Universidade de Brasília
Departamento de Economia

Série Textos para Discussão

Violence in the Capital of Brazil: An Analysis Based on the Economic Model of Crime

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Texto nº 295
Brasília, junho de 2003

Department of Economics Working Paper 295
University of Brasilia, June 2003

UNIVERSIDADE DE BRASÍLIA
DEPARTAMENTO DE ECONOMIA

TEXTO PARA DISCUSSÃO Nº 295

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Violence in the Capital of Brazil: An Analysis based on the Economic Model of Crime

André Luís Rossi de Oliveira[1]

This paper tries to identify economic and social variables that explain the occurrence of violent crimes in the Federal District of Brazil since the early 1980's. In order to do that, it uses data on deaths by homicide provided by SIM (System of Information about Mortality) under a database made available by DATASUS, a system of information about health and healthcare in Brazil, and data on economic and social variables taken from the Distrito Federal Annual Report. Some of these variables are real GDP per capita, employment index, real minimum wage and police force. Another important variable present in the model estimated is the number of land tracts sold or donated by the Government of the Federal District, and its inclusion serves the purpose of checking if there is any relationship between the increase of violent crimes and the increase in the availability of land.

The economic model of crime is based on the model presented in Becker [1968], which can be considered the seminal contribution to the field. The model states that the decisions by individuals to commit or not commit crimes depends on their assessments between the relative financial and psychological benefits and costs associated to legal and illegal activities. In this paper, the economic model of crime, with the inclusion of the land supply variable, is tested for violent crimes in the Federal District of Brazil and an initial effort is made to explain the life cycle of the homicide rate from the evolution of the effects of the economic and social variables for different ages.

I. Introduction

Crime is certainly a very complex phenomenon and should be studied under the light of several different areas, including Sociology, Psychology, Political Science, Biology and, of course, Economics. This paper, however, does not intend to borrow contributions from all those fields in order to provide a comprehensive analysis of crime. It has a much more limited scope, namely to use data on homicides available for the capital of Brazil and its surrounding cities, known as the Federal District, to test the validity of the economic model of crime.

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The economic theory of crime is based on the model presented in Becker [1968], the seminal contribution to the field, which was later developed by Ehrlich [1973]. Block and Heineke [1975] and Fender [1999], among others. The model states that the decisions by individuals to commit or not commit crimes depends on their assessments between the relative financial and psychological benefits and costs associated to legal and illegal activities.

In order to test that model, the paper estimates a regression model where the homicide rate is the dependent variable and the explanatory variables are the real GDP per capital of the Federal District, the real minimum wage, the size of the police force, an employment index and the supply of land tracts by the government. The inclusion of the latter variable is justified by the need to assess whether or not a policy of distributing such tracts, which has been common in the Federal District, has the potential of increasing crime offenses, more specifically homicides. Also, an effort is made to explain the life cycle of the homicide rate from the evolution of the effects of the economic and social variables for different ages.

There are many papers in the literature that apply the economic model of crime to Brazilian data, but none to this particular data set. Andrade and Lisboa [2000], for instance, study the male homicide rate and its relation to economic variables in the states of Minas Gerais, São Paulo and Rio de Janeiro between 1981 and 1997. The novelty of their approach is the construction of homicide rates specific for each age between 15 and 40 years old, an approach also pursued in this paper. Araújo Júnior and Fajnzylber [2001], on the other hand, are concerned about economic and demographic variables that influence the homicide rates in all states of the Brazilian Federation from 1981 to 1996. Given the longitudinal nature of their sample, they are able to run panel data regressions that take advantage of state, period and cohort specific effects.

The paper is organized as follows. Section II describes very briefly Becker's economic model of crime. Section III describes the data set while section IV presents the estimation results. Section V discusses the main results and section VI concludes.

II. The economic model of crime

One of the first authors to analyze the importance of economic factors in the determination of crime rates was Fleisher [1963]. His work provides empirical evidence

of the relationship between rates of juvenile delinquency in Boston, Cincinnati and Chicago and unemployment rates among youngsters.

Despite Fleisher's ground-breaking work, the most prominent paper on the Economics of crime is Becker [1968]. Becker offers a microeconomic model to study the social policy that should be pursued in order to minimize the social loss from crime. He starts out by identifying the various types of costs associated to committing a crime. First, there is the damage to society resulting from crime. Formally, this is represented by a net damage to society function $D(O) = H(O) - G(O)$, where O is the number of offenses and $H(.)$ and $G(.)$ are the functions measuring harm to society and (social value of) gains to offenders, respectively. Presumably, both functions are increasing in the number of offenses.

Second, there is what Becker calls the "cost of apprehension and conviction," which is basically the cost of enforcing the law. This cost is given by $C(p, O, a)$, where p is the probability of conviction and a stands for arrests. The function $C(.)$ is increasing in all its arguments.

Third, there is the social cost of punishment, which he defines as the cost to offenders plus the cost or minus the gain to others. Formally, $f' = bf$, where f' is the social cost, b is a coefficient that transforms the cost to offenders, f, into the social cost and varies considerably between different kinds of punishments.

After considering all these costs, Becker tackles the question of what determines the supply of offenses. He is interested in understanding the reasons why an individual will engage in criminal activity. His approach assumes that a person commits an offense if the expected utility to her exceeds the utility associated to legal activities. The logical consequence of that assumption is the conclusion that persons become criminals not because they have different motivations from other people, but because their benefits and costs differ.

The mathematical formulation of that assumption in Becker's paper is $O = O(p, f, u)$, which states that the total number of offenses depends on the average values of the probability of conviction p, the punishment per offense f and other variables like income from legal and illegal activities, nuisance arrests and willingness to commit a crime, all grouped in the variable u.

Becker then goes ahead and combines all the elements above in a social loss function $L = D(O) + C(p, O) + bpfO$, which is minimized with respect to f and p in order to generate the optimal conditions for a policy against crime. He is able to associate the optimal selection of p and f to the elasticities of offenses with respect to p and f and to the individuals' preferences towards risk.

We will not delve into Becker's results any further, since the main objective of this paper is not to assess a particular crime policy, but to try and test the economic model of crime empirically, using data from the Federal District of Brazil (to which the capital of Brazil, Brasília, belongs).

III. Data description

This paper focuses on violent crimes, and thus the dependent variable in the model to be estimated is the homicide rate. This rate was calculated from data on deaths by homicide provided by SIM (System of Information about Mortality) under a database made available by DATASUS, a system of information about health and healthcare in Brazil. The database also offers information for different ages, and that made it possible to calculate the homicide rates for 5-year age intervals.

The explanatory variables, which are borrowed mainly from the economic model of crime, are the following: real GDP-DF (gross domestic product of the Federal District (DF)) per capita, employment rate, real minimum wage, size of police force and supply of land tracts. Data on these variables were taken from the Distrito Federal Annual Report, but some of them had to be created from the raw data. Other possibly relevant variables like poverty level, social mobility, income inequality, sanitation and education were not available in suitable series, but can be collected from sources other that the Annual Report and included in the model in future work.

The series used in the estimations come from a sample of 16 annual observations, starting in 1985 and ending in 2000. The data available for some variables encompass more than 16 observations, but could not be used due to the shortcomings of some of the other series.

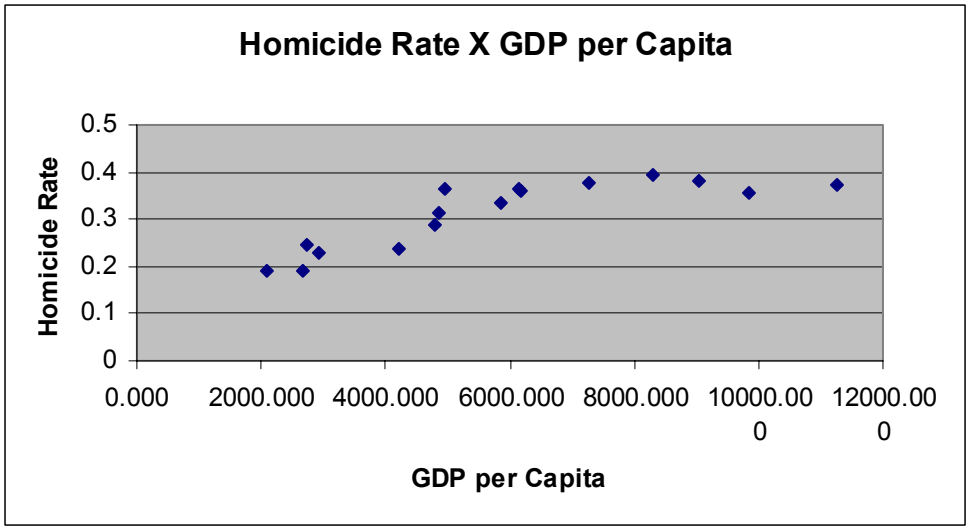
The variable employment rate is one which had to be created, since there were no consistent series on unemployment available. The employment index in this paper is

defined as the ratio of the index of employment growth (available from the Annual Report) to the index of real GDP-DF per capita growth. It is intended to serve as a proxy for unemployment, but of course its effect on homicide rates is the opposite of that of unemployment.

Another constructed variable is the real minimum wage. It is the result of deflating the nominal minimum wage by the DF cost of living index, which is not a trivial task for the Brazilian economy, given all the different currencies used during the last 20 years. The minimum wage was the same all over the country until recently, but the use of the DF price index to deflate the series entitles it, in principle, to be used as a proxy to real salary in the DF.

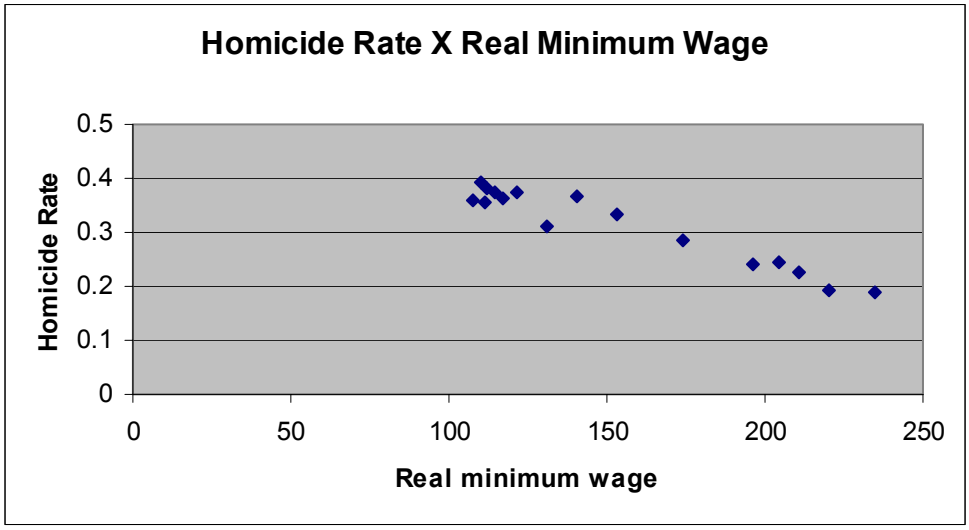
A visual identification of the relationships between the dependent and explanatory variables can be done with the help of the scatter plots shown below.

The first plot shows how the homicide rate relates to GDP-DF per capita and they seem to be positively correlated. This might at first seem inconsistent with the economic model of crime, since one would expect higher income (to which real GDP per capita is a proxy) to lead to lower homicide rates. But it seems that what in fact GDP-DF per capita is capturing is the reward to crime activities, for higher product means there is more to be gained by committing a crime. A positive correlation is consistent with the latter interpretation.

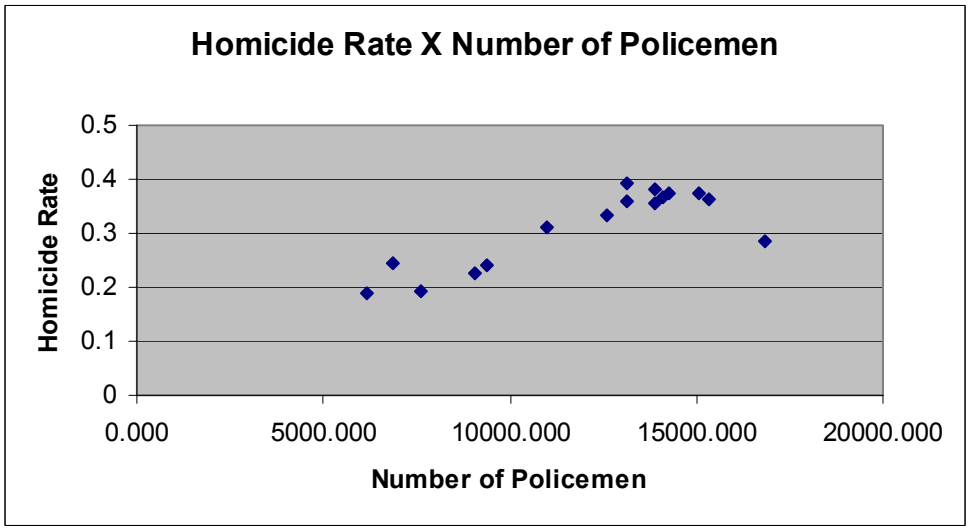


The second plot features homicide rate and real minimum wage. If in fact real minimum wage is a good proxy to real average salary or family income then the

negative correlation observed between these two variable is what is expected according to the economic theory of crime.

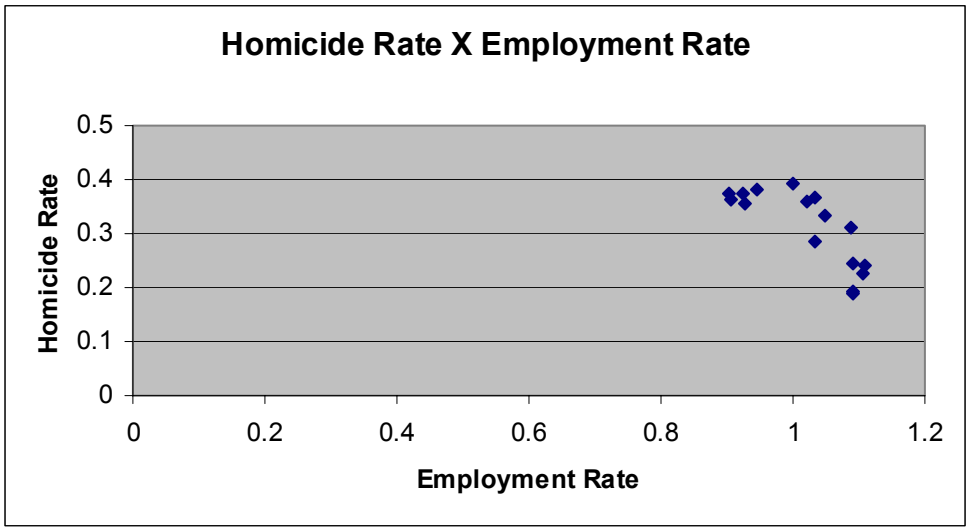


The third plot allows us to identify a possible ascending relation between the homicide rate and the size of the police force. That is unexpected, since an increase in the number of policemen should in principle reduce crime. There seems to be a question of causality here, i.e., it is possible that the size of the police force increases in response to an increase of the number of homicides, which means that the government only hires more policemen in reaction to higher crime rates.

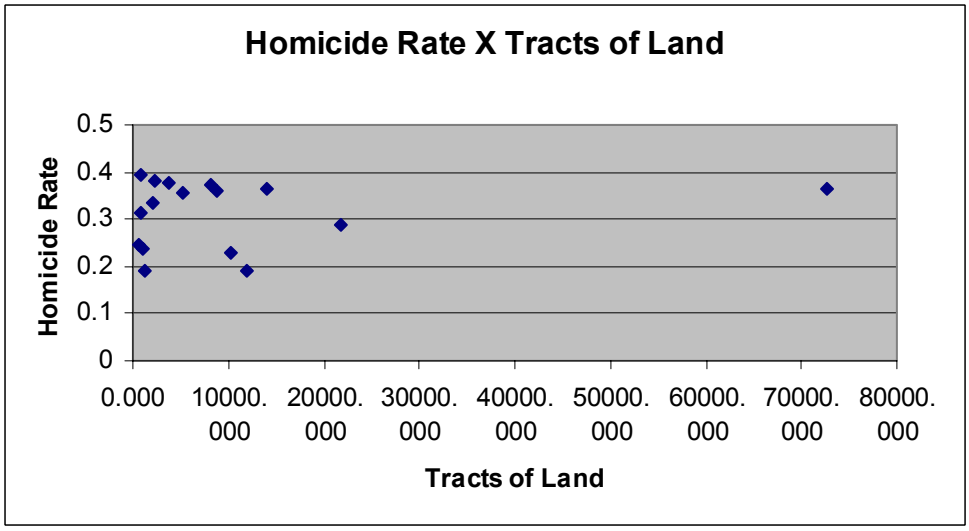


The fourth plot shows us that apparently there is no significant relationship between the homicide rate and the employment index, when in principle the homicide

rate should decline with the employment index. This might be due to the fact that the employment index had to be constructed from data from different sources, being subject to measurement errors.



Finally, the plot of homicide rate versus tracts of land also seems to indicate it would be hard to find a consistent relationship between these to variables. A possible solution is to work with lagged observations of the supply of land.



IV. Model estimation

The first model estimated was

$$HomRate_t = \beta_0 + \beta_1 GDP_t + \beta_2 Wage_t + \beta_3 Pol_t + \beta_4 Land_t + \beta_5 Emp_t + \varepsilon_t,$$

where *Homrate* is the homicide rate, *GDP* is the per capita GDP-DF, *Wage* is the real minimum wage, *Pol* is the size of the police force, *Land* stands for the supply of land tracts, and *Emp* is the employment index. All the variables in this first model were in levels. The results, obtained by ordinary least squares estimation, showed that only real minimum wage and the intercept were significant at the 10% level.

Many different specifications were tried and in every model where the real minimum wage was not present the real GDP-DF per capita was significant. On the other hand, every time real minimum wage was included real GDP-DF per capita would be rendered statistically insignificant. A regression of real wage on GDP per capita showed that in fact these two variables are closely related, which is a bit surprising. Real GDP per capita explains approximately 72% of the variation on real minimum wage.

Another interesting finding was that the current supply of land was consistently statistically insignificant in the regressions. This led to regressions using the lagged values of that supply as an explanatory variable. It turned out that the two-period lagged value of the supply of land is statistically significant, being able to explain partially the behavior of the homicide rate.

The next step was to run regressions with the variables in logarithms instead of levels, which yielded better results in terms of fitting the models. All of the estimated models were tested for heteroskedasticity and serial correlation and there was no evidence of the presence of these problems. Also, the residuals from all models were tested for normality and passed the test.[2]

The outcome of this process of trying different specifications was the following model:

$$lHomRate_t = \gamma_0 + \gamma_1 lGDP_t + \gamma_2 lPol_t + \beta_4 lLand_{t-2} + \beta_5 lEmp_t + \varepsilon_t,$$

where all variables are in logs and the supply of land tracts is lagged twice. It is important to notice that the variable real minimum wage was dropped from the model, since its presence was distorting the results.

The estimated model and some statistics are shown in the table below:

[2] The printouts from Stata can be obtained from the author upon request.

Table 1: Dependent Variable: *lHomRate*

	Coef.	Std. Err	*t*	$P > \|t\|$	95% Confidence interval	
lGDP	0.2465475	0.083541	2.951	0.016	0.0575646	0.4355303
lPol	0.3072069	0.1244359	2.469	0.036	0.0257133	0.5887005
lLand(-2)	0.0557671	0.0163891	3.403	0.008	0.0186923	0.0928419
lEmp	-0.022954	0.4711153	-0.049	0.962	-1.088691	1.042783
Constant	-6.617697	1.18666	-5.577	0.000	-9.302109	-3.933285

F(4,9) = 22.67 Prob > F = 0.0001

R-squared = 0.9097; Adj R-squared = 0.8696; Root MSE = 0.07006

It can be seen immediately that the only variable not statistically significant is (log of) the employment index, which was already expected after the analysis of the scatter plot. The R-squared and Adjusted R-squared are very high and as mentioned before the tests for heteroskedasticity and serial correlation issued no warning signals. A discussion of the coefficients will be postponed to the next section.

The same model was estimated by age interval, with the homicide rate for the population as a whole being replaced in each estimation by the homicide rate of the corresponding age interval. The intervals considered were: 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59 and 60-64 years of age. The results are presented below in compact form, with only the main statistics being shown.

Table 2:

Dependent Variable: *lHomRate* Age: 15-19			Dependent Variable: *lHomRate* Age: 20-24		
Variable	Coef.	$P>\|t\|$	*Variable*	Coef.	$P>\|t\|$
lGDP	0.2047806	0.243	*lGDP*	0.1983718	0.126
lPol	0.2418503	0.348	*lPol*	0.6578923	0.005
lLand(-2)	0.0309424	0.361	*lLand(-2)*	0.0419563	0.102
lEmp	-2.055523	0.053	*lEmp*	0.4228429	0.540
Constant	-4.949253	0.062	*Constant*	-8.68897	0.001
Adjusted R^2	0.8014		*Adjusted* R^2	0.8090	

Table 3:

Dependent Variable: *lHomRate* Age: 25-29			Dependent Variable: *lHomRate* Age: 30-34		
Variable	Coef.	$P>\|t\|$	*Variable*	Coef.	$P>\|t\|$
lGDP	0.2613487	0.102	*lGDP*	0.0986882	0.465
lPol	0.4721654	0.055	*lPol*	0.2217239	0.280
lLand(-2)	0.0838233	0.016	*lLand(-2)*	0.0146474	0.578
lEmp	1.417343	0.114	*lEmp*	-0.2125894	0.778
Constant	-8.071497	0.003	*Constant*	-3.888505	0.064
Adjusted R^2	0.6072		*Adjusted* R^2	0.3877	

Table 4:

Dependent Variable: *lHomRate* Age: 35-39			Dependent Variable: *lHomRate* Age: 40-44		
Variable	Coef.	$P>\|t\|$	*Variable*	Coef.	$P>\|t\|$
lGDP	0.1241282	0.426	*lGDP*	0.4446636	0.082
lPol	-0.2288986	0.329	*lPol*	0.4768396	0.193
lLand(-2)	0.0213885	0.483	*lLand(-2)*	0.0103269	0.822
lEmp	-0.7719135	0.382	*lEmp*	2.259576	0.112
Constant	-4.949253	0.978	*Constant*	-9.651435	0.015
Adjusted R^2	0.1262		*Adjusted* R^2	0.3295	

Table 5:

Dependent Variable: *lHomRate* Age: 45-49			Dependent Variable: *lHomRate* Age: 50-54		
Variable	Coef.	$P>\|t\|$	*Variable*	Coef.	$P>\|t\|$
lGDP	-0.0427887	0.936	*lGDP*	0.2891119	0.267
lPol	0.4143125	0.603	*lPol*	-0.727576	0.076
lLand(-2)	0.24675	0.038	*lLand(-2)*	0.1586542	0.009
lEmp	-0.4429113	0.882	*lEmp*	0.6284729	0.659
Constant	-6.840963	0.375	*Constant*	1.69651	0.636
Adjusted R^2	0.2060		*Adjusted* R^2	0.5532	

Table 6:

Dependent Variable: *lHomRate* Age: 55-59			Dependent Variable: *lHomRate* Age: 60-64		
Variable	Coef.	$P>\|t\|$	*Variable*	Coef.	$P>\|t\|$
lGDP	0.6969588	0.077	*lGDP*	-0.2320637	0.639
lPol	-0.7278399	0.195	*lPol*	1.345079	0.092
lLand(-2)	0.1778464	0.029	*lLand(-2)*	0.1067141	0.285
lEmp	0.7603501	0.708	*lEmp*	3.57678	0.218
Constant	-2.197302	0.668	*Constant*	-13.16466	0.085
Adjusted R^2	0.4472		*Adjusted* R^2	0.0546	

V. Interpretation of results

The regression results presented in table 2 refer to the model estimated for the whole population, independent of age. All the coefficients have the signs expected after inspection of the scatter plots. The homicide rate increases with real GDP-DF per capita, which is accordance with the economic theory of crime if one interprets the gross product of the state (Federal District) as a measure of the prize associated to committing a criminal offense.

The homicide rate also increases with the size of the police force and the supply of land tracts. The first result must be better studied, as mentioned before, for it may indicate that a surge in homicides causes a reaction from the government in the form of new policemen joining the force. The second result is very important for the Federal District and to the capital of Brazil, Brasília. It says that a policy of giving away or selling tracts of land indiscriminately, which has happened in the DF for a long time now, has a tendency to increase the homicide rate. It remains to be determined if that is the case because the prospect of owning a piece of land brings to Brasília and its surrounding areas individuals who are more crime-prone or for some other reason. It is

interesting to notice also that there is a two year lag between an increase in the supply of land and an increase in the homicide rate, which may be explained by the time it takes for individuals to find out about the current land policy and to move to a different location.

The homicide rate also decreases with the employment index, as expected, but the variable is not statistically significant.

Tables 2 to 6 show the results obtained when the same regressors are used but the dependent variable, homicide rate, is specific for a particular age span. The first interesting conclusion that can be reached is that the economic theory of crime fares much better for younger people than older people. In fact, the adjusted R^2 is above 50% only for the first three age periods (it is also above 50% for the homicide rate for individuals 50 to 54 years old), namely 15-19, 20-24 and 25-29 years old. Also, after the age of 29, very few variables are statistically significant.

It is also interesting to notice that the employment index is significant, with a negative coefficient, for the homicide rate for individuals 15 to 19 years old, and that's about the only regression where it is significant, although it would be significant at a 12% level in the regression for the 25-29 interval. On the other hand, real GDP-DF per capita, supply of land and police force are not significant in the 15-19 age interval, which makes the employment index even more important in explaining the homicide rate.

For individuals 20 to 24 years old, real GDP-DF per capita and supply of land are close to being significant at the 10% level, and both are positively related to the homicide rate. The size of the police force is significant and positively related to the homicide rate.

Finally, the regression for individuals 25 to 29 years old shows that almost all the variables are significant and have the same sign as in the overall regression. The exception is the employment index, which is significant only at the 12% level and has a positive coefficient.

VI. Conclusion

This paper is concerned with testing some of the insights of the economic model of crime for the Federal District of Brazil, where the capital, Brasília, is located. This is done by running regressions of the homicide rate on economic and social variables, namely the real GDP per capita of the Federal District, the real minimum wage, the size of the police force, an employment index and the supply of tracts of land by the government. The regressions are run first for the homicide rate of the population as a whole, and then for homicide rates of some age strata.

Perhaps the main finding of the paper is that the economic model of crime fares much better for young age strata, specifically for individuals aged 15 to 29. This has strong implications for authorities, who can combat crime more effectively by targeting younger people and giving them the right (economic) incentives to pursue legal activities.

Another very important finding, especially for the population of the Federal District and the capital of Brazil, Brasília, is that the homicide rate seems to react, with a two-period lag, to changes in the number of tracts of land donated or sold by the government. In order to understand the underlying reasons of that phenomenon, more study is need, but one can speculate that the prospect of getting a piece of land attracts people to the region who, if not able to make a living once there, will end up engaging in criminal activities.

Finally, the results presented in the paper indicate that the homicide rate increases with the real GDP per capita and the size of the police force, and that the employment index doesn't seem to be a good explanatory variable.

There are many extensions that can be pursued in the future. One is to try and obtain longitudinal data and run a panel data regression, which would certainly yield much richer results. Another is to incorporate other economic and social variables, such as social mobility, poverty level, sanitation, education and income inequality. A cohort analysis would also certainly be welcome.

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