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Crime, Location and the Housing Market

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Abstract

We highlight the role of commuting cost, location and housing market in crime decision. By assuming that all crimes are committed in the central business district and that criminals create both positive and negative externalities to each other, we find that high wages or large levels of police resources are a natural way to reduce crime. We also find that bigger cities experience higher levels of crime because of the fiercer competition in the housing market. Finally, we show that reducing commuting costs can also reduce crime because the resulting decrease in housing prices is lower for workers than for criminals.

Key words: Localized crime, housing market, commuting cost.

JEL Classification: J15, K42, R14.

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1 Introduction

It is well documented that there are more crime in big than in small cities (Glaeser and Sacerdote, 1999). For example, the rate of violent crime in cities with more than 250,000 population is 346 per 100,000 inhabitants whereas in cities with less than 10,000 inhabitants, the rate of violent crime is just 176 per 100,000 (Glaeser, 1998). Similar figures can be found for property crimes or other less violent crimes. It is also well documented that, within cities, crime is highly concentrated in a limited number of areas. For instance, South and Crowder (1997, Table 2) have shown that U.S. central cities have higher crime and unemployment rates, higher population densities and larger relative black populations than their corresponding suburban rings.

To our knowledge, three types of theoretical models have integrated space and location in crime behavior. First, *social interaction* models that state that individual behavior depends not only on the individual incentives but also on the behavior of the peers and the neighbors are a natural way to explain the concentration of crime by area. An individual is more likely to commit crime if his or her peers commit than if they do not commit crime (Glaeser et al., 1996; Calvó-Armengol and Zenou, 2004; Ballester et al., 2004; Calvó-Armengol et al., 2005). This explanation is backed up by several empirical studies that show that indeed neighbors matter in explaining crime behaviors. Case and Katz (1991), using the 1989 NBER survey of young living in low-income, inner-city Boston neighborhoods, found that residence in a neighborhood in which many other youths are involved in crime is associated with an increase in an individual's probability of committing crime. Exploiting a natural experience (i.e. the Moving to Opportunity experiment that has assigned a total of 614 families living in high-poverty Baltimore neighborhoods into richer neighborhoods), Ludwig et al. (2001) and Kling et al. (2005) found that the behavior or characteristics of neighbors strongly influence juvenile criminal activity. Also, Calvó-Armengol et al. (2005) test whether the position and the centrality of each delinquent in a network of teenager friends has an impact on crime effort. They show that, after controlling for observable individual characteristics and unobservable network specific factors, the individual's position in a network is a key determinant of his/her level of criminal activity.

Second, Freeman et al. (1996) provide a theoretical model that explains why criminals are concentrated in some areas of the city (ghettos) and why they tend to commit crimes in their own local areas and not in rich neighborhoods. Their explanation is based on the fact that, when criminals are numerous in an area, the probability to be caught is low so that criminals create a positive externality for each other. In this context, *criminals concentrate their effort in (poor) neighborhoods where the probability to be caught is small.* This explanation has also strong empirical support. See e.g. O'Sullivan (2000).

Finally, Verdier and Zenou (2004) show that prejudices and *distance to jobs* (legal activities) can explain crime activities, especially among blacks. If everybody believes that blacks are more criminal than whites -even if there is no basis for this- then blacks are offered lower wages and, as a result, locate further away from jobs. Distant residence increases even more the black-white wage gap because of more tiredness and higher commuting costs. Blacks have thus a lower opportunity cost of committing crime and become indeed more criminal than whites. Using 206 census tracts in city of Atlanta and Dekalb county and a state-of-the-art job accessibility measure, Ihlanfeldt (2001, 2002) demonstrates that modest improvements in the job accessibility of male youth, in particular blacks, cause marked reductions in crime, especially within category of drug-abuse violations. He found an elasticity of 0.361, which implies that 20 additional jobs will decrease the neighborhood's density of drug crime by 3.61%.[1]

In this paper, we propose an alternative but complementary explanation of the link between crime and location by highlighting the role of the housing market. In our model, jobs and crime are localized since all crimes are assumed to be committed in the Central Business District (CBD) where all jobs are located. This implies that all individuals commute to the CBD either to commit crime or to work (the two activities are mutually exclusive). As a result, the decision to commit crime depends on the commuting cost, the housing price, but also on the number of criminals in the city. Indeed, there are two types of externalities that criminals create for each other: a negative one since the higher the number of criminals the lower is the return per criminal (the more that other thieves operate in the CBD, the less that remains for a particular thief) but the lower is the probability to be caught (holding police resources constant, the greater the number of criminals operating in the CBD, the smaller the chance that any one will be caught).[2]

We first characterize the different equilibria. Not surprisingly, we found

[1] For a more detailed survey on the spatial aspects of crime, see Zenou (2003).

[2] These two externalities are also present in Freeman et al. (1996). However, their focus is totally different since they compare two different neighborhoods in which the housing market is absent whereas here we focus on one neighborhood by highlighting the role of the housing market in the crime decision.

that if the wage is large enough, then there is no crime in this city whereas if it is small enough, then everybody has the incentive of becoming a criminal. However, for intermediate values of the wage, there is some positive level of crime in the city and the criminals live far away from jobs while the workers reside close to the CBD. We then focus on this last regime and we show that in bigger cities there is more crime and increasing police resources reduces crime. We also show that, when the access to the CBD becomes more difficult, i.e. the commuting cost increases, housing prices rise but this increase is even more pronounced for workers than for criminals because the former live closer to jobs than the latter. Consequently, since workers lose relatively more than criminals, an increase in commuting costs implies that it becomes less costly to be a criminal, and, as a result, the number of criminals in the city increases.

2 The model

Consider a city that is represented by a line whose origin is taken to be zero. The Central Business District (CBD hereafter) where all jobs and shops are located is precisely at zero. Any location outside the CBD is denoted by x, which is in fact the distance to the CBD. Landlords are absent and the city is closed.

There are two types of individuals: workers and criminals and there is a continuum of each type (for simplicity the density of individuals at each location is equal to 1). The total mass of individuals in the city is N. We assume that workers and criminals are risk neutral. Each individual simultaneously chooses to locate in the city and to work or commit crime. The two activities (working and committing crime) are mutually exclusive so that a criminal cannot work and a worker cannot be a criminal. There are n criminals and thus $N - n$ workers residing in the city. As a result, the size of the city is given by N. In this model, N is given whereas n will be determined in equilibrium.

The crime is localized in that all crimes are committed in the CBD. So, the type of crime we have in mind is theft (e.g. shop lifting), robbery (not properties but rather shops), assault, damage/vandalism ... The idea is that a criminal living in x commutes to the CBD to commit a crime. Let us denote by t the commuting cost per unit of distance. A worker (thus not a criminal) living in x who commutes every day to work bears a commuting cost equals to tx (we have thus normalized to 1 the number of return trips that a worker do; for example if the unit is the week, then this normalization corresponds to five return trips every week). A criminal, who does not work, goes to the CBD only to commit crime (and may shop at the same time). Let us denote by $0 < \alpha < 1$ the fraction of commuting that is devoted to criminal activities so that a criminal residing in x has a commuting cost that amounts to $\alpha t x$. This implies that α is the (exogenous) percentage of crime that each criminal commit. For example, $\alpha = 1/5$ means that the criminals make only one fifth as many CBD trips as the workers. If the unit is the week, this means the criminal goes once a week to the CBD and thus commit one crime per week. Observe that we assume that $0 < \alpha < 1$, which means that, when someone decide to be a criminal, he always go to the CBD to commit a crime (if α is very small, then they go rarely to the CBD and thus seldom commit a crime) and criminals always commute less than workers (i.e. nobody is committing a crime everyday). Observe also that α is exogenous and assumed to be the same for all criminals. Obviously α could be a choice variable and could differ for individuals with different locations. For simplicity and tractability, we keep α as exogenous.

The fact that crime is localized in the CBD (individuals do not commit crime at their own location) has two main consequences. First, *the booty each criminal obtains depends on the number of criminals residing in the city and the number of crime committed.* Indeed, the first effect is because, when there are more criminals operating in the CBD, the less that remains for a particular criminal (think for example of thieves where more thieves implies that there is less to steal for a particular thief) so that the return per criminal must eventually fall. As a result, the booty per criminal $b(n, \alpha)$ is a decreasing function of n and obviously an increasing function of α (the more a criminal commits crime the higher the booty), i.e.

$$\frac{\partial b(n,\alpha)}{\partial n} < 0 \text{ and } \frac{\partial b(n,a)}{\partial \alpha} > 0$$

This means that there is some congestion of criminal activities. We also assume that

$$\frac{\partial^2 b(n,\alpha)}{\partial n^2} \leq 0$$

so that the booty decreases at a decreasing rate.

Second, *the probability of arrest is a function of the police resources, the number of criminals in the city and the number of crime committed.* If m denotes the police resources in the city, then the probability of arrest for a criminal is given by: $p(m, n, \alpha)$, with

$$\frac{\partial p(m,n,\alpha)}{\partial m} > 0 \text{ , } \frac{\partial p(m,n,\alpha)}{\partial n} < 0 \text{ and } \frac{\partial p(m,n,\alpha)}{\partial \alpha} > 0$$

Indeed, the more police resources is allocated to the city, the higher is the probability to arrest a criminal. However, the higher is the number of criminals in the city, the lower is this probability (see e.g. Greenwood et al., 1977, for empirical evidence on this negative relationship). Finally, the higher the number of crime committed, the higher is the probability to be caught. We assume that, whatever the values of m, n, and α, $0 < p(m,n) < 1$. We further assume that

$$\frac{\partial^2 p(m,n)}{\partial n^2} \geq 0$$

which means that this probability increases at an increasing rate.

Let us describe the behavior of workers. Each worker consumes one unit of land and a composite good z, and his utility is given by $V^{NC} = z$. Moreover, he earns a wage w but commutes to the CBD and pays a (land) rent equals to $R(x)$ when living at x. His budget constraint is thus given by:

$$z = w - tx - R(x)$$

As a result, the utility of a worker located at x is equal to:

$$V^{NC} = w - tx - R(x) \tag{1}$$

Similarly, the utility of a criminal located at x is given by:

$$V^{C} = [1 - p(m,n,\alpha)]\,[b(n,\alpha) - \alpha tx - R(x)] \tag{2}$$

In (2), one can see that if a criminal is caught, then he goes to jail and loses his booty but of course does not pay anymore commuting costs and a land rent.

We are now able to write the bid rents of workers and criminals in the city[3]. For workers, using (1), we have:

$$\Psi^{NC}(x, V^{NC}) = w - tx - V^{NC} \tag{3}$$

whereas, for criminals, using (2), we have:

$$\Psi^{C}(x, V^{C}) = b(n,\alpha) - \alpha tx - \frac{V^{NC}}{1 - p(m,n,\alpha)} \tag{4}$$

[3] The bid rent is a standard concept in urban economics. It indicates the maximum land rent that each individual located at a distance x from the CBD is ready to pay in order to achieve his utility level.

3 Choosing location and crime/work

As stated above, individuals choose simultaneously location and crime/work. Therefore, we first solve the *residential equilibrium* (i.e. we determine the exact location of all individuals in the city, their land rents and utilities) treating n the number of criminals as a parameter. We then focus on *crime and work decisions* by assuming that the city structure corresponds to that unique urban configuration.

3.1 Choosing location: the land-use urban equilibrium

For a given choice of occupational activity (crime or work), each individual chooses the location in the city that maximizes his utility subject to the corresponding budget constraint.

Let us now introduce the definition of a residential equilibrium. In fact, in equilibrium, three different regimes can arise depending on the number of criminals n in the city: there is either *a crime-free regime* ($n = 0$, regime 1), *a partial-crime regime* ($0 < n < N$, regime 2) or a *total-crime regime* ($n = N$, regime 3). Let us now present the definitions and characterizations of the unique urban equilibrium in each one of the different regimes.[4] For simplicity, the land rent outside the city is normalized to zero.

Definition 1 *A residential equilibrium with* **no crime** *(regime 1) is a vector* $(R_1(x), V_1^{NC})$ *such that:*

$$R_1(x) = \max\left\{\Psi_1^{NC}(x, V_1^{NC}), 0\right\} \quad \text{at each } x \in [0, N] \tag{5}$$

$$\Psi_1^{NC}(N, V_1^{NC}) = 0 \tag{6}$$

Equation (5) says that (absentee) landlords allocate land to the highest bids in the city. Equation (6) reflects the equilibrium conditions in the land market that ensure that, at the city fringe, the land rent is equal to the opportunity cost of land outside the city (i.e. zero). Solving (5)-(6) yields:

$$V_1^{NC} = w - tN \tag{7}$$

and

$$R_1^*(x) = \begin{cases} -tx + tN & \text{for } 0 \leq x \leq N \\ 0 & \text{for } x > N \end{cases} \tag{8}$$

[4] All variables with subscript $1, 2$ or 3 refer to regime $1, 2, 3$ respectively.

Definition 2 *A residential equilibrium with* ***total crime*** *(regime 3) is a vector* $(R_3(x), V_3^C)$ *such that:*

$$R_3(x) = \max\left\{\Psi_3^C(x, V_3^C), 0\right\} \quad \text{at each } x \in [0, N] \tag{9}$$

$$\Psi_3^{NC}(N, V_3^C) = 0 \tag{10}$$

The interpretation of (9) and (10) are exactly the same as (5) and (6). Solving (9) and (10), we obtain:[5]

$$V_3^C = [1 - p(m, N, \alpha)]\,[b(N) - \alpha t N] \tag{11}$$

and

$$R_3^*(x) = \begin{cases} -\alpha t x + \alpha t N & \text{for } 0 \leq x \leq N \\ 0 & \text{for } x > N \end{cases} \tag{12}$$

Finally, to define the regime where both criminals and workers co-exist in the same city, we first need the following result.

Proposition 1 *In regime 2, the workers reside close to the CBD whereas the criminals live at the outskirts of the city.*

Proof. It is easy to see that the bid rents (3) and (4) are both linear and decreasing in x. Moreover, since the slope of the bid rent $\Psi^{NC}(.)$ is higher than the one of $\Psi^C(.)$, then the workers bid away the criminals to the periphery. ■

This result is very intuitive. Indeed, since it is more costly for the workers to be far away from the CBD, they will have steeper bid rents and thus be able to bid away the criminals to the outskirts of the city.

Definition 3 *A residential equilibrium with* ***some crime*** *(regime 2) is a vector* $(R_2(x), V_2^{NC}, V_2^C)$ *such that:*

$$R_2(x) = \max\left\{\Psi_2^{NC}(x, V_2^{NC}), \Psi_2^C(x, V_2^C), 0\right\} \quad \text{at each } x \in [0, N] \tag{13}$$

$$\Psi_2^{NC}(N - n_2, V_2^{NC}) = \Psi_2^C(N - n_2, V_2^C) \tag{14}$$

$$\Psi_2^C(N, V_2^C) = 0 \tag{15}$$

[5] Observe that the number of criminals is equal to N.

Equation (13) says that (absentee) landlords allocate land to the highest bids in the city. Equations (14)-(15) reflect the equilibrium conditions in the land market that ensure that the land rent is continuous. Solving (14)-(15) yields:

$$V_2^C = [1 - p(m, n_2, \alpha)]\,[b(n_2, \alpha) - \alpha t N] \tag{16}$$

$$V_2^{NC} = w - tN + (1 - \alpha) t n_2 \tag{17}$$

Then, plugging (16) and (17) in (3) and (4) leads to:

$$R_2^*(x) = \begin{cases} -tx + tN - (1-\alpha)tn_2 & \text{for } 0 \leq x \leq N - n_2 \\ -\alpha tx + \alpha tN & \text{for } N - n_2 < x \leq N \\ 0 & \text{for } x > N \end{cases} \tag{18}$$

In this latter case (regime 2), it is interesting to observe that the land rent of criminals is not affected by the number of criminals n_2 whereas the one of the workers is negatively affected by n_2. This is a widely observed fact that the higher the number of criminals in an area, the lower the property price. See, for example, Gibbons (2004). Observe also that both utilities V_2^C and V_2^{NC} are affected by n_2; n_2 positively affects V_2^{NC} whereas the effect on V_2^C is ambiguous (see our discussion below). Indeed, if n_2 increases, then for a given N, this implies that the number of workers decreases (because some workers are becoming criminal) and thus they occupy less land in the central part of the city. As a result, the competition for land in the central part of the city is reduced and the land rent for workers decreases. This in turn implies that their utility level increases.

3.2 Choosing to work or to commit crime

For that, let us study V_2^C and V_2^{NC} (the general case) with respect to n_2. Let us start with the latter. We have:

$$\frac{\partial V_2^{NC}}{\partial n_2} = (1 - \alpha)t > 0 \tag{19}$$

and

$$V_2^{NC}(n_2 = 0) = w - tN > 0 \tag{20}$$

For V_2^C, we have:

$$\frac{\partial V_2^C}{\partial n_2} = -\frac{\partial p(m, n_2, \alpha)}{\partial n_2}\,[b(n_2, \alpha) - \alpha tN] + [1 - p(m, n_2, \alpha)]\,\frac{\partial b(n_2, \alpha)}{\partial n_2} = 0 \tag{21}$$

$$\frac{\partial^2 V_2^C}{\partial n_2^2} = -\frac{\partial^2 p(m,n_2,\alpha)}{\partial n_2^2}\left[b(n_2,\alpha) - \alpha t N\right] \tag{22}$$

$$-2\frac{\partial p(m,n_2,\alpha)}{\partial n_2}\frac{\partial b(n_2,\alpha)}{\partial n_2} + \left[1 - p(m,n_2,\alpha)\right]\frac{\partial^2 b(n_2,\alpha)}{\partial n_2^2} < 0$$

and

$$V_2^C(n_2 = 0) \equiv V_0^C = (1 - p_0)(b_0 - \alpha t N) > 0 \tag{23}$$

where $p_0 \equiv p(m,0,\alpha) > 0$ and $b_0 \equiv b(0,\alpha) > 0$. We further denote by $\underline{p}$ and $\underline{b}$ the minimum values of $p(m,n,\alpha)$ and $b(n,\alpha)$ respectively, i.e. $\underline{p} \equiv p(m,N,\alpha) > 0$ and $\underline{b} \equiv b(N,\alpha) > 0$. Finally, we denote by n^* the solution of (21) and by V^{C*} the corresponding utility, i.e. $V^{C*} \equiv V_2^C(n_2 = n^*)$.

Using (21)-(23), it is easy to see that, starting at a positive value V_0^C, V_2^C increases up to n^* where it reaches its maximum, and then decreases (see for example Figure 1). The intuition of this is quite easy. As stated above there are two effects. When the number of criminals increases, the probability to be caught decreases (first effect) but the booty is reduced (second effect). So when the number of criminals is quite low, increasing n_2 implies that the first effect dominates the second one (this is partly due to the assumptions $\partial^2 b(n,\alpha)/\partial n^2 \leq 0$ and $\partial^2 p(m,n,\alpha)/\partial n^2 \geq 0$). However, when the number of criminals is already quite large, i.e. $n_2 > n^*$, then the second effect dominates the first one.

[*Insert Figure* 1 *here*]

4 The equilibrium

We are now able to characterize the different regimes (Figures 1, 2, 3 and 4 give some examples). Define the following condition:

$$(1-\alpha)t > -\frac{\partial p(m,n_2,\alpha)}{\partial n_2}\mid_{n_2=0}\left[b_0 - \alpha t N\right] + (1-p_0)\frac{\partial b(n_2,\alpha)}{n_2}\mid_{n_2=0} > 0 \tag{24}$$

Then, we have:

Proposition 2

(*i*) *If the wage w is sufficiently large, i.e. $w > tN + V^{C*}$ or if the wage has intermediate value, $tN + V_0^C < w < tN + V^{C*}$, and (24) holds, then in equilibrium there is no crime (regime 1) in the city, $n_1^e = 0$. All workers enjoy the same utility level $V_1^{NC} = w - tN$ and the land rent in the city is given by (8).*

(ii) If the wage has intermediate value, $tN + V_0^C < w < tN + V^{C*}$ *and (24) does not hold, or if the wage is quite small,* $w < tN + V_0^C$*, then there is either some crime or total crime in the city. More precisely,*

(iia) If there is some crime (regime 2) in the city, the equilibrium crime level n_2^e *is given by:*

$$w = tN - (1-\alpha)tn_2^e + [1 - p(m, n_2^e, \alpha)]\,[b(n_2^e, \alpha) - \alpha tN] \qquad (25)$$

and this solution is such that $n^* \leq n_2^e < N$*. All criminals have a utility level given by (16) whereas all workers enjoy a utility level equal to (17). The land rent in the city is given by (18).*

(iib) If there is total crime (regime 3) in the city, the equilibrium crime level is $n_3^e = N$*. All criminals enjoy the same utility level (11) and the land rent in the city is given by (12).*

Proof. See the Appendix.

$$[Insert\ Figures\ 2, 3, 4\ here]$$

The following comments are in order. First, we have here the intuitive result that labor market opportunities play a major role in explaining crime behaviors. Indeed, if the wage w is large enough, i.e. $w > tN + V^{C*}$ (V^{C*} does not depend on w), then there is no crime in this city (Figure 1). On the contrary, if the wage w is small enough, i.e. $w << tN + V_0^C$ (V_0^C does not depend on w), then everybody has the incentive of becoming a criminal (Figure 2). Second, it is interesting to observe that, because of the competition in the land market, then even if the wage has intermediate value, we can end up with either a crime-free equilibrium or a total-crime equilibrium. However, here the different effects are difficult to disentangle and, in order to better understand them, we perform a comparative-statics analysis for the most realistic case, that is when some positive amount of crime exists in equilibrium (regime 2).

Proposition 3 *Consider only regime 2 in which the equilibrium number of criminals* n_2^e *is defined by (25), where* $n^* \leq n_2^e < N$*. Then to reduce crime, one must can increase the police resources* m*, and/or the wage* w *in the city, and/or reduce the commuting cost* t*. Moreover, bigger cities (i.e. higher population* N*) tend to have more crime. Finally, the effect of the number of crime per criminal on the number of criminals is ambiguous.*

Proof. See the Appendix.

We have first some standard results that have already be shown in the crime literature (see e.g. the survey of Garoupa, 1997). Indeed, not surprisingly, more police resources and/or more labor market opportunities (i.e. higher wages) do reduce crime in the city. One of the most interesting results is however the effect of t on n_2^e. For a given crime level n_2, when commuting costs t increase, both the utility of a non-criminal ($\partial V_2^{NC}/\partial t = -N + (1-\alpha)n_2 < 0$) and of a criminal decrease ($\partial V_2^C/\partial t = -(1-p(m,n_2,\alpha))\alpha n_2 < 0$) because land prices become higher everywhere in the city (competition in the land market increases since the access to the CBD becomes more costly; see (18)). However, because the first effect is stronger than the second one, i.e.[6]

$$\left|\frac{\partial V_2^{NC}}{\partial t}\right| = N - (1-\alpha)n_2 > (1-p(m,n_2,\alpha))\alpha n_2 = \left|\frac{\partial V_2^C}{\partial t}\right| \tag{26}$$

the net effect is positive. In other words, when t increases, the negative effect on land rents (i.e. the increase in housing prices) is stronger for workers than for criminals because the former reside close to the CBD for which the access becomes more costly. As a result, since in terms of utility workers lose relatively more than criminals (see (26)), it becomes less costly to be a criminal, and, as a result, the number of criminals n_2^e in the city increases.

This is an interesting and new effect since access to the CBD can play an important role in explaining criminal behaviors (access to the CBD is important for both workers and criminals because the former work there while the latter commit their crime there). Indeed, a high value of t, which means that it is very costly to commute (for example because the transportation system is very bad), increase crime in the CBD because it becomes relatively more costly to be a worker than a criminal.

This result is at odds to what has sometimes been advocated in the U.S. Indeed, some people believe that a policy that makes difficult the access to certain areas (like for example to refuse to build a new transportation system that links black inner cities to white rich suburbs) will reduce the crime level in these areas (the suburbs). Our model says that this type of policy[7] will in fact have some impact on the housing market by increasing the price in the rich area and, as a result, can induce some individuals to become criminal. However,

[6] See the proof of Proposition 3 in the Appendix.

[7] Observe that our model can also address the fact that "the heart" of the city is in the suburbs. It suffices to flip our city over so that the CBD becomes the Suburban Business District.

this results strongly depends on our assumption that crime is localized in the CBD (or here the Suburban Business District). If, on the contrary, individuals could also commit their crime where they live, then increasing commuting cost by making the access to the SBD more difficult, will certainly reduce the crime in the suburbs but increase it in inner cities.

Let us now study the effect of α, the number of crime per criminal, on n_2^e. For a given crime level n_2, when α increases, the utility of a non-criminal decreases ($\partial V_2^{NC}/\partial\alpha = -tn_2 < 0$) but the one of a criminal can decrease or increase, i.e.

$$\frac{\partial V_2^C}{\partial \alpha} = -\frac{\partial p(m, n_2, \alpha)}{\partial \alpha}\left[b(n_2, \alpha) - \alpha t N\right] + \left[1 - p(m, n_2, \alpha)\right]\left[\frac{\partial b(n_2, \alpha)}{\partial \alpha} - tN\right] \gtrless 0$$

because it is more costly to commit crime (i.e. more commuting) and the probability to be caught is higher but the booty is greater. Consequently, the net effect is ambiguous.

Finally, when N the size of the city and thus of the population increases, the price of land increases everywhere in the city (see (18)), but the increase is higher for a worker ($\partial R_2/\partial N = t > 0$) than for a criminal ($\partial R_2/\partial N = \alpha t > 0$). As a result, the relative utility of being criminal is higher so that more people become criminal.

5 Conclusion

This paper focuses on the role of commuting costs, location and housing prices in crime behaviors in cities. Jobs and crime are localized since all crimes are assumed to be committed in the Central Business District (CBD) where all jobs are located. Therefore, the decision to commit crime depends on the commuting cost, the housing price, but also on the number of criminals in the city (more criminals implies that the return per criminal is smaller but that the probability to be caught is lower). We first characterize the different equilibria. Not surprisingly, we found that if the wage is large enough, then there is no crime in this city whereas if it is small enough, then everybody has the incentive of becoming a criminal. However, for intermediate values of the wage, there is some positive level of crime in the city and the criminals live far away from jobs while the workers reside close to the CBD. We then focus on this last regime and we show that in bigger cities there is more crime and increasing police resources reduces crime. We also show that, when the access to the CBD becomes more difficult, i.e. the commuting cost increases, housing prices rise but this increase is even more pronounced for workers than for criminals because the former live closer to jobs than the latter. Consequently, since workers lose relatively more than criminals, an increase in commuting costs implies that it becomes less costly to be a criminal, and, as a result, the number of criminals in the city increases.

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Appendix

Proof of Proposition 2

There are three possible regimes in this economy. Either: (*i*) regime 1: there is no crime at all, or (*iia*) regime 2: there a positive amount of crime, or (*iib*) regime 3: there is total crime (everybody is a criminal). We want to characterize these three regimes and the resulting equilibria by varying the wage w.

1. $w \geq tN + V^{C*}$. This is the highest value the wage can take since it implies that

$$V_1^{NC}(n_1 = 0) = w - tN > V^{C*}$$

where V^{C*} is the highest utility a criminal can reach and $w - tN$ is the utility of workers when there is no criminal. In this case, it should be clear that there will be no crime in the city (regime 1) since $w - tN > V^{C*}$ guarantees that no worker wants to become a criminal. Thus,

$$n_1^e = 0$$

where n_1^e denotes the equilibrium value of criminals in regime 1. Observe that does not depend on w so that if w is sufficiently large, then there is no crime in the city.

2. $V_0^C < w - tN < V^{C*}$. Then, five cases can arise. Either (a) the V^{NC} line and the V^C curve doe not intersect at all, or (b) they intersect once but the corresponding n is less than n^*, or (c) they intersect twice, and the two corresponding n are less than n^*, or (d) they intersect twice, one n is less than n^* and one is greater than n^* but less than N, or (e) they intersect twice, one n is less than n^* and one is greater than N (and thus greater than n^*).

Observe that, any intersection that leads to an n that is less than n^* is not an equilibrium (like e.g. point A in Figure 4). Indeed, if $n < n^*$, then this intersection point is located in the upward sloping part of the V^C curve, i.e. where the return to crime is increasing in the number of criminals. Consequently, a worker could make himself better off by turning to criminal and thus the number of criminals should increase. So we can eliminate cases (b) and (c) since they are not equilibria.

Case (a)**.** To obtain case (a), it must be that the slope of the V^{NC} line at zero is higher than the slope of the V^C curve at zero, i.e. (24).

In this case, there is no crime in the city (regime 1) since working yields a higher utility level than committing crime, whatever the level of crime. We have:

$$n_1^e = 0$$

For the two next cases, it must be that (24) does not hold.

Case (d)**.** The only equilibrium is when the intersection occurs for $n^* \leq n < N$. There is thus a positive amount of crime in equilibrium (regime 2). To have a positive level of crime, it must be that:

$$V_2^C(n = n_2) = V_2^{NC}(n = n_2)$$

where V^C and V^{NC} are given by (16) and (17). This equation says that the last individual to commit crime will be exactly indifferent between being criminal and non-criminal. The solution of this equation is given by:

$$w - tN + (1-\alpha)tn_2^e = [1 - p(m, n_2^e, \alpha)] [b(n_2^e, \alpha) - \alpha tN]$$

where n_2^e denotes the equilibrium value of criminals in regime 2. We know that there is a unique solution in n_2^e to this equation (see e.g. Figure 2). We have to impose that the solution n_2^e of this equation is such that

$$n^* \leq n_2^e < N$$

Case (e)**.** The only equilibrium is when the intersection occurs for $n \geq N$. In this case, obviously, everybody chooses to be a criminal (regime 3) since the curve V^C is always above the V^{NC} line. As a result

$$n_3^e = N$$

3. $w - tN < V_0^C$. There can only be one intersection between the V^{NC} line and the V^C curve. Three cases may arise. Either (a) the intersection occurs for $n < n^*$, or (b) the intersection occurs for $n^* \leq n < N$, or (c) the intersection occurs for $n \geq N$.

As above, we can eliminate case (a) since this is not an equilibrium.

Case (b)**.** This is exactly like case **2.**(d) above (regime 2). The number of criminal n_2^e is thus given by:

$$w - tN + (1-\alpha)tn_2^e = [1 - p(m, n_2^e, \alpha)] [b(n_2^e, \alpha) - \alpha tN]$$

and it is such that

$$n^* \leq n_2^e < N$$

Case (c)**.** This is exactly like case **2.**(e) above (regime 3). As a result

$$n_3^e = N$$

Proposition 2 summarizes these results by focusing on the three regimes.

■

Proof of Proposition 3

•By totally differentiating (25), we obtain:

$$\frac{\partial n_2^e}{\partial m} = \frac{\partial p(m, n_2^e, \alpha)}{\partial m} \frac{[b(n_2^e, \alpha) - \alpha t N]}{D}$$

where

$$D \equiv -(1-\alpha)t - \frac{\partial p(m, n_2^e, \alpha)}{\partial n_2^e} [b(n_2^e, \alpha) - \alpha t N] + [1 - p(m, n_2^e, \alpha)] \frac{\partial b(n_2^e, \alpha)}{\partial n_2^e}$$

Observe that, at $n = n^*$ (see (21)),

$$-\frac{\partial p(m, n, \alpha)}{\partial n} [b(n, \alpha) - \alpha t N] + [1 - p(m, n, \alpha)] \frac{\partial b(n, \alpha)}{\partial n} = 0$$

Since $n_2^e > n^*$ and the second order condition (22) is negative, it has to be that

$$-\frac{\partial p(m, n, \alpha)}{\partial n} [b(n, \alpha) - \alpha t N] + [1 - p(m, n, \alpha)] \frac{\partial b(n, \alpha)}{\partial n} < 0$$

As a result $D < 0$. Now since $\partial p(m, n_2^e, \alpha)/\partial m > 0$, we have

$$\frac{\partial n_2^e}{\partial m} < 0$$

•By totally differentiating (25), we obtain:

$$\frac{\partial n_2^e}{\partial w} = -\frac{-1}{D} < 0$$

•By totally differentiating (25), we obtain:

$$\frac{\partial n_2^e}{\partial t} = -\frac{N - (1-\alpha)n_2^e - [1 - p(m, n_2^e, \alpha)]\, \alpha N}{D}$$

Observe that

$$N - (1-\alpha)n_2^e - [1 - p(m, n_2^e, \alpha)]\, \alpha N = N\left[1 - (1 - p(m, n_2^e, \alpha))\, \alpha\right] - (1-\alpha)n_2^e$$

It is easy to see that

$$N\left[1-(1-p(m,n_2^e,\alpha)\alpha)\right]>(1-\alpha)n_2^e$$

since it is equivalent to

$$\frac{N}{n_2^e}>\frac{(1-\alpha)}{1-(1-p(m,n_2^e,\alpha))\,\alpha}$$

which is always true. Indeed, we know that $N>n_2^e$, which implies that $N/n_2^e>1$ and $1-\alpha<1-(1-p(m,n_2^e,\alpha))\,\alpha$ is equivalent to $1-p(m,n_2^e,\alpha)<1$, which is obviously true and implies that $(1-\alpha)/\left[1-(1-p(m,n_2^e,\alpha))\,\alpha\right]<1$. Therefore,

$$\frac{\partial n_2^e}{\partial t}>0$$

•By totally differentiating (25), we obtain:

$$\frac{\partial n_2^e}{\partial \alpha}=-\frac{1}{D}\left\{tn_2^e-\frac{\partial p(m,n_2^e,\alpha)}{\partial \alpha}\left[b(n_2^e,\alpha)-\alpha tN\right]+\left[1-p(m,n_2^e,\alpha)\right]\left[\frac{\partial b(n_2^e,\alpha)}{\partial \alpha}-tN\right]\right\}$$

which cannot be signed.

•By totally differentiating (25), we obtain:

$$\frac{\partial n_2^e}{\partial N}=-\frac{t-\left[1-p(m,n_2^e,\alpha)\right]\alpha t}{D}>0$$

since $\left[1-p(m,n_2^e,\alpha)\right]\alpha<1$. ■

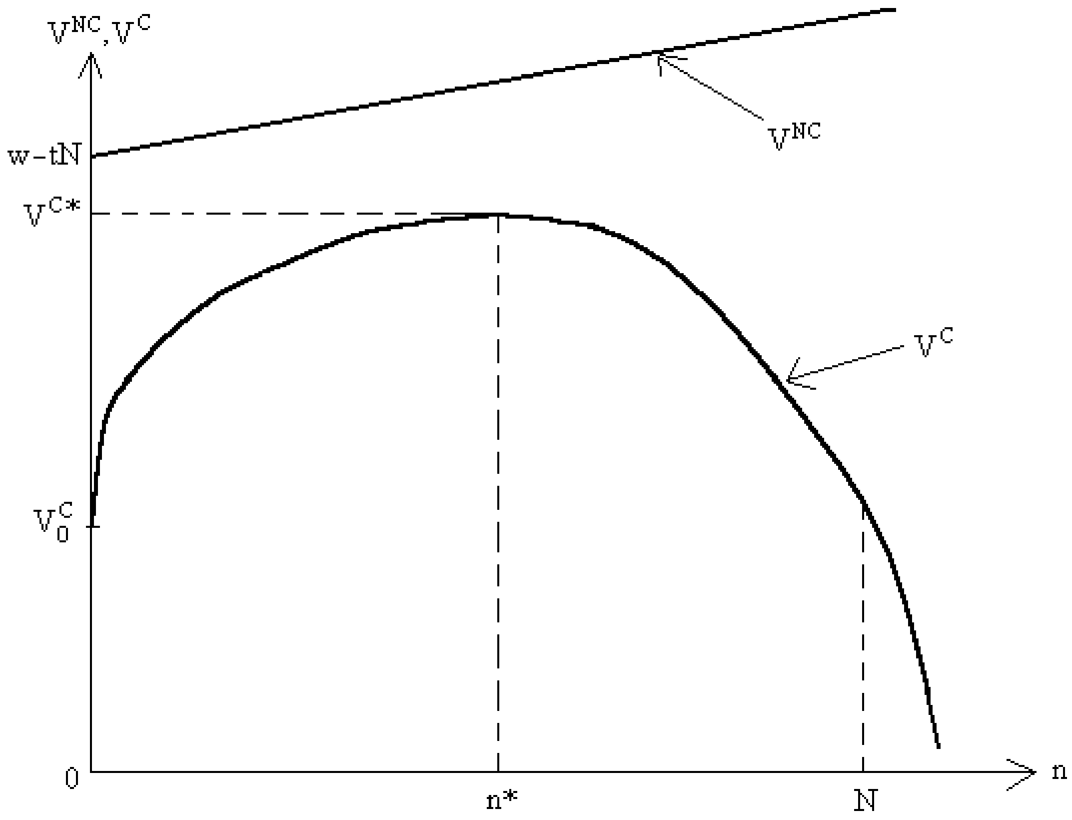

Figure 1: Crime-Free Equilibrium

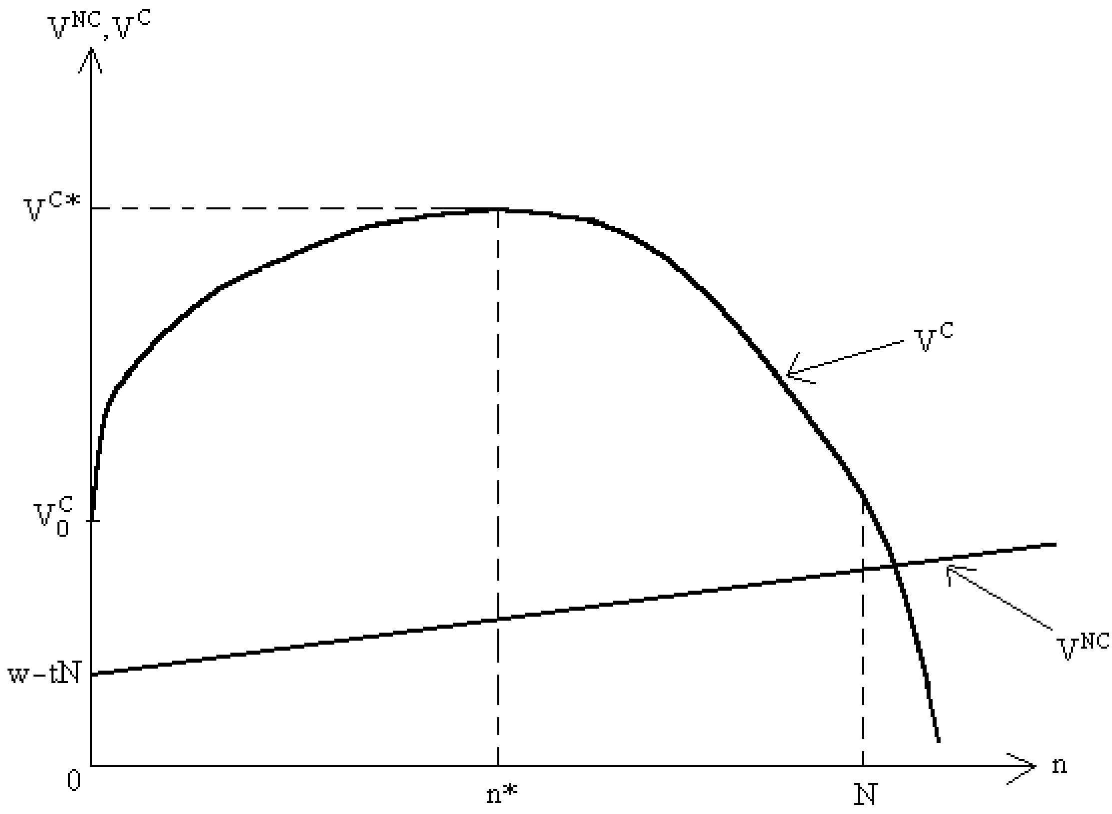

Figure 2: Total - Crime Equilibrium

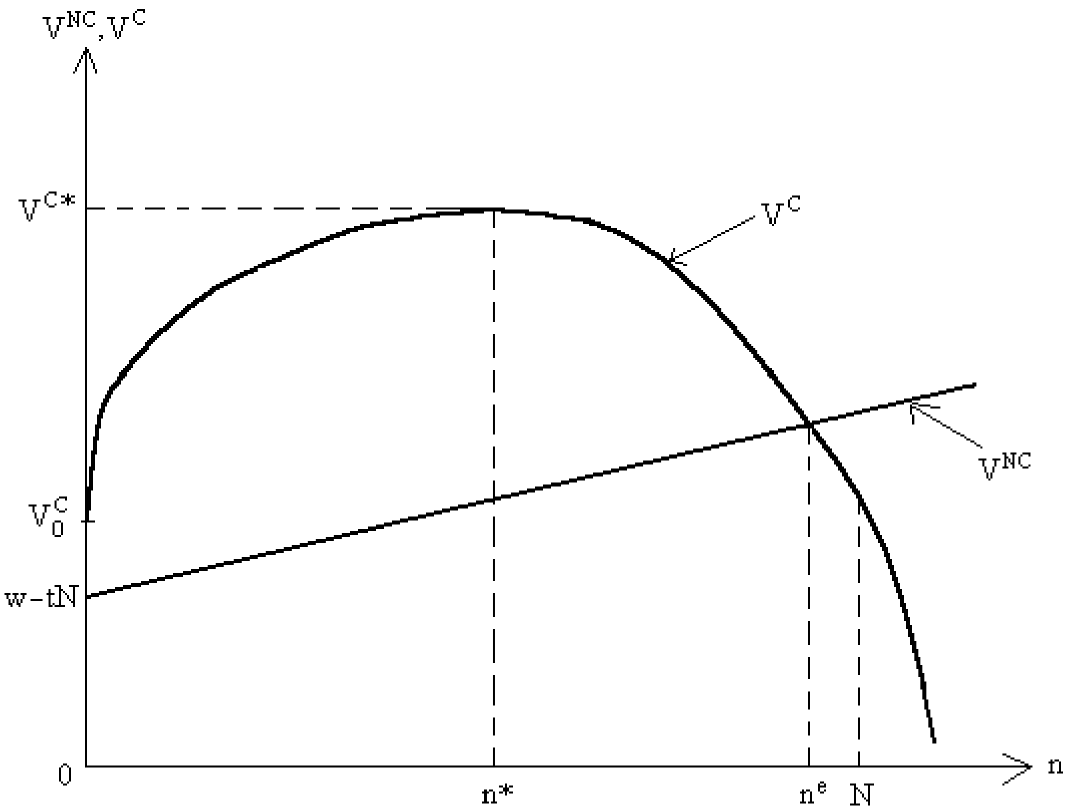

Figure 3: Crime-Ridden Equilibrium

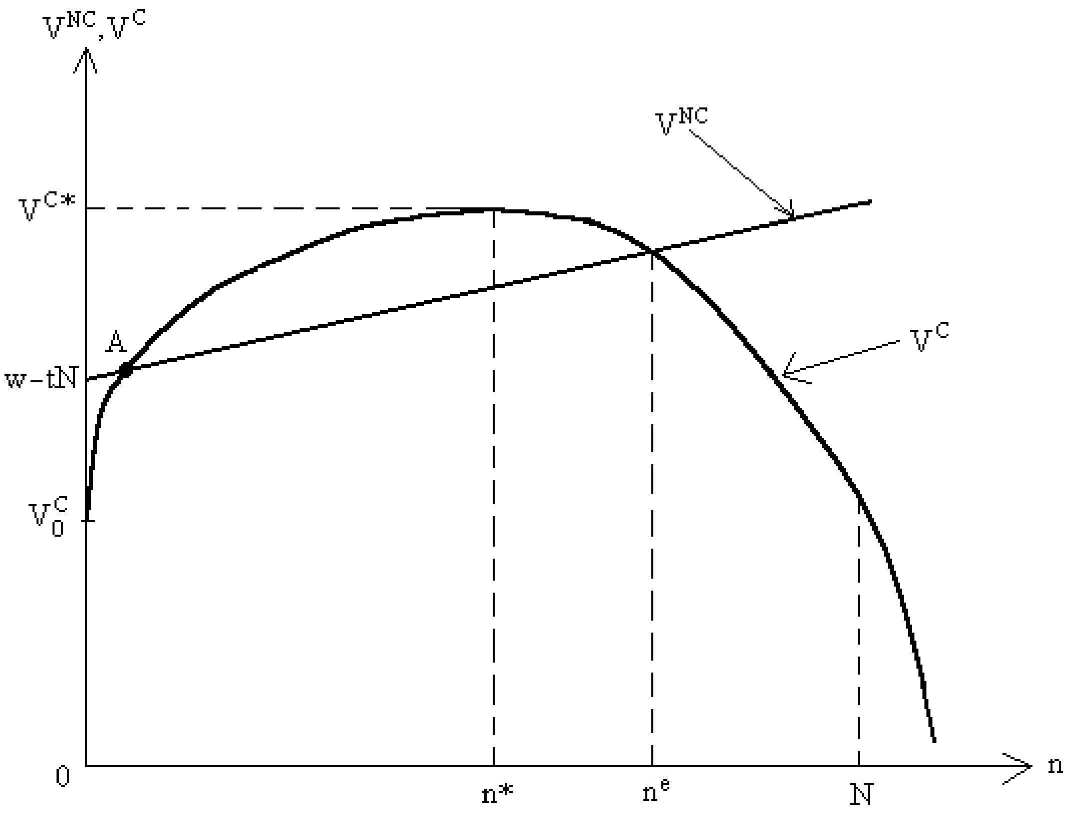

Figure 4: Equilibrium with some Crime