Property Rights, Predation, and Productivity

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Abstract

We develop a neoclassical growth model with imperfect property rights in which predation entails both waste of resources and deadweight losses, the latter becoming very large when the predation rate is high. According to the model, in the United States, the welfare costs of crime represent a loss of 18.6% of consumption per capita. For a country in the average of the last decile of the distribution of an index of business costs of crime across 94 countries, this loss is 57.8%. Moreover, a one standard deviation increase in the quality index of formal institutions securing property rights increases GDP per worker by 23% for a country with an institutional quality index equal to the average of the last decile of its distribution.

Keywords: Rent-seeking, cross-country differences in TFP and GDP per worker, business costs of crime, institutional quality, welfare costs of crime.

JEL classification: O10, O43, 047.

1 Introduction

Property rights are an important component of the institutional structure of a society, which shapes incentives in human interaction. The new institutional approach to economic development (North, 1990) emphasizes the importance of institutions in determining the incentives faced by economic agents. In particular, security of property rights affects resource allocation by shaping the incentives of individuals to carry out productive activities because it limits expropriation risks and reduces the need to divert private resources

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to protect property. Moreover, as pointed out by Besley and Ghatak (2010), security of property rights also affects the efficiency of resource allocation facilitating trade in assets and improving collateralizability of assets.

Economic agents face the choice of allocating resources between production (i.e. to produce something useful for others) and predation (i.e. to appropriate the property of others). Predation affects productivity negatively because it entails a waste of resources as well as deadweight losses.[1] Some authors highlighted the importance of the allocation of talent between productive and unproductive activities for the economic performance of a society (see, e.g., Baumol, 1990, Murphy et al., 1991, and Acemoglu and Verdier, 1998). These authors argued that entrepreneurial talent can be reallocated towards rent-seeking and organized crime when the returns to such activities are high relative to producing.

Some empirical evidence suggests that both predation and quality of formal institutions securing property rights differ greatly across countries. Figure 1 shows a significant negative relationship between an index of business costs of crime provided by the Fraser Institute (higher value of the index means lower business costs of crime) and a quality index of formal institutions securing property rights for a sample of 94 countries, which has been built using data provided by the Fraser Institute.[2] Figures 2 and 3 show that both the business costs of crime and quality of formal institutions securing property rights are respectively related —negative and positively— with gross domestic product (GDP) per worker. Finally, Figures 4 and 5 show that quality of formal institutions securing property rights and total factor productivity (TFP) are significant and positively related, while quality of formal institutions securing property rights and the ratio of capital to GDP are not. Therefore, empirical evidence suggests that if security of property rights influences GDP per worker, then its influence is mostly through TFP.[3]

The objective of this study is to provide a tractable neoclassical growth model with imperfect property rights and predation, which can be used in quantitative analysis and, in particular, to evaluate the social costs of predation in terms of productivity and consumption and the quantitative impact of differences in quality of formal institutions securing property rights on differences in TFP and GDP per worker across countries. There are

[1] A deadweight loss is a cost to society created by market inefficiency, which leads to a society with fewer available resources, while the waste of resources refers to the unproductive use of available resources.

[2] More details about these indexes are given in Section 3.

[3] Acemoglu et al. (2001), using instrumental variables in a cross-country study, argued that the positive relationship between security of property rights and GDP per worker is indeed causal.

theoretical and empirical reasons that support the view that cross-country differences in the security of property rights leading to varying predation may account for some of the observed differences in productivity across countries.

With that objective, a neoclassical growth model with imperfect security of property rights and predation is developed. The standard neoclassical growth model is implicitly based on the assumption that decisions on saving and capital accumulation occur in an institution-free world with perfect property rights. However, I move away from the standard neoclassical framework by developing a model in which there exists an aggregate predation function that determines the success of predatory activities. Therefore, in the model, security of property rights is a technological (or institutional) feature of the economic environment. Predation is modeled as the ability of individuals to unduly lay claims to ownership of goods and services. In this regard, my model has many similarities with the static models developed by Usher (1987) and Grossman and Kim (1995). In these models, individuals choose whether to engage in productive or predatory activities. However, in my model, all households derive income from capital and labor in addition to income from predatory activities destined to appropriate output from firms. In this framework, the hypothesis of a representative agent can be maintained and transitional dynamics of the model are similar to those of the standard neoclassical growth model with perfect property rights.[4]

In the model, imperfect security of property rights facilitates predation, which affects productivity by discouraging the accumulation of capital as well as by reducing TFP. On one hand, predation discourages capital accumulation because it works as a tax on production. Consequently, the ratio of capital to output is lower. On the other hand, predation reduces TFP by wasting resources on unproductive predatory activities as well as by dissuading business entry. Predation reduces profits of firms —which discourages entry— because firms allocate more resources to trying to deter predation, while a large fraction of their output is captured by predation. Fewer firms imply a lower TFP because the production function of the firms displays decreasing returns to scale.

To my knowledge, the first and only attempt to incorporate predation in the standard

[4]The only important difference with the neoclassical growth model without predation is that the equilibrium might be dynamically inefficient. The issue of dynamic inefficiency has been profusely analyzed in economic literature (see, for example, Phelps, 1961, Diamond, 1965, and Abel et al., 1989).

neoclassical growth model was made by Barelli and De Abreu Pessôa (2012).[5] Their model looks similar to the model developed in this study. However, some important differences must be pointed out. First, they built a two-sector model, whereas I prefer to develop a one-sector model, because I consider it simpler to use in empirical applications. Second, in my model, firms can devote resources to mitigate predation, whilst in Barelli and De Abreu Pessôa (2012)'s model this use is not considered. The waste of resources on activities oriented towards deterring predation (which empirically can be at least as important as the amount of resources devoted to capture rents) amplifies the negative effects of predation on productivity. Third, the deadweight losses caused by predation are not due exclusively to the reduction of capital accumulation, but also to the reduction in the number of firms. In the model, the deadweight losses caused by the decrease in the number of firms may be greater than the social costs of predation due to the waste of resources. In this regard, the implications of my model are different from those of Barelli and De Abreu Pessôa (2012)'s model, in which the deadweight losses always have a second-order importance.[6] According to the calibrated model, the effect of the deadweight losses on the reduction of long-run consumption per worker becomes higher than the effect of the waste of resources when the costs of predatory activities are high.

The simulation of the model shows that the welfare and productivity losses caused by crime —which is an important type of predation— can be noteworthy. The model is calibrated using data on the costs of crime in the United States provided by Anderson (1999). According to the calibrated model, in the United States the ratio of business costs of crime to GDP is 20% and the welfare costs of crime represent a loss of 18.6% of consumption per capita, while GDP per worker is reduced by 17.5%. Once the model has been calibrated for the United States, the ratio of business costs of crime to GDP is calculated for each country in a sample of 94 countries using the index of business costs of crime provided by the Fraser Institute. Assuming that cross-country differences in the business costs of crime are due to differences in neutral efficiency in predation, the costs of crime in terms of consumption per worker and GDP per worker can be deduced for each

[5] Some authors (see, e.g., Tornell and Velasco, 1992, Benhabib and Rustichini, 1996, and Grossman and Kim, 1996) developed models with rent-seeking and capital accumulation, but they used a type of AK technology. Predation is a way of rent-seeking, but the latter may take other forms beyond predation.

[6] There is a debate in rent-seeking literature on the relative importance of both effects (deadweight losses and waste of resources). Posner (1975) evaluated empirically both effects for a monopoly in a partial equilibrium framework. Tullock (1967) conducted pioneering wrok on the analysis of rent-seeking.

country. In particular, according to the calibrated model, the ratio of the business costs of crime to GDP of a country in the average of the sample is 28.2% and consumption per worker and GDP per worker are reduced by 25.1% and 23.8%, respectively. Moreover, the ratio of the business costs of crime to GDP of a country with a value of the index equal to the average value of the last (resp. first) decile is 64.5% (resp. 14.6%) and its consumption per worker and GDP per worker are reduced by 57.8% (resp. 14.7%) and 55.9% (resp. 13.9%), respectively.

In addition, using data provided by the Fraser Institute on the legal structure and security of property rights for 94 countries, a quality index of formal institutions securing property rights for each country in the sample is built. Assuming that neutral efficiency in predation is inversely related to this index of quality, TFP and GDP per worker for each country are computed and then compared with their empirical counterparts. In the calibrated model, countries in the first decile of the distribution of the quality index of formal institutions securing property rights have, on average, 1.25 times higher TFP and 1.46 times higher GDP per worker than countries in the last decile. In the data, the corresponding values are 2.86 and 8.36.

The percentage impact of improvements in the quality of formal institutions securing property rights on productivity is higher in countries at the bottom of the distribution and lower in countries at the top, because, according to the model, the relationships between the logarithms of TFP and GDP per worker and the logarithm of the quality index of formal institutions securing property rights are non-linear and concave. According to the calibrated model, if the quality index of formal institutions increases by one standard deviation, then, for a country with a value of the index equal to the average value of the last decile (resp. first decile) of its distribution, the ratio of business costs of predation to GDP decreases by 36% (resp. 16%), while its GDP per worker increases by 23% (resp. 2.7%), and its TFP increases by 12% (resp. 1.5%).[7]

On one hand, this paper is related to the significant empirical literature using cross-country data to evaluate the impact of institutional quality and, in particular, security of

[7] I report the impact of a one standard deviation increase because, according to the distribution of the index, it can be considered a normal (or likely) increase that might be achieved by means of reasonable institutional reforms. Pande and Udry (2006) provide an excellent and comprehensive review of the macroeconomic literature on institutions and growth that has largely relied on cross-country regression evidence. In order to summarize the findings of the literature, they also reported on the impact of one standard deviation increase in the indexes of institutional quality on productivity and growth.

property rights on economic outcomes (see, e.g., Knack and Keefer, 1995, Mauro, 1995, Hall and Jones, 1999, and Acemoglu et al., 2001). These authors followed an econometric approach and found a significant positive impact of security of property rights on productivity. However, I develop a general equilibrium growth model to evaluate the impact of security of property rights and predation on productivity and welfare. Therefore, on the other hand, this paper also relates to a strand of macroeconomic literature developing general equilibrium macroeconomic models that analyze how and to what extent institutions and economic policies causing resource misallocation can account for the observed differences in productivity across countries (see, e.g., Restuccia and Rogerson, 2008, Hsieh and Klenow, 2009, Poschke, 2010, Barseghyan and DiCecio, 2011, Moscoso-Boedo and Mukoyama, 2012, and del Rio and Sampayo, 2017).

This paper is organized as follows. The model is described in Section 2. Section 3 analyzes the quantitative impact of differences in security of property rights and predation on productivity and welfare. Section 4 concludes.

2 The model

The economy is inhabited by a continuum of identical households with measure 1. The number of members of a household at time t is $H_t = H_0 \mathrm{e}^{nt}$ —with $H_0 > 0$ and n being the population growth rate. Every individual is endowed with a unit of labor. A continuum of perfectly competitive identical firms produce a final good using labor and capital. The number of firms is endogenously determined by a free entry condition. A final good is produced that can be devoted to consumption, C_t, and investment, X_t, in addition to carrying out and deterring predation. Households derive income from renting capital and labor to firms and from predatory activities destined to capture output from firms, while firms devote resources to deter predation. The evolution law of aggregate capital, K_t, is

$$\dot{K}_t = X_t - \delta K_t, \tag{1}$$

where $0 < \delta < 1$ is the depreciation rate. Capital markets are perfect and there are not adjustment costs. Therefore, the rental price of capital in a perfectly competitive market is $r_t + \delta$, where r_t is the interest rate.

The predation rate

Aggregate output captured by households from firms by means of predation, B_t, is a function of output devoted by households to carry out predation, S_t, output devoted by firms to deter predation, D_t, and aggregate output, Y_t. In particular, it is assumed that an aggregate predation function exists, $B_t = \eta M(S_t, D_t, Y_t)$, which arises from technological and institutional factors.[8] The parameter $\eta > 0$ determines neutral efficiency in predation. A high value of η represents low security of property rights. If $\eta = 0$, then security of property rights is perfect, which is implicitly assumed by the standard neoclassical growth model. The aggregate predation function, M, is assumed to be homogeneous of degree 1.[9] Therefore, the predation rate, $b_t = \frac{B_t}{Y_t}$, is a function of the fraction of aggregate output devoted by households to carry out predation, $s_t = \frac{S_t}{Y_t}$, and the fraction of aggregate output devoted by firms to deter predation, $d_t = \frac{D_t}{Y_t}$,

$$b_t = \eta m(s_t, d_t), \tag{2}$$

where $m(s_t, d_t) \equiv M\left(\frac{S_t}{Y_t}, \frac{D_t}{Y_t}, 1\right)$. It is assumed that m is increasing and concave in s ($m_1 > 0$, $m_{11} < 0$) and decreasing and convex in d ($m_2 < 0$ and $m_{22} > 0$).[10] A part of output captured by households from firms is appropriated by households, $\tau b_t Y_t$, whilst another part is destroyed in the course of predation, $(1-\tau) b_t Y_t$, where $0 < \tau < 1$. Therefore, net aggregate output is $[1 - (1-\tau) b_t] Y_t$.

Firms

Each firm uses a Cobb–Douglas production function,

$$Y_{i,t} = \mathrm{e}^{(1-\alpha\theta)\gamma t} A^{1-\alpha} \left(K_{i,t}^{\theta} L_{i,t}^{1-\theta}\right)^{\alpha}, \tag{3}$$

where $A > 0$, $0 < \theta < 1$, $0 < \alpha < 1$, $\gamma \geq 0$, $Y_{i,t}$ is output of firm i, while $K_{i,t}$ and $L_{i,t}$ respectively are the stock of capital and variable number of workers used by a firm in production.[11] The parameter α reflects the extent of decreasing internal returns to scale

[8] Microfoundation of the predation function is an important issue that is not addressed here. However, some microstructure of the predatory sector is provided in Appendix C.

[9] A replicability argument, similar to that used in the case of a neoclassical production function, could be used to justify the assumption of homogeneity of degree 1, which is also needed to guarantee the existence of a balanced growth path.

[10] The neoclassical production function requires analogous properties on the marginal productivities of factors. In particular, the assumed properties on the predation function imply that the predation rate increases (resp. decreases) when the fraction of resources devoted to carry out predation (resp. the fraction of resources devoted to deter predation) increases, but the change rate is decreasing.

[11] Hopenhayn (1992) and Barseghyan and DiCecio (2011) use a similar production function in order

from both capital and labor and γ is the rate of technical progress.

A firm engaged in production incurs an operating cost consisting of wages paid to ξ units of overhead labor. Total variable labor is $L_t = \int_0^{N_t} L_{i,t} \text{ d } i$, while total overhead labor is equal to ξN_t, where N_t is the number of firms. In equilibrium, labor supply must be equal to total variable labor plus total overhead labor, $H_t = L_t + \xi N_t$. The previous equation can be rewritten in terms per capita as

$$1 = l_t + \xi n_t, \tag{4}$$

where $l_t = \frac{L_t}{H_t}$ is total variable labor per capita and $n_t = \frac{N_t}{H_t}$ is the number of firms per capita.

Firm i hires capital and labor and devotes an amount $D_{i,t}$ of its output to deter predation. The wage rate is W_t and the rental price of capital is $r_t + \delta$. A fraction, $b_{i,t}$, of its output is captured by predation. It is assumed that $b_{i,t} = b_t f\left(\frac{N_t}{D_t} D_{i,t}\right)$, where $f' < 0$, $f'' > 0$, $f(1) = 1$ and $-f'(1) = \psi > 0$. Parameter ψ determines specific efficiency in deterrence of predation.

Each firm maximizes its profits

$$\Pi_{i,t} = \left[1 - b_t f\left(\frac{N_t}{D_t} D_{i,t}\right)\right] Y_{i,t} - (r_t + \delta) K_{i,t} - W_t (L_{i,t} + \xi) - D_{i,t},$$

subject to the technological constraint (3). Considering that all firms are identical (which implies that $Y_{i,t} = \frac{Y_t}{N_t}$, $K_{i,t} = \frac{K_t}{N_t}$, $L_{i,t} = \frac{L_t}{N_t}$, $D_{i,t} = \frac{D_t}{N_t}$ and $b_{i,t} = b_t$), first-order conditions for the profit-maximizing problem of a firm are

$$\alpha (1 - \theta) (1 - b_t) \frac{y_t}{l_t} = w_t, \tag{5}$$

$$\alpha\theta (1 - b_t) \frac{y_t}{k_t} = r_t + \delta, \tag{6}$$

and

$$\psi \frac{b_t}{d_t} = 1, \tag{7}$$

to analyze the impact of entry costs on productivity. These authors also suppose fixed costs and an endogenous number of firms. Barseghyan and DiCecio (2011) calibrated the magnitude of the fixed costs and decreasing returns to scale to reproduce some moments of the employment distribution across plants in the United States where $y_t = \frac{Y_t}{H_t}\mathrm{e}^{-\gamma t}$ is detrended aggregate output per capita, $k_t = \frac{K_t}{H_t}\mathrm{e}^{-\gamma t}$ is detrended aggregate capital per capita, and $w_t = W_t\mathrm{e}^{-\gamma t}$ is the detrended wage rate. Equations (5) and (6) state that the after-predation marginal productivities of labor and capital equal their user costs. Predation discourages capital accumulation and employment because it works as a tax on production. Equation (7) states that the marginal revenue of resources allocated to prevent predation equals their marginal cost, which is equal to 1.

The number of firms, N_t, is determined by a free entry condition establishing that the expected value of a firm equals zero. All firms are identical and have the same profits, $\Pi_{i,t} = \Pi_t$. The free entry condition implies that profits of firms must be zero for all t, $\Pi_t = 0$. Profits are zero if and only if

$$(1-b_t)\left[1-\alpha-\alpha\left(1-\theta\right)\frac{1-l_t}{l_t}\right] = \psi b_t, \tag{8}$$

which follows from the first order conditions for a firm (5)-(7) and the equilibrium condition in the labor market (4). Equations (4) and (8) imply that the number of firms is a decreasing function of the predation rate.

Households

The utility function of household j is

$$\int_0^\infty \mathrm{e}^{-\rho t}\frac{c_{j,t}^{1-\sigma}}{1-\sigma}H_t\mathrm{d}\ t \tag{9}$$

where $\rho > n$ is the time discount rate, σ is the intertemporal elasticity of substitution, and $c_{j,t}$ is consumption per capita. A household devotes resources to consumption, capital accumulation, $X_{j,t}$, and predation, $S_{j,t}$, while it rents out capital and labor to firms and obtains a fraction $v\left(\frac{S_{j,t}}{S_t}\right)$ of the aggregate transfers generated by predation, $T_{j,t} = \tau b_t Y_t v\left(\frac{S_{j,t}}{S_t}\right)$, where $v' > 0$, $v'' < 0$, $v\left(1\right) = 1$, and $v'\left(1\right) = \chi > 0$. Parameter χ determines specific efficiency in predation-holding activities.[12]

[12] In the model, predation and its deterrence are modeled as a contest among individuals and among firms, respectively. The assumed predatory technology for households and the assumed predation-deterring technology for firms can be seen as contest success functions. Tullock (1975, 1980) introduced the contest success function in the theory of rent-seeking. See Van Long (2012) for a survey on the theory of contests. As Skaperdas (1996) wrote, "Tournaments, conflict, and rent-seeking have been modelled as contests in which participants exert effort to increase their probability of winning a price. A contest success function provides each player's probability of winning as a function of all player's efforts.".

A household maximizes its intertemporal utility (9) subject to its budget constraint

$$H_t c_{j,t} + X_{j,t} + S_{j,t} = W_t H_t + (r_t + \delta) K_{j,t} + \tau b_t Y_t v\left(\frac{S_{j,t}}{S_t}\right),$$

and the evolution law of capital $\dot{K}_{j,t} = X_{j,t} - \delta K_{j,t}$. Considering that households are identical (which implies that $c_{j,t} = \frac{C_t}{H_t}$, $X_{j,t} = X_t$, $S_{j,t} = S_t$ and $K_{j,t} = K_t$), a maximum of the optimization problem of a household is characterized by the transversality condition,

$$\lim_{t\to\infty} k_t \mathrm{e}^{-\int_0^t (r_z - n - \gamma)\mathrm{d}\, z} = 0, \tag{10}$$

together with the Euler equation,

$$\frac{\dot{c}_t}{c_t} = \frac{1}{\sigma}(r_t - \rho) - \gamma, \tag{11}$$

where $c_t = \frac{C_t}{H_t}\mathrm{e}^{-\gamma t}$ is detrended consumption per capita, and

$$\chi\tau\frac{b_t}{s_t} = 1. \tag{12}$$

Equation (12) states that the marginal revenue of predation equals its marginal cost, which is 1. It is assumed that $\sigma\gamma + \rho > \gamma + n$ is satisfied in order to ensure that the transversality condition holds.

Closing the model

Considering that all firms are identical, it follows from the production function (3) and equilibrium condition in the labor market (4) that the detrended aggregate output per capita is given by

$$y_t = q_t k_t^{\theta\alpha}, \tag{13}$$

where q_t is multifactor productivity in the final good sector,

$$q_t = \left(\frac{A}{\xi}\right)^{1-\alpha} l_t^{(1-\theta)\alpha}(1 - l_t)^{1-\alpha}, \tag{14}$$

which depends on the allocation of labor between labor directly used in production and overhead use. In particular, the multifactor productivity in the final good sector decreases when the number of firms decreases (which implies that the labor directly used in production increases), because firms display decreasing returns to scale (see Proposition 4 in Appendix A).

Net aggregate output, $(1-(1-\tau)\,b)\,Y_t$, can be allocated to consumption, C_t, investment, X_t, carrying out of predatory activities, S_t, and deterrence of predation, D_t. Therefore, the aggregate resource constraint is $C_t + X_t + D_t + S_t = (1-(1-\tau)\,b_t)\,Y_t$, which, considering (7) and (12), can be rewritten in terms of the detrended variables per capita as

$$c_t + x_t = (1-(1-\tau+\tau\chi+\psi)\,b_t)\,y_t, \tag{15}$$

where $x_t = \frac{X_t}{H_t}\mathrm{e}^{-\gamma t}$ is the detrended investment per capita. The evolution law of capital, (1), can also be rewritten in terms of detrended variables per capita as,

$$\overset{\bullet}{k}_t = x_t - (\delta+\gamma+n)\,k_t. \tag{16}$$

On the existence of an interior equilibrium

From (2), (7) and (12) it follows that, in equilibrium, the predation rate is given by

$$\eta m\,(\tau\chi b, \psi b) = b, \tag{17}$$

and the fraction of output devoted to carry out predation and the fraction of output devoted to deter predation are both proportional to the predation rate,

$$s = \tau\chi b \tag{18}$$

and

$$d = \psi b. \tag{19}$$

From (17),(18) and (19), it follows that, in equilibrium, s, d and b are constant for all t. Therefore, from (4), (8) and (14), it also follows that, in equilibrium, the number of firms per capita, n, total variable labor per capita, l, and multifactor productivity, q, are also constant.

The assumptions made on function $m\,(s,d)$ do not restrict the number of equilibria that may exist, if any. In order to ensure that a unique interior equilibrium exists, it is assumed that (i) $\widetilde{m}(b) \equiv m(\tau\chi b, \psi b)$ is strictly increasing and concave, (ii) $\lim_{b\longrightarrow 0} \widetilde{m}(b) \geq 0$, (iii) $\lim_{b\longrightarrow\infty} \widetilde{m}'(b) = 0$, and (iv) $\lim_{b\longrightarrow 0} \widetilde{m}'(b) > 1$ whenever $\lim_{b\longrightarrow 0} \widetilde{m}(b) = 0$. In an interior equilibrium, s, d, b and l must lie between 0 and 1 and $c_t + x_t$ must be strictly positive, which is satisfied if $(1 - \tau + \tau\chi + \psi)\, b$ is also between 0 and 1. Under assumptions (i)-(iv), the predation rate, b, is a strictly increasing function of neutral efficiency in predation, η (see Proposition 2 in Appendix A). Therefore, there exists a sufficiently small η such that an interior equilibrium exists (see Proposition 1 in Appendix A). However, if neutral efficiency in predation, η, is much too large, then the model displays a corner solution in which the economy collapses.[13] The resource allocation between predation and productive activities is analyzed in Appendix A.

As analyzed in Appendix B, the phase diagram of the model with imperfect security of property rights and predation is similar to the phase diagram of the standard neoclassical growth model. Therefore, dynamics of the model with imperfect property rights and predation are similar to the dynamics of the standard neoclassical growth model. The only difference is that an equilibrium of the model with imperfect property rights and predation might be dynamically inefficient even if the transversality condition is satisfied (see Appendix B).

Differences in productivity: TFP vs. the ratio of capital to GDP

It is assumed that a fraction $0 < 1 - \mu < 1$ of the resources devoted to carrying out predation and a fraction $0 < 1 - \phi < 1$ of the resources devoted to deterrring predation are included in GDP. Therefore, it follows from substituting (13) into (15) that GDP per worker, $y_{m,t}$, is given by

$$y_{m,t} \equiv c_t + x_t + \left[(1-\mu)\,\chi\tau + (1-\phi)\,\psi\right] b y_t = z k_t^{\alpha\theta} \qquad (20)$$

where $z = (1 - (1 - \tau + \mu\chi\tau + \phi\psi)\, b)\, q$ is TFP, which depends on both the measured waste of resources in predation and multifactor productivity in the final sector.[14] Equation (20) can be rewritten as $y_{m,t} = z^{\frac{1}{1-\alpha\theta}} \left(\frac{k_t}{y_{m,t}}\right)^{\frac{\alpha\theta}{1-\alpha\theta}}$. Therefore, cross-country differences in GDP per worker can be broken down into two factors: contribution of TFP, $z^{\frac{1}{1-\alpha\theta}}$, and

[13] The decentralized equilibrium is inefficient because the predatory contest for resources entails a cooperation failure. In particular, if the economic agents could commit toward cooperative strategies, or if a benevolent planner could decide resource allocation, then predation would not happen.

[14] In the model, variables per capita and per worker are equal.

contribution of the ratio of capital to GDP, $\left(\frac{k_t}{y_{m,t}}\right)^{\frac{\alpha\theta}{1-\alpha\theta}}$.[15]

A higher neutral efficiency in predation and, consequently, a higher predation rate reduce TFP in two ways. On one hand, the amount of resources wasted in predatory activities is higher. On the other hand, profits of firms decrease because a higher fraction of their output is captured by predation and also because they devote a higher fraction of their output to deter predation. Lower profits result in a lower number of firms, which reduces multifactor productivity in the final good (see Proposition 7 in Appendix A).

The ratio of capital to GDP equals the ratio of capital to output multiplied by the ratio of output to GDP, $\frac{k_t}{y_{m,t}} = \frac{k_t}{y_t}\frac{y_t}{y_{m,t}}$, where the ratio of capital to output is $\frac{k_t}{y_t} = \frac{\alpha\theta}{r_t+\delta}(1-b)$, which follows from the first order condition (6), and the ratio of output to GDP is $\frac{y_t}{y_{m,t}} = [1-(1-\tau+\mu\chi\tau+\phi\psi)\,b]^{-1}$, which follows from equations (13) and (20). Along a balanced growth path, the interest rate is constant, $r = \sigma\gamma+\rho$, and, thus, the ratio of capital to output is also constant.

The effect of a higher neutral efficiency leading to higher predation rate on the ratio of capital to GDP is ambiguous. A higher predation rate, on one hand, discourages capital accumulation and, consequently, the ratio of capital to output decreases, however, on the other hand, the ratio of output to GDP increases because more resources are wasted on unproductive predatory activities. Therefore, if $1-\tau+\mu\chi\tau+\phi\psi$ is near 1, then changes in neutral efficiency in predation and, consequently, in the predation rate have a weak impact on GDP per worker through changes in the ratio of capital to GDP (see Proposition 7 in Appendix A). This is important from an empirical point of view, as will become clear below.

Business costs of predation

The costs of predation for firm i are $b_{i,t}Y_{i,t}+D_{i,t}$. The aggregate business costs of predation are equal to the sum of the costs of predation for all firms. In a symmetric equilibrium, the detrended aggregate business costs of predation per worker are $(1+\psi)\,b_t y_t$. Therefore, the ratio of aggregate business costs of predation to GDP is

$$v_m = (1+\psi)\,b_t\frac{y_t}{y_{m,t}} = \frac{(1+\psi)\,b}{1-(1-\tau+\mu\chi\tau+\phi\psi)\,b}, \tag{21}$$

[15]Hall and Jones (1999) use a similar breakdown to calculate the contributions of differences in TFP, the ratio of capital to GDP and human capital to differences in GDP per worker across countries.

which is an increasing function of the predation rate.

Deadweight losses vs. waste of resources

Given that all households are identical, the intertemporal utility is the social welfare function. Therefore, in the long run, social welfare decreases when long-run consumption per capita falls. Moreover, reduction of social welfare in the long run will be proportional to the drop in long-run consumption per capita.

A higher neutral efficiency in predation leads to higher predation rate which reduces the long-run consumption per capita (see Proposition 6 in Appendix A) and, hence, the long-run social welfare. If an equilibrium is dynamically efficient, then it follows from the phase diagram of the model that a higher neutral efficiency in predation leading to higher predation rate reduces consumption per capita both in the short and long runs. Thus, social welfare decreases.[16] In the next section, I compute the fall of long-run consumption per capita due to an increase in the predation rate caused by an increase in neutral efficiency in predation.

Reduction in consumption is due to both the deadweight losses and waste of resources in predatory activities. In particular, a higher neutral efficiency in predation leads to higher predation rate which reduces the long-run consumption per capita because the number of firms per capita, n, and capital stock per capita, k, decrease, as well as because the term $(1-(1-\tau+\chi\tau+\psi)\,b)$ is lower.[17] The fall in long-run consumption per capita caused by the decrease in the number of firms per capita and stock of detrended capital per capita is a deadweight loss, while the fall of $(1-(1-\tau+\chi\tau+\psi)\,b)$ represents a loss due to the waste of resources.

The deadweight losses might be higher than the losses due to the waste of resources. From equations (4) and (8), it follows that the number of firms is a strictly decreasing function of the predation rate and it goes to 0 when the predation rate goes to the upper bound $\overline{b}=\frac{1-\alpha}{1-\alpha+\psi}$. Consequently, multifactor productivity in the final sector, q, goes to 0 when b goes to $\overline{b}$ and, thus, the detrended output per capita, y, detrended consumption per capita, c, and detrended capital per capita, k, also go to 0, while $(1-(1-\tau+\chi\tau+\psi)\,b)$ goes to $\left(1-(1-\tau+\chi\tau+\psi)\,\frac{1-\alpha}{1-\alpha+\psi}\right)$, which is higher than 0 if $(1-\alpha)\,\tau\,(1-\chi)+\alpha\psi <$

[16] However, if an equilibrium is dynamically inefficient, it follows from the phase diagram that consumption per capita might increase in the short run when an increase in neutral efficiency in predation leads to a higher predation rate. Therefore, in a dynamically inefficient equilibrium, the effect of higher predation on social welfare is *a priori* ambiguous.

[17] A lower number of firms per capita, n, implies lower multifactor productivity in the final sector, q.

1. This condition is satisfied for the calibrated values of the parameters further below. Therefore, if $(1-\alpha)\,\tau\,(1-\chi)+\alpha\psi<1$, then the effect of the deadweight losses on social welfare becomes more important than the effect of the waste of resources when neutral efficiency in predation and, consequently, the predation rate are sufficiently high.

Considering that along a balanced growth path $\overset{\bullet}{k}_t=0$ and $\overset{\bullet}{c}_t=0$, it follows from (15) and (16) that the detrended consumption per worker is given by

$$c=\left[1-(1-\tau+\tau\chi+\psi)\,b-(\delta+\gamma+n)\,\frac{k}{y}\right]y.$$

Differentiating the previous equation with respect to η gives

$$\frac{\mathrm{d}\,c}{\mathrm{d}\,\eta}=\underbrace{-(1-\tau+\tau\chi+\psi)\,\frac{\partial\,b}{\partial\,\eta}y}_{\text{Effect of the waste of resources}}\quad\underbrace{+\frac{c}{y}\frac{\partial\,y}{\partial\,b}\frac{\partial\,b}{\partial\,\eta}+(\delta+\gamma+n)\,\frac{\partial\,\frac{k}{y}}{\partial\,b}\frac{\partial\,b}{\partial\,\eta}y,}_{\text{Effect of the deadweight losses}}\qquad(22)$$

which breaks down the fall in long-run consumption per worker caused by an increase in neutral efficiency in predation and, consequently, in the predation rate into two effects. The first effect is that of the waste of resources, which measures the fall in long-run consumption per worker due to the increase in the waste of resources, the second is the effect of the deadweight losses, which measures the fall in long-run consumption per worker due to the distorting effects of predation: an increase in neutral efficiency in predation leads to higher predation rate, which, on one hand, reduces long-run consumption per worker because both multifactor productivity and ratio of capital to output decrease and, on the other hand, increases long-run consumption per worker because the investment rate decreases.

3 Cross-country differences in productivity and welfare

In this section, the quantitative impact of differences in neutral efficiency in predation and, consequently, in the predation rate on long-run productivity and long-run consumption per worker are analyzed. Moreover, it will be assumed that neutral efficiency in predation depends on the quality of formal institutions securing property rights and the impact of improving their quality on productivity will be evaluated.

Calibration

The model is calibrated using the data reported by Anderson (1999) on the aggregate burden of crime in the United States, which are displayed in Table 1. The data are in billions of 1997 dollars. I have classified them into four categories (see last column of Table 1): Resources devoted to carrying out predation (S), resources devoted to deterring predation (D), resources destroyed in the course of predation (O), and resources transferred by predation (T). If a cost is classified into two different categories, then half of the amount is allocated to each category, except for drug trafficking expenditures which are allocated entirely to the two categories in which are classified.[18] I explain the reason for this choice below. I have also classify the resources devoted to carrying out predation (S) and deterring predation (D) into two categories: resources included and not included in the measured GDP; the latter is denoted with an asterisk (*) in the third column of Table 1. The aggregate resources captured by predation are the sum of aggregate resources destroyed in the course of predation and aggregate resources transferred by predation, $B = O + T$. The total amounts of all categories are displayed in Table 2 together with U.S. GDP for year 1997 in billions of 1997 dollars.[19]

The figures used to calibrate the parameters related to the predatory activities are obtained from the data displayed in Table 2. According to these data, resources devoted to deterring predation, D, were about 20% of the aggregate resources captured by predation, B. From equation (7), it follows that $\frac{d}{b} = \psi$. Therefore, I set $\psi = 0.20$. Resources destroyed in the course of predatory activities, O, represent about 45% of the resources captured by predation activities, B. Therefore, I set $\tau = 0.55$. Resources devoted to carrying out predation, S, were about 14.5% of the aggregate resources captured by predation, B. From equation (12), it follows that $\frac{s}{b} = \tau\chi$. Therefore, I set $\chi = 0.26$. About 32% of the resources devoted to deterring predation and 99% of the resources devoted to carrying out predation are not accounted for in GDP. Therefore, I set $\phi = 0.32$ and $\mu = 0.99$. The aggregate resources captured by predation, B, represent about 16.7% of U.S. GDP. Therefore, I set $b\frac{y}{y_m} = 0.167$. Moreover, considering that $\frac{y}{y_m} = \frac{1}{1-(1-\tau+\mu\chi\tau+\phi\psi)b}$,

[18] I explain below why drug trafficking expenditures are entirely allocated to the two categories. Regarding other Anderson's categories of expenditure, allocating one half to each category is an arbitrary choice, but the magnitude of the involved figures is small, and the calibration depends very little on this choice.

[19] U.S. GDP for 1997 in billions of 1997 dollars is obtained by multiplying U.S. GDP for the year 1997 in billions of 2005 dollars by U.S. Parity Power Purchase in 1997. Both variables are taken from the Penn World Table 8.0 (PWT 8.0).

the calibrated value of the predation rate is $b = 0.15$. Considering that the ratio of business costs of predation to GDP is $v_m = \frac{(1+\psi)b}{1-(1-\tau+\mu\chi\tau+\phi\psi)b}$, the calibrated value of v_m is 0.20. Assuming that the aggregate predation function is $m(s,d) = \frac{s}{d}$ and considering that $b = \eta m(s,d)$ and $\frac{s}{d} = \frac{\tau\chi}{\psi}$, the calibrated value of η is 0.21.

Values for α, θ, δ, γ, σ, ρ and n must also be calibrated to simulate the model.[20] The parameter α determines the degree of the diminishing returns to scale in variable inputs at the firm level. It is set at 0.85. This value is commonly used in the literature (see, e.g., Atkeson and Kehoe, 2005; Restuccia and Rogerson, 2008; and Barseghyan and DiCecio, 2011), and it is very close to the estimated value of 0.84 in Basu (1996).[21] I set $\alpha\theta = \frac{1}{3}$, which is the value used by Hall and Jones (1999), among many other authors. Given the assumed value for α, θ is equal to 0.392. The elasticity of output with respect to capital is $\alpha\theta$ in the model. Using U.S. time series data, Kydland and Prescott (1982) calculated the elasticity of output with respect to capital being approximately 0.36, which is near the calibrated value, $\frac{1}{3}$. I prefer to use the latter because it is widely used in many works accounting for the observed differences in GDP per worker and TFP across countries. Nonetheless, using either has no significant impact on the results of the simulations below. For the rest of the parameters I set values that are standard in the literature. The average annual growth rate of U.S. GDP per worker is about 1.8%. Therefore, I set $\gamma = 0.018$. The U.S. average annual depreciation rate reported by the PWT 8.0 is about 4%. Therefore, I set $\delta = 0.04$. I assume that the instantaneous utility function takes a logarithmic form. Therefore, I set $\sigma = 1$. I also set $\rho = 0.042$, and thus the long-run interest rate is 6%. The U.S. average annual population growth rate is about 1%. Therefore, I set $n = 0.01$.

Some remarks about the calibration

According to Anderson (1999)'s data, the magnitude of the resources involved in drug trafficking is very large. If drug trafficking is considered an economic activity producing an injurious good, then it must be considered a predatory activity, and its ill consequences (e.g., of drug consumption) are costs associated with predation. However, if drug traffick-

[20] To compute relative values of GDP per worker, TFP, ratio of capital to GDP and ratio of business costs of predation to GDP for different values of η, only the parameters α and θ must be calibrated. However, to compute relative consumption per capita, the remaining parameters must also be calibrated.

[21] The lowest bound of the range of estimates recovered by Basu and Fernald (1997) using industry–level data is 0.8. Using plant–level data, Lee (2005) found that returns to scale in manufacturing vary from 0.828 to 0.91, depending on the estimator.

ing is considered an economic activity producing a useful good then it is not a predatory activity. Drug trafficking may sometimes, and for some individuals, involves an activity producing a useful good and sometimes, and for some individuals, a harmful good. However, I follow Anderson (1999) and the legal convention and I consider that drugs are purely harmful goods.

According to the Anderson's data, drug trafficking annually moves $161 billion in the United States. If drugs are injurious commodities, then this expenditure must be considered a predatory transfer from drug consumers to drug traffickers and the damages caused by their consumption must be considered resources destroyed by predation. However, it must be considered that drug trafficking involves important costs in production, transport and distribution. If there is perfect competition and constant returns to scale, then these $161 billion equal the total compensation of the productive factors, and this magnitude can be attributed to the category "Resources devoted to carrying out predation". I do it this way.[22]

Certain costs of drug trafficking can already be included in other Anderson's categories such as "Criminals' lost work days" or "Small arms and small arms ammunition". In this case, the drug-related part of the magnitude of these categories would have to be subtracted from the $161 billion, but, I do not have the necessary information to do this. However, given the magnitudes of the involved categories, the adjustment would not change the results of the calibration too much.

There are other Anderson's categories grouped in his broader category "transfers costs" that I have included in the category "Resources transferred by predation" but not in the category "Resources devoted to carry out predation". Following the same argument I made for drug trafficking expenditures, these categories might be included. However, I do not include them because the resources devoted to carrying out predatory activities described by these categories have to be included in other Anderson's categories (for example in "Criminals' lost work days" or "Small arms and small arms ammunition") to a larger extent than the resources devoted to carrying out drug trafficking because this last activity entails high costs in terms of production, transport, and distribution which mostly are not included in other Anderson's categories. However, other activities included

[22]Moreover, often organizations involved in drug trafficking are also involved in other crime activities and, consequently, the reported drug trafficking expenditures might reflect the resources devoted to carrying out other predatory activities.

in the broad Anderson's category "transfers costs" do not entail high costs in terms of production, transport and distribution.

An alternative calibration

Including drug trafficking as a predatory activity can be controversial. The magnitude of drug trafficking expenditures is large. Therefore, including drug trafficking or not among the predatory activities can be of great relevance for the calibration and, consequently, for the quantitative results of the simulations. For this reason, I again calibrate the model while excluding the Anderson's categories "Drug trafficking", "Drug control" and "Prenatal exposures to cocaine and heroine which are activities related to drug trafficking and drug consumption. The calibration procedure is as before. The calibrated parameters are $\psi = 0.225$, $\chi = 0.067$, $\tau = 0.5$, $\mu = 0.97$, $\phi = 0.335$ and $\eta = 0.88$. The calibrated predation rate is $b = 0.133$ and the calibrated ratio of business costs of predation to GDP is $v_m = 0.177$. The results of simulating the model under this alternative calibration are briefly reported below. As will be seen, the results do not differ too much from those obtained under the baseline calibration.

Business costs of crime, productivity and welfare

The model is simulated for different values of η to analyze the quantitative relationship between the business costs of predation, productivity and welfare. First, the ratio of business costs of predation to GDP, relative consumption per worker, and relative GDP per worker as well as contributions of TFP and the ratio of capital to GDP are calculated for each value of η. The results of the simulation are displayed in Figure 6. The simulated ratios of business costs of predation to GDP relative to the calibrated ratio of business costs of predation to GDP (which corresponds to the U.S. economy and is 0.20) are displayed in the horizontal axis of Figure 6. The simulated values of all other variables are displayed in the vertical axis (the values of these variables are normalized to 1 for the economy without predation, i.e. $\eta = 0$). Second, the relative effects of the deadweight losses and of the waste of resources on the fall of long-run consumption per worker also are calculated for each value of η. Figure 7 displays both effects (both relative to the total fall in long-run consumption per worker caused by an increase in η) in the vertical axis and the simulated ratios of business costs of predation relative to the United States in the horizontal axis.

The predation rate can change because neutral efficiency in predation, η, varies, but also because other parameters of the model change. However, as reported by Inklaar and Timmer (2013), the ratio of capital to GDP is not significantly correlated with GDP per worker across countries. Figure 5 also shows that there is not a significant dependence between the quality index of formal institutions securing property rights and the ratio of capital to GDP. This empirical evidence is consistent with the fact that $1-\tau+\tau\mu\chi+\phi\psi$ is constant and near 1 and that cross-country systematic changes in τ, χ or ψ are not the cause of changes in predation and GDP per worker across countries. Therefore, to generate a weak relationship of the ratio of capital to GDP with both GDP per worker and the predation rate, as well as with the quality index of formal institutions securing property rights, it is assumed that changes in predation across countries are exclusively caused by changes in neutral efficiency in predation.

As illustrated in Figure 6, for the calibrated values of the parameters, changes in neutral efficiency in predation generate small differences in the ratio of capital to GDP. Therefore, differences between the contribution of TFP and GDP per worker are small, which means that most of the differences in GDP per worker are due to differences in TFP. The reason is that $1-\tau+\tau\mu\chi+\phi\psi$ is near 1. In particular, the calibrated values for the United States imply that $1-\tau+\tau\mu\chi+\phi\psi=0.66$.

As Figure 6 shows, the relationship between the ratio of business costs of predation to GDP and GDP per worker is non-linear. The slope of the relationship increases dramatically for large values of the ratio of business costs of predation to GDP (around 3.3 times the calibrated ratio). Accordingly, small cross-country differences in the ratio of business costs of predation to GDP suppose large differences in GDP per worker when the value of the former is high. Moreover, there is an upper bound (around 3.5 times the calibrated ratio) such that, if the ratio of business costs of predation to GDP exceed it, then GDP per worker is zero.[23] The reason for the collapse is that firms do not find it profitable to produce, because the business costs of predation are very large.

Figure 6 also illustrates the magnitude of the negative consequences of predation on welfare and productivity. In the model, U.S. GDP per worker is 82.5% of the GDP per worker in the economy without predation, and U.S. consumption per worker is 81.4%.[24]

[23] Equation (21) establishes a strictly increasing relationship between the ratio of business costs of predation to GDP, v_m, and the predation rate, b. Therefore, the upper bound for the collapse could also be established on b or η.

[24] The U.S. economy corresponds to the calibrated economy.

Therefore, according to the model, the U.S. welfare costs of crime represent a loss of 18.6% of consumption per worker and GDP per worker is reduced by 17.5%.[25]

The Economic Freedom Network (EFN), led by the Fraser Institute of Canada, provides an index of the business costs of crime for a large sample of countries. A higher value of the index of business costs of crime means lower business costs of crime. I use the inverse of the index of the business costs of crime in country h relative to the United States as a proxy of the ratio of business costs of predation to GDP in country h relative to the United States. In particular, I calculate $v_{m,h} = v_m \Phi_h^{-1}$, where $v_{m,h}$ is the ratio of business costs of crime to GDP in country h, v_m is the U.S. ratio of business costs of crime to GDP (i.e., the calibrated value of 0.20) and Φ_h denotes the value of the index of the business costs of crime in country h relative to the United States. Once $v_{m,h}$ is calculated for each country, using equation (21) and that $b = \eta \frac{\tau \chi}{\psi}$, values for b_h and η_h can be calculated for each country h.

In the sample of 94 countries for the year 2005, the value of the index of business costs of crime relative to the United States ranks from 0.70 (Iceland) to 4.79 (Venezuela); its average is 1.40, standard deviation is 0.78, average of the first decile is 0.73, and average of the last decile is 3.21. The ratio of business costs of crime to GDP of a country in the average of the sample (i.e., with the value of the index at 1.40) is 28.2% and, according to the calibrated model, consumption per worker and GDP per worker are reduced by 25.1% and 23.8%, respectively. The ratio of business costs of crime to GDP of a country with a value of the index equal to the average value of the last (resp. first) decile is 64.5% (resp. 14.6%) and its consumption per worker and GDP per worker are reduced by 57.8% (resp. 14.65%) and 55.9% (resp. 13.9%), respectively.[26]

The main conclusion that can be drawn from Figure 7 is that the effect of the deadweight losses becomes higher than the effect of the waste of resources for high values of neutral efficiency in predation and, consequently, for high values of the ratio of business costs of predation to GDP. For the United States, the effect of the waste of resources is higher than the effect of deadweight losses. In particular, in the United States, 78.6%

[25] Under the alternative calibration, the U.S. welfare costs of crime represent a loss of 15.8% of consumption per worker and GDP per worker is reduced by 14.8%.

[26] Under the alternative calibration, the ratio of business costs of crime to GDP of a country in the sample average is 24.8%, while consumption per worker and GDP per worker are reduced by 21.6% and 20.4%, respectively. The ratio of business costs of crime to GDP of a country with the value of the index equal to the average value of the last (resp. first) decile is 56.8% (resp. 13%) and its consumption per worker and GDP per worker are reduced by 51.8% (resp. 11.8%) and 49.9% (resp. 11.1%), respectively

of the reduction in long-run consumption per worker caused by an increase in neutral efficiency in predation leading to an increase in the predation rate would be due to waste of resources, while 21.4% would be due to deadweight losses (see Figure 7). For a country in the sample average of the distribution of the index of business costs of crime, these percentages are 75.5% and 24.5%, respectively, while for a country in the average of the last decile, these percentages are reversed as, 21.5% and 78.5%. For a country in the average of the ninth decile (i.e., with an index of business costs of crime 2.11 times higher than the U.S. index), these percentages are 33.3% and 66.7%.[27] Therefore, an increase in neutral efficiency in predation leading to an increase in the predation rate would cause higher deadweight losses than waste of resources only in countries in the bottom of the distribution. Particularly, in countries with an index of business costs of crime around 2.8 or more times the U.S. index.[28]

Property rights and productivity

I assume that neutral efficiency in predation in country h, η_h, is inversely related to quality of formal institutions securing property rights in country h, $\eta_h = \omega\Omega_h^{\kappa}$, where $\omega > 0$, $\kappa < 0$, and Ω_h indicates the quality of formal institutions securing property rights in country h. I assume that all countries are identical except for the quality of formal institutions securing property rights. From equation (21), it follows that $\frac{1}{\eta_h} = \frac{\tau\chi}{\psi}\left(\frac{1+\psi}{v_{m,h}} + (1-\tau+\mu\chi\tau+\phi\psi)\right) \equiv \Delta_h$. Therefore, $\ln\Delta_h = -\ln\omega - \kappa\ln\Omega_h$.

A proxy for the quality of formal institutions securing property rights in each country h, Ω_h, is built using eight variables provided by the EFN. These variables are all related to the legal structure and security of property rights in a country: judicial independence, impartial courts, protection of property rights, military interference in the rule of law and political process, integrity of the legal system, legal enforcement of contracts, regulatory restrictions on the sale of real property, and reliability of the police. The arithmetic average of these eight variables is calculated. The resulting index relative to the United States is used as a proxy of quality of formal institutions securing property rights in each country. The quality index of formal institutions securing property rights ranks from 1.18 (Finland) to 0.37 (Burundi); its average is 0.81, standard deviation is 0.21, average of the first decile is 1.15 and average of the last decile is 0.47.

[27] For the alternative calibration, the results are similar.

[28] In the sample, these countries are Kenya (2.79), Mexico (2.91), Trinidad & Tobago (3.05), Honduras (3.53), Jamaica (3.72), Guatemala (3.94) and Venezuela (4.79).

The EFN calculates the arithmetic average of nine variables to obtain an index of the legal structure and security of property rights in each country of the sample.[29] The used variables are the business costs of crime and the eight variables mentioned above (See Gwartney et al. (2014)). I do not use the index of business costs of crime to elaborate a proxy of the quality of formal institutions securing property rights because I use the inverse of the index of the business costs of crime relative to the United States as a proxy of the ratio of business costs of predation to GDP in a country relative to the Uinted States; this, together with the previously calibrated values of the parameters, allows me to obtain a proxy of Δ_h.

To calibrate κ, I perform four ordinary least square regressions in which the dependent variable is $\ln \Delta_h$ and the explicative variables are the quality index of formal institutions securing property rights, Ω_h, Gini index of income distribution and GDP per worker. All variables are in logs. The regressions are performed using a sample of 75 countries with data for year 2005.[30] The results of the regressions are displayed in Table 3. The values of the regression coefficients for $\ln \Omega_h$ range from 0.83 to 1.10. [31] Introducing the Gini index and GDP per worker in the regression might provoke some downward bias on the estimate of the regression coefficient for $\ln \Omega_h$, because the institutional variable might influence income per capita and its distribution. However, if these variables are omitted, the estimate of the regression coefficient for $\ln \Omega_h$ might be biased upwards. Considering these possible biases, a reasonable value for κ is -1. Therefore, I set $\kappa = -1$. Considering that the calibrated value of η is 0.21 and that the U.S. index of security of property rights is normalized to 1, the calibrated value of ω is 0.21.

To analyze the extent to which the observed differences in quality of formal institutions securing property rights can account for the observed differences in TFP and GDP per worker across countries, the model is simulated for each value of the institutional quality index in each country, Ω_h. The results of the simulation are compared with the data. Data on capital stocks, GDP per worker and TFP are taken from the PWT 8.0 (see Feenstra et al., 2015). My sample consists of 94 countries. Data are for the year 2005. The results

[29] These variables are from three primary sources: the International Country Risk Guide, Global Competitiveness Report, and World Bank's Doing Business project

[30] Data on the Gini index are provided by the World Bank. For most countries the Gini index is for year 2005; however, for some countries, it is for a year between 2002 and 2007, because the values for year 2005 are not available.

[31] Under the alternative calibration, the dependent variable $\ln \Delta_h$ is different, but the estimated regression coefficients are very similar.

of the simulation are displayed in Figures 3 to 5.

Figure 3 plots the relationship between GDP per worker and the quality index of formal institutions securing property rights (both in logs and relative to the United States) in both the model and data. The slope of the linear relation in the model is 0.42, while that in the data is 2.90, which means that, in the data, the improvement of institutional quality by 1% is related to an average increase by around 2.9% in GDP per worker, while, in the model, improving institutional quality by 1% leads to an average increase in GDP per worker by around 0.42%. Therefore, the model accounts for 14.5% of the (average) relationship between the quality index of formal institutions securing property rights and GDP per worker observed in the data. In the model, countries in the first decile (resp. quartile) of the distribution of the institutional quality index have, on average, 1.46 (resp. 1.28) times higher GDP than countries in the last decile (resp. quartile). In the data, the corresponding value is 8.36 (resp. 5.74).

Figure 4 plots the relationship between TFP and the quality index of formal institutions securing property rights (both in logs and relative to the United States) in both the model and data. The slope of the linear relation in the model is 0.24, while that in the data is 1.45, which means that, in the data, the improvement of institutional quality by 1% is related to an average increase by around 1.45% in TFP, while, in the model, improving quality of formal institutions by 1% leads to an average increase in TFP by around 0.24%. Therefore, the model accounts for 16.6% of the (average) relationship between the quality index of formal institutions securing property rights and TFP observed in the data. In the model, countries in the first decile (resp. quartile) of the distribution of the institutional quality index have, on average, 1.25 (resp. 1.15) times higher TFP than countries in the last decile (resp. quartile). In the data, the corresponding value is 2.86 (resp. 2.48).

Figure 5 plots the relationship between the ratio of capital to GDP and the quality index of formal institutions securing property rights (both in logs and relative to the United States) both in the model and data. The slope of the linear relation in the model is positive, but small, which is consistent with the lack of a significant relationship in the data. Therefore, predation in the model affects GDP per worker through TFP and the ratio of capital to GDP, but the results of the simulation show that contribution of the ratio of capital to GDP is not significant.

According to the model, the relationships between the logarithms of TFP and GDP per worker and the logarithm of the quality index of formal institutions securing property rights are non-linear and concave. Therefore, the above linear estimates are approximations of the simulated relationships that can accurately reflect the percentage impact of the independent variable on the dependent variable around the average, but not in the tails of the distribution.[32] One has to be aware that the percentage impact of improvements in quality of formal institutions securing property rights on productivity is higher in countries at the bottom of the distribution and lower in countries at the top.

Therefore, another quantitative exercise is performed to have a more accurate view of the impact of improving institutional quality on productivity. First, I calculate the average value of the quality index of formal institutions securing property rights for each decile of its distribution (see second column of Table 4). Second, the model is simulated to calculate the relative values of GDP per worker and TFP associated with these average values of the index under the calibrated values. Third, I again simulate the model to calculate GDP per worker and TFP corresponding to the average values of the index for each decile of its distribution plus one standard deviation (0.21) of the index. Finally, I calculate the simulated percent increase in GDP per worker and TFP.

The results of the simulations (see Table 4) show that improving the quality of formal institutions securing property rights can have a large positive impact on the productivity of countries at the bottom of the distribution by reducing predation. In particular, if the institutional quality index increases by one standard deviation, then, for a country with a value of the index equal to the average value of the last decile (resp. first decile) of its distribution, the ratio of business costs of predation to GDP decreases by 36% (resp. 16%), while its GDP per worker increases by 23% (resp. 2.7%), TFP increases by 12% (resp. 1.5%), and ratio of capital to GDP increases by 6% (resp. 0.8%). Therefore, most of the increase in GDP per worker is due to the increase of TFP, not to the increase in the ratio of capital to GDP.[33]

[32] Under the alternative calibration, the slope of the linear relation in the model between the quality index of formal institutions securing property rights and TFP (resp. GDP per worker) is 0.18 (resp. 0.32). Countries in the first decile of the distribution of the quality index of formal institutions securing property rights have, on average, 1.18 times higher TFP and 1.35 times higher GDP per worker than countries in the last decile.

[33] Under the alternative calibration, if the institutional quality index increases by one standard deviation, then, for a country with a value of the index equal to the average value of the last decile (resp. first decile) of its distribution, the ratio of business costs of predation to GDP decreases by 35% (resp. 16%), while its GDP per worker increases by 18% (resp. 2.3%), TFP increases by 9.5% (resp. 1.2%), and ratio

4 Conclusion

I have developed a neoclassical growth model with imperfect property rights in which economic agents allocate resources both for carrying out and deterrring predatory activities, as well as for productive activities. In this context, predation has a negative impact on productivity because it involves the waste of resources in unproductive predatory activities, while it also discourages capital accumulation and business entry, which are deadweight losses. In the rent-seeking literature, there is a debate on the relative importance of the waste of resources and deadweight losses. In the model, the deadweight losses might be very large, higher than the losses due to waste of resources for large values of the predation rate.

The welfare and productivity losses caused by crime —which is an important type of predation— can be noteworthy. In particular, according to the model, the U.S. welfare costs of crime represent a loss of 18.6% of consumption per capita and U.S. GDP per worker is reduced by 17.5%. Moreover, for a country in the average of the distribution of the index of business costs of crime for 94 countries, consumption per capita and GDP per worker are reduced by 25.1% and 23.8%, respectively, because of crime. For a country with a value of the index equal to the average of the last decile, consumption per capita and GDP per worker are reduced by 57.8% and 55.9%, respectively. According to the calibrated model, in the United States, 78.6% of the reduction in consumption per capita would be due to the waste of resource, while 21.4% would be due to the deadweight losses. However, for a country in the average of the last decile, these percentages are reversed to, 21.5% and 78.5%.

The improvement of quality of formal institutions securing property rights could be a successful development policy strongly enhancing productivity by reducing predatory activities. In the model, countries in the first decile of the distribution of the quality index of formal institutions securing property rights have, on average, 1.25 times higher TFP and 1.46 times higher GDP per worker than countries in the last decile. In the data, the corresponding values are 2.86 and 8.36. Moreover, if the quality index of formal institutions securing property rights increases by one standard deviation, then, for a country with an institutional quality index equal to the average of the last decile of its distribution, the ratio of business costs of predation to GDP is reduced by 36%, while

of capital to GDP increases by 5.5% (resp. 0.8%).

GDP per worker (resp. TFP) increases by 23% (resp. 12%).

Undoubtedly, security of property rights may influence resource allocation in different ways, as pointed out by Besley and Ghatak (2010). For this reason, to develop growth models in which security of property rights influences productivity in other ways besides predation may improve our understanding of the importance of security of property rights for economic development.

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A Predation and resource allocation

Definition *A predation rate,* $0 < b < 1$*, solving (17) and such that* s*,* d*,* l *and* $(1 - \tau + \tau\chi + \psi)\, b$ *are between* 0 *and* 1 *is an interior predatory equilibrium of the model.*

The following proposition states that there exists a small enough η such that a unique interior equilibrium exists.

Proposition 1 *There exists a sufficiently small* $\underline{\eta} > 0$ *such that for all* $\eta \leq \underline{\eta}$ *the system of equations formed by (8), (17), (18) and (19) has a unique interior solution with* s*,* d*,* b*,* l and $(1 - \tau + \tau\chi + \psi)\, b$ *belonging to the interval* $(0, 1)$.

Proof: From the properties of function $\widetilde{m}(b) \equiv m(\tau\chi b, \psi b)$ and the intermediate value theorem, it follows that equation (17) has a unique solution. The values of b, s and d that solve (17), (18) and (19) go to 0 when η goes to 0. If b goes to 0, then $(1 - \tau + \tau\chi + \psi)\, b$ goes to 0 and l goes to $0 < \frac{\alpha(1-\theta)}{1-\alpha\theta} < 1$. Therefore, it follows from equations (8), (17), (18) and (19) that there exists a value of η sufficiently close to 0 such that s, d, b, l and $(1 - \tau + \tau\chi + \psi)\, b$ lie between 0 and 1.$\square$

Proposition 2 states how changes in predatory efficiency affect the predation rate and the resource allocation to predatory activities.

Proposition 2 *If* $\eta < \underline{\eta}$*, then (i)* s*,* d *and* b *are strictly increasing functions of* η*,* τ *and* χ*, and (ii)* s *and* b *are strictly decreasing functions of* ψ*, while* d *is a strictly increasing function of* ψ*.*

Proof: From the equilibrium condition (17) and the properties of function $m(\tau\chi b, \psi b)$, it follows that, in equilibrium,

$$0 < \eta\left(\tau\chi m_1(\tau\chi b, \psi b) + \psi m_2(\tau\chi b, \psi b)\right) < 1. \tag{A.1}$$

Differentiating equations (17), (18) and (19) with respect to η yields

$$\frac{\mathrm{d}\, b}{\mathrm{d}\, \eta} = \frac{m(\tau\chi b, \psi b)}{1 - \eta\left(\tau\chi m_1(\tau\chi b, \psi b) + \psi m_2(\tau\chi b, \psi b)\right)},$$

$$\frac{\mathrm{d}\, s}{\mathrm{d}\, \eta} = \frac{\mathrm{d}\, b}{\mathrm{d}\, \eta}\chi\tau,$$

and

$$\frac{\mathrm{d}\, d}{\mathrm{d}\, \eta} = \frac{\mathrm{d}\, b}{\mathrm{d}\, \eta}\psi.$$

Differentiating equations (19), (17) and (18) with respect to χ yields

$$\frac{\mathrm{d}\ s}{\mathrm{d}\ \chi}=\frac{\tau b\left(1-\psi\eta m_{2}\left(\tau\chi b,\psi b\right)\right)}{1-\eta\left(\tau\chi m_{1}\left(\tau\chi b,\psi b\right)+\psi m_{2}\left(\tau\chi b,\psi b\right)\right)},$$

$$\frac{\mathrm{d}\ d}{\mathrm{d}\ \chi}=\frac{\eta m_{1}\left(s,\frac{\psi}{\tau\chi}s\right)\tau\psi b}{1-\eta\left(\tau\chi m_{1}\left(\tau\chi b,\psi b\right)+\psi m_{2}\left(\tau\chi b,\psi b\right)\right)},$$

and

$$\frac{\mathrm{d}\ b}{\mathrm{d}\ \chi}=\frac{m_{1}\left(\tau\chi b,\psi b\right)\tau b}{1-\eta\left(\tau\chi m_{1}\left(\tau\chi b,\psi b\right)+\psi m_{2}\left(\tau\chi b,\psi b\right)\right)}.$$

Differentiating equations (19), (17) and (18) with respect to τ yields

$$\frac{\mathrm{d}\ s}{\mathrm{d}\ \tau}=\frac{\chi b\left(1-\eta\psi m_{2}\left(\tau\chi b,\psi b\right)\right)}{1-\eta\left(\tau\chi m_{1}\left(\tau\chi b,\psi b\right)+\psi m_{2}\left(\tau\chi b,\psi b\right)\right)},$$

$$\frac{\mathrm{d}\ d}{\mathrm{d}\ \tau}=\frac{\eta m_{1}\left(\tau\chi b,\psi b\right)\chi\psi b}{1-\eta\left(\tau\chi m_{1}\left(\tau\chi b,\psi b\right)+\psi m_{2}\left(\tau\chi b,\psi b\right)\right)},$$

and

$$\frac{\mathrm{d}\ b}{\mathrm{d}\ \tau}=\frac{m_{1}\left(\tau\chi b,\psi b\right)\chi b}{1-\eta\left(\tau\chi m_{1}\left(\tau\chi b,\psi b\right)+\psi m_{2}\left(\tau\chi b,\psi b\right)\right)}.$$

Therefore, the (i) statement in Proposition 2 follows from previous equations, together with condition (A.1) and the facts that $m_1\left(s,\frac{\psi}{\tau\chi}s\right)>0$ and $m_2\left(s,\frac{\psi}{\tau\chi}s\right)<0$ are satisfied.

Differentiating equations (19), (17) and (18) with respect to ψ yields

$$\frac{\mathrm{d}\ s}{\mathrm{d}\ \psi}=\frac{\eta m_{2}\left(\tau\chi b,\psi b\right)\tau\chi b}{1-\eta\left(\tau\chi m_{1}\left(\tau\chi b,\psi b\right)+\psi m_{2}\left(\tau\chi b,\psi b\right)\right)},$$

$$\frac{\mathrm{d}\ b}{\mathrm{d}\ \psi}=\frac{\eta m_{2}\left(\tau\chi b,\psi b\right)b}{1-\eta\left(\tau\chi m_{1}\left(\tau\chi b,\psi b\right)+\psi m_{2}\left(\tau\chi b,\psi b\right)\right)},$$

and

$$\frac{\mathrm{d}\ d}{\mathrm{d}\ \psi}=\frac{b\left(1-\eta\tau\chi m_{1}\left(\tau\chi b,\psi b\right)\right)}{1-\eta\left(\tau\chi m_{1}\left(\tau\chi b,\psi b\right)+\psi m_{2}\left(\tau\chi b,\psi b\right)\right)}.$$

where $1-\eta\tau\chi m_1\left(\tau\chi b,\psi b\right)=1-m_1\left(\tau\chi b,\psi b\right)\frac{\tau\chi b}{m(\tau\chi b,\psi b)}>0$ because $m_{11}<0$. Therefore, the (ii) statement in Proposition 2 follows from previous equations, together with condition (A.1) and the fact that $m_2\left(\tau\chi b,\psi b\right)<0$ is satisfied, which completes the proof of Proposition 2. □

An increase of η represents a neutral increase in efficiency in predation. An increase of η implies (i) an increase of the predation rate, b, given s and d, (ii) an increase of the fraction of output devoted to capture rents, s, which increases b, and (iii) an increase of the fraction of output devoted to deter predation, d, which reduces b. The latter two effects simply offset. Therefore, b increases when η rises.

An increase of χ represents an increase in specific efficiency in predation-holding activities. An increase of χ (i) encourages households to devote more resources to capture rents, s, which implies an increase of b, and (ii) firms react to this increase of b increasing the resources devoted to deter predation, d. A decrease in the fraction of output destroyed in the course of predatory activities (i.e. an increase of τ) has the same consequences as an increase in χ.

An increase of ψ represents an increase in specific efficiency in deterrence of predation. An increase of ψ (i) encourages firms to devote resources to deter the capture of rents, d, which reduces b, while (ii) it also discourages households to devote resources to capture rents, s, which reduces b and, in turn, (iii) it impels firms to reduce the resources devoted to deter the capture of rents, d. Consequently, the effect of an increase of ψ on d is *a priori* ambiguous. It depends on how much a lower s influences b: if a lower s greatly reduces b, then firms reduce the fraction of resources devoted to deter the capture of rents, but if a lower s provokes a small reduction of b, then firms increase the fraction of resources devoted to deter the capture of rents. Properties of function m imply that elasticity of m with respect to s is lower than 1 in equilibrium ($\varepsilon_{m,s} \equiv m_1(\tau\chi b, \psi b) \frac{\tau\chi b}{m_1(\tau\chi b, \psi b)} < 1$), which implies that the net effect of an increase of ψ on d is positive.

The following proposition states how the equilibrium number of firms is affected by changes in efficiency in predation.

Proposition 3 *If $\eta < \underline{\eta}$, then (i) total variable labor per capita, l, (resp. the number of firms per capita, n) is a strictly increasing (resp. decreasing) function of η, τ and χ, (ii) if $\varepsilon_{m,s}(1-b) - \varepsilon_{m,d} b > 1-b$, then total variable labor per capita, l, (resp. the number of firms per capita, n) is a strictly decreasing (resp. increasing) function of ψ, and (iii) if $\varepsilon_{m,s}(1-b) - \varepsilon_{m,d} b < 1-b$, then total variable labor per capita, l, (resp. the number of firms per capita, n) is a strictly increasing (resp. decreasing) function of ψ. Where*

$$0 < \varepsilon_{m,s} = m_1(\tau\chi b, \psi b) \frac{\tau\chi b}{m(\tau\chi b, \psi b)} < 1 \quad \text{(A.2)}$$

is the elasticity of the predation function with respect to s *evaluated in* $b = \eta m(\tau\chi b, \psi b)$*, and*

$$0 < \varepsilon_{m,d} = m_2(\tau\chi b, \psi b)\frac{\psi b}{m(\tau\chi b, \psi b)} < 1 \tag{A.3}$$

is the elasticity of the predation function with respect to d *evaluated in* $b = \eta m(\tau\chi b, \psi b)$*.*

Proof: Differentiating equation (8), it follows that l is a strictly increasing function of b. From (4), it follows that n is a strictly decreasing function of l. Thus, n is a strictly decreasing function of b. Proposition 2 states that b is a strictly increasing function of η, χ and τ. Therefore, the (i) statement in Proposition 3 follows. Equation (8) can be rewritten as

$$z = 1 - \alpha - \psi\frac{b}{1-b} \tag{A.4}$$

where $z \equiv \alpha(1-\theta)\frac{1-l}{l}$. Differentiating equation (A.4) with respect to ψ yields

$$\frac{\mathrm{d}\,z}{\mathrm{d}\,\psi} = -\frac{1}{1-b}\left(b + \frac{1}{1-b}\psi\frac{\mathrm{d}\,b}{\mathrm{d}\,\psi}\right). \tag{A.5}$$

Taking into account that

$$\frac{\mathrm{d}\,b}{\mathrm{d}\,\psi} = \frac{\eta m_2(\tau\chi b, \psi b)\,b}{1 - \eta(\tau\chi m_1(\tau\chi b, \psi b) + \psi m_2(\tau\chi b, \psi b))}.$$

Therefore, $\frac{\mathrm{d}\,z}{\mathrm{d}\,\psi} > 0$ if and only if

$$1 + \frac{1}{1-b}\frac{\eta\psi m_2(\tau\chi b, \psi b)\,b}{1 - \eta(\tau\chi m_1(\tau\chi b, \psi b) + \psi m_2(\tau\chi b, \psi b))} < 0, \tag{A.6}$$

and $\frac{\mathrm{d}\,z}{\mathrm{d}\,\psi} < 0$ if and only if

$$1 + \frac{1}{1-b}\frac{\eta\psi m_2(\tau\chi b, \psi b)\,b}{1 - \eta(\tau\chi m_1(\tau\chi b, \psi b) + \psi m_2(\tau\chi b, \psi b))} > 0. \tag{A.7}$$

Taking into account that, in equilibrium, $\eta\tau\chi = \frac{\tau\chi b}{m(\tau\chi b, \psi b)}$, $\eta\psi = \frac{\psi b}{m(\tau\chi b, \psi b)}$ and $b = \eta m(\tau\chi b, \psi b)$ are satisfied, then a little of algebra and conditions (A.6) and (A.7) show that $\frac{\mathrm{d}\,z}{\mathrm{d}\,\psi} > 0$ if and only if

$$(1-b)\,m_1(\tau\chi b, \psi b)\frac{\tau\chi b}{m(\tau\chi b, \psi b)} - b m_2(\tau\chi b, \psi b)\frac{\psi b}{m(\tau\chi b, \psi b)} < 1 - b,$$

which establishes (ii), and that $\frac{\mathrm{d}\, z}{\mathrm{d}\, \psi} < 0$ if and only if

$$(1-b)\, m_1 (\tau\chi b, \psi b) \frac{\tau\chi b}{m(\tau\chi b, \psi b)} - b m_2 (\tau\chi b, \psi b) \frac{\psi b}{m(\tau\chi b, \psi b)} > 1-b,$$

which establishes (iii). Therefore, the proof of Proposition 3 is completed.□

An increase of η, τ or χ reduces the number of firms because their profits go down. On one hand, an increase of any of these parameters provokes an increase of the predation rate, which reduces profits of firms because predation works as a tax on production. On the other hand, an increase of any of these parameters encourages firms to devote more resources to deter predation in response to a higher predation. The higher costs of deterring predation reduce profits and discourage entry.

However, an increase of ψ has an ambiguous effect on the profits of firms and, hence, on the number of firms. On one hand, their profits are higher because the predation rate decreases. On the other hand, their profits are lower because firms devote a higher fraction of their output to deter predation. Proposition 3 establishes that if the weighted sum of the elasticities of predation with respect to s and d is large enough, then the first effect predominates; but, if it is small, then the second effect predominates.

The following proposition states that a higher number of firms increases productivity.

Proposition 4 *If $\eta < \underline{\eta}$, then q is a strictly decreasing (resp. increasing) function of total variable labor used in production, l (resp. the number of firms per capita, n).*

Proof: Differentiating equation (14) with respect to l yields

$$\frac{\mathrm{d}\, q}{\mathrm{d}\, l} = \frac{q}{1-l} \left(\alpha (1-\theta) \frac{1-l}{l} - (1-\alpha) \right).$$

From equation (8), it follows that $\alpha (1-\theta) \frac{1-l}{l} - (1-\alpha) = -\psi \frac{b}{1-b} < 0$, which establishes Proposition 4.□

On one hand, more firms -i.e., a higher $(1-l)$- increase aggregate productivity because firms face diminishing returns to scale. On the other hand, more operating firms imply that fewer workers are engaged directly in production -i.e., a smaller l-, which reduces q. However, the first effect predominates.

The following proposition states how multifactor productivity is affected by changes in efficiency in predation.

Proposition 5 *If $\eta < \underline{\eta}$, then (i) q is a strictly decreasing function of η, τ and χ, (ii) if $\varepsilon_{m,s}(1-b) - \varepsilon_{m,d}b > 1-b$ then q is a strictly increasing function of ψ, (iii) and if $\varepsilon_{m,s}(1-b) - \varepsilon_{m,d}b < 1-b$ then q is a strictly decreasing function of ψ, where $\varepsilon_{m,s}$ and $\varepsilon_{m,d}$ are respectively given by (A.2) and (A.3) and they are evaluated in $b = \eta m(\tau\chi b, \psi b)$.*

Proof: Proposition 5 follows from Proposition 2, Proposition 3 and Proposition 4.□

The higher is η, τ or χ, the lower are the profits of firms because higher is the predation rate and more resources are devoted to deter predation. Therefore, the equilibrium number of firms is lower, which affects negatively multifactor productivity because there are diminishing returns to scale. However, if an increase of ψ implies a decrease (resp. an increase) of the equilibrium number of firms, then multifactor productivity, q, decreases (resp. increases).

The following proposition states the consequences of changes in efficiency in predation on consumption per capita, capital per capita and output per capita along a BGP.

Proposition 6 *Along a BGP, (i) output per capita, y, consumption per capita, c, and capital per capita, k, are decreasing functions of η, τ and χ, (ii) if $\varepsilon_{m,s}(1-b) - \varepsilon_{m,d}b > 1-b$, then output per capita, y, and capital per capita, k, are increasing functions of ψ, where $\varepsilon_{m,s}$ and $\varepsilon_{m,d}$ are respectively given by (A.2) and (A.3) and they are evaluated in $b = \eta m(\tau\chi b, \psi b)$.*

Proof: Along a BGP $\dot{k}_t = 0$ and $\dot{c}_t = 0$ for all t. It follows from (6) and (13) that along a BGP

$$k = \left(\frac{(1-b)\,\alpha\theta}{r+\delta} q\right)^{\frac{1}{1-\alpha\theta}} \tag{A.8}$$

and

$$y = q^{\frac{1}{1-\alpha\theta}} \left(\frac{\alpha\theta}{r+\delta} q\right)^{\frac{1}{1-\alpha\theta}}, \tag{A.9}$$

where $r = \sigma\gamma + \rho$. Proposition 2 states that b is a strictly increasing function of η, χ and τ. Proposition 5 states that q is a strictly decreasing function of ψ. Therefore, from Proposition 2, Proposition 5 and equations (A.8) and (A.9), it follows that k and y are strictly decreasing functions of η, χ and τ.

It follows from (B.2) that along a BGP

$$c = (1 - \Phi b)\, q k^{\alpha\theta} - \Delta k. \tag{A.10}$$

where $\Phi \equiv 1 - \tau + \chi\tau + \psi$ and $\Delta \equiv \gamma + n + \delta$. Differentiating (A.10) with respect to b yields:

$$\frac{\mathrm{d}\, c}{\mathrm{d}\, b} = -\Phi q k^{\alpha\theta} + (1 - \Phi b)\, k^{\alpha\theta} \frac{\mathrm{d}\, q}{\mathrm{d}\, b} + \left[(1 - \Phi b)\, \alpha\theta q k^{\alpha\theta - 1} - \Delta\right] \frac{\mathrm{d}\, k}{\mathrm{d}\, b}. \tag{A.11}$$

Differentiating (8) with respect to b, it follows that l is a strictly increasing function of b. Proposition 4 states that q is a strictly decreasing function of l. Therefore, in an interior equilibrium, $\frac{\mathrm{d}\, q}{\mathrm{d}\, b} < 0$. From the fact that $\frac{\mathrm{d}\, q}{\mathrm{d}\, b} < 0$ and equation (A.8), it follows that $\frac{\mathrm{d}\, k}{\mathrm{d}\, b} < 0$. If $\Phi < 1$, then $(1 - \Phi b)\, \alpha\theta q k^{\alpha\theta - 1} - \Delta > 0$ since $\sigma\gamma + \rho + \delta > \Delta$. Therefore, from equation (A.11), it follows that if $\Phi < 1$, then $\frac{\mathrm{d}\, c}{\mathrm{d}\, b} < 0$.

From (A.8), it follows that

$$\frac{\mathrm{d}\, q}{\mathrm{d}\, b} \frac{1}{q} - (1 - \alpha\theta) \frac{\mathrm{d}\, k}{\mathrm{d}\, b} \frac{1}{k} = \frac{1}{1 - b}.$$

Using previous equation, equation (A.11) can be rewritten as

$$\frac{\mathrm{d}\, c}{\mathrm{d}\, b} = \frac{1 - \Phi}{1 - b} q k^{\alpha\theta} + \frac{(1 - \Phi b)\, q k^{\alpha\theta} - \Delta k}{k} \frac{\mathrm{d}\, k}{\mathrm{d}\, b},$$

which, using equation (A.10), can be rewritten again as

$$\frac{\mathrm{d}\, c}{\mathrm{d}\, b} = \frac{1 - \Phi}{1 - b} q k^{\alpha\theta} + \frac{\mathrm{d}\, k}{\mathrm{d}\, b} \frac{c}{k}.$$

If $\Phi > 1$, taking into account that $\frac{\mathrm{d}\, k}{\mathrm{d}\, b} < 0$, then $\frac{\mathrm{d}\, c}{\mathrm{d}\, b} < 0$. Therefore, from $\frac{\mathrm{d}\, c}{\mathrm{d}\, b} < 0$ and Proposition 2, it follows that c is a strictly decreasing function of η, χ and τ.

Proposition 2 states that b is a strictly decreasing function of ψ. Proposition 5 states that, if $\varepsilon_{m,s}(1 - b) - \varepsilon_{m,d} b > 1 - b$, then q is a strictly increasing function of ψ. Therefore, (ii) statement follows from Proposition 2, Proposition 5 and equations (A.8) and (A.9). □

A higher predation rate reduces capital, output and consumption per capita because predation works as a tax which discourages both capital accumulation and entry of firms and because it also diverts resources from productive to unproductive uses. An increase of η, τ and χ has an unambiguous impact on the long run variables because it implies an increase in the predation rate, in the fraction of resources devoted to carry out predation and in the fraction of resources devoted to deter predation, as well as a decrease in multifactor productivity.

However, an increase of ψ implies a decrease of b, which contributes to increase capital and output per capita along a BGP, but multifactor productivity, q, could increase or decrease. If a higher ψ implies a higher multifactor productivity, then capital per capita and output per capita increase along a BGP, but if a higher ψ implies a lower multifactor productivity, q, then the effect on capital per capita and output per capita along a BGP is ambiguous. The effect of an increase of ψ on consumption per capita is ambiguous, even if the predation rate falls and multifactor productivity increases. The reason is that a higher ψ implies an increase in the fraction of output devoted to deter predation, which might imply a reduction of consumption per capita.

The following proposition states that changes in neutral efficiency in predation affect both TFP and the ratio of capital to GDP, as well as the ratio of business costs of predation to GDP.

Proposition 7 *Along a BGP, (i) the ratio of business costs of predation to GDP,* v_m*, is a strictly increasing function of neutral efficiency in predation,* η*, (ii) GDP per capita is a strictly decreasing function of neutral efficiency in predation,* η*, (iii) TFP is a strictly decreasing function of neutral efficiency in predation,(iv) if* $\tau(\mu\chi - 1) + \phi\psi > 0$ *then the ratio of capital to GDP is a strictly increasing function of* η*, (v) if* $\tau(\mu\chi - 1) + \phi\psi < 0$ *then the ratio of capital to GDP is a strictly decreasing function of* η*, and (vi) if* $\tau(\mu\chi - 1) + \phi\psi = 0$ *then the ratio of capital to GDP does not depend on* η*.*

Proof: Differentiating equation (21) with respect to b yields

$$\frac{\mathrm{d}\, v_m}{\mathrm{d}\, b} = (1+\psi)\frac{1}{\left[1-(1-\tau+\mu\chi\tau+\phi\psi)\, b\right]^2} > 0. \tag{A.12}$$

Therefore, (i) statement in Proposition 7 follows from (A.12) and Proposition 2. GDP per capita is given by $y_m = zk^{\alpha\theta} = (1-(1-\tau+\mu\chi\tau+\phi\psi)\, b)\, y$, therefore (ii) statement in Proposition 7 follows from Proposition 2 and Proposition 6. TFP is $z = (1-(1-\tau+\mu\chi\tau+\phi\psi)\, b)\, q$, therefore, (iii) statement in Proposition 7 follows from Proposition 2 and Proposition 5. The ratio of capital to GDP is

$$\frac{k}{y_m} = \frac{\alpha\theta}{\sigma\gamma+\rho+\delta}\frac{1-b}{1-(1-\tau+\mu\chi\tau+\phi\psi)\, b}$$

Differentiating previous equation with respect to b yields

$$\frac{\mathrm{d}\left(\frac{k}{y_m}\right)}{\mathrm{d}\,b} = \frac{\alpha\theta}{\sigma\gamma+\rho+\delta}\frac{\tau\left(\mu\chi-1\right)+\phi\psi}{\left[1-\left(1-\tau+\mu\chi\tau+\phi\psi\right)b\right]^2}. \tag{A.13}$$

Therefore, (iv), (v) and (vi) statements in Proposition 7 follow from (A.13) and Proposition 2.□

B Transitional dynamics and dynamic inefficiency

Transitional dynamics

The transitional dynamics of the model with predation are similar to the transitional dynamics of the standard neoclassical growth model without predation. In equilibrium, s, d, b, l and q are constant for all t. Therefore, taking into account that detrended output per capita is given by (13) and using the first-order condition for the profit-maximizing problem of a firm (6) and the resource constraint (15), the Euler condition (11) and the evolution law of detrended capital per capita (16) can be rewritten as

$$\frac{\overset{\bullet}{c}_t}{c_t} = \frac{1}{\sigma}\left(\alpha\theta\left(1-b\right)qk_t^{\theta\alpha-1} - \delta - \rho\right) - \gamma \tag{B.1}$$

and

$$\overset{\bullet}{k}_t = \left(1 - \left(1 - \tau + \tau\chi + \psi\right)b\right)qk_t^{\theta\alpha-1} - c_t - \left(\delta + \gamma + n\right)k_t, \tag{B.2}$$

which together with the transversality condition (10) and an initial stock of detrended capital per capita, k_0, characterize the equilibrium dynamics of the model. The neoclassical standard growth model with perfect property rights arises as a parametric limit case when η goes to 0.

On dynamic efficiency

Along a BGP, both detrended capital per capita and detrended consumption per capita remain constant, $\dot{k}_t = 0$ and $\dot{c}_t = 0$. Therefore, it follows from equation (B.1) that, along a BGP, detrended capital per capita is $k^* = \left(\left(1-b\right)q\frac{\alpha\theta}{\sigma\gamma+\rho+\delta}\right)^{\frac{1}{1-\alpha\theta}}$. From equation (B.2), it follows that steady detrended consumption per capita is a function of detrended capital per capita, $c = \left(1 - \left(1-\tau+\tau\chi+\psi\right)b\right)qk^{\theta\alpha-1} - \left(\delta+\gamma+n\right)k$. The Golden Rule stock of detrended capital per capita is the stock of detrended capital per capita which maximizes steady detrended consumption per capita, $k^g = \left(\left(1-\left(1-\tau+\tau\chi+\psi\right)b\right)q\frac{\alpha\theta}{\delta+\gamma+n}\right)^{\frac{1}{1-\alpha\theta}}$. Therefore, $k^* > k^g$ if and only if $\frac{1-b}{1-(1-\tau+\tau\chi+\psi)b} > \frac{\sigma\gamma+\rho+\delta}{\delta+\gamma+n}$.

The phase diagram of the system of equations in (B.1) and (B.2) is similar to the phase diagram of the standard neoclassical growth model. Accordingly, if $k^* > k^g$, then a Pareto improvement can be achieved by reducing the long-run stock of detrended capital per capita. Therefore, an equilibrium might be dynamically inefficient even if the transversality condition is satisfied. The reason for a possible overaccumulation of capital even if the transversality condition is satisfied is that marginal productivity of capital does not reflect its social return because part of the output is wasted on unproductive predatory activities. However, if the transversality condition is satisfied (i.e. $\sigma\gamma + \rho > \gamma + n$), then a sufficient condition for dynamic efficiency is that $1 - \tau + \chi\tau + \psi \leq 1$. This condition is satisfied for the calibrated values of the parameters in Section 3.

The focus of development policies has fluctuated between promoting the accumulation of productive factors and improving institutions. The possibility of dynamic inefficiency suggests that to do the former, ignoring the latter, might even be counterproductive.

C Some microstructure of the predatory sector

Households

Output captured by household j by means of predation is $H_j = H(S, D, Y, S_j)$ and the obtained transfers are $T_j = \tau H_j$. A household solves the following maximization problem: $\max_{S_j} \tau H(S, D, Y, S_j) - S_j$. Therefore, it is assumed that predatory activities of households present an externality because when one household maximizes utility by choosing how many resources to devote to predation, it takes the total amount of resources devoted to predation by all households as given, but the effectiveness of the resources spent by one household depends on both individual and aggregate expenditures. The first order condition of the household maximization problem is $\tau H_4(S, D, Y, S_j) = 1$. It is assumed that

$$H(S, D, Y, S_j) = \widetilde{\eta} M(S, D, Y) v\left(\frac{S_j}{S}\right),$$

where $\widetilde{\eta} > 0$. It is assumed that $v' > 0$ and $v'' < 0$ in order to guarantee the existence of a maximum of the household maximization problem. The aggregate resources captured by predation are

$$H = \int_0^1 H_j \text{ d } j = \int_0^1 \widetilde{\eta} M(S, D, Y) v\left(\frac{S_j}{S}\right) \text{ d } j.$$

In a symmetric equilibrium $S_j = S$. Therefore, in a symmetric equilibrium $v\left(\frac{S_j}{S}\right) = v(1) \equiv \varphi$ and

$$H = \int_0^1 \widetilde{\eta} M(S, D, Y) \varphi \text{ d } j = \eta M(S, D, Y),$$

where $\eta \equiv \widetilde{\eta}\varphi$. The first order condition can be rewritten as $\tau\widetilde{\eta}\frac{M(S,D,Y)}{S} v'\left(\frac{S_j}{S}\right) = 1$.In a symmetric equilibrium the first order condition is $\tau\eta\frac{M(S,D,Y)}{S}\chi = 1$, where $v'(1) \equiv \varpi$ and $\chi = \frac{\varpi}{\varphi}$ is the elasticity of function v in a symmetric equilibrium.

Firms

Output captured by predation to firm i is $B_i = F(S_, D, Y, N, Y_j, D_j)$. A firm solves the following maximization problem: $\min_{D_i} F(S_, D, Y, N, Y_i, D_i) + D_i$.Therefore, it is assumed that activities of firms oriented toward deterring predation present an externality because when one firm maximizes profits by choosing how many resources to devote to deterrence, it takes the total amount of resources devoted to deterrence by all firms as given as well as the number of firms; however, the effectiveness of the resources spent by one firm depends on both individual and aggregate expenditures. The first order condition of the firm minimization problem is $-F_6(S_,D,Y,N,Y_i,D_i) = 1$. It is assumed that

$$F(S_,D,Y,N,Y_i,D_i) = \widetilde{\eta}M(S,D,Y)\frac{Y_i}{Y}f\left(\frac{N}{D}D_i\right)$$

The aggregate resources captured to firms by predation are

$$F = \int_0^N \widetilde{\eta}M(S,D,Y)\frac{Y_i}{Y}f\left(\frac{N}{D}D_{i,t}\right)\ \mathrm{d}\ i$$

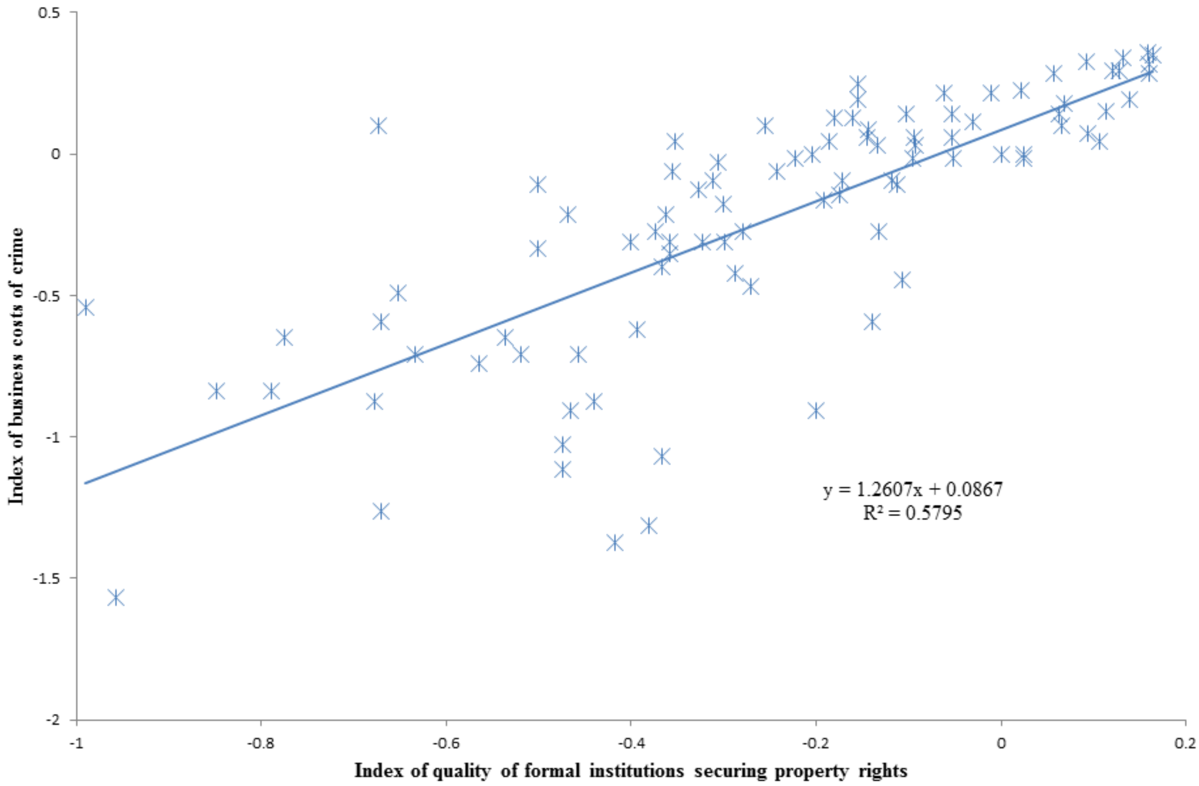
In a symmetric equilibrium, $Y_i = \frac{Y}{N}$ and $D_i = \frac{D}{N}$. Therefore, in a symmetric equilibrium the aggregate resources captured to firms by predation are

$$F = \int_0^N F(S_,D,Y,N,Y_i,D_i)\ \mathrm{d}\ i = \int_0^N \widetilde{\eta}\frac{M(S,D,Y)}{N}f(1)\ \mathrm{d}\ i.$$

It is assumed that $f(1) = v(1) \equiv \varphi$ in order to guarantee that $F = H = B$ and, thus, the existence of a symmetric equilibrium. The first order condition of the firm minimization problem is $-\widetilde{\eta}M(S,D,Y)\frac{Y_i}{Y}f'\left(\frac{N}{D}D_{i,t}\right)\frac{N_t}{D_t} = 1$. It is assumed that $f' < 0$ and $f'' > 0$ in order to guarantee the existence of a minimum of the firm minimization problem. In a symmetric equilibrium the first order condition is $\eta M(S,D,Y)\psi\frac{1}{D_t} = 1$,where $f'(1) \equiv -\xi$ and $\psi = \frac{\xi}{\varphi}$ is the elasticity of function f in a symmetric equilibrium.

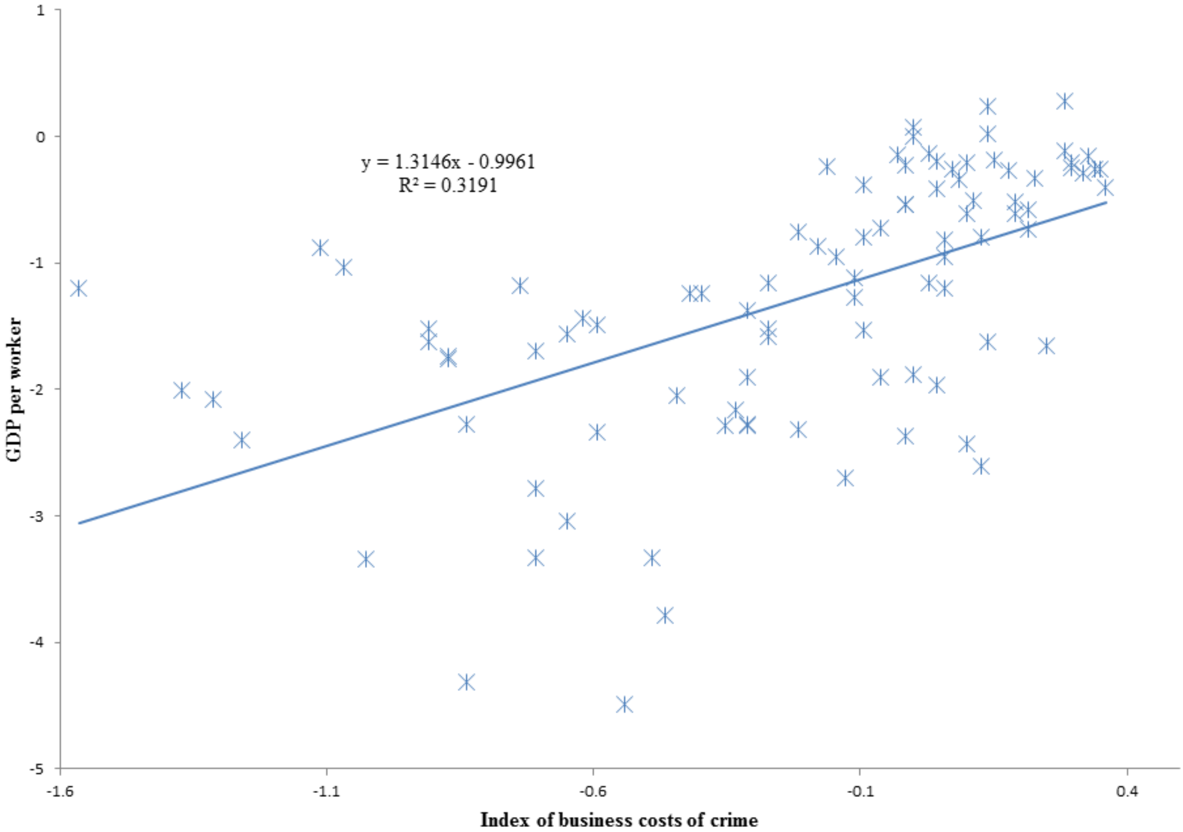
Firm behavior might be described in another way. It might be assumed that firms contest predation. Let B be aggregate output captured by households by means of predation, then output captured to firm i by predation is $B_i = h_iB$, where h_i depends on the relative size of the firm and the relative resources devoted to carrying out predation, $h_i = \frac{Y_i}{Y}f\left(\frac{N}{D}D_{i,t}\right)$ with $f(1) = 1$.

Figure 1: Security of property rights and the business costs of predation



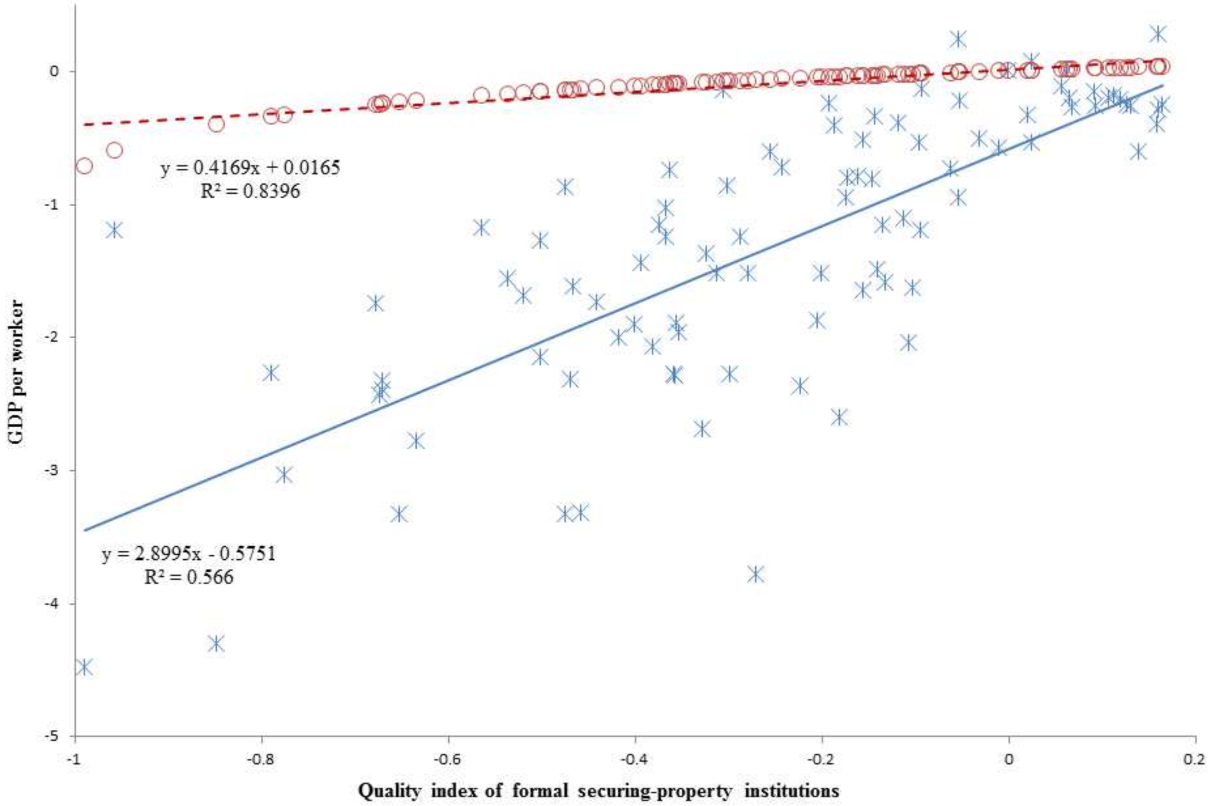
Both variables are in logs and relative to the U.S. The solid line is the regression line fitted to the data. The index of business costs of crime is a component of the Economic Freedom of the World Index (EFW) elaborated by the Fraser Institute (U.S.=1). The index of security of property rights is an arithmetic average of eight indexes related to the legal structure and security of property rights in a country used to built the EFW (judicial independence, impartial courts, protection of property rights, military interference in rule of law and the political process, integrity of the legal system, legal enforcement of contracts, regulatory restrictions on the sale of real property, and reliability of police) (U.S.=1). Data on both indexes are for year 2005.

Figure 2: Business costs of predation and GDP per worker



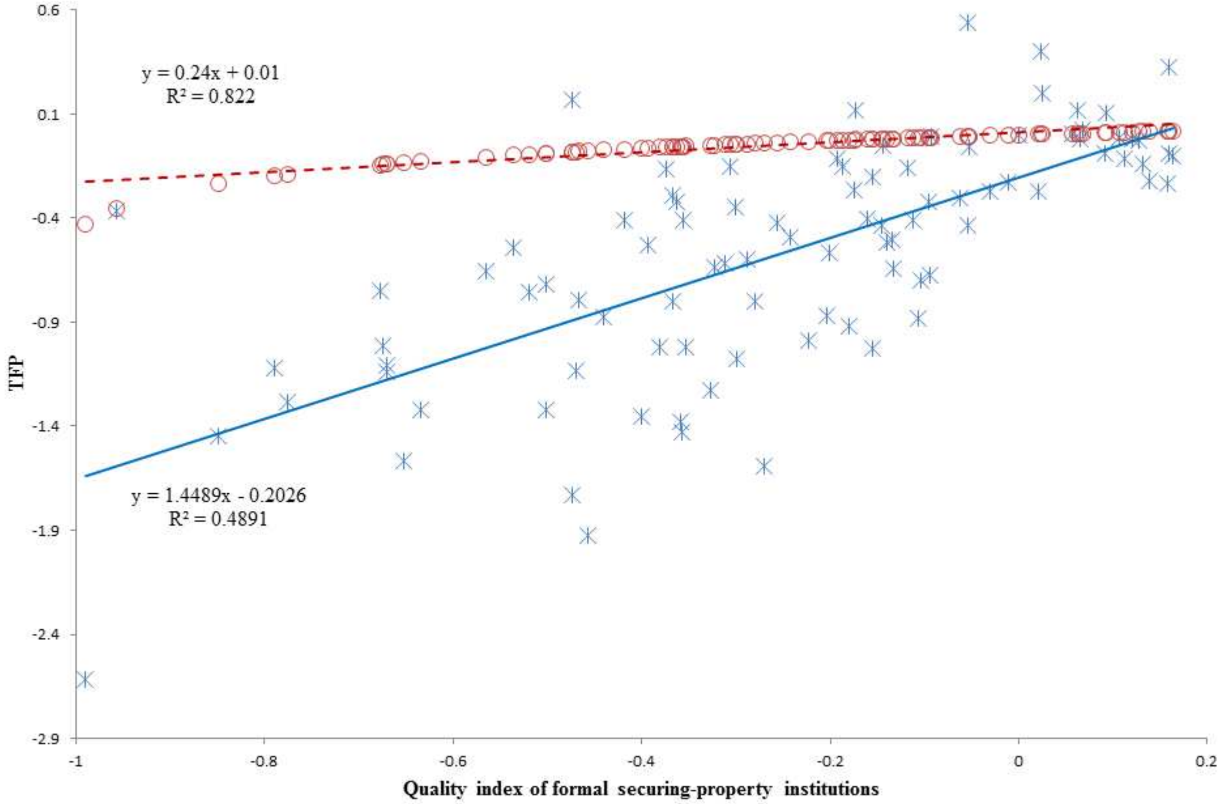
Both variables are in logs and relative to the U.S. The solid line is the regression line fitted to the data. The index of business costs of crime is a component of the Economic Freedom of the World Index (EFW) elaborated by the Fraser Institute (U.S.=1). Data on GDP per worker are taken from the PWT 8.0. Data are for year 2005.

Figure 3: Security of property rights and GDP per worker



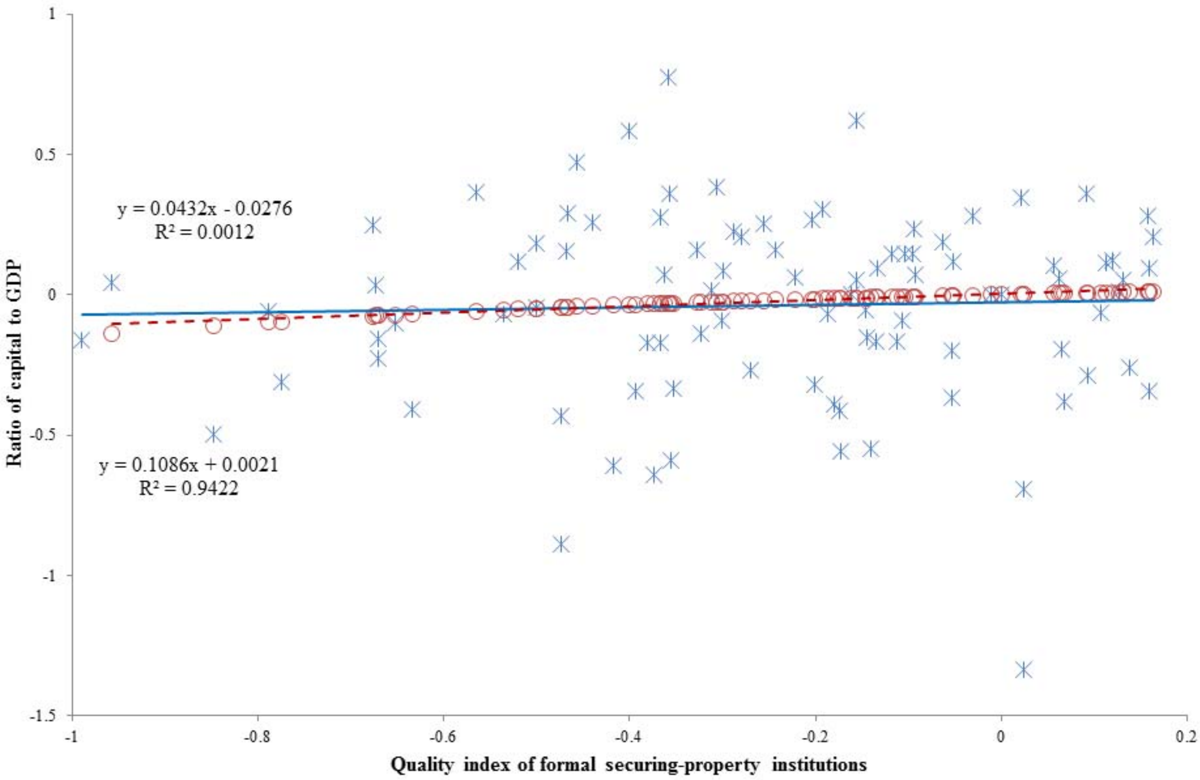
Both variables are in logs and relative to the U.S. Asterisks represent observed data and cricles represent simulated data. The solid line is the regression line fitted to the observed data and the dashed line is the regression line fitted to the simulated data. The index of quality of formal institutions securing property rights is an arithmetic average of eight indexes related to the legal structure and security of property rights in a country used to built the EFW (judicial independence, impartial courts, protection of property rights, military interference in rule of law and the political process, integrity of the legal system, legal enforcement of contracts, regulatory restrictions on the sale of real property, and reliability of police) (U.S.=1). Data on GDP per worker are taken from the PWT 8.0. Data are for year 2005.

Figure 4: Security of property rights and TFP



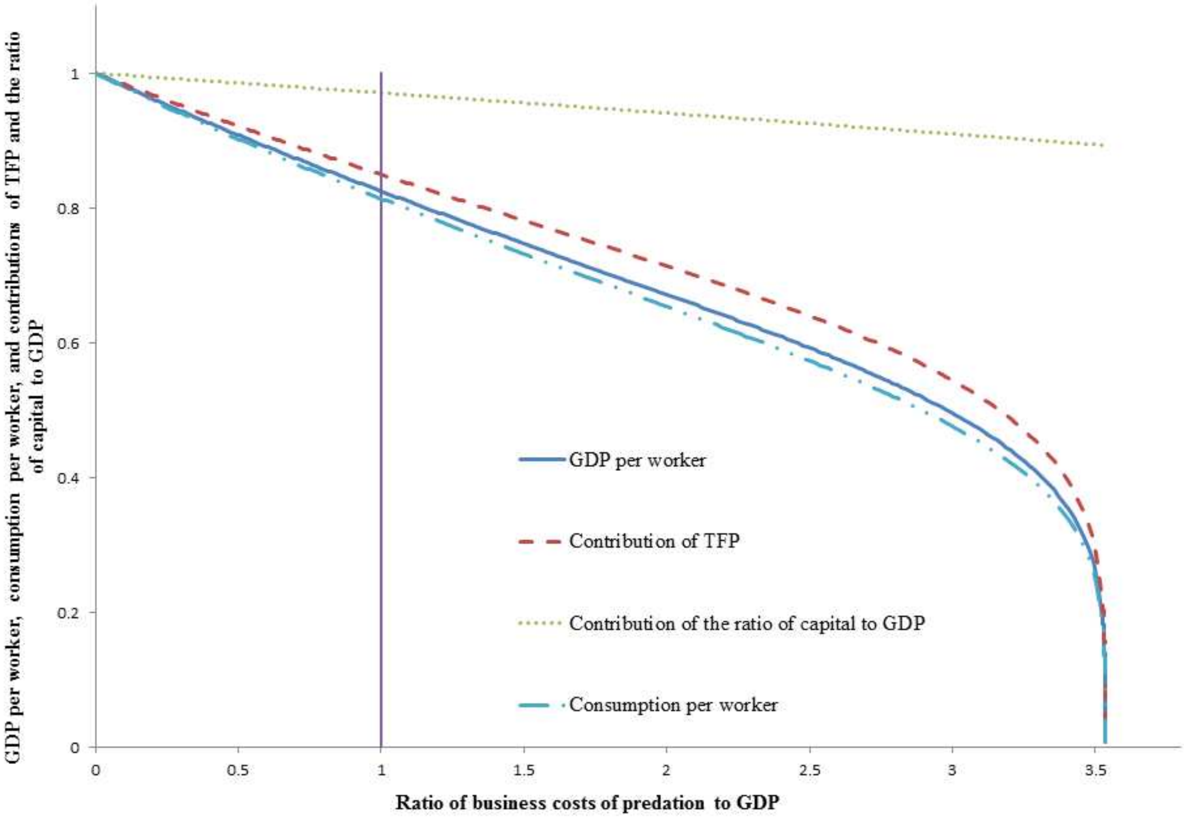
Both variables are in logs and relative to the U.S. Asterisks represent observed data and cricles represent simulated data. The solid line is the regression line fitted to the observed data and the dashed line is the regression line fitted to the simulated data. The index of quality of formal institutions securing property rights is an arithmetic average of eight indexes related to the legal structure and security of property rights in a country used to built the EFW (judicial independence, impartial courts, protection of property rights, military interference in rule of law and the political process, integrity of the legal system, legal enforcement of contracts, regulatory restrictions on the sale of real property, and reliability of police) (U.S.=1). Data on TFP are taken from the PWT 8.0. Data are for year 2005.

Figure 5: Security of property rights and the ratio of capital to GDP



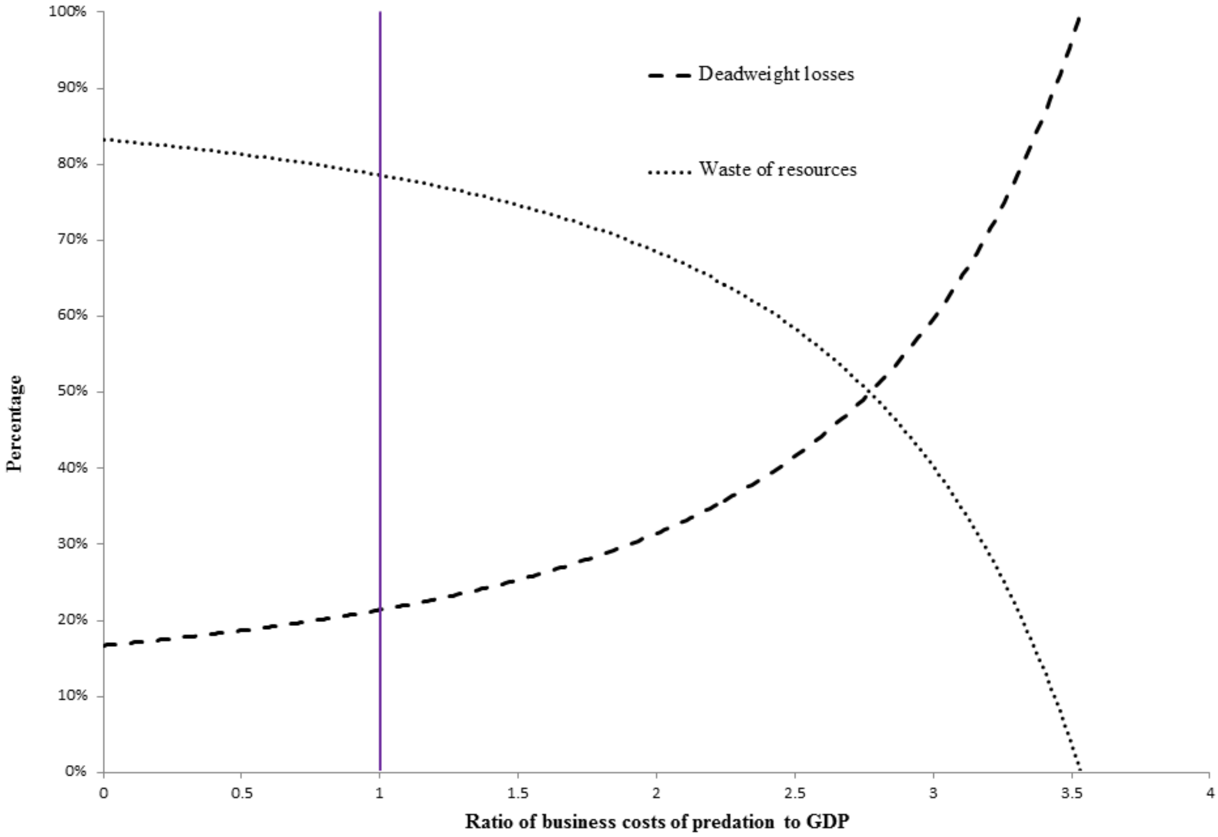
Both variables are in logs and relative to the U.S. Asterisks represent observed data and cricles represent simulated data. The solid line is the regression line fitted to the observed data and the dashed line is the regression line fitted to the simulated data. The index of formal institutions securing property rights is an arithmetic average of eight indexes related to the legal structure and security of property rights in a country used to built the EFW (judicial independence, impartial courts, protection of property rights, military interference in rule of law and the political process, integrity of the legal system, legal enforcement of contracts, regulatory restrictions on the sale of real property, and reliability of police) (U.S.=1). Data on capital stocks and GDP are taken from the PWT 8.0. Data are for year 2005.

Figure 6: Business costs of crime, consumption per worker, GDP per worker and contributions of TFP and the ratio of capital to GDP



GDP per worker, consumption per worker, contribution of TFP and contribution of the ratio of capital to GDP are normalized to 1 for the economy without predation. The calibrated economy, which corresponds to the U.S. economy, is marked with a solid vertical line. The ratio of business costs of predation to GDP is expressed relative to the calibrated ratio of business costs of predation to GDP, which corresponds to the value of this ratio in the U.S. The U.S. ratio of business costs of predation to GDP is 0.20.

Figure 7: Deadweight losses vs. waste of resources



The calibrated economy, which corresponds to the U.S. economy, is marked with a solid vertical line. The ratio of business costs of predation to GDP is expressed relative to the calibrated ratio of business costs of predation to GDP, which corresponds to the value of this ratio in the U.S. The U.S. ratio of business costs of predation to GDP is 0.20. Both the effect of the deadweight losses and the effect of the waste of resources are relative to the total decrease in long-run consumption per worker.

Table 1 (Part 1): The costs of crime

The costs of crime	$ Billion	Type
Crime-Induced Production		
Drug traficking	160.584	S*, T
Police proteccion	47.129	D
Corrections	35.879	D
Prenatal exposure to cocaine and heroin	28.156	O
Anticrime components of federal agency budgets	23.381	D
Judicial and legal services, states and local	18.901	D
Guard	17.917	D
Drug control	10.951	D
DUI cost to driver	10.302	D
Medical care for victims	8.990	O
Computer viruses and security	8.000	D,O
Alarm systems	6.478	D
Passes for business access	4.659	D
Locks, safes and vaults	4.359	D
Vandalism (except arson)	2.317	O
Small arms and small arms ammunition	2.252	D,S
Replacements due to arson	1.902	O
Surveillance cameras	1.471	D
Safety lighting	1.466	D
Protective fences and gates	1.159	D
Airport security	0.448	D
Nonlethal weaponry (for example, mace)	0.324	D,S
Electronic retail article surveillance	0.149	D
Theft insurance (less indemnity)	0.096	O
Guard dogs	0.049	D
Expenditures by mothers against drunk driving	0.049	D
Library theft detection	0.028	D

Table 1 (Part 2): The costs of crime

The costs of crime	$ Billions	Type
Opportunity Costs		
Time spent securing assets	89.567	D*
Criminal's lost work days		
In prision	35.097	S*
Planning and executing crimes	4.109	S*
Victims' lost work days	0,876	O
Time spent on neighborhood watches	0.655	D*
Value of Risk to Life and Health		
Value of lost life	439.88	O
Value of injuries	134.515	O
Transfers Costs		
Occupational fraud	203.952	T
Unpaid taxes	123.108	T
Health insurance fraud	108.61	T
Financial institutions fraud	52.901	T
Mail fraud	35.986	T
Property/casualty insurance fraud	20.527	T
Telemarketing fraud	16.609	T
Business burglary	13.229	T
Motor vehicle theft	8.913	T
Shoplifting	7.185	T
Household burglary	4.527	T
Personal theft	3.909	T
Household larceny	1.996	T
Coupon fraud	0.912	T
Robbery	0.775	T

D= Resources devoted to deterrring predation; S=resources devoted to carrying out predation; O= Resources destroyed in the course of predation; T=Resources transferred by predation; B=T+O=Resources captured by predation. An asterisk, *, denotes resources devoted to deterring or carrying out predation not included in GDP. Source: Anderson (1999)

Table 2: Resources involved in predation

Resources involved in predation	$ Billions
Resources captured by predation ($B = O + T$)	1384.456
Resources destroyed in the course of predation (O)	620.732
Resources transferred by predation (T)	763.724
Resources devoted to carrying out predation (S)	201.078
Not included in predation (μD)	199.79
Resources devoted to deterring predation (D)	280.284
Not included in GDP (ϕD)	90.222
1997 U.S. GDP	8278.901

Table 3: Regressions

	Coefficient (Standard deviation)			
Formal institutions	1.101 (0.103)	0.827 (0.096)	1.052 (0.155)	0.869 (0.131)
Gini index		−0.631 (0.105)		−0.639 (0.107)
GDP per worker			0.017 (0.041)	−0.016 (0.034)
R^2	60.9	74	61	74.1

The dependent variable is $\ln \Delta_h$. All variables are in logs. The Gini index and the index of formal institutions securing property rights are significant at 95% in all regressions. GDP per worker is not significant at 90% in any regression.

Table 4: Improving quality of formal institutions

	Percentage variation				
Decile	Ω	v_m	TFP	$\frac{k}{y_m}$	y_m
1	1.152	-16.31%	1.52%	0.84%	2.72%
2	1.068	-17.47%	1.77%	0.98%	3.17%
3	0.959	-19.27%	2.22%	1.23%	3.98%
4	0.886	-20.68%	2.62%	1.45%	4.70%
5	0.844	-21.59%	2.90%	1.60%	5.21%
6	0.775	-23.30%	3.49%	1.93%	6.29%
7	0.712	-25.07%	4.19%	2.30%	7.57%
8	0.666	-26.56%	4.87%	2.65%	8.81%
9	0.596	-29.24%	6.34%	3.39%	11.50%
10	0.466	-35.86%	12.42%	5.86%	22.65%

Ω is the index of quality of formal institutions, v_m is the ratio of business costs of predation to GDP, TFP is Total Factor Productivity, $\frac{k}{y_m}$ is the ratio of capi-, tal to GDP, and y_m is GDP per worker.