype. The results in this section suggest that such policies could emerge, to a certain degree, as a rational response to conflict, rather than as the result of clientelism, corruption, or a sheer taste for redistribution.

5.1 Taxes and Social Conflict

Consider a tax-subsidy scheme such that workers in the productive sectors receive a subsidy equal to a fraction s of the wage firms pay to them. To fund these subsidies, capitalists pay a tax equal to a proportion t of the rent to capital. In addition, the government keeps a balanced budget:

$$sw(\overline{L} - L_A) = tr\overline{K}. \tag{6}$$

Given taxes t, subsidies s, and the government's budget constraint, the equilibrium condition for the appropriation sector becomes:

$$\frac{A\left(L_A\right)}{L_A}\left[r\overline{K} + w(\overline{L} - L_A)\right] = \left(1 - A\left(L_A\right)\right)\left(1 + s\right)w. \tag{7}$$

The model is completed with equations (1) to (4).

Proposition 6 *Giving a subsidy to productive labor reduces the level of conflict* $\left(\frac{dL_A}{ds}\rfloor_{s=0} < 0\right)$.

Proof. The equilibrium condition for the appropriation sector can be written as $A\left(L_A\right) = \frac{wL_A + (1-A(L_A))swL_A}{r\overline{K}+w\overline{L}}$. Differentiating this condition with respect to s, and evaluating the expression at $s = 0$, we obtain: $\frac{dL_A}{ds}\left(s = 0\right) = \frac{(1-A(L_A))wL_A}{A'(L_A)\left(r\overline{K}+w\overline{L}\right)-w}$. The denominator is negative from the concavity of $A\left(L_A\right)$ and the equilibrium condition in the appropriation sector without subsidies. Then, $\frac{dL_A}{ds}\left(s = 0\right) < 0$. ■

The intuition for this result is straightforward. Subsidizing productive labor increases the opportunity costs of engaging in appropriation, thus reducing the latter. A subsidy to

productive labor results in a shift of labor away from appropriation activities and towards the productive sectors of the economy. Therefore, the tax-subsidy scheme has a positive effect on the total amount of output in an economy with an appropriation sector, providing an efficiency rationale for a set of policies that are usually considered solely redistributive.

If lump sum taxes and transfers were possible, then our tax-subsidy scheme would be Pareto optimal, because the total value of production could be increased while making sure capitalists are being left at least as happy as before paying any taxes. When dealing with the issue of social conflict, however, it may not be appropriate to assume that all transfers among agents are possible. For example, it might be impossible to tax the agents in the appropriation sector.

If we restrict ourselves to the case in which the government can only tax and subsidize agents in the productive sectors, the issue of the Pareto optimality of subsidies to productive labor becomes more complicated. We must study the effects of this policy in the net wages and rental price of capital. It is straightforward to see that a subsidy to productive labor always makes workers in the productive industries better off. The subsidy has two effects: first, it has a direct positive effect in the gross total wage; and second, it reduces the appropriation sector and hence the expropriation suffered by workers. Both effects go in the same direction, increasing the net income of workers. Those in the appropriation sector must also be better off given that in equilibrium they are indifferent regarding their career choices. In the case of owners of capital, the two effects go in opposite directions: under the tax-subsidy scheme, they pay a tax but the "appropriation tax" diminishes. If the second effect overcomes the first, we have that the proposed scheme makes both workers and capitalists better off. We now show by example that there are economies where the tax-subsidy scheme proposed above is Pareto-improving.

Example 1 *Taxes, subsidies, and social conflict in a Cobb-Douglas economy:*

Consider an economy with production functions $q_1 = K_1^{\frac{2}{3}} L_1^{\frac{1}{3}}$ *for the capital intensive sector, and* $q_2 = K_2^{\frac{1}{3}} L_2^{\frac{2}{3}}$ *for the labor intensive sector. Let us set the total endowments of the two factors of production at levels* $\overline{K} = \overline{L} = 100$*. In this example we characterize the equilibrium both for the case without an appropriation sector* ($L_A = 0$) *and the case in which there is an appropriation sector with the following technology:* $A(L_A) = \frac{L_A}{150+L_A}$*. In the latter case we consider both the situation with no intervention* ($s = t = 0$) *and a situation with state intervention through a tax-subsidy scheme. In this case, we consider a subsidy to productive labor of 10%* ($s = 0.1$)*, which is funded through a tax on capital. The public budget is balanced in equilibrium.*

Figure 2 shows the output combinations that can be obtained in equilibrium for the three cases. The graph coincides with the production possibility frontier for the economy without an

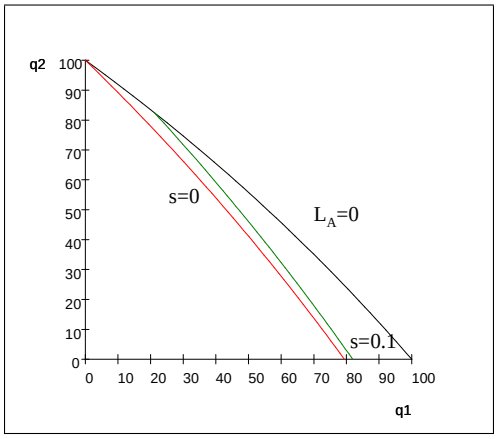

Figure 2: Equilibrium output pairs

appropriation sector (given the Pareto optimality of equilibria). That is not the case under social conflict, where the set of production pairs that can be obtained is to the south-west of the pairs for the economy without social conflict. The existence of social conflict introduces a wedge between what it is technically feasible and what can be obtained in equilibrium. Interestingly, a subsidy to productive labor moves the set of production pairs under conflict toward the ones without conflict. In fact, the subsidy allows for the total elimination of conflict in some cases, making both graphs coincide in the left upper part of the figure (when p_1 *is relatively small). While subsidies to productive labor make all workers better off, that is not necessarily the case with owners of capital. Figure 3 shows the net income of capital (net*

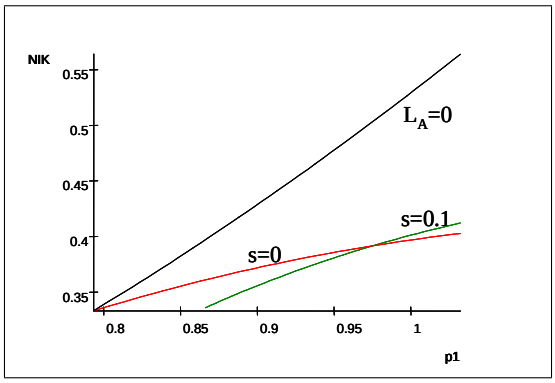

Figure 3: Net income of capital

of government taxes and appropriation losses, labeled with "NIK") as a function of p_1 *for the three different scenarios (*L_A*=0, s=0, s=0.1). The figure shows that social conflict results in a lower income for capitalists. For relatively high levels of* p_1*, and given the existence of the appropriation sector, capitalists are better off with a subsidy to productive labor (and a tax*

to capital) than without it.

The welfare effects discussed in this example will not disappear in a dynamic economy with endogenous investment. If taxes on capital and subsidies to productive labor can reduce conflict so much as to reduce the total burden on capitalists, they will increase capital accumulation rather than decrease it.

Finally, note that even when lump sum redistribution is feasible, in our model the optimal intervention will be distortinary. Policy induced distortions are necessary to increase the incentive to work and decrease the incentive to loot. There is a literature seeking to explain why income redistribution adopts inefficient forms. Explanations have been linked to asymmetric information or commitment problems (Coate and Morris 1995, Dixit and Londregan 1995). In our model, the apparently inefficient instruments may be in fact efficient, while distortion-free instruments will not achieve the goal of reducing conflict.

5.2 Trade Policy Intervention and Social Conflict

Domestic trade policy in the small economy

Here we explain how trade policy intervention in the small open economy can reduce social conflict, and how this intervention can be Pareto-improving. Consider a country that is a net importer of goods produced in its labor intensive industry, and is a net exporter of goods produced in its capital intensive industry. Our Proposition 4 indicates that social conflict can be decreased through an increase in the price of the labor intensive good and a decrease in the price of the capital intensive good. Therefore, if the government desires to attain a reduction in conflict, it might consider imposing a tariff on imports. This protection will increase the price that domestic producers in the labor intensive sector can obtain for their goods, causing an expansion of the sector, an increase in wages, and a drop in social conflict. This drop could be large enough for both capitalist and workers to benefit from the protection of the labor intensive industry. A reduction in social conflict can also be attained by taxing the exports of the capital intensive sector. In the converse case that the country is a net exporter of labor intensive goods, and a net importer of capital intensive goods, a government that wishes to decrease conflict would impose subsidies on both the labor intensive exports and the capital intensive imports.

International trade policy and social conflict

In recent years we have witnessed significant international policy efforts at preventing, controlling, and ending armed conflict. The peace-keeping branch of the UN, for example, carries initiatives in a large number of countries. Some of these–notably some countries in

Africa–have been involved both in interstate and civil conflicts where appropriation is widely known to play an important role.[13]

On the other hand, Western democracies and the global community as represented by the UN pursue development efforts in the Third World, which include a trade-related dimension. Organizations such as the UN's Conference on Trade and Development (UNCTAD) and the United Kingdom's Direction for International Development (DFID) are spearheads to various initiatives that seek to help developing countries increase their exports to richer nations. However, the policies discussed in the context of trade and development strategies are never linked to the initiatives that the same set of actors pursue regarding peace-keeping. Our model suggests that they should be connected, and how.

To see this, suppose we view access to first world markets for, say, processed agricultural products, as an improvement in the price for processed agricultural goods produced in a Subsaharan economy. Now note those goods are relatively labor intensive in the latter economies. Then our model predicts that better access to European markets for those goods would cause the labor intensive sector in Subsaharan economies to expand. This would make labor relatively scarcer, raising wages and diminishing conflict in Subsaharan Africa. Unfortunately, less developed countries face significant barriers to the markets in developed countries. Moreover, these barriers (tariff barriers especially) are biased against less technology intensive exports (see Meller 2003).

It follows from our model that when the possibility of lower protection to First World agriculture is discussed within the World Trade Organization, its benefits in terms of lower conflict in Africa might have to be taken into account. At the same time, higher European tariffs, subsidies and sanitary barriers to agricultural products may entail costs in terms of more painstaking peace efforts abroad. Our model also warns that export oriented strategies as pursued by UNCTAD and DFID might have to focus on the fact that not every income-enhancing change may reduce conflict. Fostering the expansion of labor intensive industries could constitute a pacifying force. But the expansion of extractive, more capital intensive activities (that happen to attract significant Western involvement), on the contrary, may fuel conflict instead. See our discussion on "conflict diamonds" in the next section.

[13]The pervasive presence of appropriation of goods and even human beings in the context of Africa's civil wars is well documented. Mentions to looting and banditry in official documents are ubiquitous. An example is provided by the UN Secretary-General's report S/1997/80, on 26 January 1997 (available at <http://www.un.org/Depts/dpko/unamsil/UnamsilR.htm>). Therein the Secretary-General stated how thousands of village hunters were being recruited to defend villages "against looting from both the RUF and undisciplined RSLMF elements." (RUF means Revolutionary United Front and RSLMF means Republic of Sierra Leone Military Forces.)

5.3 First World Technological Progress and Third World Conflict

One would think that developing nations will be helped by technology transfers from rich nations: better technologies expand the production possibility frontier and make a country unambiguously richer. However, if developed nations are more capital intensive than developing ones, the innovations the former make available to the latter might be biased towards the capital intensive industry.[14] The problem with the adoption of such innovations is that, as shown in Section 4, neutral technical progress in the capital intensive industry will increase conflict. Moreover, the increase in conflict can overcome the direct effect of technical progress on the production possibilities of the economy, resulting in a decrease in total production. As shown in the example below, the decrease in production can be so significant that even capitalists are worse off by the adoption of a technological innovation in the capital intensive sector. Firms in the capital intensive sector have incentives to adopt a better technology and make profits. In equilibrium, all firms in the sector adopt the improved technology and make zero profits. The impact on factor prices increases conflict, and this increase can be as strong as to leave all owners of labor and capital worse off.

Example 2 *Technological progress and conflict:*

Consider an economy with production functions $q_1 = K_1^{\frac{2}{3}} L_1^{\frac{1}{3}}$ *for the capital intensive sector,* $q_2 = K_2^{\frac{1}{3}} L_2^{\frac{2}{3}}$ *for the labor intensive sector, and the following appropriation technology:* $A(L_A) = \frac{3}{260} + \frac{1}{260} L_A$. *Let us set the total endowments of the two factors of production at levels* $\overline{K} = \overline{L} = 100$ *and let* $p_1 = 1$. *Figure 4 shows the total value of production in the economy for different levels of technological progress (*θ*) in the capital intensive sector. While an increase of 5% in the productivity of sector 1 results in an increase of total production, further increases actually have a negative effect on the total production of the economy.*

Figure 5 (below) shows the net incomes of capital and labor (labeled NIK and NIL respectively). Technical progress in the capital intensive sector hurts labor. There are two reasons for this: first, technical progress in the capital intensive sector reduces the gross wage paid by firms; second, there is an increase in the appropriation losses brought by the increase in conflict. The two forces work in different directions for capitalists. While technical progress in the capital intensive sector results in an increase in the gross rental price of capital, it also results in an increase in the appropriation they suffer. Figure 5 shows that the second effect overcomes the first one for relatively high rates of technical progress. As a result, both workers and capitalists are made worse off by technical progress.

The example suggests that developing nations with serious conflict issues may not want to adopt every technological improvement that richer countries make available to them,

[14] On appropriate technology improvements and their diffusion see Basu and Weil (1998).

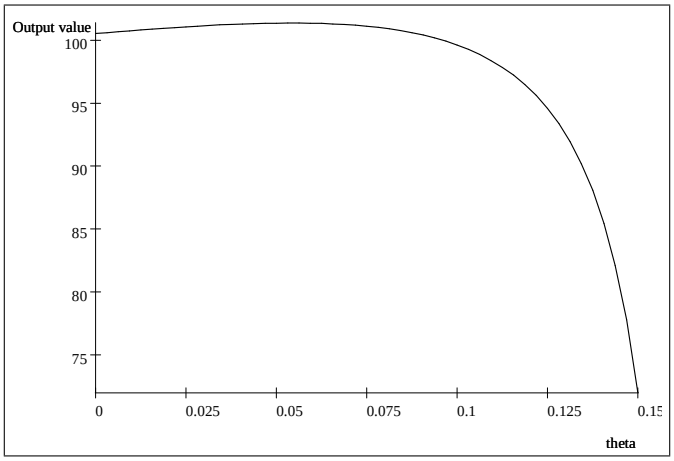

Figure 4: Technological progress and total production

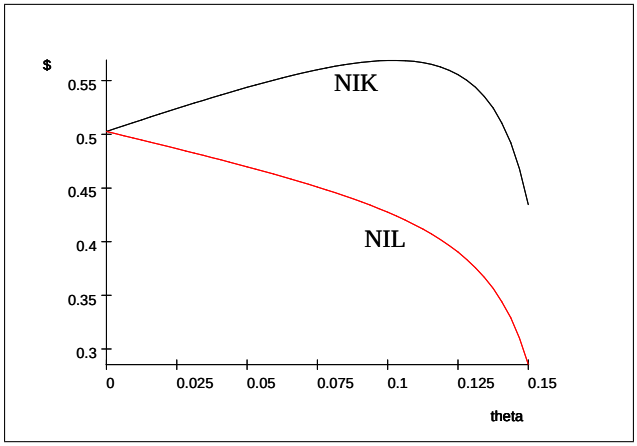

Figure 5: Technical progress and payments to factors.

even if these come as a gift. In addition, a conflict-prone society may want to discourage innovation in the capital intensive sector, while encouraging it in the labor intensive sector. This course of action and the trade policies analyzed in the following subsection mirror the interventions proposed by Latin American structuralists (see for instance Prebisch, 1959) and other advocates of state-guided "national development strategies."

Another way to affect the relative productivity of sectors is through education. Basic education increases the productivity of labor and, hence, the productivity of the labor intensive sector relative to the capital intensive one. In this way, basic education increases wages relative to the return to capital and reduces conflict, as long as the impact of basic

education on appropriation abilities is relatively weaker than on productive ones.[15]

6 Conflict and Factor Specificity

It may be argued that the predictions of our model are unrealistic in the short run, when some factors of production are fixed. For example, one might expect the Stolper-Samuelson theorem to fail: a positive shock to the price of oil could generate an increase in wages–rather than a decrease–even when oil extraction is a relatively capital intensive sector. But if more valuable natural resources will raise wages, can we still account for the curse of natural resources, whereby the availability of more valuable natural resources increases conflict? If anything, it would seem that such phenomenon must be explained with a model that is compatible with delivering higher conflict *and* higher wages when, say, the price of a natural resource increases. In this section we attain precisely this explanation. We study the well known Ricardo-Viner model with industry-specific factors and add the appropriation sector. Therefore, the model is as in section 3, except that while labor is still mobile across sectors, capital is not. There are two kinds of capital (K_1 and K_2) which are specific to each productive industry. The endowments of capital are denoted with $\overline{K}_1$ and $\overline{K}_2$ respectively. The model with industry specific factors can be thought to capture short run movements (when capital is fixed), while our basic model in section 3 can be thought to capture long run effects (when all factors are mobile).

We show that natural resource shocks that raise wages are indeed compatible with higher, rather than lower, levels of conflict. The key aspect is that when extractive activities are relatively capital intensive, a shock to the price of natural resources will expand the returns to appropriation even more than it increases its opportunity costs.

Note that when there are industry specific factors of production, the definition of a sector as "labor intensive" is not too meaningful if one sticks with the definition used before, in terms of unit input requirement ratios. In the modified setup, we follow convention by saying that an industry is relatively labor intensive when the participation of labor in that industry's income is relatively high. Using standard notation, let $\sigma_i < 0$ denote the elasticity of substitution between labor and capital in sector i, and let $\theta_{L_i} \equiv \frac{wL_i}{wL_i + rK_i}$ be the distributive share of labor in the income of sector i. We can now state,

Proposition 7 *An increase in p_1 results in an increase in conflict $\left(\frac{dL_A}{dp_1} \geq 0\right)$ if and only if $\frac{\sigma_1\theta_{L1}}{1-\theta_{L1}} \geq \frac{\sigma_2\theta_{L2}}{1-\theta_{L2}}$. When elasticities of substitution are the same across industries (i.e., when*

[15] For other theories on the interrelation of social struggle and education see Galor and Moav (2003) and references therein.

$\sigma_1 = \sigma_2$), then an increase in p_1 results in an increase in conflict if and only if industry 1 is relatively capital intensive (i.e., when $\theta_{L1} < \theta_{L2}$).

Proof: See Appendix.

This proposition provides a clear condition under which a change in international prices would result in an increase in conflict. For example, if the elasticities of substitution are the same in both productive sectors, an increase in p_1 results in an increase in conflict if, and only if, sector one is relatively capital intensive. In addition, if the payments to labor are equal in both sectors, an increase in p_1 results in an increase in conflict if, and only if, sector one has, in absolute value, a lower elasticity of substitution than sector 2. The reason is that the lower (in absolute value) the elasticity of substitution of sector 1, the smaller the positive impact of the increase of prices on wages.

This result holds regardless of the fact that an increase in p_1 will result in an increase in wages. The increase in p_1 results in an increase in the income of capital (the net effect of an increase in sector 1 and a decrease in sector 2) that is greater than the increase in wages. This causes the potential disputable wealth to rise more than wages, in turn making appropriation activities more attractive to workers. The model with specific factors makes clear that the main conclusions of this paper do not depend on the sign of the impact of shocks on wages. Instead, the results depend on the relative impact that shocks have on the retribution to capital and wages, as this governs the relative movements of the benefits and costs of conflict.

Is it also the case that an increase in the specific endowment of the diamond industry (i.e. rough diamonds) would result in an increase in conflict? While in this model it is difficult to characterize in general the effects of endowment changes on the level of conflict, we provide such results for a Cobb-Douglas economy.

Proposition 8 *In a Cobb-Douglas economy, an increase in the endowment of capital of the capital (labor) intensive sector results in an increase (decrease) of conflict.*

Proof: See Appendix.

If we interpret natural resources such as oil or diamonds as specific capital to extractive activities, then we may offer a new explanation for the curse of natural resources. Increases in the price and availability of diamonds, say, will increase conflict if diamond extraction is relatively capital intensive or displays a low elasticity of substitution between labor and capital. Thus, the model can be used to analyze the issue of "conflict diamonds." These are rough diamonds that are seen to fuel conflict because rebel factions have direct access to them and use the revenues to finance themselves (see Ross 2003). As a result, governments

and parties concerned with the diamond trade have engineered a certification process within an initiative known as the Kimberley process.[16] The aim is to stamp out "conflict diamonds" and keep them away from the diamond market. The disturbing implication of our model is that every diamond may be a conflict diamond: perfectly legal diamonds that have not been handled by rebels may also increase conflict.

7 Conclusion

This paper extends two canonic general equilibrium models of a small open economy by considering a realistic distortion: the imperfect enforcement of property rights. This allows us to study how economy-wide forces affect appropriation activities ("social conflict"), and to reconsider what may constitute sound policy advice.

Societies often implement policies that economists consider inefficient. Work on the political economy of endogenous policies (see, inter alia, Stigler 1971, Peltzman 1976, Becker 1983, and Coate and Morris 1995) has shown that such policies may be shaped by political constraints. A similar case can be made when a social constraint is incorporated into economic analysis in the form of appropriation activities: policies that make no sense in the traditional models may become attractive to society (and its politicians) in the face of property rights that are both imperfect and endogenous. Examples are taxing capital to subsidize productive labor, trade interventions that lower protection of capital intensive industries relative to labor intensive ones, and "national development strategies" that distort the profile of technical innovations that are adopted by firms. This also helps to explain why implementing reforms that appear efficient a priori may be delayed and become unpopular when implemented.[17]

Our policy results reflect the logic of the theorem of the second best (Lipsey and Lancaster, 1956). While many distortinary policies could be rationalized as efficient by some model featuring an initial distortion, we believe our theory deserves attention for two reasons. First, it is based on two canonic models that have shaped the economic intuitions underlying widespread policy advice. Second, the initial distortion we incorporate, the imperfect enforcement of property rights, is realistic and economically important.

Our theory suggests a novel research and policy agenda surrounding conflict economies. For instance, there could be gains to coordinating peace-keeping efforts and international trade agreements. Similarly, it may be useful to reassess development strategies and various economic reforms from the perspective of their impact on social conflict. In addition, our

[16] See <http://www.kimberleyprocess.com>.

[17] On delayed reforms, see Alesina and Drazen (1991), and Fernandez and Rodrik (1991). See Lora and Olivera (2005) on reform unpopularity in Latin America.

simple theory generates a number of predictions that are empirically relevant. The theory helps explain apparently paradoxical stylized facts concerning civil wars: both unfavorable circumstances (such as droughts) and favorable ones (such as higher availability of natural resources) increase the likelihood of civil war. The theory's implications are also compatible with the observed positive correlation between crime and inequality although it makes a more precise prediction: increases in inequality will only increase conflict when damaging the relative remuneration of the factor that is intensively used in conflict activities. According to our model, reducing inequality without affecting the incentives to undertake productive activities (as with social programs that provide lump-sum redistributions) may not diminish conflict.

Future work may extend the analysis to dynamic settings where agents can accumulate capital. We expect that the effects we have identified will still be present, such as that of taxing capital to subsidize productive labor: if, as we have shown, this policy can reduce conflict so much as to reduce the overall burden on capitalists, it will increase, rather than decrease, capital accumulation. Future work could also re-examine state intervention across countries.[18] This presence varies widely both in terms of the regulation of business and in terms of welfare institutions (Shleifer, 2004). This variety may embody different approaches to purchasing social peace.

[18] Di Tella and MacCulloch (2003) investigate popular attitudes towards state intervention across countries.

8 Appendix

8.1 Extensions

In this appendix we study several extensions to the basic model of section 2 and find that the results are robust: first, we study the case in which the appropriation sector displays varying degrees of competition from monopoly to perfect competition. Second, we study the case when appropriation uses both labor and capital. Finally, we study appropriation with endogenous enforcement.

Imperfect competition in the appropriation sector

We assume now that, instead of a perfectly competitive appropriation sector, there is a given number of appropriation groups. Each appropriation group hires labor and must pay a wage equivalent to the (net of appropriation) wage workers can earn in the productive industries. We assume that a group's share of the total amount of appropriated resources equals its share of labor in the sector. In this way, the revenues for group i are $\frac{L_{Ai}}{L_{Ai}+L_{A-i}} A\left(L_{Ai}+L_{A-i}\right)\left[r\overline{K}+w(\overline{L}-L_{Ai}-L_{A-i})\right]$, where L_{Ai} and L_{A-i} represent the demand of labor of group i and the rest of the conflict sector, respectively. The group will choose L_{Ai} to maximize profits. In equilibrium and appealing to symmetry the first order condition yields an analog to equation (5) in section 3:

$$\left[\frac{N-1}{N}\frac{A\left(L_A\right)}{L_A}+\frac{1}{N}A'\left(L_A\right)\right]\left(r\overline{K}+w\overline{L}\right)=w, \tag{8}$$

where $L_A=\sum_i^N L_{Ai}$. Note that when $N\to\infty$ the last equation reduces to equation (5). This more general model yields analogous comparative statics results to those we show for the perfectly competitive case.

Proposition 9 *An increase in the price of the capital intensive output results in an increase in conflict* $\left(\frac{dL_A}{dp_1}\geq 0\right)$.

Proof. Differentiating equation (8) with respect to $\frac{r}{w}$ we obtain: $\frac{dL_A}{d\frac{r}{w}}=-\frac{\frac{\overline{K}L_A}{\left(\frac{r}{w}\overline{K}+\overline{L}\right)^2}}{\frac{N-1}{N}\left(A'-\frac{A}{L_A}\right)+\frac{A''L_A}{N}}$.

Concavity of $A\left(L_A\right)$ implies $A'<\frac{A}{L_A}$and $A''<0$, making the denominator negative. Hence, $\frac{dL_A}{d\frac{r}{w}}>0$. The result then follows by Lemma 1 (Stolper-Samuelson). ■

As in Section 4, changes in technology can be studied in a way analogous to the one just used to study price changes and the extension of the results in Section 5 follows.

The case when appropriation employs labor and capital

We now show that the results of the paper also hold when both capital and labor are used in a competitive appropriation sector under the condition that this sector is labor intensive relative to the whole economy. Consider the economy from section 2 with the only difference that now we have n appropriation groups hiring both labor and capital. Each group $i = 1, ..., n$, hires labor l_i and capital k_i, to produce an appropriation effort $a_i = a(l_i, k_i)$ at minimum cost. The total fraction of wealth that is appropriated in the economy is $A(a_1 + ... + a_n)$. The technology $a(.)$ has constant returns to scale, while $A(.)$ has decreasing returns to scale (possibly reflecting congestion effects). We assume that a group's share of the total amount of appropriated resources equals its share of appropriative effort. Appropriation groups pay factor prices net of appropriation (i.e., $[1 - A(.)]\, r$ and $[1 - A(.)]\, w$, respectively). Cost minimization yields the minimum cost demand functions for factors $l_i(\frac{r}{w}, a_i)$ and $k_i\left(\frac{r}{w}, a_i\right)$. Then group i maximizes,

$$\frac{a_i}{\sum_{j=1}^{n} a_j} A(a_1+...+a_n)\left\{r\left(\bar{K} - K_A\right) + w\left(\bar{L} - L_A\right)\right\} - [1 - A(a_1 + ... + a_n)]\left[wl_i(a_i) + rk_i(a_i)\right],$$

where $K_A = k_1 + ... + k_n$ and $L_A = l_1 + ... + l_n$.

The first order condition is, after some algebra and considering the symmetry of our equilibrium,

$$\left\{\frac{(n-1)}{n^2 a} A(a_1 + ... + a_n) + \frac{1}{n}\frac{dA(a_1 + ... + a_n)}{da_i}\right\}\left\{r\left(\bar{K} - K_A\right) + w\left(\bar{L} - L_A\right)\right\} -$$
$$- \left\{1 - \left(1 - \frac{1}{n}\right) A(a_1 + ... + a_n)\right\}\left[r\frac{dk_i}{da_i} + w\frac{dl_i}{da_i}\right] + \frac{dA(a_1 + ... + a_n)}{da_i}\left[w\frac{L_A}{n} + r\frac{K_A}{n}\right] = 0.$$

Because $a(l_i, k_k)$ has constant returns to scale, marginal costs $r\frac{dk_i}{da_i} + w\frac{dl_i}{da_i}$ equal average costs $\frac{rk_i + wl_i}{a_i}$, and in a symmetric equilibrium, $a_1 = a_2 = ... = a_n \equiv a$. We can then write,

$$\left\{\frac{(n-1)}{n^2 a} A(na) + \frac{1}{n}\frac{dA(na)}{da}\right\}\left\{r\left(\bar{K} - K_A\right) + w\left(\bar{L} - L_A\right)\right\} -$$
$$- \left\{1 - \left(1 - \frac{1}{n}\right) A(na)\right\}\left[r\frac{dk_i}{da_i} + w\frac{dl_i}{da_i}\right] + \frac{dA(na)}{da}\left[w\frac{L_A}{n} + r\frac{K_A}{n}\right] = 0.$$

Now define $\alpha = \lim_{n\to\infty} na$ (it is simple to show that α must be finite). Doing some algebra and taking $n \to \infty$ we obtain,

$$A(\alpha)\left\{r\left(\bar{K} - K_A\right) + w\left(\bar{L} - L_A\right)\right\} = \{1 - A(\alpha)\}\left(rK_A + wL_A\right).$$

which can in turn be written,

$$A(\alpha)\left(\frac{r}{w}\bar{K} + \bar{L}\right) = \frac{r}{w}K_A\left[A(\alpha)\right] + L_A\left[A(\alpha)\right]. \tag{9}$$

We study next how changes in prices affect the level of activity of the appropriation sector.

Proposition 10 *An increase in the price of the capital intensive output results in an increase in the level of activity of the appropriation sector* $\left(sgn\left(\frac{dA}{dp_1}\right) = sgn\left(\frac{d\alpha}{dp_1}\right) > 0\right)$ *if and only if the appropriation sector is labor intensive relative to the economy* $\left(\frac{L_A}{K_A} > \frac{\bar{L}}{\bar{K}}\right)$.

Proof. We only need to study the comparative statics of α w.r.t. $\frac{r}{w}$ because the positive effect of p_1 on $\frac{r}{w}$ comes from the Stolper-Samuelson theorem. Differentiating (9) w.r.t. $\frac{r}{w}$ and rearranging we obtain,

$$\frac{d\alpha}{d\frac{r}{w}} = \frac{K_A(\alpha) - \frac{\frac{r}{w}K_A(\alpha)+L_A(\alpha)}{\frac{r}{w}\bar{K}+\bar{L}}\bar{K}}{\frac{dA}{d\alpha}\left\{\frac{\frac{r}{w}K_A(\alpha)+L_A(\alpha)}{A(\alpha)} - \left[\frac{r}{w}\frac{dK_A(\alpha)}{d\alpha} + \frac{dL_A(\alpha)}{d\alpha}\right]\right\}},$$

where the denominator is negative because $A(\alpha)$ has decreasing marginal returns, and hence average cost is larger than marginal cost. The numerator is negative (and hence $\frac{d\alpha}{d\frac{r}{w}} > 0$) iff,

$$K_A(\alpha) - \frac{\frac{r}{w}K_A(\alpha) + L_A(\alpha)}{\frac{r}{w}\bar{K} + \bar{L}}\bar{K} < 0,$$

which a little rearranging shows to be true iff,

$$\frac{\bar{L}}{\bar{K}} < \frac{L_A(\alpha)}{K_A(\alpha)},$$

proving the result. ■

As in Section 4, changes in technology can be studied in a way analogous to the one just used to study price changes and the extension of the results in Section 5 follows.

Appropriation and the enforcement of the law

Until now we have implicitly assumed that the amount of resources allocated to enforce property rights is given and does not react to economic shocks. We now study the possibility that the government may choose the amount of resources devoted to enforcing property rights, with the goal of minimizing the overall mass of resources that are driven away from production.

Assume that the fraction of production appropriated depends on both the amounts of labor devoted to the appropriation sector (L_A) and to an enforcement sector (L_E). The technology of appropriation is summarized by the function $A(L_A, L_E)$, which is increasing and concave in L_A and decreasing in L_E. The overall burden of conflict is then given by the addition of criminals and enforcers, as they are all detracted from the labor force. Here we show that our previous results capture the behavior of the overall burden of conflict $L_A + L_E$.

We assume that agents decide whether to join a productive industry or the appropriation sector given the level of enforcement the government has chosen. This means the government chooses the socially optimal level of enforcement given the parameters of the model, knowing that the amount of labor in the appropriation sector will depend on the level of enforcement. In other words, the government chooses L_E to minimize the total amount of labor allocated to non-productive activities $(L_A + L_E)$ where L_A depends on L_E. After this, workers make career decisions and production takes place. We assume that the government obtains the enforcement labor by either a draft, or by equally taxing capital and labor and devoting the revenues to pay public wages that enforcement agents will find attractive. Either assumption implies that equations (1) to (3) remain unaltered. The right hand side of equation (4) now reads $\overline{L} - L_A - L_E$, and equation (5) becomes $\frac{A(L_A,L_E)}{L_A}\left[r\overline{K} + w(\overline{L} - L_A - L_E)\right] = [1 - A(L_A, L_E)]w$. Whenever a solution without specialization exists, the following holds:

Proposition 11 *An increase in the price of the capital intensive output results in an increase in the burden of conflict.*

Proof. The equilibrium condition for the appropriation sector can be written as $A(L_A, L_E) = \frac{1}{\frac{r}{w}\overline{K}+\overline{L}-L_E}L_A$. Hence, in equilibrium L_A will depend on L_E. If the optimal value of L_E is zero, then the problem devolves into the basic model. If there exists a solution without specialization and positive enforcement, it is given by an interior solution of $\underset{L_E}{Max}\,(L_A + L_E)$. The first order condition for this problem is $\frac{dL_A}{dL_E} + 1 = 0$. Since both an increase in p_1 and a neutral technology improvement of the capital intensive sector results in a greater $\frac{r}{w}$, we need to study the sign of $\frac{d(L_A+L_E)}{d\frac{r}{w}}$. Differentiating we obtain: $\frac{d(L_A+L_E)}{d\frac{r}{w}} = \frac{\partial L_A}{\partial L_E}\frac{dL_E}{d\frac{r}{w}} + \frac{\partial L_A}{\partial \frac{r}{w}} + \frac{dL_E}{d\frac{r}{w}}$. By the government's first order condition we have that $\frac{d(L_A+L_E)}{d\frac{r}{w}} = \frac{\partial L_A}{\partial \frac{r}{w}}$. It is straightforward to show that $\frac{\partial L_A}{\partial \frac{r}{w}}$ is positive and the result follows from Lemma 1 (Stolper-Samuelson). ■

As in Section 4, changes in technology can be studied in a way analogous to the one just used to study price changes and the extension of the results in section 5 follows.

8.2 Proofs for Section 6

Proof of Proposition 7. Up to the addition of the appropriation sector, our way of solving the model follows Mussa (1974). The equilibrium conditions of the model now are:

$$L_1^d\left(\frac{w}{p_1}, \overline{K}_1\right) + L_2^d\left(w, \overline{K}_2\right) + L_A = \overline{L} \tag{10}$$

$$\frac{A(L_A)}{L_A}\left[p_1 f_1\left(L_1^d\left(\frac{w}{p_1}, \overline{K}_1\right), \overline{K}_1\right) + f_2\left(L_2^d\left(w, \overline{K}_2\right), \overline{K}_2\right)\right] = [1 - A(L_A)]w \tag{11}$$

where L_1^d and L_2^d are the demand functions of labor and f_1 and f_2 are the production functions in each productive sector.

Totally differentiating the equilibrium conditions with respect to p_1 (with w and L_A written as implicit functions of p_1) one gets a system of two equations and two unknowns, $\frac{dw}{dp_1}$ and $\frac{dL_A}{dp_1}$. Solving for $\frac{dL_A}{dp_1}$ (and using the fact that $\frac{df_1}{dL_1} = \frac{w}{p_1}$ and $\frac{df_2}{dL_2} = w$) we find that:

$$\frac{dL_A}{dp_1} = \frac{A(L_A)\left[\frac{1}{p_1^2}\frac{dL_1^d}{d\left(\frac{w}{p_1}\right)}\left(p_1 f_1 + f_2\right) - f_1 \times \left(\frac{1}{p_1}\frac{dL_1^d}{d\left(\frac{w}{p_1}\right)} + \frac{dL_2^d}{dw}\right)\right]}{\left[A' \times \left(Y_K + w\overline{L}\right) - w(1-A)\right]\left(\frac{1}{p_1}\frac{dL_1^d}{d\left(\frac{w}{p_1}\right)} + \frac{dL_2^d}{dw}\right) - A \times \left[\frac{df_1}{dL_1}\frac{dL_1^d}{d\left(\frac{w}{p_1}\right)} + \frac{df_2}{dL_2}\frac{dL_2^d}{dw}\right] + (1-A)\,L_A} \tag{12}$$

where Y_K denotes the income of capital.

Given that $\frac{dL_1^d}{d\left(\frac{w}{p_1}\right)}$ and $\frac{dL_2^d}{dw}$ are negative, note the denominator is positive if and only if:

$$A'(L_A)\left(Y_K + w\overline{L}\right) - w \leq \frac{A(L_A)\left[\frac{df_1}{dL_1}\frac{dL_1^d}{d\left(\frac{w}{p_1}\right)} + \frac{df_2}{dL_2}\frac{dL_2^d}{dw}\right] - (1 - A(L_A))\,L_A}{\left(\frac{1}{p_1}\frac{dL_1^d}{d\left(\frac{w}{p_1}\right)} + \frac{dL_2^d}{dw}\right)} - wA \tag{13}$$

The left hand side of equation (13) is negative by the concavity of A and the equilibrium condition of the appropriation sector. The right hand side of equation (13) can be shown to be positive doing some algebra and using the fact that $\frac{df_1}{dL_1} = \frac{w}{p_1}$ and $\frac{df_2}{dL_2} = w$. Hence, the denominator in (12) is positive. We now show the numerator is also positive. This requires that the term in between brackets be positive. This is shown to be true (using again the fact that $\frac{df_1}{dL_1} = \frac{w}{p_1}$ and $\frac{df_2}{dL_2} = w$) if and only if $\frac{1}{p_1^2}\frac{dL_1^d}{d\left(\frac{w}{p_1}\right)} f_2 > f_1 \frac{dL_2^d}{dw}$, which can be written as $q_2 e_{L_1}\frac{L_1^d}{wp_1} > q_1 e_{L_2}\frac{L_2^d}{w}$ (where $e_{L_1} = \frac{dL_1^d}{d\left(\frac{w}{p_1}\right)}\frac{w}{L_1^d p_1}$ and $e_{L_2} = \frac{dL_2^d}{dw}\frac{w}{L_2^d}$). This expression is equivalent to $e_{L_1}\frac{wL_1^d}{q_1 p_1} > e_{L_2}\frac{wL_2^d}{q_2}$, which can in turn be written as $e_{L_1}\theta_{L1} > e_{L_2}\theta_{L2}$ (θ_{Li} represents the participation of labor in the income of industry i). Because of the fact that $e_{L_i} = \frac{\sigma_i}{1-\theta_{Li}}$, our expression becomes $\frac{\sigma_1}{1-\theta_{L1}}\theta_{L1} > \frac{\sigma_2}{1-\theta_{L2}}\theta_{L2}$ which is the condition in the proposition.■

Proof of Proposition 8. Let $q_1 = K_1^{\alpha} L_1^{1-\alpha}$ and $q_2 = K_2^{\beta} L_2^{1-\beta}$ be the production functions in the productive sectors. Then the equilibrium conditions in (10) and (11) become:

$$(1-\alpha)^{\frac{1}{\alpha}}\left(\frac{p_1}{w}\right)^{\frac{1}{\alpha}}\overline{K}_1 + \alpha^{\frac{1}{1-\alpha}}\left(\frac{1}{w}\right)^{\frac{1}{1-\alpha}}\overline{K}_2 + L_A = \overline{L}$$

$$A\left(L_A\right)\left((1-\alpha)^{\frac{1-\alpha}{\alpha}}\left(\frac{p_1}{w}\right)^{\frac{1}{\alpha}}\overline{K}_1 + (1-\beta)^{\frac{1-\beta}{\beta}}\left(\frac{1}{w}\right)^{\frac{1}{\beta}}\overline{K}_2\right) = \left(1 - A\left(L_A\right)\right) w L_A$$

From the equilibrium conditions it follows that multiplying p_1 for a factor Δ will have the same effect on the equilibrium value of the endogenous variables than multiplying K_1 for a factor $\Delta^{\frac{1}{\alpha}}$. Therefore, noting that in this case $\sigma_1 = \sigma_2 = -1$, $\theta_{L1} = \alpha$ and $\theta_{L2} = \beta$, the result follows from Proposition 7.■

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