

Competition in law enforcement and capital allocation

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A B S T R A C T

This paper studies inter-jurisdictional competition in the fight against crime and its impact on occupational choice and the allocation of capital. In a world where capital is mobile, jurisdictions are inhabited by individuals who choose to become either workers or criminals. Because the return of the two occupations depends on capital, and because investment in capital in a jurisdiction depends on its crime rate, there is a bi-directional relationship between capital investment and crime which may lead to capital concentration. By investing in costly law enforcement, a jurisdiction makes the choice of becoming a criminal less attractive, which in turn reduces the number of criminals and makes its territory more secure. This increased security increases the attractiveness of the jurisdiction for investors and this can eventually translate into more capital being invested. We characterize the Nash equilibria—some entailing a symmetric outcome, others an asymmetric one—and study their efficiency.

1. Introduction

Security matters when it comes to investment decisions. Indeed, capital owners prefer to invest where crime rates are lower because the likelihood of being deprived of the return on their investment is lower.¹ Adjacent local authorities, responding to those preferences, compete by investing in law enforcement to lower their respective crime rates, and to make their jurisdiction relatively safer than others for investors. Understanding the mechanics of such competition and the choice of law enforcement chosen by adjacent jurisdictions is the focus of this paper.

In the United States, there are many cases of “twin” cities, with similar characteristics, which nevertheless exhibit very different crime rates. For example, the crime rate against properties is 60% higher in Minneapolis than in St-Paul, 100% higher in Tampa than in St Petersburg, and 46% higher in Oakland than in San Francisco.² Many potential explanations for the concentration of criminal activ-

ities has been suggested. Freeman et al. (1996) and Helsley and Strange (1999) suggest that congestion in enforcement can explain these phenomena, as more criminals can dilute the probability of capture and conviction. Many economists like Sah (1991), Glaeser et al. (1996) or Silverman (2004), argue that social interactions of some form or another contribute to the presence of multiple equilibria in crime rates. In particular, Zenou (2003) proposes that a criminal life becomes more attractive in high crime rate communities. Drawing from both of these potential explanations, there also exists a large body of literature on the “broken window” effect; see Lochner (2007) and Rosado (2008). Frictions in the labor market could be another mechanism. Burdett et al. (2003) generate the co-existence of high-crime/low-wage regions with low-crime/high-wage ones because firms in low crime areas can offer higher wages. Schrag and Scotchmer (1994), Verdier and Zenou (2004), Curry and Klumpp (2009) and O’Flaherty and Sethi (2010) all suggest that discrimination and prejudices may play an important role in creating disparity in crime rates among populations.³ One of the main three contributions of our paper is to propose a new explanation for this concentration in criminality, based on the interaction between crime, capital location, wages and enforcement.

When security levels differ, capital owners will adjust their investments in consequence; when crime becomes more concentrated, capital may also become more concentrated, although

¹ Rosenthal and Ross (2010) estimate that some types of business are less willing to locate in high violent crime areas. For example, retailers and high end restaurants prefer to operate in low violent crime areas as compared to wholesalers in the same industry or low end restaurants. This is an example on how capital—at least some types of capital—is seeking safer environments.

² Other examples of “twin” cities that exhibit very different property crime rates include Kansas City (Missouri) and Kansas City (Kansas), East St-Louis (Illinois) and St-Louis (Missouri), or Los Angeles and Anaheim.

³ O’Flaherty and Sethi (2010) also incorporate the fact that non criminals may outbid criminals to be able to live in crime and drug free environments.

obviously in different locations. Another important feature of our analysis is that residents of a jurisdiction make the choice between legal and illegal activities.⁴ For an individual, this occupational choice largely depends on the amount of capital—a complement in production—in the jurisdiction in which he or she resides: more capital increases wages, but also translates into a higher reward for criminal activities. Since investment in capital in a particular jurisdiction depends on the crime rate in that jurisdiction, there is a complex bi-directional relationship between investment and crime. By adding occupational choice to the otherwise classic problem of capital location, we can create agglomeration effects, both for crime and capital.

The key mechanism in our analysis can be explained as follows: In standard models without occupational choices, the unit return of capital in a given jurisdiction is a decreasing function of the stock of capital. With occupational choice, an extra unit of capital may lead to more individuals choosing to become workers (rather than criminals), and this in turn can make capital more productive. It follows that if an extra unit of capital sufficiently increases the number of workers (and decreases the number of criminals), then the unit return of capital may well be an increasing function of the stock of capital located in a jurisdiction. Of course, whether the unit return of capital is an increasing or a decreasing function of capital affects the allocation of capital in an important way. With declining unit returns, capital will tend to be equally distributed. However, with increasing unit returns, capitalists will find it advantageous to concentrate their capital in a single jurisdiction. Consequently, our model is able to explain the concentration of criminal activities in one location, and the concentration of capital investments and high wages in another location. In particular, our model predicts that jurisdictions with larger endowments in capital can more easily maintain lower crime rates. This suggests some degree of persistence in crime rates, something supported by the data as shown by *Stahura and Huff (1986)*.

The second main contribution of our paper is connected to the literature on regional competition and capital allocation. Our model predicts that jurisdictions with larger endowment in capital may in fact be able to attract new capital more easily. Initial gaps in capital allocation may not be closed with capital mobility, and may in fact be accentuated instead. This is a departure from the traditional literature involving capital mobility, like the tax competition literature for example. As *Cai and Treisman (2005)* pointed out however, convergence is far from being the norm when it comes to capital allocation. As it was the case for concentration in crime rates, there is also no consensus on the underlying reasons of the concentration of capital; see *Duranton and Puga (2004)* for a detailed survey of the literature. For example, *Cai and Treisman (2005)* explain this lack of convergence as resulting from technological differences making it easier for some jurisdictions to attract mobile capital. Differences in crime rates generated by residents' occupational choices generate similar effects in our paper.

Finally, our last main contribution is to study competition in law enforcement across jurisdictions within this context. The nature of the law enforcement game between jurisdictions is also very different depending on whether the per unit return of capital is decreasing or increasing with investment. For the case of an increasing per unit return on capital, we show that no pure strategy equilibrium exists for simultaneous games. Interestingly, looking at sequential games not only allows us to solve for pure strategy equilibria, but also allows us to discover that the welfare

properties of such types of equilibria are quite different. In particular, law enforcement choices may not be inefficient. While there is an extensive literature on capital tax competition,⁵ the literature on competition in crime deterrence is more limited. *Marceau (1997)* and *Wheaton (2006)* for example, both concentrate directly on the competition between regional governments. However, many features of decisions made by competing governments are similar to the one faced by competing private agents. *Clotfelter (1978)*, *Shavell (1991)*, *Hui-Wen and Png (1994)*, *Helsley and Strange (1999)* or *Hotte and Van Ypersele (2008)* all investigate these issues. All those papers have one thing in common, they all demonstrate that the “laissez-faire” equilibrium could feature a level of law enforcement greater than the socially efficient level. In the current paper, we show that equilibria with efficient enforcement by all regions also exist. The nature of the competition in law enforcement we face in this paper, also relates well to the current literature on tax competition with discontinuity, as in *Konrad and Kovenock (2009)* or *Marceau et al. (2010)*.

This paper is organized as follows: In Section 2 we present a model with mobile capital and occupational choice. Private sector behavior is described in Section 3 and the enforcement policies chosen independently by the jurisdictions are characterized in Section 4. In Section 5, we explore the consequences of relaxing some important assumptions of our model. Allowing for mobility is the one that generates the most important results. We analyze workers' and criminals' mobility separately. While neither types of mobility change the essence of our argument, workers' mobility makes it more likely for agglomeration effects to be present, and criminal' mobility makes it less likely. Finally, we conclude in *Appendix*.

2. The model

There are two jurisdictions, a and b . The aggregate production function in each jurisdiction $i \in \{a, b\}$ is given by $F(L^i, K^i)$, where L^i and K^i are the labor force and the capital in place in Jurisdiction i , respectively. The properties of F are standard: $F_K > 0$, $F_L > 0$, $F_{KK} < 0$, $F_{LL} < 0$, and $F_{LK} \geq 0$, where $F_h = \partial F(L^i, K^i) / \partial h$ and $F_{hj} = \partial^2 F(L^i, K^i) / \partial h \partial j$. We assume that total return to capital is always increasing in the stock of capital: $\partial(K F_K) / \partial K = F_K + K F_{KK} > 0$.⁶

In each jurisdiction, the population consists of a continuum of agents of measure 1, each of whom chooses to become either a worker or a criminal. If L^i is the number of workers in Jurisdiction i , then the number of criminals in this jurisdiction is $C^i = 1 - L^i$.⁷ An individual who chooses to become a criminal steals part of the total return on capital.⁸ The proportion of the total return on the capital a criminal is able to steal is denoted by α . Thus, an agent who decides to become a criminal obtains $\alpha K^i F_K(L^i, K^i)$. Alternatively, if he chooses to become a worker, he is paid according to the marginal product of labor, which amounts to a payoff given by $F_L(L^i, K^i)$.

A large number of atomistic capitalists endowed with a total of \bar{K} units of mobile capital choose to allocate their capital between

⁵ See the survey by *Wilson (1999)*.

⁶ This is unconditionally satisfied for a wide variety of production functions, like the Cobb–Douglas production function $K^\beta L^{1-\beta}$. In other cases, some restrictions need to be imposed; with the CES production function $[K^r + L^r]^{1/r}$, this condition is satisfied as long as inputs are not too complementary—i.e. r is not too small. Even when the condition is not generally satisfied, restricting the upper bound for \bar{K} would be sufficient; this is equivalent to assuming free disposal of capital since investments become undesirable beyond that point.

⁷ In reality, few individuals specialize solely in criminal activities. For a discussion on this topic, see *Blumstein et al. (1986)*. However, to keep our model as simple as possible, we decided to assume that agents choose one of the two activities, as in *Murphy et al. (1993)*.

⁸ Obviously, criminals could also steal part of the return to labor. Without altering the fundamental nature of our problem, this would add its share of complication. To keep our analysis as transparent as possible, we abstract from this possibility.

⁴ The interaction between crime and occupational choice has been examined in a number of papers, e.g. *Baumol (1990)*, *Murphy et al. (1993)*, *Acemoglu (1995)*, *Baland and Francois (2000)*, *Imrohoroglu et al. (2000)*, and *Lloyd-Ellis and Marceau (2003)*. However, none of these papers account for capital investment and inter-jurisdictional competition.

the two jurisdictions. The amount of capital invested in Jurisdiction a is denoted K_m^a , and $K_m^b = \bar{K} - K_m^a$ is that invested in Jurisdiction b . Capital is allocated by the owners after the choice of law enforcement by each government. The governments are assumed to be committed to their enforcement policy. Once capital is allocated, it becomes completely immobile. We also assume that in each of the two jurisdictions, immobile capital owners already have some capital in place. Denote by K_o^i the total amount of capital already in place in Jurisdiction i . Each of those capital owners are identical to the owners of mobile capital in all aspects, except for the fact that they cannot choose where to locate their capital. This distinction between mobile and immobile capital is often used in the tax competition literature, as in [Janeba and Peters \(1999\)](#) or in [Marceau et al. \(2010\)](#). Note that in Section 5.1, where we discuss the dynamic implications of our model, the difference between mobile and immobile capital will become clearer. Without loss of generality, we assume that $K_o^a \geq K_o^b \geq 0$.

In Jurisdiction i , the government chooses the level of law enforcement, d^i , which it can buy at a cost of 1 per unit. Law enforcement positively affects the probability $P(d^i)$ of arresting criminals, where $P'(d^i) < 0$.⁹ Criminals are subject to sanction S , which is exogenously given, and is the same in both region. Governments finance their expenditures d^i by use of a pure lump sum tax.

Governments are assumed to maximize total output net of enforcement costs. This implies that all residents and both mobile and immobile capital owners are treated equally. This is consistent with all capital owners residing in the region where their capital is employed. Alternatively, governments could only care for workers—by maximizing wages—, or for capital owners—by maximizing the return on capital. At the limit, governments could maximize legal output—i.e. output minus what is appropriated by criminals. This would be consistent with governments caring for everyone but the criminals. All of these alternative objective functions would generate slightly different tradeoffs, but the general results of the paper would qualitatively remain the same.

The timing is as follows. First, jurisdictions simultaneously choose their level of law enforcement. This investment is perfectly observable and is irreversible. Then, capitalists allocate their mobile capital between the two jurisdictions. Investments in capital are perfectly observable and irreversible. The residents of each jurisdiction then make their occupational choice (worker or criminal). Finally, production takes place, theft takes place, and payments are awarded. The model is solved using backward induction. In Section 5, we discuss the issue of mobility, and so this timing will be altered accordingly.

3. Private sector behavior

3.1. Occupational choice

We solve for the occupational choice equilibrium of the residents of Jurisdiction i for given levels of enforcement d^i and capital $K^i = K_o^i + K_m^i$. Since agents choose the activity that generates the largest payoff, the equilibrium number of workers in Jurisdiction i , say $L^i(K^i, d^i)$, is such that the returns on both occupations are equalized. Thus, $L^i(K^i, d^i)$ solves the following equation:

$$F_L(L^i, K^i) = \alpha K^i F_K(L^i, K^i) - P(d^i)S. \quad (1)$$

⁹ In a previous version of this paper, we assumed that law enforcement not only deters crime, but could also reduce α . Obviously, this gives additional incentives to invest in law enforcement, but all results remains qualitatively the same. For simplicity, and to keep in line with the classical literature on law enforcement, we have chosen to ignore this additional effect in this version. In Section 5, we further discuss alternative forms of enforcement.

In other words, the number of workers must adjust so that the wage, which is simply the marginal product of labor $F_L(\cdot)$, is equal to the return to criminal activity, $\alpha K F_K(\cdot)$ net of the expected punishment. When $F_L(0, K) > \alpha K F_K(0, K) - P(d^i)S$, some individuals become workers ($L > 0$). Similarly, $F_L(1, K) < \alpha K F_K(1, K) - P(d^i)S$ is required for some individuals to become criminals ($L < 1$). We assume that both conditions are satisfied for the relevant range of K . Given these two conditions, and given that the left hand side of Eq. (1) is monotonically decreasing, while the right-hand side is monotonically increasing with L , the solution to Eq. (1) is unique and denoted $L^i(K^i, d^i)$.

On the one hand, an increase in K^i generates an increase in the wage a worker receives, provided that $F_{LK}(\cdot) > 0$. On the other hand, an increase in K^i translates into an increase in $K^i F_K^i$, the total return on capital. Since the return to criminal activity is a proportion of this total return, an increase in K^i also leads to an increase in the return to criminal activity. The relative size of each effect determines whether an increase in K^i leads to more workers or to more criminals. To see this, note that from Eq. (1), we have:

$$\frac{\partial L^i(K^i, d^i)}{\partial K^i} = \frac{F_{LK}(L^i, K^i) - \alpha[F_K(L^i, K^i) + K^i F_{KK}(L^i, K^i)]}{\alpha K^i F_{LK}(L^i, K^i) - F_{LL}(L^i, K^i)} \quad (2)$$

The denominator of this last expression is positive, while the sign of its numerator is ambiguous. Thus, the impact of a change in the capital stock K on equilibrium employment L depends on the sign of $F_{LK} - \alpha[F_K + KF_{KK}]$. This implies that when $F_{LK} >$ (resp. $<$) $\alpha[F_K + KF_{KK}]$, then labor (resp. criminality) increases when capital increases. The incentive for a resident to participate in the legal sector increases only if the wage increase due to additional capital is large enough. Note that for the particular case of $F_{LK}(\cdot) = 0$, an increase in capital leads to an increase in criminal activity for the recipient jurisdiction. An increase in law enforcement effort d^i unambiguously reduces the incentive to become a criminal, and consequently increases the labor supply, i.e. $\partial L^i(K^i, d^i) / \partial d^i = P(d^i)S / [\alpha K F_{KL} - F_{LL}] > 0$.

Consider now the following condition:

Condition I: $F_{LK}(L^i, K^i) \geq \alpha[F_K(L^i, K^i) + K^i F_{KK}(L^i, K^i)]$, $\forall K^i \in [K_o^i, K_o^i + \bar{K}]$ and $\forall L_i \in [0, 1]$.

Condition I guarantees that $\partial L^i(K^i, d^i) / \partial K^i \geq 0$. Intuitively, Condition I requires that the increase in wages following the arrival of new capital dominates the increase in the return on criminal activities. We now turn to the characterization of the capital location choice, with particular attention paid to potential agglomeration effects.

3.2. Capital location choice and agglomeration effects

The mobile capitalists allocate their \bar{K} units of capital between the two jurisdictions. Denoted by $\rho^i(K^i, d^i)$ is the per unit return on capital invested in Jurisdiction i . Since a proportion α of the total return on capital is stolen by each criminal, we get $\rho^i(K^i, d^i) = [1 - \alpha C(K^i, d^i)]F_K[L^i(K^i, d^i), K^i]$. In a standard model of capital location with no crime, the per unit return on capital in a given jurisdiction decreases with the investment, because the marginal product of capital is itself a decreasing function of capital. Moreover, if both jurisdictions differ only in terms of their initial stock of capital, the jurisdiction with less capital will initially attract more mobile capital. In fact, provided that there is enough mobile capital, and that technologies are identical, marginal products and capital stocks will be equalized in the two jurisdictions. No agglomeration would occur in such a case.

In the literature, agglomeration effects are sometimes introduced directly by assuming that the technology exhibits increasing returns in capital, as in [Boadway et al. \(2004\)](#), but more interesting are the cases in which agglomeration effects arise endogenously. [Duranton and Puga \(2004\)](#) surveyed the literature on agglomera-

tion effects, and classified them as coming from three different channels: from the sharing of resources or gains, from the improvement in matching and finally, from learning. In the case of our paper, agglomeration effects arise from sharing the gains of specialization. When Condition I is satisfied, more capital implies that more residents specialize in legal production, which itself contributes to attract more capital. Residents then share the benefit of higher wages (and a higher return on fix factors).

In the current framework, the return to capital in the two jurisdictions will differ because enforcement may differ between the two jurisdictions. More importantly, it will also differ because the number of criminals will vary relatively to the size of the investment in capital. Consider first the difference in enforcement between jurisdictions. Enforcement is good for capitalists because it reduces the amount of the return on capital that is stolen by criminals, and it is also good because it deters individuals from becoming criminals. *Ceteris paribus*, a jurisdiction with more enforcement will attract more capital. Consequently, two jurisdictions could end up with different levels of capital simply because of differences in their choice of enforcement. Of course, despite differences in capital allocation, no agglomeration effect is at work here. If $d^a > d^b$, Jurisdiction a will attract more capital, but capital will still be allocated to the point where the per unit return in one jurisdiction is equal to the per unit return in the other jurisdiction, provided the marginal return on capital is decreasing in capital.

The effect of the stock of capital on the per unit return on capital in a given jurisdiction is much more interesting. The impact of a change in capital on this per unit return is given by:

$$\frac{\partial \rho^i(K^i, d^i)}{\partial K^i} = \alpha F_K(\cdot) \frac{\partial L^i(K^i, d^i)}{\partial K^i} + [1 - \alpha C^i(K^i, d^i)] \left[F_{KK}(\cdot) + F_{LK}(\cdot) \frac{\partial L^i(K^i, d^i)}{\partial K^i} \right]. \quad (3)$$

The first term on the right-hand side of Eq. (3) shows that when K^i changes, the number of criminals changes; this change in the number of criminals will affect the proportion of the total return of capital that is stolen. The second term represents the more traditional impact of a change in K^i on the per unit return, but with one difference. When capital in Jurisdiction i increases, the marginal return on capital decreases; this is captured by $F_{KK}(\cdot) < 0$. However, when capital increases, the number of workers also changes, and so does the marginal return of capital through the cross effect $F_{LK}(\cdot) \partial L^i(\cdot) / \partial K^i$. Consequently, when more capital leads to more workers, the per unit return on capital invested in Jurisdiction i may be an increasing function of the stock of capital invested in i . Intuitively, because the labor supply and the crime rate both depend on the amount of capital located in a jurisdiction, it is possible for the per unit return on capital to increase when capital investment increases. A larger number of workers translates into a larger marginal product of capital. Furthermore, when the number of workers increases, the number of criminals is reduced and this also leads to an increase in the total return on capital.

Below, we show that the sign of $\partial \rho^i(K^i, d^i) / \partial K^i$ is a key determinant of the equilibrium allocation of capital. We focus on two simple cases: (a) $\partial \rho^i(K^i, d^i) / \partial K^i < 0 \forall K^i$; and (b) $\partial \rho^i(K^i, d^i) / \partial K^i > 0 \forall K^i$. We also briefly discuss the case in which the sign of $\partial \rho^i(K^i, d^i) / \partial K^i$ varies with K^i . It should be obvious that when Condition I is not satisfied, the per unit return on capital decreases with the stock of capital.

Denoted by $K(d^a, d^b)$ is the equilibrium capital investment in Jurisdiction a , while the equilibrium capital investment in Jurisdiction b is given by $\bar{K} - K(d^a, d^b)$.

Proposition 1. *Whenever Condition I is not satisfied, the equilibrium capital investments $K(d^a, d^b)$ in Jurisdiction a , and $\bar{K} - K(d^a, d^b)$ in Jurisdiction b are given by the solution to:*

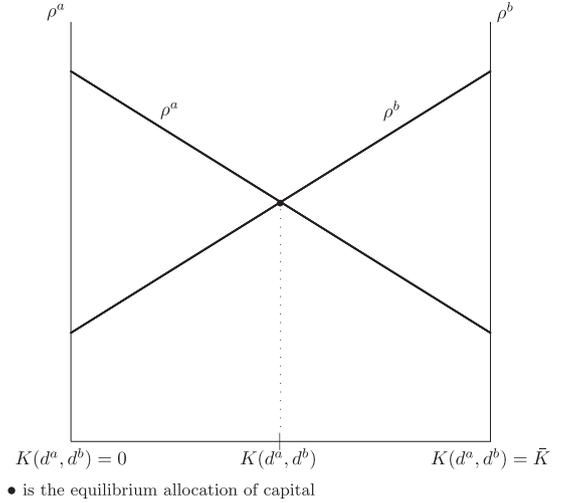


Fig. 1. Case with $\partial \rho^i / \partial K^i < 0$ and $d^a = d^b$.

$$\begin{aligned} & [1 - \alpha C^a(d^a)] F_K[L^a(d^a), K_o^a + K(d^a, d^b)] \\ & = [1 - \alpha C^b(d^b)] F_K[L^b(d^b), K_o^b + \bar{K} - K(d^a, d^b)]. \end{aligned} \quad (4)$$

Under this type of equilibrium, $K(d^a, d^b)$ is an increasing function of d^a , and a decreasing function of d^b .

All proofs can be found in Appendix A. Proposition 1 is easily understood by an examination of Fig. 1. When Condition I is not satisfied, the net returns on capital, ρ^a and ρ^b , are both decreasing in capital. Capital owners prefer to invest in the jurisdiction in which the per unit return on capital is the highest. The more capital owners invest in a given jurisdiction, the lower the per unit return on capital is. In equilibrium, capitalists allocate their capital so that the per unit return in both jurisdictions is equalized, which is represented by $K(d^a, d^b)$ in Fig. 1. Note that for a given level of enforcement by a jurisdiction leads to an increase in capital invested on its territory. Consequently, both jurisdictions will compete to attract capital investment by offering a secure environment to the capitalists. Thus, this environment entails no agglomeration effects; it follows that Condition I is a necessary condition for the presence of agglomeration effects. In such a case, $K(d^a, d^b)$ is an increasing function of d^a and a decreasing function of d^b .

Furthermore, Condition I (i.e. labor supply being increasing in capital), is not a sufficient condition for the presence of increasing returns to investment. What is in fact required is that labor supply increases at a high enough rate. The following condition, Condition II, is the sufficient condition for the per unit return on capital to be increasing with the stock of capital¹⁰:

Condition II:

$$\begin{aligned} \alpha C^i F_{KL}(L^i, K^i) & > \alpha [F_K(L^i, K^i) + K^i F_{KK}(L^i, K^i)] \\ & + \frac{F_{LL}(L^i, K^i) F_{KK}(L^i, K^i) - F_{KL}(L^i, K^i)^2}{\alpha F_K(L^i, K^i)}, \\ \forall K^i & \in [K_o^i, K_o^i + \bar{K}] \quad \text{and} \quad \forall L_i \in [0, 1]. \end{aligned}$$

Obviously, for Condition II to be satisfied, Condition I itself has to be satisfied. In addition, there are three other requirements. First, labor supply, and by consequence criminality, must be responsive enough to changes in capital, which is obtained when F_{LK} is large. Second, criminality must have a sufficient impact on

¹⁰ The derivation of Condition II can be found in Appendix A.

capital owners, and therefore α^C must also be large enough. For example, without crime, Condition II cannot be satisfied. Finally, as seen in the last term on the right hand side of Condition II, the more concave the production function is, the harder it is for Condition II to be satisfied. With a highly concave production function, the benefit associated with a reduction in criminality is unlikely to overcome the traditional decreasing marginal return to capital. Note that if $\partial L^i / \partial K^i > 0$, but F_{LK} is not large enough to ensure that $\partial \rho^i(K^i, d^i) / \partial K^i > 0$ —i.e. Condition II is not satisfied—then the resulting equilibrium will be similar to that described in [Proposition 1](#). To summarize, under Condition II, the per unit rate of return on capital is increasing in capital: $\partial \rho_i(K^i, d^i) / \partial K_i > 0$. [Proposition 2](#), which we now introduce, deals with the possibility of increasing return on capital or agglomeration effects and describes an equilibrium in which all mobile capital is invested in a single jurisdiction.

Proposition 2. *Whenever Conditions I and II are satisfied, there exists at least one equilibrium in which all mobile capital is invested in one jurisdiction. In particular, there exists an equilibrium in which all mobile capital \bar{K} is invested in Jurisdiction a if $\rho^a(K^a, d^a) \geq \rho^b(K^b, d^b)$, and one in which all mobile capital \bar{K} is invested in Jurisdiction b if $\rho^b(K^b, d^b) \geq \rho^a(K^a, d^a)$.*

When the per unit return on capital $\rho_i(K^i, d^i)$ is increasing with investment, then capitalists benefit from concentrating their capital in a single jurisdiction.

The question then becomes: Which jurisdiction will obtain the mobile capital? Unfortunately, the answer is neither simple nor unique. Two types of problems arise. First, coordination is an issue. As we can clearly see it in [Fig. 2](#), there can exist up to three equilibria: a globally stable equilibrium, a locally stable equilibrium, as well as an unstable equilibrium. For obvious reasons, we chose to ignore the unstable equilibrium in the rest of this paper. Out of the two stable equilibria, the globally stable equilibrium yields a higher total payoff. However, because there are a large number of independent capitalists who choose to invest their capital simultaneously, it is conceptually quite possible that they could coordinate on the “wrong” jurisdiction, i.e. a jurisdiction in which total payoff is not maximized. For convenience, we only focus on the globally stable equilibrium, one in which capitalists coordinate on the jurisdiction in which total payoff is maximized.¹¹ The second problem is to identify the jurisdiction which is the most attractive for capital owners. As previously discussed, both the enforcement effort and the initial capital influence the per unit return on capital. Enforcement effort has a positive effect on the per unit return on capital, and so does the initial capital stock when Condition II is satisfied. Consequently, we can derive the following result.

Corollary 1. *When the two jurisdictions have the same initial endowment in capital ($K_0^a = K_0^b$), there exists an equilibrium in which all mobile capital \bar{K} is invested in Jurisdiction a if $d^a > d^b$, and one in which all mobile capital \bar{K} is invested in Jurisdiction b if $d^a < d^b$. If $d^a = d^b$, then $K(d^a, d^b) = \bar{K}$ with probability q , and $K(d^a, d^b) = 0$ with probability $(1 - q)$ is an equilibrium allocation for any $q \in [0, 1]$.*

As can be seen in [Fig. 2](#), the net returns on capital, ρ^a and ρ^b , are both increasing in capital. Given an equal initial capital allocation, if the level of enforcement is larger in Jurisdiction a, then mobile capitalists prefer to concentrate their capital in that particular jurisdiction. Naturally, all the capital is invested in Jurisdiction b

¹¹ Note that we could have ensured that the payoff maximizing jurisdiction is chosen by assuming a unique mobile capital owner or, alternatively, by assuming that a large number of capital owners make their location choices sequentially. Finally, note that when $\rho^a(K^a, d^a) = \rho^b(K^b, d^b)$, the two stable equilibria are identical, and so we could imagine that one is randomly selected.

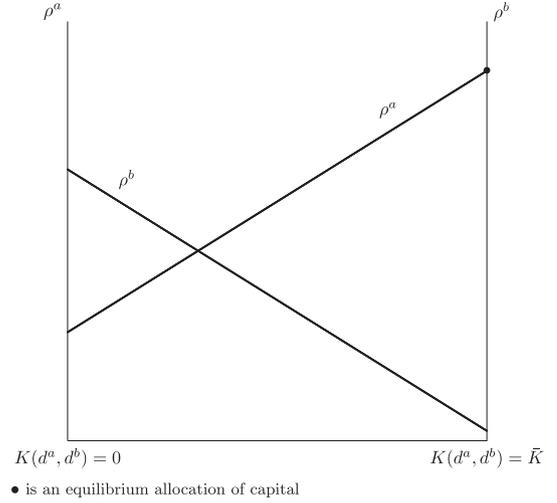


Fig. 2. Case with $\partial \rho^i / \partial K^i > 0$ and $\rho(K_0^a, d^a) > \rho(K_0^b, d^b)$.

if $d^a < d^b$. If both jurisdictions provide the same level of enforcement, the capitalists are then indifferent between concentrating their capital in one jurisdiction or the other. Again, to simplify, we assume that all capital owners pick Jurisdiction a with probability p . Initial capital endowment also plays a role in determining where mobile capital will locate.

Corollary 2. *When the two jurisdictions have the same level of enforcement effort ($d^a = d^b$), there exists an equilibrium in which all mobile capital \bar{K} is invested in Jurisdiction a if $K_0^a > K_0^b$, and one in which all mobile capital \bar{K} is invested in Jurisdiction b if $K_0^a < K_0^b$. If $K_0^a = K_0^b$, then $K(d^a, d^b) = \bar{K}$ with probability q , and $K(d^a, d^b) = 0$ with probability $(1 - q)$ is an equilibrium allocation for any $q \in [0, 1]$.*

Abstracting from possible differences in enforcement levels, the jurisdiction with more initial capital will attract all mobile capital. This is simply because the per unit return of capital is larger in the jurisdiction with more initial capital. In such an environment, agglomeration effects are at work. Not only does all mobile capital locate in the same jurisdiction, but it also does so in the jurisdiction which has the largest initial capital stock.

Note that the locational choice of mobile capital in the case in which a given jurisdiction has both more initial capital and exerts more enforcement effort is obvious, whereas that in which one jurisdiction dominates in one aspect and not in the other is more complicated. Nevertheless, agglomeration effects are still at work.

4. Enforcement policies and capital allocation

We now examine the choice of law enforcement by the two jurisdictions. Both jurisdictions are assumed to maximize a general welfare function $\Omega[L, K, d]$, which includes enforcement costs. For example, governments could maximize total output net of enforcement costs. This would imply that workers, criminals and both immobile and newly arrived mobile capital owners would be treated equally. Alternatively, one can imagine that governments only care about workers, or only about workers and immobile capital owners. The last two examples are often used in the tax competition literature. This function Ω is assumed to be differentiable and strictly concave in enforcement effort. Thus, the problem of Jurisdiction a for any d^b is given by:

$$\max_{d^a} \Omega[L^a(d^a, d^b), K_0^a + K(d^a, d^b), d^a] \quad (5)$$

where $L^a(d^a, d^b) = L^a[K(d^a, d^b), d^a]$. The problem of Jurisdiction b can be obtained by simply interchanging a and b in Eq. (5) above.

The resulting Nash equilibrium outcomes are strikingly different depending on whether Conditions I and II apply. When Conditions II is not satisfied, the per unit return on capital is decreasing in capital, agglomeration effects are not present, and capital is allocated to the point where its per unit return is equalized in all jurisdictions, as stated in [Proposition 1](#). Under reasonable assumptions about the welfare function, this corresponds to the situation described in [Marceau \(1997\)](#), [Helsley and Strange \(1999\)](#) and in other papers we discussed in the introduction. Each jurisdiction inefficiently exerts too much effort in enforcement. Such a result is also reminiscent of those obtained in the literature on policy competition between governments.¹² By increasing enforcement, a region attracts some capital, but it imposes a negative externality on the other jurisdictions which lose some capital. Using the terminology of [Eaton and Eswaran \(2002\)](#) and [Eaton \(2004\)](#), the actions of the regions would need to be *plain substitutes*. In such a case, both jurisdictions will choose a level of enforcement larger than the efficient level (i.e. too much investment compared to what a central authority would select if it maximized the sum of both objective functions). Note that because enforcement is inefficient, so are occupational choices: in other words there are too few criminals in this world.

When Conditions I and II are satisfied, mobile capital locates in a single jurisdiction. In such an environment, the nature of the game between the jurisdictions is very different. For immediate purposes, we define $\Omega[K^i, d^i] = \Omega[L^i(K^i, d^i), K^i, d^i]$ which describes the payoff of jurisdiction i when K^i units of capital locate on its territory, and when it invests d^i in enforcement. We shall define $d^*(K_o^i)$ as the level of enforcement chosen by jurisdiction i when no mobile capital is located on its territory: $d^*(K_o^i) = \arg \max_d \Omega[K_o^i, d]$. Similarly, let $d^*(K_o^i + \bar{K})$ denote the level of enforcement chosen by a jurisdiction when all the mobile capital locates on its territory: $d^*(K_o^i + \bar{K}) = \arg \max_d \Omega[K_o^i + \bar{K}, d]$. **Condition III:** Both $d^*(K_o^i)$ and $d^*(K_o^i + \bar{K})$ are assumed to be increasing in K_o^i . Moreover, $d^*(K_o^i + \bar{K}) > d^*(K_o^i)$.

Under this condition, the region with more capital has more incentive to invest in enforcement. This condition holds for a wide range of objective functions, including the three mentioned above with only minor assumptions about the production function. If we ignore the competition to attract mobile capital, the region endowed with more capital would have higher enforcement and a lower crime rate. To characterize the competition game to attract mobile capital, we first need to define $\hat{d}(K_o)$ as the level of enforcement solving $\Omega[K_o + \bar{K}, \hat{d}(K_o)] = \Omega[K_o, d^*(K_o)]$. [Fig. 3](#) depicts the payoffs of the jurisdictions in this law enforcement game. [Fig. 3](#) shows that $\hat{d}(K_o) > d^*(K_o)$ is defined as the enforcement level such that a jurisdiction is indifferent between attracting mobile capital but at the cost of over-investing in law enforcement, and not attracting the mobile capital while choosing the optimal enforcement. Clearly, it must be that $\hat{d}(K_o) > d^*(K_o + \bar{K}) > d^*(K_o)$, and the following chain of inequalities must hold:

$$\begin{aligned} \Omega[K_o^i + \bar{K}, d^*(K_o^i + \bar{K})] &> \Omega[K_o^i, d^*(K_o^i)] = \Omega[K_o^i + \bar{K}, \hat{d}(K_o^i)] \\ &> \Omega[K_o^i, d] \quad \forall d \neq d^*(K_o^i). \end{aligned}$$

A jurisdiction never chooses enforcement higher than $\hat{d}(K_o^i)$; the jurisdiction would be better off choosing $d^*(K_o^i)$ and obtaining no mobile capital. We can also easily see from [Fig. 3](#) that a larger endowment of capital K_o^i implies a higher $\hat{d}(K_o^i)$. The region that started with more capital is willing to go farther when it comes to law enforcement. This will be very important in characterizing the equilibrium policies. Similarly, a jurisdiction never chooses a

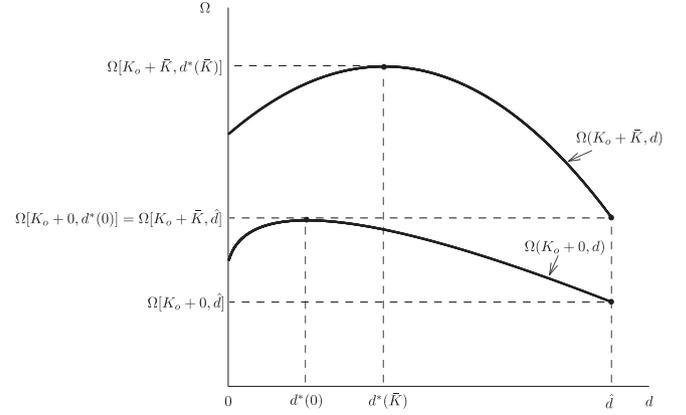


Fig. 3. The payoffs.

strategy $d < d^*(K_o^i)$. For the game considered, a strategy for a jurisdiction is simply a level of enforcement d^i , on the strategy the set $d^i \in [d^*(K_o^i), \hat{d}(K_o^i)]$.

Proposition 3. *Whenever Conditions I and II are satisfied, the simultaneous enforcement game has a pure strategy Nash equilibrium where $d^a = d^*(K_o^a + \bar{K})$ and $d^b = d^*(K_o^b)$ if and only if $\rho^a [K_o^a + \bar{K}, d^*(K_o^a + \bar{K})] > \rho^b [K_o^b + \bar{K}, \hat{d}(K_o^b)]$. Otherwise, the game has no pure strategy equilibrium.*

Note that Condition III is not required for [Proposition 3](#) to be obtained. To understand [Proposition 3](#), recall that $K_o^a \geq K_o^b$. When the difference in capital endowments is sufficiently large, even if region a plays its most preferred enforcement level, region b is not interested in competing with region a . Investment in law enforcement can simply not compensate for the disadvantage created by the large asymmetry in capital endowment. Mobile capital locates in region a , and both regions simply play their most preferred enforcement levels. Note that the traditional over-enforcement result disappears, and enforcement is chosen optimally.

When the difference in capital endowments becomes small enough, region b can now potentially “steal” the mobile capital. A pure strategy equilibrium no longer exists. If one region makes itself attractive by investing in enforcement, then the other region simply reacts by investing a bit more in enforcement so as to “steal” the mobile capital. This goes on until region b prefers choosing $d^*(K_o^b)$ instead of competing. Then, region a ’s best response becomes $d^*(K_o^a + \bar{K})$, and we are back to where we started with both regions interested in competing for mobile capital. It is interesting to note that the absence of a pure strategy equilibrium can be obtained with no specific formulation of the objective function.

When no pure strategy equilibrium exists, a mixed strategy equilibrium exists in which both regions randomize according to a continuous distribution function on the supports $[d^a(K_o^a + \bar{K}), \hat{d}(K_o^b)]$, where region b also plays $d^*(K_o^b)$ with positive probability. [Marceau et al. \(2010\)](#) perform a complete analysis of similar games in the context of tax competition, so the detailed properties of such equilibria can be found there.¹³ However, one concern with such a mixed strategy equilibrium however, is that it is not temporally consistent. Recall that after the regions have drawn an enforcement level, mobile capital locates in the most attractive region. However, regions may want to change their enforcement level *ex post*, since it is not necessarily optimal given the allocation of capital. Consequently,

¹² See, for example, [Mintz and Tulkens \(1986\)](#), [Wildasin \(1988\)](#), [Wilson \(1986, 1999\)](#), or [Zodrow and Mieszkowski \(1986\)](#).

¹³ Note that such mixed strategy equilibrium is also reminiscent of the equilibria characterized in [Levitan and Shubik \(1972\)](#), [Varian \(1980\)](#), or [Kreps and Scheinkman \(1983\)](#).

it makes more sense to think of this enforcement game as a sequential game, in which one of the two regions first selects its enforcement level, and then the other region follows. This has become a standard assumption in the tax competition literature with discontinuous capital allocation as in Baldwin and Krugman (2004) or in Marceau et al. (2010). Whenever $\rho^a [K_o^a + \bar{K}, d^*(K_o^a + \bar{K})] > \rho^b [K_o^b + \bar{K}, \hat{d}(K_o^b)]$, the same pure Nash equilibrium described in Proposition 3 is the unique subgame perfect Nash equilibrium for any playing order in the sequential game. Proposition 4 describes what happens for this same game when the difference in capital endowment is not sufficiently large.

Proposition 4. *Whenever Conditions I, II, and III are satisfied, the subgame perfect Nash equilibrium of the sequential enforcement game is characterized by region a receiving all mobile capital for any order of play. Region b selects $d^*(K_o^b)$ for any order of play, while region a selects $d^*(K_o^a + \bar{K})$ if it plays second, and selects $\max\{\tilde{d}^a, d^*(K_o^a + \bar{K})\}$ if it plays first, where \tilde{d}^a is given by $\rho^a [K_o^a + \bar{K}, \tilde{d}^a] = \rho^b [K_o^b + \bar{K}, \hat{d}(K_o^b)]$.*

Consider the *ex post* implications of such an equilibrium. First, mobile capital always locates in the jurisdiction initially better endowed in immobile capital. Jurisdiction a who started with higher welfare continues to benefit from higher welfare after mobile capital has located within its boundary. The proportion of criminals is lower because of a larger stock of capital and stronger enforcement. If it plays last, jurisdiction a chooses the optimal enforcement level. If it has to play first, however, it has to commit to an excessive level of law enforcement, unless setting $d^*(K_o^a + \bar{K})$ is already sufficiently high enough to discourage b from even trying to compete. Jurisdiction b receives no new capital, but it always chooses the optimal law enforcement effort. Since there is less capital in this jurisdiction, wages are lower, and more residents choose to become criminals, leading to a higher crime rate. On the other hand, jurisdiction a experiences a relatively moderate crime rate and relatively large output and wage levels. This simple model can therefore help explain why the welfare levels of two nearby jurisdictions may not converge.

The relationship we obtain between capital allocation, welfare, wages and crime rates matches very well with the examples of twin cities that we discussed in the introduction. These are phenomena that no other papers have looked at in conjunction. Another implication of our model is that the crime rate and the level of law enforcement are negatively correlated. However, the actual relationship between crime rates and law enforcement expenditures is debatable. Many reasons which lie outside of our model can be responsible for this. For example, in our model, expenditures on law enforcement are all devoted to the monitoring of potential infractions, as opposed to investigating crimes. In a paper in which the spatial distribution of crime is not the focus, Mookherjee and Png (1992) examined the two aforementioned types of expenditures. They show that with investigating expenditures, more crime inevitably leads to higher costs and/or lower clearing rates. Thus, if we were to take into consideration investigation activities in our model, the relationship between crime rate and law enforcement expenditures could be quite different.

Note that when capital is highly mobile and when there are increasing net returns to capital, at least one region (and possibly both) sets its enforcement effort efficiently. It is interesting to see that more capital mobility can actually increase aggregate welfare. A similar result is obtained in Marceau et al. (2010) for the case of tax competition. The combination of sequential play and increasing net returns on capital means that the “winner” is *ex ante* known, and it serves as a discipline device for the jurisdiction that cannot win. In fact, even if we were to extend our model to include

n jurisdictions, $n - 1$ of them would chose the efficient enforcement level. The jurisdiction with the largest stock of immobile capital would always succeed to attract all the mobile capital, but it may have to over-invest in enforcement to do so, depending on the order of play. All other aspects of our model would remain the same. We now investigate the implications of a series of more substantial extensions.

5. Limitations and generalizations

The basic model we presented has the advantage of delivering clear results concerning the interaction between capital allocation, crime rate and inter-jurisdictional competition in law enforcement, but obviously many important ingredients that could potentially alter those interactions have been left out. In this section, we explore the most obvious ones, starting by investigating a dynamic version of our one-shot game.

5.1. Dynamic

A dynamic version of our model would give a natural interpretation for the initial endowment in capital K_o^i in period t as simply being the capital carried over from period $t - 1$. In any given period t , new mobile capital \bar{K} would be at stake. The allocation of such capital would then determine the initial capital for period $t + 1$, and so on. On the one hand, if Conditions I and II are not satisfied, the net return on capital across regions will tend to equalize, and initial capital endowment differences will shrink. On the other hand, if Conditions I and II are satisfied, capital would tend to agglomerate, and both jurisdictions' capital endowment would move apart. As endowments of now immobile capital move apart, it becomes easier and easier for the prosperous region to attract new mobile capital. Eventually, endowments could be so far apart that the pure strategy Nash equilibrium where both regions pick the efficient enforcement effort becomes unique, as described by Proposition 3.

Modeling how individuals make their occupational decision is less obvious however. The easiest way would be to assume that individuals can choose a new line of activity every period. Wages and return on criminal activities would always be equalized, and Conditions I and II would be derived the same way. Alternatively, one can easily imagine that there exists some degree of time dependence in the choice individuals make.¹⁴ Imagine an overlapping generation model, where individuals make a choice of career when young based on the relative returns at that time, but are incapable (or capable at some cost) of switching paths later on in their life. This reflects the fact that individuals who embark on a life of crime have difficulty abandoning it or vice versa; this is perhaps due to the specificity of human capital. At any point in time, relative returns may not be equalized. In particular, if the number of new individuals free to make a choice is too small relative to the stock of older individuals who have already made one, it would be possible to observe a gap between the two returns. However, in the long run, both returns should closely follow each other. Incorporating this feature in the model, as well as the arrival of new capital, could mean that Conditions I and II bounce between being satisfied and not being satisfied. Jurisdictions could experience periods of convergence and periods of divergence, but all the main features of our one-period model would remain the same in a such dynamic model.

In the introduction, we mentioned that one interesting property of our model is that it can replicate the persistence in crime rate we observe in the data. With a dynamic version of our model, we could

¹⁴ Beck and Shipley (1989) using data from 11 different states, estimated that more than 60% of released inmates were re-arrested for a felony or serious misdemeanor within 3 years.

push this argument farther. In fact, our model could predict from exogenous initial conditions, which types of cities are going to experience prosperity and low crime rates, and which types of cities are not going to. San Francisco, for example, has a much lower crime rate than Oakland, it also had a much larger initial capital endowment. Obviously, many counter-examples exist. This, however, does not necessarily imply that we should reject the basic mechanism identified in our model. Imagine a rich dynamic version of our model where exogenous shocks are introduced, such as the destruction of existing capital, the decline of some industries, or investments coming from higher levels of governments. All these types of exogenous shock could easily reverse a trend set by some given initial conditions. Alternatively, one can focus on the fact that in a dynamic version of our model, crime rates at the jurisdiction level would be persistent across time, something that is observable in the data.¹⁵

5.2. Mobility

In the current framework, individuals (criminals and workers) are immobile. While this assumption considerably simplifies the analysis, it is important to explore the consequences of relaxing it. When introducing mobility in such an environment, one needs to acknowledge that results will be highly sensitive to the set up of the game, and to the modeling of mobility costs. For example, without moving costs, and with individuals being able to choose where to operate at the same time as they are making their occupational decisions, returns across regions and across activities would be equalized. Without being trivial, one can easily see that the possibility of an increasing net marginal return on capital ρ remains, as is the case under Condition II in the basic model. Indeed, bunching capital in one region may now generate a safer environment through two mechanisms: (1) more capital may convince more individuals to become workers, and, (2) more capital may stimulate the migration of individuals who have a higher likelihood of becoming workers *post* migration. However, treating occupational decisions on a par with mobility decisions is, in our opinion, problematic. As was discussed in Section 5.1, choosing whether to commit a crime or not is a much more important and persistent decision than choosing where to work, or where to commit a particular infraction. For this reason, we focus on an alternative timing in which individuals make their occupational decision first, and then migrate if they so desire.

Imagine the following variation on the timing presented in Section 2. As before, governments announce enforcement policies d^i first, and then capital owners, fully anticipating what is to come, choose where to invest their capital. Next, individuals choose their occupation based on the relative returns in their *own* region. Finally, workers and criminals observe the return for a similar activity in the other region and may choose to migrate if the benefit outweighs a migration cost $m \geq 0$. Note that when individuals are making their occupational decisions, they are completely myopic with regards to their future migration decisions, because of a lack of information about returns in the other regions for example.¹⁶ This assumption is similar to the “voter myopia” assumption used in Epple and Romer (1991) and other papers on “Tiebout sorting” and voting.¹⁷ To clearly understand the difference between workers’ mobility and criminals’ mobility, we analyze both separately and in turn, starting with that of the workers.

Once government policies have been announced, capital has located, and individuals have made their occupational decisions,

workers in region i who may earn wage $F_L(L^i, K^i)$, can choose to migrate if this is beneficial. The final allocation of workers across regions will be given by

$$F_L(L^a + \ell, K^a) - F_L(L^b - \ell, K^b) = m, \quad (6)$$

where ℓ represents the number of workers who migrate from one region to the other.¹⁸ Obviously, ℓ is a function of K^a and K^b , as well as d^a and d^b , but also of moving cost m . Without moving costs, wages will be the same in the two regions, but with $m > 0$, a positive wage gap will remain. The initial distribution of workers L^a and L^b is determined as before. In particular, the initial number of workers L^a and L^b are given by Eq. (1), and so Condition I remains the same. If satisfied, an increase in capital would lead to an increase in the workforce. With Condition I satisfied, an increase in capital in region a would not only cause an increase in L^a , but also an increase in ℓ . Intuitively, as capital increases, it promotes compliance with the law (L^i increases), and at the same time, more individuals migrate to the region because of higher wages. If Condition I is not satisfied, L^a will decrease, but ℓ on the other hand will still increase. The same applies for region b except for the fact that ℓ is decreasing in K^b . Lemma 1 formalizes the idea.

Lemma 1. *Workers migration ℓ increases with K^a and decreases with K^b .*

We can redefine the net rate of return on capital as $\rho^a = [1 - \alpha C^a] F_K[L^a + \ell, K^a]$. Note that $C^a = 1 - L^a$, reflecting the fact that criminals do not migrate. Also note that F_K depends on $L^a + \ell$, the *post* migration number of workers in region a . The effect of K^a on this rate of return is given by:

$$\frac{\partial \rho^a}{\partial K^a} = \alpha F_K(\cdot) \frac{\partial L^a}{\partial K^a} + [1 - \alpha C^a] \left[F_{KK}(\cdot) + F_{LK}(\cdot) \left(\frac{\partial L^a}{\partial K^i} + \frac{\partial \ell}{\partial K^a} \right) \right]. \quad (7)$$

As we compare the effect capital has on ρ when workers are immobile—as given by expression (3)—*versus* mobile—as given above—, it becomes clear that capital influences ρ in the same way, except for the additional positive term $\partial \ell / \partial K^a$. Assuming immobile workers, if ρ is increasing with capital (Condition II satisfied), then the rate of return will also be increasing with capital when workers’ mobility is taken into account. Even if Condition II is not satisfied, ρ can still be increasing in capital. Consequently, adding the mobility of workers expands the set of circumstances under which agglomeration effects are possible. Workers’ mobility gives additional incentives to bunch capital together, so not only will more individuals decide to become workers, but also more workers will migrate to this region.

Workers’ mobility makes it more likely that capital will be asymmetrically distributed. The more important the asymmetry in the allocation of capital, the larger the initial wage gap. However, wages converge to some extent when workers migrate from one region to the other. The lower mobility costs are, the more similar wages will be as more workers will choose to migrate. Finally, because of this last phenomenon, crime rates will tend to move even farther apart. The population of criminals will become more dense in the less favoured region, and less dense in the region that receives new workers.

We now examine what happens when criminals are mobile and workers are immobile. With the timing remaining the same, a criminal in region a would earn $\alpha K^a F_K(L^a, K^a) - P(d^a)S$, while a criminal in region b would earn $\alpha K^b F_K(L^b, K^b) - P(d^b)S$. Denote by c the number of criminals who choose to migrate from region a to b . For c to be well behaved—continuous function—, we assume that

¹⁵ See Stahura and Huff (1986) for example.

¹⁶ If they were able to perfectly forecast all returns, all would be equivalent to the example discussed above in which both decisions are made simultaneously.

¹⁷ For a discussion of the related literature, and of the implications of such assumptions, see Kessler and Lulfesmann (2005).

¹⁸ Note that nothing restricts ℓ from being negative. A negative ℓ implies that workers are migrating from b to a . However, since our model is perfectly symmetric except for the fact that $K^a \geq K^b$, in any type of well coordinated equilibrium, wages in region a will be at least as large as wages in region b .

the migration cost m is now uniformly distributed on the support $[m^l, m^h]$.¹⁹ With a return to crime larger in a than in b , all criminals with $m \leq \bar{m}$ will migrate from b to a , where²⁰

$$\bar{m} = \alpha [K^a F_K(L^a, K^a) - K^b F_K(L^b, K^b)] - [P(d^a) - P(d^b)]S. \quad (8)$$

From this last expression, it is easy to see that the number of criminals moving from b to a is given by $c = \bar{m}/(m^h - m^l)$.

Lemma 2. *Criminals migration c increases with K^a and decreases with K^b .*

An increase in capital in region a increases the return on capital in this region, and so more criminals find it attractive to migrate to that region. As was done for the case of workers' mobility, we can redefine the net rate of return on capital as $\rho^a = [1 - \alpha(C^a + c)]F_K L^a$, K^a . The effect of K^a on this rate of return is given by:

$$\frac{\partial \rho^a}{\partial K^a} = \alpha F_{KK}(\cdot) \left[\frac{\partial L^a}{\partial K^a} - \frac{\partial c}{\partial K^a} \right] + [1 - \alpha C^a] \left[F_{KK}(\cdot) + F_{LK}(\cdot) \left(\frac{\partial L^a}{\partial K^a} + \frac{\partial \ell}{\partial K^a} \right) \right]. \quad (9)$$

The exact opposite of what we said for workers' mobility applies to criminals' mobility. Whenever Condition II is not satisfied, the return on capital continues to be decreasing in capital. And even when Condition II is satisfied, criminals' mobility may make ρ decreasing in capital because of the mobility effect $\partial c/\partial K^a$. Thus, having mobile criminals makes it less likely that agglomeration effects will exist. Criminals migrate where capital goes, so the concentration of capital is less attractive.

Government policies are decided as before, but in an environment in which net returns on capital are more likely to be decreasing, and so mobile capital tends to spread out. Because capital is more likely to be spread out, wages across regions are less likely to be far apart.

Consequently, workers' versus criminals' mobility can have drastically different consequences on the location of capital, wages, and crime rates. The fact that criminals' mobility tends to equalize crime rates and to promote excessive competition between regions may not be that surprising; a much simpler model, such as that of [Marceau and Mongrain \(2002\)](#), would generate the same results. Results concerning workers' mobility are more interesting in that sense. Without the interaction between capital allocation and occupational choice, the results we obtain are less likely to emerge. This framework of study can also shed some new light on policies that influence mobility. For example, improvements in workers' commuting opportunities may increase disparities in capital and crime rates. As for the relative importance of workers' versus criminals' mobility, this essentially remains an empirical issue. [Noonan \(2005\)](#), for example, finds using data from the city of Chicago that infrastructures such as parks, railroads, and major roads have strong barrier effects on criminal activity.

The combination of mobility and of some type of heterogeneity relative to the willingness to be surrounded by crime could make the asymmetric distribution of capital even more likely. For example, in [O'Flaherty and Sethi \(2010\)](#), richer honest individuals leave city centers to avoid being in contact with street vices; a similar type of effect in our model would only make agglomeration of capital more likely.

On a final note, our model could easily be modified to include skilled and unskilled labor. Imagine that unskilled laborers are immobile and that they can chose between legal and illegal activities, as is the case in our basic model. The skilled laborers, on the

other hand, are mobile, and have strict preferences for the legal sector. The production function could take the form of $F(K, L, S)$, where S and L are the skilled and unskilled laborers. With mobility, the return to skilled labor $F_S(K, L, S)$ will naturally be equalized across jurisdictions. In this environment, the agglomeration of capital and low criminality will also lead to the agglomeration of skilled laborers as long as skilled labor is complementary with capital and unskilled labor.

5.3. Diversion versus deterrence

There is a large body of literature that examines the problem faced by multiple agents choosing independently their protection effort against crime. To name a few, [Marceau \(1997\)](#), [Boylan \(2004\)](#) and [Wheaton \(2006\)](#) look at regional government decisions, [Clotfelter \(1978\)](#), [Shavell \(1991\)](#), [Hui-Wen and Png \(1994\)](#) or [Hottel and Van Ypersele \(2008\)](#) concentrate on individual private protection, while [Helsley and Strange \(1999\)](#) focus on private group protection taking the form of gated communities. One important lesson we learned from this literature is that law enforcement activities (equivalently, private protection) influence criminality through different channels, and each different channel leads to important differences in terms of efficiency. More precisely, two different types of externalities exist, and their consequences are diametrically opposed. On the one hand, when a region (or an individual) invests in law enforcement activities (or private protection), it can divert crime away into another region (or onto another individual). This is referred to as the diversion effect of regional law enforcement (or private protection) as discussed in the papers mentioned above. Because a region does not take into consideration the negative impact diversion has on surrounding regions, law enforcement expenditures will tend to be too high. On the other hand, investments in law enforcement may also have a general deterrence effect. Law enforcement efforts in one region may depress the return to criminal activity enough so that the overall number of criminals decreases, or equivalently, incarcerated criminals in one region may mean less criminals overall. Consequently, law enforcement in one region can also create a positive externality, meaning that expenditures will tend to be too low.

As far as the basic version of our model is concerned, it is interesting to note that neither of these two externalities are present. Since criminals are assumed to be immobile, the diversion externality is simply not present. Similarly, because all the benefits of deterrence are confined to the region itself, all benefits in term of lower crime rates are consequently internalized. The reason why we still get over-investments in law enforcement is due to an externality similar to that which exists in the tax competition literature with mobile capital. By making its region safer, a local government benefits from an inflow of mobile capital, and because it does not take into consideration the outflow of capital from other regions, it invests too much in law enforcement.

When we relax our initial assumptions as in the previous subsection and allow for criminals' mobility, both types of externalities mentioned above become relevant. On the one hand, law enforcement competition becomes more intense as regions can also reduce crime rates by influencing the migration of criminals. Over deterrence becomes a more salient problem, and it increases \hat{t} and \bar{t} , as governments have an additional incentive to invest in law enforcement. On the other hand, law enforcement by any of the two regions reduces the total number of criminals, and so the positive externality associated with deterrence is present. Consequently, as some of the papers mentioned above pointed out, law enforcement may be over- or under-provided. However, because of the additional externality created by the flow of capital, it is more likely to be over-provided as compared to what is obtained in the previous literature.

¹⁹ This assumption is required to ensure that migration is not an "all or nothing" type of decision. Alternatively, we could have assumed that α is decreasing in the number of criminals.

²⁰ If the return was to be larger in b instead, then c would then be defined as the number of criminals migrating from a to b .

5.4. Appropriation technology

It is also relevant to discuss our modeling of the appropriation technology. In our basic model, we assume that each criminal steals a constant fraction α of the return on capital or “booty”, regardless of law enforcement choices, of the number of other criminals, or of the size of the “booty” itself. In the context of our model, α could easily be a negative function of law enforcement and all our results would remain qualitatively the same. Law enforcement would, in addition to having a deterrence effect, have a protection effect as well. In fact, we could completely replace sanctioning by pure protection only, and our results would still be qualitatively the same. As discussed in [Helsley and Strange \(1999\)](#), sanctions and protection have similar effects on criminals’ behavior. At a lower value of α , crime becomes less attractive. The only significant difference is that protection, on top of deterring crime, can also reduce crime severity. This does not alter the government’s decisions significantly. However, it does increase the marginal benefit of law enforcement.

Another natural assumption, found in [Freeman et al. \(1996\)](#) or [Helsley and Strange \(1999\)](#), would be to suppose that $\alpha(C)$ depends negatively on the number of criminals due to a congestion effect. Eq. (1) describing occupational choices $L(K^i, d^i)$ would become:

$$F_L(L^i, K^i) = \alpha(1 - L^i)K^i F_K(L^i, K^i) - P(d^i)S. \quad (10)$$

Condition I stating when additional capital makes working more attractive would remain the same, but the denominator of $\partial L(K^i, d^i)/\partial K^i$ would be larger. This implies that whether or not additional capital deters crime follows the same restriction as before, but if it does, the effect would be smaller. Intuitively, if more capital reduces the number of criminals, then the benefit to each remaining criminals goes up, prompting more people to become criminals. The same applies if capital increases the number of criminals. The benefits of each crime would go down due to the congestion effect, and so crime would become less attractive. Because $\partial L(K^i, d^i)/\partial K^i$ needs to be positive, but also large enough for the agglomeration effect to exist, introducing congestion would render this agglomeration effect less likely.

Finally, the proportion of the “booty” stolen by a criminal could be a decreasing function of the “booty” itself, as would be the case if private protection was taken into account. Eq. (1) would then become:

$$F_L(L^i, K^i) = \alpha[K^i F_K(L^i, K^i)]K^i F_K(L^i, K^i) - P(d^i)S, \quad (11)$$

where $\alpha[K^i F_K(L^i, K^i)]$ would be decreasing with $K^i F_K(L^i, K^i)$. This would imply that the right hand side of Eq. (11) is no longer necessarily increasing with capital. As noted by [Hotte and Van Ypersele \(2008\)](#) and others, if private protection is sufficiently elastic with respect to what there is to protect, the return to crime may be decreasing with the size of the “booty”. Consequently, the modified Condition I would simply become more easily satisfied as it would require that $F_{LK}(\cdot) \geq [\alpha(\cdot) + \alpha'(\cdot)][F_K(\cdot) + K^i F_{KK}(\cdot)]$, and as a direct consequence, the agglomeration effect would be more likely to emerge.

This paper has shown that in an economy with occupational choice and with jurisdictions competing in enforcement to attract mobile capital, the equilibrium may result in an uneven distribution of crime and capital across space. When new capital stimulates strong upward pressure on wages, the jurisdiction that is initially better endowed with capital has an advantage in attracting new capital, while the other is left with a much higher crime rate. Equilibrium outcomes may or not may be efficient. The creation of a central organization to coordinate law enforcement policies could be beneficial in such a context, depending on the constraints it faces and the strengths and weaknesses of centralization. For example, a central organization may be forced, by political con-

straints, to select a uniform level of enforcement in all jurisdictions. Also, it could be that a central agency is not as efficient at identifying criminals. To analyze the opportunity of creating such a central agency, our model would have to be extended to take these factors into account.

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Appendix A. Proofs

Proof of Proposition 1. When $\partial L^i(K^i, d^i)/\partial K^i = 0$, $i = a, b$, it follows from Eq. (3) that $\partial \rho^i/\partial K^i < 0$, $i = a, b$. In such a case, mobile capital is allocated between the two jurisdictions until the per unit return is equalized. Consequently, $K(d^a, d^b)$ satisfies Eq. (4), which simply states that $\rho^a[K_o^a + K(d^a, d^b)] = \rho^b[K_o^b + \bar{K} - K(d^a, d^b)]$. Differentiating Eq. (4) yields that:

$$\frac{\partial K(d^a, d^b)}{\partial d^a} = \frac{\alpha'(d^a)C^a F_K(\cdot) - [\alpha F_K(\cdot) + (1 - \alpha C^a)F_{LK}(\cdot)]\partial L^a/\partial d^a}{[1 - \alpha C^a]F_{KK}(L^a, K_o^a + K^a) + [1 - \alpha C^b]F_{KK}(L^b, K_o^b + K^b)}$$

$$\frac{\partial K(d^a, d^b)}{\partial d^b} = \frac{-\alpha'(d^b)C^b F_K(\cdot) + [\alpha F_K(\cdot) + (1 - \alpha C^b)F_{LK}(\cdot)]\partial L^b/\partial d^b}{[1 - \alpha C^a]F_{KK}(L^a, K_o^a + K^a) + [1 - \alpha C^b]F_{KK}(L^b, K_o^b + K^b)}$$

The denominator of these two expressions is clearly negative. Consequently, $\partial K(d^a, d^b)/\partial d^a$ is positive since its numerator is negative, and $\partial K(d^a, d^b)/\partial d^b$ is negative since its numerator is positive.

Similarly, when $\partial L^i(K^i, d^i)/\partial K^i < 0$, $i = a, b$, it follows from Eq. (3) that $\partial \rho^i/\partial K^i < 0$, $i = a, b$. In such a case, mobile capital is allocated between the two jurisdictions until the per unit return is equalized. Consequently, $K(d^a, d^b)$ satisfies Eq. (4), which simply states that $\rho^a[K_o^a + K(d^a, d^b)] = \rho^b[K_o^b + K - K(d^a, d^b)]$. Totally differentiating Eq. (4) yields that:

$$\frac{\partial K(d^a, d^b)}{\partial d^a} = \frac{-[\alpha F_K(\cdot) + (1 - \alpha C^a)F_{KL}(\cdot)]\partial L^a/\partial d^a}{\Delta},$$

$$\frac{\partial K(d^a, d^b)}{\partial d^b} = \frac{[\alpha F_K(\cdot) + (1 - \alpha C^b)F_{KL}(\cdot)]\partial L^b/\partial d^b}{\Delta},$$

where

$$\Delta = \alpha F_K(\cdot)(\partial L^a(\cdot)/\partial K^a) + [1 - \alpha C^a(\cdot)][F_{KK}(\cdot) + F_{KL}(\cdot)(\partial L^a(\cdot)/\partial K^a)] + \alpha F_K(\cdot)(\partial L^b(\cdot)/\partial K^b) + [1 - \alpha C^b(\cdot)][F_{KK}(\cdot) + F_{KL}(\cdot)(\partial L^b(\cdot)/\partial K^b)].$$

The denominator of these two expressions is clearly negative. Consequently, $\partial K(d^a, d^b)/\partial d^a$ is positive since its numerator is negative, and $\partial K(d^a, d^b)/\partial d^b$ is negative since its numerator is positive.

Derivation of Condition II: For $\partial \rho^i/\partial K^i > 0$, the following must be satisfied:

$$\alpha F_K \frac{\partial L^i}{\partial K^i} + [1 - \alpha C^i] \left[F_{KK} + F_{LK} \frac{\partial L^i}{\partial K^i} \right] > 0.$$

This is equivalent to:

$$\frac{\partial L^i}{\partial K^i} > \frac{-F_{KK}}{\frac{\alpha}{1-\alpha C} F_K + F_{KL}}.$$

Therefore, using Eq. (2), we can show that $\partial \rho^i / \partial K^i > 0$ if and only if:

$$\alpha C^i F_{KL} > \alpha [F_K + K^i F_{KK}] + \frac{1 - \alpha C^i}{\alpha} \frac{F_{LL} F_{KK} - F_{KL}^2}{F_K}.$$

As a way to ease the exposition, we use the corresponding sufficient condition

$$\alpha C^i F_{KL} > \alpha [F_K + K^i F_{KK}] + \frac{F_{LL} F_{KK} - F_{KL}^2}{\alpha F_K},$$

as Condition II. \square

Proof of Proposition 2. When Conditions I and II are both satisfied, then $\partial \rho^i / \partial K^i$ is positive for all values of K^i . Since the per unit return on capital is increasing in K in both jurisdictions, we either have $\rho^a|_{(K^a=K_0^a+\bar{K})} \geq \rho^b|_{(K^b=K_0^b)}$ or $\rho^a|_{(K^a=K_0^a)} \leq \rho^b|_{(K^b=K_0^b+\bar{K})}$. If all capitalists invest in the jurisdiction with the highest return, it is optimal for a given capitalist to also invest in that jurisdiction. Consequently, there exist at least one equilibrium in which all capital locates in a single jurisdiction. In particular, if $\rho^a|_{(K^a=K_0^a+\bar{K})} \geq \rho^b|_{(K^b=K_0^b)}$ there exist an equilibrium where all mobile capital goes to a , and if $\rho^a|_{(K^a=K_0^a)} \leq \rho^b|_{(K^b=K_0^b+\bar{K})}$ there exist an equilibrium where all mobile capital goes to b . \square

Proof of Corollary 1. Given $K_0^a = K_0^b$, then $\rho^a|_{(K^a=K_0^a)} > \rho^b|_{(K^b=K_0^b)}$ if and only if $d^a > d^b$. Consequently, there exist an equilibrium where the entire \bar{K} is invested in a . Given that the per unit return on capital is increasing in capital, this equilibrium dominates any other allocation. When $d^b > d^a$, it must be that $\rho^a|_{(K^a=K_0^a)} < \rho^b|_{(K^b=K_0^b)}$, therefore an equilibrium exist where the entire \bar{K} is invested in b . When $d^a = d^b$, then $\rho^a|_{(K^a=K_0^a)} = \rho^b|_{(K^b=K_0^b)}$. The capitalists are then indifferent between investing all their capital in a or b . \square

Proof of Corollary 2. The proof of Corollary 2 is identical to that of Corollary 1, but with varying K instead of varying d . \square

Proof of Proposition 3. When $\rho^a[K_0^a + \bar{K}, d^*(K_0^a + \bar{K})] > \rho^b[K_0^b + \bar{K}, \hat{d}(K_0^b)]$, playing $d^*(K_0^a + \bar{K})$ is a dominant strategy for region a . Then, the best response for region b is to play $d^*(K_0^b)$. However, when $\rho^a[K_0^a + \bar{K}, d^*(K_0^a + \bar{K})] \leq \rho^b[K_0^b + \bar{K}, \hat{d}(K_0^b)]$ there is no pure strategy equilibrium.

For any d^b such that $\rho^b[K_0^b + \bar{K}, d^b] > \rho^a[K_0^a + \bar{K}, d^*(K_0^a + \bar{K})]$, all mobile capital would locate in region b . Region a would benefit from setting d^a such that $\rho^a[K_0^a + \bar{K}, d^a]$ is just above $\rho^b[K_0^b + \bar{K}, d^b]$. The same applies for region b until d^b is such that $\Omega[K_0^b + \bar{K}, d^b] < \Omega[K_0^b, d^*(K_0^b)]$. Note that the same is true for a , but since $K_0^b < K_0^a$ this always happen at a lower level of enforcement level for b than for a . Consequently, capital locates in region a , and region b would prefer playing its most prefer enforcement level is $d^*(K_0^b)$. However, if region b pick $d^*(K_0^b)$, region a most prefer enforcement level would be the maximum between $d^*(K_0^b + \bar{K})$ and a level of enforcement high enough to make sure that $\rho^a[K_0^a + \bar{K}, d^a]$ is just above $\rho^b[K_0^b + \bar{K}, d^b]$. Finally, if region a pick $d^*(K_0^b + \bar{K})$ (or a level of enforcement high enough to make sure

that $\rho^a[K_0^a + \bar{K}, d^a]$ is just above $\rho^b[K_0^b + \bar{K}, d^b]$), then region b would be better playing d^b such that $\rho^b[K_0^b + \bar{K}, d^b]$ is just above $\rho^a[K_0^a + \bar{K}, d^a]$, and we are back to the first situation described above. Consequently, there are no pure Nash equilibrium. \square

Proof of Proposition 4. If region a plays first, it will pick \hat{d}^a such that $\rho^a[K_0^a + \bar{K}, \hat{d}^a] = \rho^b[K_0^b + \bar{K}, \hat{d}(K_0^b)]$ unless $\hat{d}^a < d^*(K_0^a + \bar{K})$, in which case region a picks $d^*(K_0^a + \bar{K})$. Jurisdiction b best response is then to play $d^*(K_0^b)$, and mobile capital locates itself in a . If region b plays first, it will pick $d^*(K_0^b)$, as no level bellow $\hat{d}(K_0^b)$ can prevent region a from profitably attracting mobile capital. Jurisdiction a best response is then to play $d^*(K_0^a + \bar{\theta})$, and capital locates itself in a .

Proof of Lemma 1. Migration outcome ℓ is determined by Eq. (6). From this equation we can derive that

$$\frac{\partial \ell}{\partial K^a} = - \frac{F_{KL}(L^a + \ell, K^a) + F_{LL}(L^a + \ell, K^a) \frac{\partial L^a}{\partial K^a}}{F_{LL}(L^a + \ell, K^a) + F_{LL}(L^b - \ell, K^b)}.$$

We will now show that $F_{KL}(\cdot) + F_{LL}(\cdot) \frac{\partial L^a}{\partial K^a}$ is positive. If we expand this expression, we can see that it is positive if and only if

$$F_{KL}(\cdot) > \frac{-F_{LL}(\cdot)}{\alpha K^a F_{LK}(\cdot) - F_{LL}(\cdot)} (F_{LK}(\cdot) - \alpha [F_K(\cdot) + K^a F_{KK}(\cdot)]),$$

which is satisfied. The same can be shown for $-\ell$ when K^b changes. \square

Proof of Lemma 2. The outcome of migration is given by $c = \bar{m}/(m^h - m^l)$, therefore we need to show that \bar{m} is increasing in K^a . From Eq. (8) we get that

$$\frac{\partial \bar{m}}{\partial K^a} = \alpha [F_K(L^a, K^a) + K^a F_{KK}(L^a, K^a)] + \alpha K^a F_{KL}(L^a, K^a) \frac{\partial L^a}{\partial K^a} > 0.$$

Similarly, we can show that c decreases with K^b . \square

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