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Urban Crime and Labor Mobility*

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Abstract

We present a model of crime where two municipalities exist within a metropolitan statistical area (MSA). Consistent with the literature, local law enforcement has a crime reduction effect and a crime diversion effect. The former confers a spillover benefit to the other municipality, while the latter a spillover cost. If the net spillovers are positive (negative), then the respective Nash enforcement levels are too low (high) from the perspective of the MSA. When we allow for Tiebout type mobility, labor will move to the location offering lower disutility of crime (including the tax burden). To attract labor, both jurisdictions would like to reduce crime in their municipality. Interestingly, this could raise or reduce enforcement compared with the immobility case. If it was too high (low) under immobility, it will be raised (reduced) further under mobility. In the symmetric case, neither can gain any labor, but the competition for it pushes the jurisdictions further away from the efficient outcome. Thus, mobility is necessarily welfare reducing. Next, we consider asymmetry in the context of differences in efficiency of enforcement. The low cost municipality has the lower crime damage (inclusive of the tax burden) and attracts labor. Mobility is necessarily welfare reducing for the high cost municipality and for the MSA, but it has an ambiguous effect on the low cost municipality. Finally, we extend the model and allow residents to choose between productive and criminal activities. We conclude that to the extent that enforcement increases the number of criminals ("replacement effect"), jurisdictions have an incentive to reduce their enforcement levels relative to the no-occupational choice case. Additionally, the equilibrium levels of enforcement are more likely to be overprovided in the presence of occupational choice.

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1 Introduction

Most of the literature in local public finance concludes that as intercity or interregional mobility of goods, capital, and/or people increases, the level of local public goods tends to become inefficiently low. In this paper, we consider local crime enforcement and examine how different levels of household mobility affect the local provision of enforcement. Specifically, we identify conditions under which a shift from an economic environment characterized by household (or labor) immobility to one with perfect mobility may lead to either under, over, or efficient provision of local crime enforcement. We also analyze how a higher degree of mobility affects the pattern of crime and crime enforcement expenditures when jurisdictions differ in the cost of providing these activities.

Crime is a social ill that imposes substantial economic costs on society. Studies have shown, for example, that crime tends to be associated with slower economic growth at both the national level (Mehlum et al., 2005) and the local level, such as cities and metropolitan areas (Leichenko, 2001). Evidence also suggests that crime has a significant negative effect on property values (Naroff et al., 1980; Schwartz et al., 2003) and may be associated with increased residential segregation by income and education, as households with high levels of income and education migrate away from crime-ridden neighborhoods (Wilson, 1987; Cullen and Levitt, 1999). This process may exacerbate matters by creating concentrations of poverty and unemployment, which fuel further increases in crime as well as a host of other social pathologies (Case and Katz, 1991; Glaeser et al., 1996).

For these reasons, state and local governments devote substantial resources to crime prevention. During the 2003-2004 fiscal year, for instance, local governments (e.g., cities, towns, counties) in the United States spent more than $60 billion on police protection alone - nearly 5 percent of total direct local government expenditures in that year.[1]

Public spending on crime prevention, however, tends to be highly uneven, even across municipalities within the same metropolitan statistical area (MSA). Within the St. Louis MSA, for example, the three most populous counties - St. Louis, St. Louis city, and St. Charles - tend to allocate strikingly different amounts of resources to police protection. The largest county, St. Louis, spent $136 per capita in 1997 on police protection. St. Louis city, which contains the historical central business district, devoted nearly two and a half times this amount to law enforcement: $308 per capita. Spending in suburban St. Charles County, on the other hand, was much lower: $111

[1] These figures are derived from the American FactFinder at the U.S. Census Bureau.

dollars per capita.[2] To be sure, much of this pattern can be explained by the fact that crime rates are significantly higher in St. Louis city than either St. Louis county or St. Charles county.[3]

Nevertheless, differences such as those described earlier require a more careful look at the logic behind such spending. In particular, do local jurisdictions within metropolitan areas select appropriate levels of public expenditure to fight crime? How does one jurisdiction's choice influence that of another? How does the mobility of a local population influence the behavior of local governments with respect to their spending decisions? We seek to explore these issues in this paper.

There is a substantial literature on urban crime where the incentives of criminals and local governments are explored. One of the earliest references to this issue is in Tiebout (1956, p. 423), where he views policing in the context of a local public good and voting with one's feet:

> '*For example, those who argue for a metropolitan police force instead of local police cannot prove their case on purely economic grounds. If one of the communities were to receive less police protection after integration than it received before, integration could be objected to as a violation of consumer's choice.*"

Tiebout's analysis abstracts from externalities (on other municipalities) that may be associated with such local public goods. Recent contributions of Helsley and Strange (1999), Wheaton (2006), and Pinto (2007), among others, show that externalities are inextricably linked to crime.[4] Helsley and Strange (1999) find that if a community chooses a higher level of gating, it enjoys crime reduction but other communities suffer from higher levels of crime (due to crime diversion). Wheaton (2006) finds that unilateral increases in local law enforcement has the effect of "spatially displacing" criminals along with reducing their active numbers through incarceration. Along similar lines,

[2]These figures are derived from the USA Counties data files at the U.S. Census Bureau.

[3]According to the FBI data reported in the USA Counties data files, the number of crimes per 100000 residents in St. Louis city, St. Louis county, and St. Charles county in 1997 were, respectively, 13577, 4020, and 3154. The spatial concentration of criminal activities has received some attention in the crime literature. For example, Burdett et al. (2003) incorporates criminal activities into a search-theoretic model and shows that two neighborhoods, ex-ante identical, can end up experiencing different levels of crime. Burdett et al. (2004) extends their previous model by allowing for on-the-job search. Crime concentration arises in Verdier and Zenou (2004) as a result of locational segregation and racial inequality. In our paper we approach this issue in a completely different way: we examine the role played by labor mobility in shaping the spatial distribution of local crime enforcement activities and its impact on the allocation of crime.

[4]Of course, such externalities can be pervasive in the case of local public goods. For example, Boarnet (1998) considers infrastructure development at the county level. When a county spends on developing its infrastructure, it attracts productive resources from neighboring counties. This leads to negative output spillovers.

Pinto argues that enforcement spillovers may be either positive or negative depending on whether the crime-reducing (deterrence) effects dominate the crime-diverting effects.

The focus of our paper is police enforcement, as opposed to private security measures discussed in Hui-Wen and Png (1994). A recent paper by Lee and Pinto (2009) looks at private security measures coexisting with publicly funded policing. The substitution between private and public security measures raises the paradoxical possibility that a rise in policing by a municipality may end up attracting crime rather than diverting it.

In the light of Tiebout (1956), one is tempted to ask how crime enforcement incentives may be affected when residents vote with their feet by moving away from areas with relatively high net crime damage (i.e., net of tax burden). To our knowledge, the existing literature has not directly addressed this issue. This paper is an attempt to fill that gap.

We consider a framework where two neighboring jurisdictions face the same group of criminals (see Wheaton, 2006, for example). If one municipality raises enforcement, the probability of crime and the extent of crime damage are affected in the other municipality. These will, in general affect the net marginal benefit for that municipality, inducing an enforcement response. This strategic interdependence is modeled assuming Nash behavior, where a jurisdiction chooses its optimal enforcement level assuming the other jurisdiction's enforcement level to be given.

Under labor immobility, the Nash enforcement equilibrium that emerges is associated with two types of spillovers. First, the increased enforcement will put some criminals behind bars and this will potentially reduce crime in both jurisdictions. This confers a positive spillover that is not internalized by the enforcing jurisdiction. Second, greater enforcement by a jurisdiction will divert some criminals toward the neighboring jurisdiction, which is now a relatively soft target. This crime diversion is a negative spillover. Equilibrium enforcement levels are too low (or too high) for the metropolitan area as a whole, depending on the relative strengths of these two opposing spillovers.

When we allow for labor mobility, people will move into the jurisdiction that has the lower net crime damage. If a jurisdiction wants to attract greater economic activity, it will try to attract labor by lowering its relative net crime damage. If there is a net negative spillover of enforcement by, say, jurisdiction A on jurisdiction B, this will create an incentive for A to raise its enforcement further to increase B's relative crime damage. Starting from immobility, the incentive for A will be to raise enforcement. Recall that if there is a net negative externality, A's enforcement was too high at the Nash (immobility) equilibrium. Mobility creates an incentive to raise it further, worsening the distortion from the perspective of the metro area. In the symmetric case, both jurisdictions are worse off. Thus, Tiebout type mobility worsens the existing market failure. This is interesting from the perspective of Tiebout sorting, which suggests that choice of jurisdictions in which people can locate may solve the market failure problem for local public goods. To be sure, we must note that our findings do not directly contradict Tiebout (1956), because he abstracted from externalities for local public goods.[5]

The previous analysis does not include an "occupational-choice" between becoming a worker or a criminal. It has been claimed in the literature that when the supply of criminals is endogenous, higher levels of enforcement that lead to the interdiction of criminals may generate an even larger pool of offenders. This effect is known as the "replacement" or "interdiction effect".[6] In the paper, we extend the model and examine the extent to which the presence of the "replacement effect" affects the previous results.[7]

The organization of the paper is as follows. Section 2 analyzes the strategic determination of enforcement policies in the absence of labor mobility. This framework will serve as our benchmark case. Section 3 introduces labor mobility and compares the Nash equilibria that emerge with and without mobility. Section 4 analyzes the implications of asymmetry in enforcement costs between jurisdictions. In Section 5, we extend the model and allow residents to choose between productive and criminal activities. Section 6 concludes.

2 The Model with Immobile Labor

Consider an economy with two jurisdictions, A and B, subject to criminal activities. Local governments decide in a decentralized way the level of law enforcement efforts in each region. We assume in this section that residents are completely immobile.

Two things are common in the models of Wheaton (2006) and Pinto (2007), among others. First,

[5] There is some similarity between the externalities that we consider and the inter-jurisdictional spillovers analyzed by Ogawa and Wildasin (2009), where they find that decentralized policymaking can lead to efficient outcomes. Our context is different, so their finding is not a generic feature of our model (in the present analysis enforcement levels will be efficient only when opposing spillover effects balance each other out). Likewise, the paper differs substantially from the kind of efficient outcome discussed in Oates and Schwab (1988) where environment is a local public good (without inter-jurisdictional spillovers) and capital is mobile, while labor is not.

[6] See, for example, Sah (1991), Huang et al. (2004).

[7] We thank the Associate Editor and an anonymous referee for raising this point.

a rise in enforcement by a jurisdiction reduces the overall number of active criminals in a metro area. Second, it deflects crime to other jurisdictions by making itself a harder target. There is a striking similarity between these results and what is observed in the literature on transnational terrorism (see Bandyopadhyay and Sandler, 2009, for example). Greater levels of defensive actions create negative spillovers, by deflecting terror to other potential target nations, while greater preemption reduces global terror and confers positive spillovers. One way to model these spillovers is to adapt an approach that was used in Dixit (1987). For simplicity, first consider a given level of crime (independent of aggregate enforcement) that can occur in the metro area. If jurisdiction A raises enforcement, the crime shifts to B and vice versa. If A chooses the same amount of enforcement as B, the crime is equally distributed. A simple way to capture the distribution of the allocation of crime across is by using a probability function $p(\cdot)$, where p is the probability of crime in A. Along the lines of Dixit (1987), we propose that this function is[8]

$$p(e^A, e^B) = \frac{e^B}{E}, \; p_1 = -\frac{e^B}{E^2}, \; p_2 = \frac{e^A}{E^2}, \; E = e^A + e^B, \tag{1}$$

where e^A and e^B are the enforcement levels chosen in A and B, respectively. Note that crime is equally distributed when the two jurisdictions have the same enforcement levels. The signs of the derivatives p_1 and p_2 indicate that when one area raises its enforcement level, the probability of crime in the other area must rise. This captures crime diversion discussed in the literature.[9]

However, it is unrealistic to assume that a rise in enforcement will have no effect on aggregate crime. In particular, the literature has consistently shown that aggregate crime falls with greater enforcement (for instance, due to incarceration effects). We allow for this by introducing a reduced-form metro area-wide crime damage function (with damage measured in units of the numeraire

[8] We follow the convention that for a function $f(\cdot)$, $f_i(\cdot)$ is the partial derivative with respect to its i-th argument. Also, $f_{ij}(\cdot)$ is the partial derivative of $f_i(\cdot)$ with respect to its j-th argument.

[9] The choice of this functional form is purely for tractability reasons. Note that, implicitly, this specification assumes that law enforcement is essentially a local public good, i.e., everyone within a given jurisdiction enjoys the same level of "public safety". In earlier versions of the paper, we used a more general functional form given by

$$p = \frac{e^B/(L^B)^\gamma}{e^A/(L^A)^\gamma + e^B/(L^B)^\gamma},$$

where L^A and L^B are, respectively, the population or units of labor in regions A and B, and $0 \leq \gamma \leq 1$ is a parameter that represents the degree of "publicness" of local law enforcement. For instance, if $\gamma = 0$, crime prevention is a public good, while if $\gamma = 1$, it is a private good. It turns out that the choice of the functional form does not affect the main conclusion of our paper, i.e., the idea that labor mobility decreases welfare. Since using the more general specification makes the results unnecessarily complicated, we assume that $\gamma = 0$.

consumption good X):[10]

$$D = D(E),\ D' < 0,\ \text{and } D'' > 0. \tag{2}$$

The signs of the derivatives assume that as aggregate enforcement rises, MSA level crime damage falls, although at a diminishing rate. Thus, expected total damage in A due to criminal activities in that region is pD and expected total damage in B is $(1-p)D$. When e^A increases, for a given D, expected crime damage falls in A by Dp_1 and increases in B by the same amount. This is pure crime diversion and is a negative externality on B. However, D falls when aggregate enforcement rises to the tune of D'. This benefits A by pD', and B by $(1-p)D'$. The latter effect is a positive externality on B. Thus, local law enforcement causes a crime diversion effect (accompanied by a negative externality) and a crime reduction effect (accompanied by a positive externality). The sum of these two externalities is critical in determining the extent and direction of inefficient enforcement provision for the MSA. Let $\bar{L}^A$ denote the units of labor in jurisdiction A. Then, expected damage per capita in A is $(pD/\bar{L}^A)$.[11]

Production in region j region requires labor L^j and a region specific input, land, denoted N^j, which for simplicity is normalized to one. The production function for X in A is

$$X^A = F(L^A, N^A) \equiv f^A(L^A),\ \text{with } f^{A\prime}(L^A) > 0,\ \text{and } f^{A\prime\prime}(L^A) < 0, \tag{3}$$

where L^A is the labor used to produce X in A.[12] Under labor immobility, $L^A = \bar{L}^A$. Let us assume that enforcement is produced through a transformation technology $e^A = (X_e^A/c^A)$, $c^A > 0$, where X_e^A is the amount of X that is needed to produce e^A units of enforcement in A. A tax t^j (in output

[10] Bandyopadhyay and Sandler (2009) use a similar terror damage function where preemption reduces the global terror that can be produced by an international network of terrorists. Pinto (2007) assumes that the number of potential criminals depends on the amount of law enforcement efforts exerted by local jurisdictions. In the present model, this effect would be captured by the damage function.

[11] Essentially, this term attempts to describe in a simple way all the relevant features of criminal activities commonly studied in the literature on urban crime. In the present analysis, the set of workers and the set of criminals are given. In other words, we do not consider the "occupational choice" decision between becoming a worker in the formal sector or a criminal. Several models that study the economics of crime incorporate occupational choice decisions (Burdett et al. (2004), Huang et al. (2004), and Calvó-Armengol and Zenou (2004)), but they address different issues. Burdett et al. (2004) and Huang et al. (2004) develop equilibrium search models of crime to study the connection between crime and labor market opportunities. Calvó-Armengol and Zenou (2004) examine the role of social interactions and criminal behavior in a game-theoretic framework.

[12] We assume in the spirit of the specific factors model in trade that $F(L, N)$ exhibits constant returns to scale (CRS) in the two inputs. Since the region specific input is fixed (at unity), $F(L, N)$ reduces to $f(L)$, where the latter has positive but diminishing marginal product of labor.

units) on a unit of labor in j is used to finance enforcement activities.[13] The regional government budget constraint becomes:

$$c^j e^j = t^j L^j, \quad j = A, B. \tag{4}$$

Using the CRS property of $F(\cdot)$ and the assumption of labor immobility, we can write regional product of A as

$$\begin{aligned} W^A(e^A, e^B) &= w^A \bar{L}^A + r^A - c^A e^A - p(e^A, e^B) D(e^A + e^B) \\ &= f^A(\bar{L}^A) - c^A e^A - p(e^A, e^B) D(e^A + e^B). \end{aligned} \tag{5}$$

where w^A is the factor reward for labor in A and r^A is the return to the fixed local factor of production. The local authority in A maximizes W^A by choosing e^A under the Nash assumption regarding e^B. Maximizing W^A is equivalent to minimizing

$$V^A(e^A, e^B) = p(e^A, e^B) D(e^A + e^B) + c^A e^A. \tag{6}$$

The first-order condition of this minimization is[14]

$$V_1^A(e^A, e^B) = 0 \Leftrightarrow -pD' - Dp_1 = c^A \tag{7}$$

The first term on the left-hand side (of the second equality) is the reduction in expected damage to A, due to the crime reduction effect. The second term is the fall in expected crime due to the crime diversion effect. At the margin, A sets e^A to equalize the sum of these benefits to the marginal cost of enforcement. Equation (7) implicitly defines A's Nash reaction function:

$$e^A = e^A(e^B), \text{ where } \frac{de^A}{de^B} = -\frac{V_{12}^A(e^A, e^B)}{V_{11}^A(e^A, e^B)}, \tag{8}$$

[13] Since our focus is on labor (or household) mobility, we assume that the fixed local input does not suffer from criminal activities and it is not subject to taxation. This assumption is important when labor is completely mobile, which we consider in 3.

[14] The second-order condition for a (strict) minimum is $V_{11}^A = (2p/E^2)(D - ED') + pD'' > 0$, which is clearly satisfied since $D' < 0$ and $D'' > 0$.

and

$$V^A_{12}(e^A, e^B) = \frac{(1-2p)(D'E - D)}{E^2} + pD''. \tag{9}$$

Note that if $V^A_{12} \leq 0$, then $de^A/de^B \leq 0$. Similarly, B's first-order condition is

$$V^B_2(e^A, e^B) = 0 \Leftrightarrow (1-p)D' - Dp_2 = c^B \Rightarrow e^B = e^B(e^A). \tag{10}$$

Expressions (7) and (10) jointly define the enforcement Nash equilibrium.

At a symmetric equilibrium (i.e., $p = 1/2$), (9) reduces to

$$V^A_{12}(e^A, e^B) = pD'' > 0. \tag{11}$$

Expressions (8), (10), and (11) imply that, at a symmetric equilibrium, the Nash reaction functions of A and B are negatively sloped. In other words, enforcement levels are strategic substitutes for each other. Figure 1 presents this case. This is interesting in the context of Proposition 2 of Helsley and Strange (1999), who find that gating expenditures are strategic substitutes whenever the marginal aggregate cost of crime (in a community) is decreasing. Their intuition is the following: as gating by community j rises, it will shift criminals to community i. Diminishing marginal cost of crime will reduce the marginal benefit from gating for i, leading to lower gating by i as a Nash response.

The mechanism behind our finding is the following: a rise in e^B raises aggregate enforcement E (given e^A). When $D'' > 0$, the aggregate marginal benefit for raising enforcement (i.e., $-D'$) falls with E. For a given p, this reduces the marginal expected benefit (i.e., $-pD'$) for A. Expressions (9) and (11) show that this is the only effect that matters in a symmetric equilibrium, and thus enforcement levels are strategic substitutes. Although there are analytical similarities, the reason for strategic substitutability here is distinct from Helsley and Strange (1999), where the decreasing marginal cost of crime was the driving force behind strategic substitutability. In our context, it is the decreasing marginal effectiveness of aggregate enforcement that renders A's enforcement less effective (when B raises its enforcement) and contributes to its reduction.

Let us now consider the cooperative (MSA level) outcome:

$$\begin{aligned} W^C(e^A, e^B) &= W^A + W^B \\ &= f^A(\bar{L}^A) + f^B(\bar{L}^B) - V^A(e^A, e^B) - V^B(e^A, e^B). \end{aligned} \tag{12}$$

Using (7) and (12),

$$W_1^C\big|_{NE} = -V_1^B(\cdot), \text{ where } , V_1^B = -Dp_1 + (1-p)D'. \tag{13}$$

The second equality in (13) suggests that $V_1^B(\cdot)$ can be of either sign, depending on the relative strengths of the positive externality $(1-p)D'$, and the negative externality $-Dp_1$ on B created by a marginal increase in enforcement by A. Using (7), (13) can be reduced to

$$V_1^B(\cdot) = D' + c^A \Rightarrow W_1^C\big|_{NE} < 0, \text{ if and only if } |D'| < c^A. \tag{14}$$

Thus, for the MSA, evaluated at the Nash equilibrium a rise in e^A reduces efficiency (in other words, e^A is excessively high at the Nash equilibrium) if the marginal fall in crime damage is lower than the marginal cost of e^A.

Proposition 1. *The Nash enforcement levels in a symmetric equilibrium are equal to, greater than, or less than the efficient levels, depending on whether the marginal cost (i.e., $c^A = c^B = c$) is equal to, greater than, or less than the marginal value of the MSA-wide crime damage function.*

The proof is in the preceding derivations. A marginal rise in enforcement by a jurisdiction creates both a positive and a negative spillover on the other. The former is due to a reduction of crime at the MSA level (as more criminals are removed from action), which benefits both jurisdictions; the latter is due to the shifting of crime to the other jurisdiction. These exactly offset each other when the marginal cost of enforcement equals the MSA-wide marginal crime reduction. Otherwise, the Nash equilibrium is inefficient. If marginal cost exceeds (is lower than) the crime reduction, the negative (positive) spillover dominates and we have overprovision (underprovision) of enforcement.

3 Enforcement under Mobile Labor

This section allows for Tiebout type labor mobility, where people move between A and B so as to equate the real income of a labor unit between the two potential locations.[15] Factor rewards in the locations are

$$w^j = f^{j\prime}(L^j), \text{ and } r^j = f^j(L^j) - w^j L^j, \text{ where } j = A, B. \tag{15}$$

As in the previous case, we assume that local law enforcement activities in region j are financed with a tax on labor in that region, i.e.,

$$t^j = \frac{c^j e^j}{L^j}, \quad j = A, B. \tag{16}$$

Expected net-of-tax real income of a unit of labor is given by[16]

$$u^A = w^A - t^A - \frac{pD}{L^A}, \text{ and } u^B = w^B - t^B - \frac{(1-p)D}{L^B}. \tag{17}$$

Using (6), (15), (16), and (17), equilibrium migration implies

$$u^A = u^B \Rightarrow f^{A\prime}(L^A) - \frac{V^A(e^A, e^B)}{L^A} = f^{B\prime}(L^B) - \frac{V^B(e^A, e^B)}{L^B}. \tag{18}$$

Note that

$$L^A + L^B = \bar{L}^A + \bar{L}^B = \bar{L}. \tag{19}$$

Using (18) and (19) we obtain the equilibrium allocation of labor across jurisdictions $L^A = L^A(e^A, e^B)$, and $L^B = \bar{L} - L^A(e^A, e^B) = L^B(e^A, e^B)$. When the levels of local enforcement change,

[15]The context here is enforcement competition in the presence of Tiebout type mobility. A good parallel is the work of Brueckner (2000), where Tiebout sorting is analyzed in the presence of tax competition. Unlike that paper we do not consider preference heterogeneity. The Tiebout element comes in through ex ante identical consumers voting with their feet to choose the location that is just right for them. In equilibrium this leads to ex post equalization of their utilities from the two potential locations.

[16]Assuming that criminal activities are exclusively targeted to residents or labor, the expressions in (17) can be justified as follows. Each unit of labor in A earns w^A and pays t^A. A representative resident of that jurisdiction is victimized with probability p, suffering a loss equivalent to D/L^A. Thus, expected real income in A is $p(w^A - t^A - D/L^A) + (1-p)(w^A - t^A) = w^A - t^A - pD/L^A$. A similar reasoning applies to region B.

labor allocation changes as follows:[17]

$$L_1^A(\cdot) = \frac{\left[(V_1^B/L^B) - (V_1^A/L^A)\right]}{-H}, \quad L_2^B = -L_2^A(\cdot) = \frac{\left[(V_2^A/L^A) - (V_2^B/L^B)\right]}{-H}, \text{ and}$$
$$H = f^{A\prime\prime}(\cdot) + f^{B\prime\prime}(\cdot) + \frac{V^A}{(L^A)^2} + \frac{V^B}{(L^B)^2} < 0. \tag{20}$$

Consider the no-mobility case examined in the previous section. At that Nash equilibrium, the levels of e^A and e^B are such that $V_1^A = V_2^B = 0$. Therefore, evaluated at the no-mobility equilibrium, the expressions in (20) become

$$\begin{aligned} L_1^A(\cdot) &= \frac{V_1^B}{-HL^B} \Rightarrow sign\{L_1^A\} = sign\{V_1^B\}, \text{ and} \\ L_2^B(\cdot) &= \frac{V_2^A}{-HL^A} \Rightarrow sign\{L_2^B\} = sign\{V_2^A\}. \end{aligned} \tag{21}$$

Next, we examine how the patterns of crime and crime enforcement change when residents become completely mobile, considering the no-mobility case as the starting point. Proposition 2 below addresses this issue. The rest of this section assumes symmetry, but we relax this assumption in section 4.

Proposition 2. *Unless the initial Nash equilibrium is efficient (i.e., $V_1^B = V_2^A = 0$), labor mobility raises (reduces) Nash enforcement levels compared with the immobility case when the net crime externality on the other municipality (V_1^B for locality A) is positive (negative) and necessarily aggravates the pre-existing market failure problems arising due to the presence of net crime externalities. Welfare of both municipalities is lower under free mobility of labor.*

Proof. Consider the following three cases:

Case 1: $V_1^B > 0$. When $V_1^B > 0$, the diversion effect dominates the incarceration effect. Notice from (13) that in this case the Nash enforcement levels are too high. Additionally, in this case

[17] We assume that the equilibrium level of L^A is (dynamically) stable implying that $H < 0$. Suppose that L^A increases gradually as the difference between u^A and u^B gets larger. Specifically, let $\Delta u = u^A - u^B$ and $\dot{L}^A = h(\Delta u)$, where $\dot{L}^A \equiv dL^A/dt$ and $h'(\cdot) > 0$. In equilibrium, $\dot{L}^A = 0$. Then, the equilibrium value of L^A is dynamically stable if (at the equilibrium) $dh(\Delta u)/dL^A < 0$, or if $h'(\cdot)[d(\Delta u)/dL^A] < 0$. Since $h'(\cdot) > 0$, the stability condition reduces to

$$\frac{d\Delta u}{dL^A} = f^{A\prime\prime}(\cdot) + f^{B\prime\prime}(\cdot) + \frac{V^A}{(L^A)^2} + \frac{V^B}{(L^B)^2} < 0.$$

Hence, we assume that the production functions in A and B are sufficiently concave at the migration equilibrium, such that (20) is satisfied. In general, this restricts the parameter space (the parameters that define the functional forms of the production and damage functions) where a sensible migration equilibrium occurs.

$V_2^A > 0$ and, therefore, $L_1^A > 0$ and $L_2^B > 0$. Using (5) and (18) we may represent the regional income function for A in the mobility case as:[18]

$$W^A(e^A, e^B) = f^A[L^A(e^A, e^B)] - V^A(e^A, e^B). \tag{22}$$

The Nash first-order condition for A is

$$W_1^A(e^A, e^B) = f^{A\prime}(\cdot)L_1^A(\cdot) - V_1^A(\cdot) = 0. \tag{23}$$

Evaluated at the no-mobility Nash equilibrium,

$$W_1^A\big|_{no\ mob\ NE} = f^{A\prime}(\cdot)L_1^A(\cdot) > 0. \tag{24}$$

By raising enforcement, A shifts some crime to B. This makes some labor relocate to A raising its welfare (given B's enforcement). Both jurisdictions face similar incentives to raise their enforcement levels. Note that there cannot be efficiency gains in the production side, because the final symmetric equilibrium splits the labor force evenly as in the no-mobility case. The end result is that the jurisdictions engage in wasteful competition for labor, and raise their enforcement levels higher than the already excessive levels that existed in the no-mobility Nash equilibrium.

Case 2: $V_1^B = 0$. From (20) we find that in this case $L_1^A = 0$. Thus, there is no incentive for A (or B) to alter their enforcement levels due to mobility. From proposition 1 we know that under this condition the Nash equilibrium is efficient. Since there is no incentive in this case to depart from that equilibrium, the mobility and immobility equilibria converge and they are both efficient.

Case 3: $V_1^B < 0$. In this case, $L_1^A < 0$ and so is L_2^B. Notice from (13) that in case 3, enforcement is too low compared with the efficient level (i.e., the diversion effect is dominated by the incarceration effect). Following the logic of (23), we find that there is now an incentive for both jurisdictions

[18] As it is well recognized in the immigration literature, labor mobility leads to welfare calculations that are somewhat controversial. Our utilitarian representation implies that the output of the municipality net of crime related costs (expected damage and enforcement costs) is the measure of local welfare. In that case, as long as marginal product is positive, a municipality will want to add more labor because that will raise local output. However, because of diminishing returns in production, the wages of existing residents fall. In this case, in an ex ante sense, the objectives of the existing residents and that of the municipality (which counts the income of the potential entrant as well) seem to be at odds. The qualitative nature of the analysis that follows is unaltered if instead we were to assume a somewhat more general representation for the local welfare function, where the only requirement is that local welfare is a positive function of the size of its labor force. If not, the analysis is not changed, but the welfare results will be reversed.

to reduce enforcement to attract labor. Labor mobility exacerbates the problem by inducing local governments to reduce enforcement further away from the efficient level. The jurisdictions end up with lower welfare under mobility compared with the no-mobility case. As far as we are aware, this efficiency-reducing effect of Tiebout type mobility has not been noted in the literature on crime and enforcement. There are elements of the tax competition literature here (see, for example, Wildasin, 1986, or Wilson, 1999). However, our results are distinct because the market failure in our context is primarily driven by crime externalities. Factor mobility compounds that distortion. It is only this latter effect that is related to the tax competition results. $\square$

Thus, unless the initial levels of e^A and e^B are efficient, a higher level of labor mobility will tend to aggravate the under- or over-provision problem commonly observed when decisions are made by local governments in a context of inter-jurisdictional externalities.

4 Implications of Asymmetry

There are at least two potential sources of asymmetry in this context: asymmetry in production functions and in enforcement technologies. We concentrate on the latter because the focus here is on crime and enforcement and not on relative production efficiency. Also, it is probably reasonable to assume that production technology will not differ greatly between neighboring jurisdictions. On the other hand, efficiency of enforcement is a central issue in the literature. For example, Wheaton (2006) proposes that it is the efficiency of enforcement of smaller jurisdictions that may explain his paradoxical empirical finding that lower enforcement may be associated with lower crime.

We adapt a technique from Bergstrom and Varian (1985) to consider implications of cost asymmetry where the aggregate level of the cost is constant. This is achieved when we consider a mean preserving spread of the marginal costs of enforcement of A and B (c^A, c^B, respectively).[19] Assume that

$$c^A = \bar{c} - \varepsilon, \text{ and } c^B = \bar{c} + \varepsilon, \quad \varepsilon > 0. \tag{25}$$

From (25) we can see that as ε rises, the jurisdictions become more asymmetric, while the average

[19]As we will see below, this approach lends analytical tractability. In addition, it has the virtue of comparing jurisdictions on the basis of relative efficiency, because the average efficiency of the MSA is held constant.

efficiency (i.e., $(c^A + c^B)/2 = \bar{c}$) for the MSA is unchanged. Let us now sum the first-order conditions (7) and (10):

$$D' + D(p_1 - p_2) + c^A + c^B = 0. \tag{26}$$

Using (2) and (25) in (26),

$$D'(E) - \frac{D(E)}{E} = -2\bar{c} \Rightarrow E = E(\bar{c}) = \bar{E}. \tag{27}$$

(27) implies that the aggregate level of enforcement E and hence, the function D, are not affected by ε. Recognizing this, total differentiation of (7) yields

$$-D'dp - Ddp_1 = dc^A \Rightarrow \frac{de^A}{d\varepsilon} = \frac{E^2}{ED' - D} < 0 \Rightarrow \frac{de^A}{d\varepsilon} = -\frac{de^B}{d\varepsilon} > 0. \tag{28}$$

A rise in ε will raise A's equilibrium enforcement level exactly to the tune of its reduction for B because the aggregate level E is unchanged. Using (14) and (25),

$$V_1^B(\cdot) = D' + c^A = D' + \bar{c} - \varepsilon. \tag{29}$$

Similarly,

$$V_2^A(\cdot) = D' + c^B = D' + \bar{c} + \varepsilon \Rightarrow V_2^A(\cdot) > V_1^B(\cdot). \tag{30}$$

The crime-increasing effect on A of a rise in enforcement by B exceeds the corresponding spillover effect for a rise in A's enforcement. Of course, as cost asymmetry rises, it affects relative crime damage and causes labor migration. To see this, consider the effect of asymmetry on V^A and V^B, respectively. Noting that $de^A = -de^A$ and also that $dc^A = -dc^B = -\varepsilon$, we can totally differentiate the expressions for V^A and V^B to obtain (for the no-mobility case)

$$\begin{aligned} \frac{dV^A}{d\varepsilon} &= -(D' + c^B)\frac{de^A}{d\varepsilon} - e^A = -V_2^A \frac{de^A}{d\varepsilon} - e^A, \text{ and} \\ \frac{dV^B}{d\varepsilon} &= -(D' + c^A)\frac{de^B}{d\varepsilon} - e^B = -V_1^B \frac{de^B}{d\varepsilon} + e^B. \end{aligned} \tag{31}$$

Proposition 3. *In the asymmetric Nash enforcement equilibrium: (i) The low-cost municipality provides more enforcement; (ii) The expected damage from crime (including enforcement costs financed by taxation) is lower in that municipality and it attracts labor; (iii) If marginal products are equal at the pre-migration equilibrium, allocative efficiency is not affected (for small changes); (iv) Enforcement competition to attract labor leads to further losses by aggravating the pre-existing market failure problems; (v) The high-cost municipality must lose, the low-cost municipality may or may not gain, and joint welfare must necessarily fall.*

Proof. We proceed by considering the three cases analyzed in the previous section.

Case 1: $V_1^B > 0$. In view of (30), V_2^A must be positive as well. In turn, using (21), we infer that $L_1^A > 0$ and $L_2^B > 0$. Thus the analysis of this case is analogous to that in section 3. Both jurisdictions face similar incentives and raise their enforcement levels. Using (28) and (31) we can infer that at the asymmetric no-mobility equilibrium, V^A is lower than V^B (note that in case 1: $(dV^A/d\varepsilon) < 0, (dV^B/d\varepsilon) > 0)$. Using (18), this will suggest, ceteris paribus, that labor will want to move to A to avoid the higher expected disutility from crime (and tax payments) in B. The effect of mobility on the jurisdiction's welfare (evaluated at the asymmetric no-mobility equilibrium, but assuming that initially population or labor is identical in both regions so that $f^{A'} = f^{B'}$) may be analyzed as

$$\begin{aligned} dW^A &= f^{A'}(\cdot)dL^A - V_2^A de^B, \\ dW^B &= f^{B'}(\cdot)dL^B - V_1^B de^A = -f^{B'}(\cdot)dL^A - V_1^B de^A, \\ dW^A + dW^B &= -V_1^B de^A - V_2^A de^B. \end{aligned} \tag{32}$$

From (32) it is clear that to the extent that mobility will raise L^A as well as enforcement levels in both jurisdictions, A's welfare may or may not rise. However, B's and the MSA's welfare must unambiguously fall.

Case 2: $V_1^B = 0$. In this case, $L_1^A = 0$ and A's enforcement level is not affected by mobility. However, V_2^A is positive, implying that $L_2^B > 0$. Thus, B has an incentive to raise enforcement. From (32), note that the welfare effects of a change in e^A are weighted by V_1^B and, therefore, vanish. Because V_2^A is positive and e^B rises, welfare in B and MSA level welfare must fall. Welfare in A may rise if the labor enhancement sufficiently raises output in that location.

Case 3: $V_1^B < 0$. Here $L_1^A < 0$, thus A has an incentive to lower enforcement to attract labor. Thus, $V_1^B de^A > 0$. It is possible for V_2^A to assume either sign or be zero. If $V_2^A > 0$, B raises enforcement to attract labor. Thus, $V_2^A de^B > 0$. Using (32), this implies that joint welfare must fall. If $V_2^A < 0$, then from (21), $L_2^B < 0$, and B will reduce enforcement to attract labor. Again, $V_2^B de^B > 0$. Thus, regardless of the sign of V_2^A (including zero, in which case $V_2^A de^B = 0$), we may infer (from (32)) that joint welfare must fall.

Finally, let us consider the MSA level welfare in a somewhat different way:

$$\begin{aligned} W^C(e^A, e^B) &= W^A + W^B \\ &= f^A(L^A) + f^B(L^B) - D(e^A, e^B) - c^A e^A - c^B e^B. \end{aligned} \tag{33}$$

In the no-mobility case,

$$W_1^C(\cdot) = -(D' + c^A) = -V_1^B, \text{ and } W_2^C(\cdot) = -(D' + c^B) = -V_2^A. \tag{34}$$

Given (30), this implies that $W_2^C(\cdot) < W_1^C(\cdot)$. In the absence of a corner solution (i.e., $e^B = 0$), enforcement in both jurisdictions cannot be efficiently chosen. Thus, case 2 of section 3 where the Nash interior outcome is also efficient must disappear, with at least one of the two jurisdictions choosing too much or too little enforcement. Indeed, because $V_2^A > V_1^B$, V_2^A (and, hence L_2^B) is positive for a larger range of parameters compared with V_1^B (and hence L_1^A), where B has an incentive to raise enforcement. This is bad from an efficiency perspective, because B is the relatively high-cost provider of enforcement. □

5 Occupational Choice and the Replacement Effect

The analysis thus far does not include an "occupational choice" between becoming a worker or a criminal. If the supply of labor (or criminals) depends on the level of crime enforcement, then additional effects come into play. An effect that has received some attention in the literature on crime is known as the "replacement" or "interdiction effect" (Sah (1991), and Huang et al. (2004)). The idea is that higher spending on crime enforcement that leads to the interdiction of criminals may generate an even larger pool of offenders. Since incarceration reduces the number of effective criminals, then, at the margin, the expected payoff of crime rises inducing some individuals to switch from productive to illegal activities. In other words, the "vacancies" produced by the removal of criminals from the market of offenders are filled up by new criminals. The counterpart is a decline in the supply of productive workers. In this section, we assume that residents can choose between productive and criminal activities, and examine the extent to which it affects the previous results.

Let the damage function D in equation (2) depend on the number of active criminals m in the entire metro-area, so that $D \equiv \beta(m)$, with $\beta' > 0$, and $\beta'' < 0$. Suppose that there is a stock of preexisting criminals $\bar{m}$, who are not employable in the productive sector. Enforcement levels, chosen in stage one, lead to the incarceration of some members of this preexisting stock. The number of criminals incarcerated is

$$\phi \equiv \phi(e^A + e^B) \equiv \phi(E),\ \phi' > 0,\ \text{and}\ \phi'' < 0. \tag{35}$$

After observing the levels of crime prevention, individuals residing in each location choose between working in the productive sector or being a criminal in stage two. Let μ^j denote the number of residents in jurisdiction $j = A, B$, who choose to become criminals. Then, $m \equiv \bar{m} - \phi(E) + \mu^A + \mu^B$. Substituting into the damage function gives

$$D \equiv D(E, \mu^A, \mu^B) \equiv \beta[\bar{m} - \phi(E) + \mu^A + \mu^B]. \tag{36}$$

Equations (36) and (2) are identical when $\mu^A = \mu^B = 0$.[20] The analysis below considers the case where productive labor is immobile between jurisdictions.[21] We assume that a productive labor unit in j earns the local legal wage, pays taxes, and may be a victim of crime as in the earlier section. Also, when a resident of jurisdiction j becomes a criminal, she simply earns the metro-wide reward for the active (i.e., non-incarcerated) criminal D/m. Therefore, occupational choice is

[20] Note that $D_E = -\beta'\phi' < 0$. In addition, we assume that $D_{EE} = \beta''\phi'^2 - \beta'\phi'' > 0$, consistent with (2).

[21] It can be shown that the governments' optimization problems in the mobility case are the same as that in the immobility case analyzed in this section. This happens because net utility of productive labor is equalized between jurisdictions even under immobility in this context, because it must equal the common metro-wide return to criminal activity. A formal proof is in an Appendix available upon request. If there is a disutility from being a criminal (as in Verdier and Zenou (2004), or Conley and Wang (2006), for example), and if that disutility is sufficiently high, then we revert to the analysis of the previous sections. The reality perhaps lies somewhere in between, and an analysis that allows for such disutility, and heterogeneity in moral aversion to criminal income will throw more light on the issue.

guided by the following conditions:

$$
\begin{aligned}
u^A &\equiv w^A - t^A - \frac{pD(E,\mu^A,\mu^B)}{L^A} = \frac{D(E,\mu^A,\mu^B)}{m}, \quad \text{and} \\
u^B &\equiv w^B - t^B - \frac{(1-p)D(E,\mu^A,\mu^B)}{L^B} = \frac{D(E,\mu^A,\mu^B)}{m},
\end{aligned} \tag{37}
$$

where $L^j = \bar{L}^j - \mu^j$, $w^j = f^{j\prime}(L^j)$, and $t^j = c^j e^j / L^j$. Equations (37) implicitly define $\mu^A \equiv \mu^A(e^A, e^B)$ and $\mu^B \equiv \mu^B(e^A, e^B)$. The effects of e^A and e^B on μ^A and μ^B are, in general, ambiguous. The ambiguity arises because local enforcement affects the relative payoffs of criminal activities in opposite directions. First, the return of local productive activities change because enforcement affects taxes paid by labor and expected damage in the jurisdiction. Second, it raises the per-capita booty for criminals. Finally, it has an effect on the incentives of becoming a criminal in the other jurisdiction, which ultimately influences the local relative payoffs. Thus, a priori, it is not clear which effect will dominate.[22] In general, when μ_i^j ($j = A, B; i = e^A, e^B$) is positive, new criminals shift from the productive labor pool, replenishing the depleted stock of criminals.

In a decentralized equilibrium, government A chooses the level of e^A that maximizes $W^A(e^A, e^B) = f^A[\bar{L}^A - \mu^A(\cdot)] - p(\cdot)\beta(\cdot) - c^A e^A$. The first-order condition for A's Nash enforcement choice is:

$$
W_1^A = -(f^{A\prime} + p\beta')\mu_1^A - p\beta'\mu_1^B - \beta p_1 + p\beta'\phi' - c^A = 0. \tag{38}
$$

Evaluating (38) at the no occupational choice (i.e., $\mu_i^j = 0$) equilibrium gives $-\beta p_1 + p\beta'\phi' - c^A = 0$. Substituting into (38), we find that

$$
W_1^A\big|_{no\ OC} = -(f^{A\prime} + p\beta')\mu_1^A - p\beta'\mu_1^B < 0, \text{ if } \mu_i^j > 0. \tag{39}
$$

Expression (39) indicates that when an increase in e^A induces individuals to shift from productive to criminal activities in either A or B (replacement effect), the government in A has an incentive to scale back its equilibrium enforcement level. Similar analysis applies to B.

Now, since aggregate welfare is $W^C(e^A, e^B) = W^A(e^A, e^B) + W^B(e^A, e^B)$, then $W_1^C = W_1^A + W_1^B$. Evaluating this last expression at the Nash equilibrium determined by equation (38) gives $W_1^C\big|_{NE} =$

[22] The mathematical details are spelled out in an Appendix that is available upon request. Note that in our model the "replacement effect" takes place partly because $\partial(D/m)/\partial E = (\phi'/m)[(\beta/m) - \beta'] > 0$, since $\beta' > 0$ and $\beta'' < 0$. In other words, when law enforcement increases, the booty per criminal rises as well.

$W_1^B|_{NE}$, where

$$W_1^B|_{NE} = -f^{B\prime}\mu_1^B - (1-p)\beta'(\mu_1^A + \mu_1^B) + (1-p)\beta'\phi' + \beta p_1. \tag{40}$$

Considering the damage function defined in (36), it is evident that the last two terms of (40) capture the same external effects of e^A on jurisdiction B described by expression (13), i.e., without occupational choice. When the replacement effects μ_1^A and μ_1^B are positive, two additional externalities arise. First, as individuals shift from productive to criminal activities in B, production declines in that jurisdiction (this effect is represented by the first term of (40)). And second, as the total number of criminals increase due to the replacement effect, the damage in B becomes even larger (second term of (40)). Using (38) in the expression for W_1^B and simplifying:

$$W_1^C|_{NE} = W_1^B|_{NE} < 0, \text{ if and only if } -f^{A\prime}\mu_1^A - f^{B\prime}\mu_1^B - \beta'(\mu_1^A + \mu_1^B) + \phi'\beta' < c^A. \tag{41}$$

Condition (41) is similar to (14), except that it includes additional terms arising out of the replacement effects in jurisdictions A and B.

Proposition 4. *When the replacement effect is positive, i.e.,* $\mu_i^j > 0, j = A, B, i = 1, 2$*, each jurisdiction has an incentive to scale back its enforcement compared to the no-occupational choice case. In addition, in the presence of occupational choice the Nash enforcement levels are more likely to exceed the efficient levels (compared to the Nash equilibrium enforcement levels determined in Section 2).*

The first part of the proposition follows immediately from (39). For the proof of the second part, consider expression (41). It is clear that when $\mu_1^A > 0$ and $\mu_1^B > 0$, the inequality is more likely to be satisfied. This is because as some workers become criminals, there is loss in production in both jurisdictions represented by $f^{j\prime}\mu_i^j$, and an increase in crime given by $\beta'(\mu_1^A + \mu_1^B)$. In turn, this means that in the presence of occupational choice, enforcement is more likely to be over-provided.

6 Concluding Remarks

In a framework with multiple jurisdictions where crime enforcement policies are interdependent, unilaterally optimal policies for a jurisdiction may not be optimal for the MSA. The paper outlines the conditions under which local governments may end up over-providing or under-providing enforcement compared with the efficient level. The main finding of the paper is that the introduction of Tiebout-type labor mobility necessarily worsens the outcome from an efficiency point of view. Under symmetry, the only effect of mobility is to encourage wasteful enforcement competition (for labor) between jurisdictions.

The paper also examines the extent to which asymmetry affects the previous conclusions. Specifically, under asymmetry in enforcement costs, wasteful enforcement competition further aggravates the distortions. However, in this context it is possible for the low-cost jurisdiction to improve its welfare at the cost of the other jurisdiction and the MSA as a whole.

Finally, the model is extended to include an occupational choice between becoming a worker or a criminal. It is shown that when enforcement increases the number of criminals (due to the "replacement effect"), jurisdictions have an incentive to reduce their enforcement levels relative to the no-occupational choice case. Additionally, the equilibrium levels of enforcement are more likely to exceed the efficient levels in the presence of occupational choice.

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Urban Crime and Labor Mobility

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APPENDIX NOT FOR PPUBLICATION

A Appendix

A.1 Occupational Choice and Labor Immobility: Comparative Statics

After appropriate substitutions into the system of equations (37), we obtain:

$$\begin{aligned} F &\equiv f^{A\prime}(\bar{L}^A - \mu^A) - \frac{pD(E,\mu^A,\mu^B) + c^A e^A}{\bar{L}^A - \mu^A} - \frac{D(E,\mu^A,\mu^B)}{\bar{m} - \phi(E) + \mu^A + \mu^B} = 0, \\ G &\equiv f^{B\prime}(\bar{L}^B - \mu^B) - \frac{(1-p)D(E,\mu^A,\mu^B) + c^B e^B}{\bar{L}^B - \mu^B} - \frac{D(E,\mu^A,\mu^B)}{\bar{m} - \phi(E) + \mu^A + \mu^B} = 0. \end{aligned} \tag{A.1}$$

Complete differentiation of (A.1) with respect to e^A allows us to derive $\mu_1^A \equiv (\partial\mu^A/\partial e^A)$ and $\mu_1^B \equiv (\partial\mu^B/\partial e^A)$:[23]

$$\mu_1^A = \frac{1}{H}\left(F_{\mu^B}G_{e^A} - G_{\mu^B}F_{e^A}\right), \tag{A.2}$$

$$\mu_1^B = \frac{1}{H}\left(G_{\mu^A}F_{e^A} - F_{\mu^A}G_{e^A}\right), \tag{A.3}$$

where

$$F_{\mu^A} = -\left[f^{A\prime\prime} + \frac{p\beta + c^A e^A}{(\bar{L}^A - \mu^A)^2} + \frac{p\beta'}{(\bar{L}^A - \mu^A)} - \frac{1}{m}\left(\frac{\beta}{m} - \beta'\right)\right], \tag{A.4}$$

$$F_{\mu^B} = -\left[\frac{p\beta'}{(\bar{L}^A - \mu^A)} - \frac{1}{m}\left(\frac{\beta}{m} - \beta'\right)\right], \quad G_{\mu^A} = -\left[\frac{(1-p)\beta'}{(\bar{L}^B - \mu^B)} - \frac{1}{m}\left(\frac{\beta}{m} - \beta'\right)\right], \tag{A.5}$$

$$G_{\mu^B} = -\left[f^{B\prime\prime} + \frac{(1-p)\beta + c^B e^B}{(\bar{L}^B - \mu^B)^2} + \frac{(1-p)\beta'}{(\bar{L}^B - \mu^B)} - \frac{1}{m}\left(\frac{\beta}{m} - \beta'\right)\right], \tag{A.6}$$

$$F_{e^A} = \frac{(p\beta'\phi' - p_1\beta - c^A)}{(\bar{L}^A - \mu^A)} - \frac{\phi'}{m}\left(\frac{\beta}{m} - \beta'\right), \quad G_{e^A} = \frac{(1-p)\beta'\phi' + p_1\beta}{(\bar{L}^B - \mu^B)} - \frac{\phi'}{m}\left(\frac{\beta}{m} - \beta'\right), \tag{A.7}$$

$$H = F_{\mu^A}G_{\mu^B} - F_{\mu^B}G_{\mu^A}. \tag{A.8}$$

The solution is "stable" if $F_{\mu^A} + G_{\mu^B} > 0$ and $H > 0$. Since our focus is on a symmetric equilibrium, i.e., $F_{\mu^A} = G_{\mu^B}$ and $F_{\mu^B} = G_{\mu^A}$, then the previous conditions also imply that $F_{\mu^A} = G_{\mu^B} > 0$.

It is clear from (A.2) and (A.3) that the impact of e^A on μ^A and μ^B is, in general, ambiguous. However, under certain conditions, $\mu_1^A >$ and $\mu_1^B > 0$ are plausible. In other words, the "replacement effect" may be observed in equilibrium. Expressions F_{e^A} and G_{e^A} play an important role in explaining the signs of μ_1^A and μ_1^B. Note that while the first term in F_{e^A} describes the change in the utility of labor when e^A increases, the second term captures the corresponding change in the reward per criminal. Thus, when $F_{e^A} > 0$ ($F_{e^A} < 0$), e^A tends to increase (decrease) the relative payoff of labor. Similarly, G_{e^A} describes the change in relative payoffs in jurisdiction B due to an increase in e^A.

Consider the impact of e^A on μ^A. Two effects take place in equilibrium. First, if $F_{e^A} < 0$, then a higher e^A increases the relative payoffs of criminal activities in A, and consequently, μ^A tends to rise. This effect is captured

[23] Similar results hold for e^B.

by the term $-G_{\mu^B} F_{e^A}$ in $(A.2)$, which represents the direct impact of e^A in jurisdiction A. Second, an increase in e^A also affects the incentives to become a criminal in jurisdiction B. When $G_{e^A} < 0$, the relative payoffs of criminal activities increase in that jurisdiction. To the extent that residents in B are induced to join the pool of criminals m, it will affect the relative payoffs in jurisdiction A, and, consequently, μ^A. This effect is captured by the term $F_{\mu^B} G_{e^A}$ in $(A.2)$. If $F_{\mu^B} < 0$, as residents in B decide to become criminals, it will tend to increase the incentive of residents in A to become criminals. A similar reasoning can be used to explain $\mu_1^B > 0$.

A.2 Occupational Choice and Labor Mobility

When residents in A and B can choose between productive and criminal activities, and if, in addition, labor is mobile, then the equilibrium conditions become:

$$f^{A\prime}(L^A) - \frac{pD(E,\mu) + c^A e^A}{L^A} = f^{B\prime}(L^B) - \frac{(1-p)D(E,\mu) + c^B e^B}{L^B}, \tag{A.9}$$

$$f^{A\prime}(L^A) - \frac{pD(E,\mu) + c^A e^A}{L^A} = \frac{D(E,\mu)}{m}, \tag{A.10}$$

$$\bar{L} + \mu = L^A + L^B, \tag{A.11}$$

where $\mu = \mu^A + \mu^B$ and $m = \bar{m} - \phi(E) + \mu^A + \mu^B$. Since labor is mobile across jurisdictions, the net return to productive activities should be the same in A and B, as indicated by (A.9). Additionally, in a model with occupational choice, the net return to labor in each jurisdiction must be equal to the return to criminal activities. This condition is represented by expression (A.10). Finally, (A.11) establishes the resource constraint. The system of equations (A.9) - (A.11) jointly determine $\{L^A, L^B, \mu\}$.

Next, we compare the solutions determined by the system of equations (37), when labor is immobile, to the corresponding solutions of the labor mobility case, determined by equations (A.9)-(A.11). Consider a solution $\{\mu^A, \mu^B\}$ of (37), or alternatively, $L^A = \bar{L}^A - \mu^A$ and $L^B = \bar{L}^B - \mu^B$. Then, the latter will also be a solution of the system of equations (A.10)-(A.11), with $\mu^A + \mu^B = \mu$. This is clear because equations (A.9) and (A.10) can be rewritten, respectively, as

$$f^{A\prime}(L^A) - \frac{pD(E,\mu) + c^A e^A}{L^A} = \frac{D(E,\mu)}{m}, \text{ and } f^{B\prime}(L^B) - \frac{(1-p)D(E,\mu) + c^B e^B}{L^B} = \frac{D(E,\mu)}{m},$$

which are essentially the same conditions as those characterized by (37). Thus, a solution of the labor immobility case is also a solution of the labor mobility case. The latter result, however, holds when the solution to (37) is interior, i.e., $\mu^A > 0$ and $\mu^B > 0$. Additionally, when labor is mobile, the values of μ^A and μ^B cannot be uniquely determined, only the aggregate value $\mu = \mu^A + \mu^B$. This means that even though L^A, L^B, and μ are the same in both cases, a solution in the mobility case is compatible with different combinations of μ^A and μ^B. Nevertheless, at a symmetric and interior equilibrium, which is the situation analyzed in this paper, the solutions are identical.

It follows from the previous result that when local residents are allowed to choose between productive and illegal activities, the equilibrium levels of public enforcement chosen by local governments in the cases of labor mobility and labor immobility should be the same.