Economic conditions, enforcement, and criminal activities in the district of Abidjan

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Abstract Based on 1978–2007 annual data on crimes recorded by the criminal police division and through a simultaneous equations model, we have shown that the probability of apprehension affects negatively the incidence of thefts and homicides as well as the incidence of aggregate crime. We have also provided evidence that exogenous shocks such as the devaluation of the CFA franc, the military coup d'état, and the civil war have significantly influenced criminal activity in Abidjan. The civil war which occurred in Côte d'Ivoire, while driving to a booming of property crimes, has deterred violent crimes given the crackdown effect of temporary massive presence of military and paramilitary forces in the streets of the city of Abidjan. In addition, using a sample of 1,600 households, our inquiry on the likelihood of crime victimization has pointed out that the risk of being victimized of any kind of crime increases with the income; the fact of being displaced due to the civil war and the decrease in the number of police stations in the neighborhood.

Keywords Crime · Enforcement · Devaluation · Political instability · Abidjan

JEL Classification C32 · C35 · H40 · H50 · K42

1 Introduction

Crime has increased dramatically in Côte d'Ivoire during these last decades. As reported by the Criminal Police division, the national crime rate ranged from 5 per 100,000 inhabitants in 1990 to 18 per 100,000 inhabitants in 1998. This trend is accentuated in the large cities which are actually the principal economic development

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poles of the country. The southern area seems to be the most affected by the incidence of crime, mainly the district of Abidjan¹ where approximately 40% of aggregate crimes are committed. In this city, the crime rate ranged from 98 per 100,000 inhabitants to 151 per 100,000 inhabitants between 1999 and 2000 reaching even 178 per 100,000 inhabitants in 2001. Crime incidence apparently rose substantially since the beginning of the political instability, where in 2005 for instance, on the average, 2,558.667 offenses are recorded monthly by the central police station in Abidjan.

This general tendency covers property crimes such as larcenies and car thefts and violent crimes as well as burglaries, assaults, homicides, armed robberies, and drug related offenses. Furthermore, the statistics of the national justice department indicate that property crimes represent more than 76% of the decisions of courts and 80% of these crimes are violent (Kimou 2001). Additionally, it should be noticed that crime generates negative external effects.

First of all, crime affects the physical capital assets, which can lead to a low economic growth rate (Rubio 1998).² Likewise, crime deteriorates the human capital and the accumulation of the human capital (Fajnzylber et al. 1996). Moreover, crime erodes the social capital (Putnam 1993; Glaeser et al. 1996; Glaeser 1999). Lastly, the role of the government can be weakened by the persistence of criminality. Indeed, when citizens entrust their safety to private companies, the government seems useless and ineffective in supplying the basic public goods (the World Bank 1997). In summary, crime creates feelings of insecurity, modifies the allowance of property rights, and causes poverty due to its negative impact on the economic growth.

Likewise, in the view of the Ministry of Internal Security, there is a noticeable evolution of criminal activity with reference to the means used by criminals. From simple knives or hand-made weapons, offenders have now passed to more sophisticated firearms. The forms of this type of crime are standard: car thefts, assaults, hold ups, and terrors on the roads.

In addition, even though the economic situation of Côte d'Ivoire has declined significantly since the 1980s, with the fall in the prices of its export products (cocoa and coffee in particular) and accelerated right after the 1994 CFA devaluation, the economic conditions are still critical. The growth rate of the GDP declined constantly going from 5.7% in 1997 to 4.8% in 1998 and from 1.6% in 1999 to 1.2% in 2002 (Azam and Koidou 2002).

This harmful economic situation contributed to the degradation of the living conditions of the population of Côte d'Ivoire in general and especially of people living in the district of Abidjan.³ This period is also that of an unprecedented political violence with the first military coup in December 1999 and the beginning of the civil war in 2002.

¹ Around 4 million people live in Abidjan city out of a total population estimated to nearly 18 million inhabitants.

² Rubio (1998) showed that due to homicide augmentation, capital accumulation in Colombia felt about 38% of the level it should reach. The World Bank (1997) also indicated that tourism stagnation in many Latin American countries is due to lack of investment in hostelry and tourism infrastructures because of the rise of criminal activity.

³ According to Roubaud (2003), 44% of the households living in Abidjan city assert to live harshly with the income they earn.

This paper backs up the economics of crime and sociological theories of lifestyle exposure and routine activities to argue that political instability, economic conditions, and enforcement policies significantly affect the prevalence of serious criminal activities in the main development pole of Côte d'Ivoire.

The main purpose of the paper is to find out the main socio-economic factors that affect the incidence of urban crime in the city of Abidjan. To limit the scope of the paper, we focus on the deterrent effect of the police resource in preventing crime while controlling for the role of income through the incidence of 1994 CFA devaluation, and some exogenous shocks such as the first military coup d'état and the civil war.

Combining both a simultaneous equations modeling of the supply for offenses and a crime victimization analysis, we show on the one hand that the 1994 CFA devaluation led to the booming of aggravated assaults (income effect) may be due to an improving economic condition, while victimization is significantly associated with income and the area of residence. On the other hand, except for aggravated assaults, we found a deterrent effect of police resources and of a crackdown effect of the civil war on violent crime due to a massive patrols of well-equipped military and paramilitary forces during the political unrest.

The remaining of this paper is as follows: Sect. 2 presents the literature review, in Sect. 3, we present the data and an overview of criminal activities, in Sect. 4, we describe the empirical strategy, and Sect. 5 summarizes the main empirical findings before suggesting some policy implications in our concluding remarks.

2 Literature review

Since the seminal article of Becker (1968) extended by Ehrlich (1973, 1996), the offender is considered as an agent facing a choice problem given the direct cost, the opportunity cost, and expected return from the offense. From that perspective, empirical research has in general confirmed the theoretical conclusions of the Becker–Ehrlich model, indicating the negative relationship between the amount of crime and deterrence tools on the one hand and the improvement from the socioeconomic conditions on the other hand.

For Ehrlich (1973), the probability that an individual enters illegal activity can be described by a whole of explanatory variables including the probability of detection and the severity of the punishment. Using a Cobb–Douglas deterrence production function, and a simultaneous equations model, the author shows that the rate of all the types of crime is conversely and significantly tied to the probability of detection and to the related punishment level. He also concludes that the productivity of deterrence actions is negatively influenced by the size and the density of the population and positively affected by the extent of poverty, and the level of education of the adult population. These results reinforce the idea that potential criminals respond to incentives.

In the developing countries and especially in Africa, the study of the motivations of the crime was especially directed toward the role of the inequalities and poverty. This analysis is carried out either with primary data, i.e., the case of Miguel (2005)

in the analysis of violence toward the people of third age in Tanzania or with cross section as in Demombynes and Özler (2005) which showed that the inequality and poverty positively influence criminality in South Africa.

In the same way, using a random Poisson process, Fafchamps and Minten (2005) showed that burglaries and the robbery of agricultural goods increase with poverty in rural Madagascar. According to them, the situation was driven from the political crisis due to the needs to maintain their living standard which grew worse because of an exogenous shock.

One of the problems in the analysis of criminal behavior is that crime is not directly observable. In spite of this difficulty, Fafchamps and Minten (2005) and Roché (2005) used self-reported data to analyze the determinants of delinquency of youngsters, respectively, in the United States of America and in France. However, undertaking such a study requires not only a good amount of confidentiality and voluntaries, but also a long period to conquer individuals' confidence. Such an approach is possible with the age of the target population which is primarily made up of young high school pupils whereas the same step toward the adult population is likely not to provide satisfactory results.

Kalb and Williams (2001) circumvented this difficulty by carrying out a retrospective investigation. Here, the criminal characteristics of the individuals are identified previously before the interview. Consequently, one avoids during the consultation to ask to the respondent questions about their propensities with delinquency.

This kind of initiative is appropriate for the developed world where the economic structures and the materials of the police force make it possible to have information on each citizen. Moreover, the dependent variable is the experiment of arrest of the individual, but we do not have any information on the type of committed crime. It is probably one of the reasons for which the majority of the empirical results come from regressions based on reported crime data.

Nevertheless, two major problems appear with aggregate reported data of the crime: the issue of endogeneity and that of underreporting of criminal statistics. In addition, even though they do not provide information on the individual characteristics of offenders, official data have the advantage of providing broad information on the prevalence of the phenomenon in a given community. Furthermore, reported statistics make it possible to have a long series which are indeed invaluable to highlight changes of regulation of the criminal phenomenon (Lagrange 2001).

In the same way, the quality of crime data very often do not permit to control simultaneously the impact of both economic variables and deterrence instruments. Primary data do provide information on the profile of offenders, their income, and their employment status, but do not inform on the incidence of deterrence policies (Corman and Mocan 2005).

Hence, another approach to question the determinants of crime require to analyze the vulnerability to the phenomenon for several reasons. Analyzing crime victimization helps to better identify the exposed population and to propose a suitable crime prevention policy. The investigations on crime victimization are the most exact instruments to appreciate the incidence of the phenomenon, mainly in developing countries where underreporting is very important (Gaviria and Pages 2002).

Even though the examination of crime victimization has been often undergone in developed countries such as France (Fougère et al. 2007) that approach seems

more appropriate for the developing countries because of the statistical weaknesses. In Latin America, the question is of interest (Gaviria and Pages 2002; Fajnzylber et al. 2001 and Gomes and Paz 2005). In Africa, some recent works have addressed the issue. We have, for instance, a research in Mozambique (Barslund et al. 2007) and another one in South Africa (Powdthavee 2005).

Using the sociological theory of “life-style exposure perspective” (Hindelang et al. 1978)⁴ and that of the “routine activity perspective” (Cohen et al. 1981),⁵ Barslund et al. (2007) found on the one hand that individuals living in a larger household size have less probability to be a victim of crime due to an intra-household protection network and on the other hand that the share of adults provides a significant negative effect on the probability of being victim of crime.

The combination of the two approaches would be advantageous in the apprehension of criminality in the district of Abidjan. In fact, a times series analysis helps to consider trend of the phenomenon whilst inquiry on victimization spells out people who are likely to be vulnerable.

3 Data and overview of criminal activities

This paper uses both reported crime data and victimization survey conducted in the district of Abidjan. This section describes incidence of crime in the light of the two sets of data used in our empirical investigation.

3.1 Reported crime data

The data are from several sources and are related to both criminal statistics and to the socio-economic influences.

The data on crime are collected from the department of statistics of the Criminal Police Division. These statistics do not provide detailed information on assaults, violence and threats, law abidingness, in particular, the financial delinquency and drugs enforcement.

However, the main categories of crimes whose definition remains stable and able to reveal the critical trends of delinquency and crime are recorded. Therefore, we collected annual reports on crime committed in the district of Abidjan from 1978 to 2007. These series are related to homicides, armed robberies or aggravated assaults, burglaries, or thefts and illegal holding of firearms.

These data come primarily from all injuries known by the Criminal Police Division. They also encompass the number of arrests per type of offense. The Criminal Police Division is the main department of the national police to provide credible and

⁴The theory of lifestyle suggests that differences in the probability of being victim of crime can be explained by differences in the lifestyles of the potential victims.

⁵Quite similar to the lifestyle perspective, the theory of the routine activity perspective argues that non-household activities increase the probability of victimization by making the individual more visible and accessible to potential criminals.

Chart 1 Rate of aggravated assaults and illegal possession of firearms from 1978 to 2007

reliable statistics on illegal activities in the district of Abidjan. Their office of Abidjan records mostly the volume of crimes committed on the territory of the district of Abidjan.

The other data we consider in this study are those related to the socio-economic environment on crime such as inequality, demography, and police action. Data relating to public expenses devoted to security are from the Ministry of Finances.

The population size and the Gini inequality index data for the district of Abidjan are provided by censuses and surveys on living standards held by the National Institute of Statistics (INS), which is a reference in the provision of such data relating to Côte d'Ivoire.

The trend of aggregate crime rate in Abidjan is dominated by the prevalence of violent offenses. In Abidjan city, violent crimes refer to murders and armed robberies or aggravated assaults. Violent crimes account for more than three-quarters of aggregate crimes, reflecting therefore the widespread feeling of insecurity among urbanites.

As shown in Chart 1, the trend of violent crimes seems positively correlated to that of illegal possession of firearms in the first sub-period (the peak). That phenomenon could be related to excessive circulation of light weapons during the civil war in the neighboring countries such as Liberia and Sierra Leone. However, the apparent absence of correlation between the slope of the trend of violent crimes and that of illegal firearms after 1989 (Chart 1) does not mean that the political instability in Côte d'Ivoire has not affected the severity of violent crimes. In fact, as indicated in Table 1, on the average, the incidence of aggravated assaults and homicides is higher during the political instability period (1999–2007) than any other period.

In summary, between 1978 and 2007, the average crime rate is relatively very high for each series of crime. However, during the socio-political instability period there is apparently a booming in criminal activities and incidence of offenses seems mostly dominated by violent crimes.

Table 1 Summary statistics: Incidence of crime in the district of Abidjan from 1978 to 2007

Variables	Entire period (1978–2007)		First sub-period (1978–1988)		Second sub-period (1989–1998)		Third sub-period (1999–2007)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Homicides	52	31.36	26.90	25.45	71.55	16.89	66.77	28.15
Aggravated Assaults	1,807.1	1,662.7	375.72	282.24	1,971.44	1,246.66	3567	1,314.31
Illegal firearms	38.83	23.04	38	28.04	54.33	19.67	26.66	7.88
Thefts or burglaries	187.7	233.88	106.81	79.75	72	38.77	416.66	322.03
Aggregate crime	2,269.43	2,106.42	525.9	275.84	1,933.33	1,112.49	4,951.88	1,371.07

Table 2 Pairwise correlation: illegal firearms and crimes

Variables	Entire period (1978–2007)		First sub-period (1978–1989)		Second sub-period (1990–1998)		Third sub-period (1999–2007)	
	Illegal firearm	Illegal firearms	Illegal firearms	Illegal firearms	Illegal firearms	Illegal firearms	Illegal firearms	Illegal firearms
Homicides	0.5210**	0.6868**	–0.324	–0.4033				
Aggravated Assaults	–0.0881	0.8481**	–0.0928	–0.2132				
Theft	0.0583	0.5118	–0.2395	0.4892				
Aggregate crimes	–0.1311	0.9715**	–0.1905	–0.0763				

** Denotes significance at 5% level

However, this pre-eminence of violent crimes does not mean that property crimes are minimal. This situation would reflect rather the problem of underreporting of official crime data. The United Nations Program for Development (UNDP, 2001) has shown that in Abidjan city, people are more prone to complain about crime when there is a physical attempt or when their properties are violently uprooted.

Moreover, according to Fajnzylber et al. (2001), since people are not indifferent to a corpse, police officers are quickly alerted in case of homicides, armed robberies, or aggravated assaults whilst the propensity to declare thefts or larcenies are minimal.

The pairwise correlation analysis (see Table 2) allows understanding of what kind of crime relates to each other. For instance, that approach could provide some evidence on the relationship between the illegal holding of guns and other types of crime on the one hand, and on the second hand help to test the degree of that correlation across periods.

The pairwise correlation analysis shows that the illegal circulation of firearms is positively and significantly correlated to murders, aggravated assaults, and aggregate crime in the first sub-period characterized by civil conflict in neighboring countries. In addition, during the entire period that positive correlation still holds, but only for homicides. That result suggests that violent crimes are very sensitive to the circulation of light weapons, precisely in a conflict era.

Nonetheless, there is no correlation between the illegal possession of firearms and crime in the second and third sub-periods. Such a result could highlight the problem of underreporting of official statistics related to crime. In fact, data reported on firearms occur mostly during police operations and often do not emanate from com-

plaints from the victims of property or violent crimes. Such a result suggests that offenses on weapons are not correlated to other offenses, which is likely to be far from reality.

3.2 Victimization data

Victimization data are from a survey undertaken by the Observatory of Public Opinion on Democracy and on Human Rights (ODDH).⁶ This survey was carried out from October to November 2006 under the technical supervision of the National Institute of Statistics (INS). It has covered the city of Abidjan and has focused on a sample of 1,700 households randomly selected. The interview has targeted mainly the heads of household and households' members above 12 years of age. The data collection was conducted in nine of the ten municipalities of the city of Abidjan.

Even though these data⁷ are not drawn from a purposely conducted crime victimization survey, still a section of the questionnaire referred to important inquiries relating to the exposure to crime. Indeed that section offered detailed information on victims of larcenies, burglaries, assaults, and other forms of offenses such as harassment, bribery, sexual abuse, and physical and verbal attempts. The questionnaire had also reported useful information on the experience with enforcement of the public security including, feeling of protection by the State, appreciation of police and justice services, and trust to the criminal system.

The database also encompasses individual and household characteristics and various household's expenditures such as recurrent and dated expenses relating to education, clothing, leisure, funeral, and remittances toward relatives. Due to missing information, data processing has permitted to exclude 100 households and identify a final sample of 1,600 households and 6,446 individuals. However, only information on household heads has been made available to us, so our database comprises 1,600 observations.

To investigate the determinant of crime victimization, other data at the community level have been also collected. These are the density of the population of a given municipality, the number of police stations in the municipality, and the distance to the nearest police station. The demographic data are those of 2002 from the projection of INS based on the 1998 general census. The number of police stations is provided by the Ministry of Home Affairs.

As far as the distance to the nearest police station is concerned, individuals have not reported during the interview the average length they walk to reach the nearest police station. Therefore, we could not get that information from our sample. To overcome that difficulty, using the maps of the clusters of enumeration areas from which the 1,600 households have been selected, the Department of Cartography of the INS has estimated the average distance to the nearest police station. This procedure helped to associate each household with its average distance to the nearest police station.

Data collected from ODDH show that men are more concerned with security issues than women (51%), but both men and women believe that security (19%) is the

⁶Project established in CIREs with the financial support of European Union.

⁷The survey focused on democracy, political, and social governance prospects.

Table 3 Comparison: reported crime and survey victimization in 2006

	Victimization rate from the survey (%)	Reported crime rate in 2006 (per 100,000 people)
Assault	14.18	1,813
Larceny or Burglary	16.00	564
Aggregate crime	33.31	2,889

third public good to be provided by the State after justice (48%) and health services (37%).

In addition, 33.3% of household heads have reported having been victim of a crime and 42.6% of whom have asserted being victim of assaults while others claimed to have paid bribes or have been a victim of sexual abuse, harassment, or other type of crime. In addition, nearly 80% of victims are men and 52.5% of individuals surveyed believe feeling unsafe in Abidjan.

One of the important contributions of the analysis of victimization is the fact that it helps to tackle the real criminal situation in the developing world. Actually, while the victimization rate from the survey is about 33%, the criminal police division has reported 2,889 offenses per 100,000 in the city of Abidjan (see Table 3). This underreporting issue is more pronounced for property crimes such as larcenies and burglaries as shown in Table 3. In fact, in 2006, only 564 thefts (including larcenies and burglaries) for 100,000 people were officially known, while the survey points out a victimization rate of 16%.

4 Empirical strategy

This body of the study presents the economic theory of criminal behavior that sustains our investigation and its resulting econometric modeling.

4.1 Estimating the supply for offense

The formalization is based on Becker (1968) and Ehrlich (1973, 1996).

Under the assumption of rationality, a person i willing to engage in a particular crime is motivated by the following:

- the expected illegitimate payoff per offense (that is the probability of not being apprehended $(1 - p_i)$ times the loot (b_i)),
- the direct cost endured by the offender to get the loot (c_i) ,
- the opportunity cost, i.e., the lost of alternative legal wage (w) ,
- the subjective probability of apprehension (p_i) , the eventual penalty if convicted (f_i) ,
- and the moral values and the preference for risk.

Assuming that the individual is risk neutral and pursues only one illegal activity, his expected advantage from a crime (π_i) can be written as

$$\pi_i = (1 - p_i) \times b_i - c_i - w_i - p_i \times f_i. \quad (1)$$

For an individual having some “moral” values, the net advantage of a crime would have to exceed a certain threshold (m), to which he can assign pecuniary value, before the individual commits a crime.

Let d represent the decision to commit an offense ($d = 1$) or not ($d = 0$); the potential criminal's behavior is then cleared by

$$\begin{aligned} d &= 1 && \text{if } \pi_i \geq m_i, \\ d &= 0 && \text{if } \pi_i \leq m_i. \end{aligned} \quad (2)$$

This simple formalization of an individual's criminal behavior helps to understand the different flows of the aggregated crime level in the society. In fact, it is possible to capture the reaction of the population vis-à-vis legitimate and illegitimate opportunities given the economic performance and the distribution of moral values in the community.

Therefore, if the distribution of moral values is well defined, the individual's amount of offenses (q_i), will be an increasing function of the net advantage of crime. That is the number of offenses supplied by the individual i , (s_i) is then

$$q_i = s_i(\pi_i), \quad \text{with } s'_i(\pi_i) \geq 0. \quad (3)$$

Since crime is comprised of discrete actions, the dependent variable could generally be specified in terms of directly observable number of offenses one commits q_i what leads to this behavioral function:

$$q_i = \varphi_i(p_i, f_i, u_i), \quad \text{with } \frac{dq_i}{dp_i} \leq 0 \text{ and } \frac{dq_i}{df_i} \leq 0. \quad (4)$$

Expression (4) indicates that the quantity of committed felonies by a person is a decreasing function of the probability of detection (p_i) and the level of punishment (f_i).

This quantity is also explained by other variables (u_i) but the sense of causality is to be found. At an aggregate level, the behavioral function could also be regarded as a collective offense supply function in a given period of time, that is,

$$Q = \Psi(P, F, U), \quad (5)$$

where P , F , and U are the average level of p_i , f_i , and u_i , and where Q is the total sum of a given offense i . Also, the crime rate or the supply for offense per capita is a function of the same variables.

According to Ehrlich (1973), a simple form of supply for offense function could be

$$\left(\frac{O}{N}\right)_t = P_t^{\beta_1} F_t^{\beta_2} I_t^{\beta_3} E_t^{\beta_4} D_t^{\beta_5}. \quad (6)$$

Assuming that taste for crime may be either proportional to some quantifiable variables or uncorrelated in the natural logarithm with all explanatory variables (Ehrlich 1973), it is possible to specify that stochastic function as

$$\left(\frac{O}{N}\right)_t = \gamma P_t^{\beta_1} F_t^{\beta_2} I_t^{\beta_3} E_t^{\beta_4} D_t^{\beta_5} \exp(\mu). \quad (6')$$

Hence, the first level of the model to be estimated is

$$\ln\left(\frac{O}{N}\right)_t = \alpha + \beta_1 \ln(P_t) + \beta_2 \ln(F_t) + \beta_3 \ln(E_t) + \beta_4 \ln(I_t) + \beta_5 D_t + \mu_t$$

with $\alpha = \ln(\gamma)$,

(7)

where α is a constant and μ stands for random errors of measurement other stochastic effects and is assumed to have a normal distribution. $(O/N)_t$ denotes the crime rate, P is the average probability of detection, F measures the average of sentence length, I refers to income inequality, E represents the average income level, and D the year dummy taking into seasonality and other social shocks.

Though police action is the concrete manifestation of public deterrence policy, the number of police officers to be enrolled is not only related to the intensity of criminal activity, but also to the economic conditions. For that reason, following Henderson and Palmer (2002), we postulate the following stochastic deterrence production function:

$$P = B(G)^{\lambda_1} \left(\frac{O}{N}\right)^{\lambda_2} Z^\delta \exp(\xi). \quad (8)$$

Since the probability of detection, and thus the number of police officers (P) is an increasing function of public expenses (G) and a decreasing function of the crime rate (O/N) , we estimate and assume that: $\lambda_1 \geq 0$ and $\lambda_2 \leq 0$, with Z denoting other non-measurable influences of criminal behavior. A linear transformation of (8) leads to the second equation to be estimated:

$$\ln(P_t) = B_0 + \lambda_1 \ln(G_t) + \lambda_2 \ln\left(\left(\frac{O}{N}\right)_t\right) + \lambda_3 \ln(\text{density}) + \lambda_4 \ln(P_{t-1}) + \xi_t, \quad (8')$$

where G indicates the public expenditures devoted to the criminal justice system, density designates the density of the population, and P_{t-1} , the lagged value of the probability of apprehension.

To sum up, our simultaneous equations model which has been estimated is composed of (7) and (8); we have therefore the following system:

$$\ln\left(\frac{O}{N}\right)_t = \beta_0 + \beta_1 \ln(P_t) + \beta_2 \ln(F_t) + \beta_3 \ln(E_t) + \beta_4 \ln(I_t) + \beta_5 D_t + \mu_t,$$

$$\ln(P_t) = B_0 + \lambda_1 \ln(G_t) + \lambda_2 \ln\left(\left(\frac{O}{N}\right)_t\right) + \lambda_3 \ln(\text{density}) + \lambda_4 \ln(P_{t-1}) + \xi_t.$$

Our explained variable is the crime rate. For a given offense, crime rate is measured by the total number of reported crimes by a fraction of 100,000 inhabitants, that is,

$$(\text{crime rate})_t = \frac{\text{number of offenses}}{\text{Total population}} \times 100,000.$$

Four series of crimes are analyzed in our study. Those are aggregate crime, aggravated assaults, homicides and thefts, or burglaries. The control and explanatory covariates of our model are:

- *Inequality* is captured by the Gini concentration index. The Gini index measures the extent to which the distribution of income among individuals or households deviates from a perfectly equal distribution. A high index therefore suggests an increase in inequality, which is likely to lead to a serious crime incidence in terms of a means of survival. We test the hypothesis that a rising inequality positively affects crime, mainly property crimes.
- *Instability, political violence, and civil war* is captured by two dummy variables taking into account seasonality. One addresses the impact of the military coup and the other one measures the consequences of the civil war. The military coup dummy is 1 for the period after 1999 and 0, otherwise and lastly, the civil war dummy takes 1 for the period after 2002 and 0, otherwise.
- *Illegal firearms*: this variable is added in order to take into account the flows of light weapons as potential explanation of serious crime in a conflict context. It is expected that an increase in the rate of illegal possession of firearms should raise criminal activity.
 - *The population size* is also an important determinant of crime. It is expected that crime be negatively related to the size of the population.
 - *Income*: the effect of income is captured by the devaluation year dummy which takes the value of 1 for all periods after 1994 and 0, otherwise. Under the hypothesis that the channel through which the 1994 CFA devaluation affect crimes is through its effect on income, the expected relationship between that variable and the urban crime rate is ambiguous. Indeed, the effect of 1994 CFA devaluation on urban incomes was itself mixed, with some households gaining and others losing.
- *The probability of detection* is captured by the number of police per capita. However, in the context of crisis the country is facing, data on police resources in Côte d'Ivoire is challenging. It is true that the physical presence of an extra policeman increases the likelihood of arrest when a criminal commits his act. Similarly, the increase in the number of police officers will raise investigation resources devoted to address and arrest the perpetrators of a crime after their act (Swimmer 1974).

Following Ehrlich (1973), for a given crime, the probability of apprehension and conviction can be captured by the number of criminals arrested and brought to the total number of crimes recorded by police. A good proxy for the probability of detection is obtained by dividing the number of perpetrators apprehended by the total number of crimes reported. An increase in the probability of detection should alter the level of criminal activity.

For our simultaneous equations model of crime to be identified, the number of instruments in the model needs to exceed the number of endogenous covariates. For this purpose, we have chosen three instruments which are:

- *Public expenditures*, measured by the proportion of annual expenditures devoted to internal security (police and gendarmerie) in the special budget for investment. An increase of that proportion is expected to reduce the volume of criminal activity in Abidjan through its impact on the probability of apprehension.
- *The density of the population* which is also used as an instrument to the probability of apprehension, since the density may also be negatively related to the probability

of apprehension because of the ease with which an offender could elude the police in a densely populated area (Ehrlich 1973).

- *Lagged probability of apprehension*: according to Kpodar (2007), a lagged value of the endogenous explanatory variable is a good instrument of that variable. We have therefore used lagged probability of apprehension as an additional instrument.

4.2 Estimating likelihood of victimization

Following Barslund et al. (2007), we postulate that the probability that an individual be exposed to a given crime exhibits the reduced form as follows:

$$\Pr(y_{ic} = 1 | x_{ic}, z_c) = f(x_{ic}, z_c, \varepsilon_{ic}), \quad (9)$$

where y_{ic} is a variable indicating whether the household head i living in area c is a victim of a crime. The dependent variable takes the value one if the individual has been victim of a crime and zero, otherwise; x_{ic} and z_c are respectively individual characteristics of the household head and the municipality where it lives, and ε_{ic} is an individual error term. Assuming that the error term is normally distributed, relation (9) can be estimated through a probit model. The appropriate regression approach for such a discrete choice model is the maximum likelihood method.

Besides usual individual socio-economic characteristics, to take into account the role of social interactions in exposure to crime, the definition of our explanatory variables also referred to the sociological theories of lifestyle defined by Hindelang et al. (1978) and that of routine activities of Cohen et al. (1981).

The theory of lifestyle suggests that individuals who are young, male, single, and have low income levels have a higher risk of being a victim of crime because they are more active in the public domain, use less time inside the family, and are often associated with persons exhibiting criminal tendencies.

The theory of routine activities is quite similar to that of lifestyle, but permits in addition to capture the differences in the risk of victimization among social groups.

Following Barslund et al. (2007), we have defined our explanatory variables in the light of both economic and sociological theories of crime. Thus, we have built five major categories of variables relating to exposure, guardianship, proximity, attraction, and community.

5 Empirical results

5.1 Results for supply for offenses

Before estimating our model of supply for an offense, several specification tests have been conducted. These are the normality test, the error specification test, the endogeneity test for the explanatory variable, i.e., the probability of apprehension, and the heteroskedasticity test (see the Appendix). These tests show that our model of supply for an offense is well specified (see Table 9), with normality distribution of the error term (see Table 10) and a constant variance (see Table 11), and that the model does exhibit an endogenous covariate (see Table 8). Also, there may be other

endogeneity issues in the explanatory variables. One is ‘illegal firearms’. Since we do not have instruments for “illegal firearms” to conduct a specific endogeneity test, we have checked through a causality test whether that independent variable is correlated with the residual. In such a context, this would suggest that the variable of interest is endogenous. The test has been conducted for each type of crime as indicated in Table 13; showing that “illegal firearms” is not significantly related to the residual; therefore, we may consider it as an exogenous explanatory variable. The supply for an offense model has been estimated using ordinary and two-stage least squares. The results are presented in Tables 4 and 5.

Since the probability of arrest is a key variable for crime enforcement, following Swimmer (1974), we have compared the coefficient of the probability of arrest in the OLS and 2SLS regressions (see Table 6). As indicated in Table 6, with the exception of aggravated assaults, two-stage least squares alters the regression estimate of the probability of arrest. Incidence of homicide, thefts, and aggregate crime which are inversely correlated to the probability of arrest in both OLS and 2SLS regression, have respectively a significant coefficient lower 7.6%, 2.4%, and 6.3% with the simultaneous equation estimates. Furthermore, not only the OLS regression overestimate the probability of arrest, but the values of the R-squared for each type of crime, indicating goodness of fit, are better in the simultaneous regressions than in the OLS ones. From these observations, the results of 2SLS appear as a valid estimate of the supply for an offense. Also, our simultaneous equation of supply for an offense exhibit three instruments for the unique endogenous covariate, indicating that the model is overidentified. The following comments are based upon the two stages estimate.

5.1.1 Impact of the socio economic covariates

The socio-economic variables are inequality and population size. Inequality measured by the Gini concentration index is not significant for whatever crime aspect is considered as a dependent variable, except for thefts. That result seems consistent with that of Powdthavee (2005) in South Africa, where crime, mainly property crime is found to be positively associated with inequality. However, the population size negatively affects all the series of offenses. This is consistent to many empirical findings like that of Ehrlich (1973) and Fafchamps and Minten (2005), where the size of the population is found to prevent crime.

5.1.2 The effect of illegal firearms

We expected a booming impact of illegal firearms on criminal activities. That assumption has been validated only for aggravated assaults. We found a positive and significant relationship between assaults and illegal light weapons. That result is rather of common sense, since most of assaults are undertaken under the threat of firearms.

5.1.3 The effect of enforcement tools

A policy to discourage crime should be related to negative incentives to engage in illegal occupation. These types of incentives are captured by the probability of arrest.

Table 4 Results—ordinary least squares: four types of crime. Presentation: explanatory variables on rows dependent variables on columns

Log crime rate (dependant variable)	Constant	Inequality	Population	Illegal firearms	Devaluation dummy	Civil war dummy	Military coup dummy	Probability of arrest	R-squared
Thefts	12.16	2.75	-1.16***	-0.05	0.32	1.27**	-0.29	-0.36**	0.81
Aggravated assaults	0.71	0.65	-8.79e-07***	0.37**	0.95	-1.17**	0.46	-0.11	0.84
homicides	11.23	-0.1	-1.10e-06***	0.003	0.24	-0.12	-0.03	-0.81**	0.67
Aggregate crime	26.42	0.01	-1.01***	0.19	-0.22	0.05	0.63**	-0.89***	0.92

Table 5 Results—two stages least squares: four types of crime. Presentation: explanatory variables on rows, dependent variables on columns

Log crime rate (dependant variable)	Constant	Gini index	Population	Illegal firearms	Deval. dummy	Civil war dummy	Military coup dummy	Probability of arrest	R-squared
Thefts	12.41	2.81**	-1.18***	-1.186	0.153	1.15**	-1.41	-0.39*	0.83
Aggravated assaults	0.21	0.77	-8.91e-07***	0.36**	0.85*	-1.23**	0.37	-0.12	0.84
homicides	6.89	-0.48	-9.53e-07***	-0.02	-0.04	-0.68**	-0.17	-0.83***	0.86
Aggregate crime	26.97	0.01	-1.03***	0.16	-0.45	0.001	0.52**	-0.95***	0.94

Note: instrumented variable, “probability of arrest”. Instruments: public expenditure, area population density, and lagged probability of arrest. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively

Table 6 Percentage difference between ordinary least squares and two stage least squares in estimating the probability of arrest

Log of Crime Rate	Supply of crime Equations		
	OLS Estimate	2SLS Estimate	Percentage Underestimate ^a
Thefts	−0.36**	−0.39*	7.6
Aggravated assaults	−0.11	−0.12	–
Homicides	−0.81**	−0.83**	2.4
Aggregate crime	−1.89***	−1.95***	6.3

^aPercent difference = $(bOLS - b2SLS) / b2SLS$

There is a negative and significant incidence of the probability of apprehension on thefts, homicides, and aggregate crime. That finding is in accordance with the theory of crime and in most of the empirical results in the literature. It is a confirmation of the Becker–Erllich paradigm. However, although inversely associated with aggravated assaults, we found no significant deterrent impact of police resources on that type of crime. That situation may rather be related to the ineffectiveness of police actions given corruption in the police force. Meanwhile, from a static comparative perspective, our results suggest that any increase in the probability of arrest of 10%, *ceteris paribus*, should drive to a decrease in the incidence of thefts, homicides, and aggregate crimes, respectively, of 3.9%, 8.3%, and 9.5%.

Several exogenous shocks occurred during these last decades in Côte d'Ivoire, namely, the devaluation of the regional currency (FCFA) in 1994, the military coup d'état in 1999, and the civil war in 2002. We would like to check whether these events have driven to a boom of criminal activity in the city of Abidjan. For that purpose, a Chow stability test has been carried out for the years 1994, 1999, and 2002. The probabilities of that test for each type of crime (see Table 12 in the [Appendix](#)) imply rejection of the null hypothesis of stability of the coefficient between the different subgroups of interest. The effect of these shocks is captured by the different year dummies in each individual crime.

As far as is devaluation concerned Even though Côte d'Ivoire's economic growth rate was declining during the decade prior to the devaluation, growth rate of the GDP accelerated right after the 1994 CFA devaluation. Furthermore, due to the positive impact of the 1994 CFA devaluation on economic growth both in Ivorian rural and urban areas, at the margin, urban workers should have more disposable income than before that economic shock. Also, the effect of the 1994 CFA devaluation on urban incomes was itself ambiguous, with some households gaining and others losing.

Finally, if one takes into account only the income effect of devaluation, its impacts on crime should be ambiguous referring to the economic motivation to turn to criminal activities. Therefore, our findings indicate that the devaluation of the CFA franc in 1994, has not significantly affected the different series of crimes except aggravated assaults for which the impact is positive and significant. The income effect of devaluation on aggravated assaults may exhibit the idea that any increase in income consecutive to the 1994 CFA devaluation, increases the expected return from crime,

what could motivate criminal activities, since there is not a significant deterrent impact of police action on that particular type of crime. Furthermore, that phenomenon could be tied to the loss of purchase power of some urbanites who might turn to illegal occupations.

Concerning the military coup d'état We show that the military coup d'état has induced an increase in criminal activities in Abidjan. We found a positive and significant relationship between the 1999 dummy and the rate of aggravated assaults and aggregate crime rate. The coup d'état occurred in a context of political unrest and recurrent social demonstrations. That situation has been worsened during the military transition, with a tougher economic condition, a weak state, and an increase in the illegal possession of firearms. Even though the military power tried to implement an extra judiciary policing of crime, protests from international human rights organization, altered their intent to really deter violent crimes.

In reference to the civil war Our findings show that the civil conflict has affected both property and violent crimes. In reverse to the military coup d'état effect, we found a negative and significant impact of the civil war on the incidence of homicides and aggravated assaults. That result shows that the civil war has caused a serious drop in violent crime. In fact, during the civil war, Abidjan has been the main target of rebel groups, the district has been well protected, and government forces in that area were relatively important and well equipped. The city has also experienced repeated curfews and there was a massive presence of police, paramilitary, and military forces in the streets. Since assaults and murders are sensible to the presence of police resources, that situation which may have increased temporarily the probability of detection, led to a reduction in violent offenses. That result is in accordance with Di Tella and Schargrodsky (2004) who found that a temporary massive presence of police officers in a block of Buenos Aires after a terrorist attack in Argentina has reduced significantly the incidence of car thefts. Therefore, the crackdown effect of military forces during the civil conflict may have deterred major crimes such as armed robberies in Abidjan.

However, the positive relationship between larcenies or thefts and the civil war dummy indicates a booming of that sort of offenses during that period of poor economic conditions. Even though most assaults are economically motivated, property crimes are not as sensitive to the presence of police as are violent crimes, rather they seem more influenced by economic conditions. Our finding therefore seems consistent with that of Fafchamps and Minten (2005), who have found that the political crisis in Madagascar led to a booming of property crimes, namely theft of agricultural goods.

5.2 Results for crime victimization

Table 7 shows the main results of our econometric regression of an instrumented variable probit model of crime victimization. The figures in brackets are the robust standard deviations. The average distance to the nearest police stations and the local density of the population are used as instruments for number of police stations.

Table 7 Instrumented variables probit results

Variable	Victim		Thefts		Assault	
	Coefficient (std error)	t-Stats	Coefficient (std error)	t-Stats	Coefficient (std error)	t-Stats
Single	0.2760* (0.148)	1.86	0.1898324 (0.168256)	1.13	0.25964 (0.1775)	1.46
Married	0.0929* (0.1296)	0.72	0.2346945 (0.155000)	1.51	0.04518 (0.15048)	0.30
Densely neighborhood	0.12101 (0.077)	1.56	0.157877* (0.090141)	1.75	0.08378 (0.0910)	0.92
Residential neighborhood	0.3484* (0.1317)	2.64	0.2044689* (0.1234673)	1.66	0.3019** (0.1514)	1.99
HH adult members	0.0024 (0.001)	1.38	-0.0001923 (0.0018628)	-0.10	0.003522* (0.0020)	1.73
Gender: male	0.072 (0.111)	0.65	0.285729** (0.1229369)	2.32	-0.0915 (0.1334)	-0.69
Age	0.0590 (0.453)	0.13	0.0095236 (0.010357)	0.92	-0.1763 (0.5172)	-0.34
Age squared	-8.4e-6 (0.000)	-0.08	-0.000122 (0.000124)	-0.98	0.00007 (0.00013)	0.58
Displaced due to war	0.3278* (0.122)	2.67	0.480414*** (0.1221011)	3.93	-0.10422 (0.1398)	3.93
Primary Education	0.1212 (0.112)	1.08	-0.0949984 (0.1316353)	-0.72	0.185514 (0.131693)	1.41
Secondary Education	0.315** (0.097)	3.23	0.1527133 (0.1104621)	1.38	0.25174** (0.114641)	2.20
Higher Education	0.312** (0.111)	2.80	0.1354429 (0.1237813)	1.09	0.26674** (0.130649)	2.04
Income per capita	0.0505* (0.030)	1.65	-8.59e-08* (5.12e-08)	-1.68	0.19831** (0.100677)	1.97
Employed in a paid job	-0.1142 (0.094)	-1.21	-0.0866568 (0.1119281)	-0.77	0.0242159 (0.111988)	0.22
Self-employed	0.1924* (0.103)	1.87	0.1204503 (0.1157601)	1.04	0.208375* (0.12222)	1.70
Number of police stations	-0.656* (0.242)	-2.71	0.0859091 (0.0860755)	1.00	-0.66708** (0.280925)	-2.37
Household size	-0.0643 0.0702	-0.92	0.0080317 (0.0133443)	0.60	-0.013104 0.0132316	-0.99
Observations	1,600		1,600		1,600	
Wald chi2(17)	59.73		42.63		33.87	
Log pseudolikelihood	-1,808.0548		-3,021.1576		-1,467.7955	

Note: instrumented variable, "Number of police stations". Instruments: distance to the nearest police station and area population density. *, **, *** indicate Significance at the 10%, 5%, and 1% levels, respectively. Base: individual widowed, individual female, individual noneducation, individual unemployed, household neighborhood: fairly populated area, individual non-displaced due to war

Three types of victimization have been considered, namely the probability of being victimized of aggregated crime, that of larceny or burglaries, and the probability of being victimized of assaults. Coefficients of significant variables are in bold characters. However, some of these explanatory variables may be related to one another. To deal with this issue of multi-collinearity, a pairwise correlation matrix between covariates has been generated. Table 14 indicates that even though we may suspect a correlation between variables that correlation is quite weak since it is not close to 1.00, and does not merely change the results of the regression. The analysis of our findings is related to the identified groups of variables.

Exposure to crime There is a positive relationship between the marital status and the probability of being a victim of crime; but that result only holds for aggregate crime. So, compared with widowed, being single, or married increases the probability of victimization in the city of Abidjan. That result is consistent with that of Fougère et al. (2007) in France, where exposition to crime is found to be more pronounced for single individuals compared with married ones. In fact, even though our findings indicate that single and married household heads are exposed to crime in Abidjan city, that probability of victimization is greater for single individuals than married ones.

However, even though we found no relationship between age and the likelihood of victimization, gender appears as a significant determinant of victimization. In fact, there is a positive and significant relationship between being male and exposure to thefts (including larcenies and burglaries). This is in accordance with what is found by Gomes and Paz (2005) in the city of São Paulo and the result of Barslund et al. (2007) in Mozambique, where males are found to have a higher probability of victimization of any type of crime than a female.

Lastly, in reference to employment status, the results reveal that the likelihood of victimization of aggregate crime and assaults is higher for self-employed individuals compared with unemployed ones. Furthermore, while we found no effect between being employed in a paid job and victimization, the significant impact of self-employment on victimization of assaults is critical. In fact, self-employed individuals are likely to spend much more time in the street in the group of an active population, which could increase their vulnerability to crime in the light of the theory of routine activities of Cohen et al. (1981).

Attractiveness to crime shows that there is a significant linkage between income per capita and the probability of being a given crime victim. Although we find a positive relationship between income and the likelihood of victimization for aggregate crime and assaults, we notice a negative impact of income on the victimization of thefts. That result shows the ambiguous effect of income in the understanding of criminal behavior. Firstly, the positive impact of income on victimization is consistent with Barslund et al. (2007), Fajnzylber et al. (2001), and the economic theory of crime developed by Becker (1968). It is clear that crime, namely property crime is basically motivated by the expected net returns; therefore, wealthy individuals are more likely to be targeted. On the reverse, wealthier individuals can undertake a minimum of deterrent investment (electronic protections, watchdogs, alarms, travel in private cars, etc.) so to avoid some petty crimes such as larcenies Gaviria and Pages (2002).

Proximity to crime There is also a positive relationship between the risk of becoming a victim of any kind of crime (assault, theft, etc.) and education. But here, only secondary and higher educations have a significant impact. This result seems related to opportunity costs of crime, where highly educated individuals are expected to have a higher level of income (human capital effect), therefore, to be more targeted by offenders. Indeed in Abidjan, secondary and higher educational attainments are mostly associated with middle class and richer households; they are consequently related to higher probability of victimization. This result is consistent with Gaviria and Pages (2002) who have shown that more educated people, from rich and middle classes are more prone to be victims of crime.

Guardianship Even though it was expected that the size of household reduces the risk of victimization, we found no relationship between that variable and the probability of victimization. However, there is a positive relationship, though weakly significant, between the share of adults in the household and the probability of being the victim of assaults. That result, though inconsistent with that of Barslund et al. (2007) and that of Gomes and Paz (2005) where the number of adults in the household is a source of security against burglaries, seems common sense. In fact, only adult household members are present in the labour market, and consequently are the ones who are likely to have targeted durable goods (cars, for instance) subject to assaults.

Community variables are those relating to the neighbourhood, displaced households, and the number of police stations. Our findings show that the probability of victimization of thefts, assaults, or aggregate crime significantly increases with the fact of living in residential neighborhood compared with people living in densely populated municipalities who are only exposed to thefts. Living in the municipalities of Port-Bouet and Cocody exposes more to assaults than living in other municipalities. However, people living in the densely populated municipalities of Abobo, Adjamé, and Attécoubé have a higher probability of being victimized of larceny or burglaries. That result suggests that larcenies and burglaries best fit densely populated municipalities.

Risk of victimization of assaults in the sparsely populated municipality of Port-Bouet is in accordance with the findings of Fafchamps and Minten (2005) in their case study of Madagascar, where crime incidence is found to be positively related to isolation. Also, the positive relationship between the probability of victimization of assaults and living in the residential municipality of Cocody is consistent with the economic theory of crime. In fact, Cocody is usually perceived as an area where a good number of relatively wealthy people live in Abidjan.

The specificity of Côte d'Ivoire requires analyzing the effect of the political instability on the likelihood of crime victimization. For that reason, we have checked whether being forced to move to Abidjan exposes more to crime than urbanites usually residing in that city. We shall test the assumption that displaced people are not truly integrated and supported by the community while in Abidjan, what makes them more vulnerable to crime. We found that there is a positive and significant relationship between having moved to Abidjan due to the civil war and exposure to crime, particularly victimization of thefts. Intuitively, that result could be apprehended into two ways. Firstly, it can be attributed to a data collection bias. In fact, the questionnaire has not clearly limited time of criminal experiments while reporting the data.

Thus, individuals can live in Abidjan and report the loss they have encountered during their displacement or before they arrived in the city of Abidjan. Secondly, being a victim of war reinforces the vulnerability because of the insecurity caused by the lack of housing or the lack of knowledge of risky areas, which makes them easier targets for offenders.

Another important variable in the prevention of crime is the number of police stations in a given neighborhood. We found a negative and significant relationship between the probability of apprehension (number of police stations) and the probability of victimization of aggregate crime and assaults. In accordance with the economic theory of crime, risk of victimization is lowered by the presence of police resources. While there is no significant link between the likelihood of victimization of thefts (including larcenies and burglaries) and the number of police stations, the deterrent effect of the probability of detection is found to be more pronounced for assaults than for aggregate crime. That result is consistent with Di Tella and Schargrodsky (2004) in their inquiry on the impact of the massive presence of police officers on crime incidence in Buenos Aires, that assaults, namely car assaults are found to be more sensible in the presence of police officers than other crimes.

5.3 Sensitivity analysis

The sensitivity analysis aims at understanding the impact of policy simulation on crime victimization. We address this question by computing on the one hand the average predicted probability of crime victimization and on the other hand determining the likelihood of victimization if some enforcement variables namely “individual income” and “number of police stations” are set at a given threshold. More precisely, we wanted to explore the risk of exposure to crime if the individual income is increased by 10% or if the number of police stations is doubled.

Our findings indicate that the increase of the individual income by 10% increases the average predicted probability of victimization by 1.6% and that of exposure to assaults by 4.9%. On the reverse, the increase of the individual income by 10% reduces slightly the likelihood of victimization of larceny (by 0.023 per 1 million).

These findings are consistent with economic theory, showing the undetermined relationship between income and exposure to crime. It is true that wealthier individuals are mostly the main targets of economically motivated crimes, but it has also been proven that they are the ones who can invest in private protection against property offenses such as larcenies or thefts.

For that concern, the deterrence issue, the results indicate that a doubling of the number of police stations reduces the likelihood of victimization by 15.6% and that of the risk of being assaulted by 6.3%. It is clear that even though doubling the number of police resources deters crime; the effect of such a policy differs from the type of the offense we enforce. That result is also consistent with theory of crime, showing that an increase in the number of police stations increases the aggregate probability of detection, what reduces the likelihood of victimization. That finding is also in accordance with some empirical results like that of Di Tella and Schargrodsky (2004) indicating that even though assault is very sensible to the presence of police resources, mostly a certain time is required before the police be alerted after an attack, which could reduce the effect of police stations on those categories of crime.

5.4 Underreporting and crime enforcement: comparison between macro- and micro-data

Our findings indicate the negative relationship between crime and the probability of detection. In the two-stage regression, the probability of arrest is found to deter all the different series of crime, namely thefts, aggravated assaults, homicides, and aggregate crime. These results have been confirmed in the micro-data analysis. Except for thefts, we show that any increase in the number of police stations (the probability of apprehension), reduced the likelihood being victimized of assaults, and aggregate crime. In the micro-data, the insignificant relationship between police resources and victimization of larceny may be related to data limitation. That result may exhibit the problem of underreporting of larcenies and indicate that only serious thefts are reported to the police, since larcenies are not very sensible to the presence of police.

6 Conclusion

Our work is part of research on how to ensure an environment of stability and security valuable for a post conflict economic development in Côte d'Ivoire. Our approach has been to understand the effects of socio-economic and public policies on crime in the district of Abidjan, the economic capital city of the country. Based on theoretical models on the motivations to turn to crime, we have estimated a simultaneous equations model of supply for offenses. Three types of offenses, namely aggravated assault, homicide, theft and aggregate crime have been analyzed. To better understand the incentives to criminal behavior and to deal with the issue of underreporting, another empirical investigation relating to the likelihood of victimization has been tackled with an instrumented probit model.

Two sources of data are involved in this analysis. These are annual crime reports from 1978 to 2007 from the Department of Statistics of the Criminal Police Division and a survey relating to 1,600 households conducted in November 2006 in the city of Abidjan. Hypotheses relating to the probability of apprehension, to the incidence of inequality, to the illegal circulation of firearms, and to exogenous shocks such as the devaluation of the regional currency (FCFA) in 1994, the military coup d'état in 1999, and the civil war in 2002 have been tested.

In accordance with the economic theory of crime, our findings point out that except for aggravated assaults, the probability of arrest reduces the incidence of any type of crime in Abidjan. Furthermore, at the micro-level, we have shown that doubling the number of police stations reduces the likelihood of victimization of aggregate crime by 15.6% and that of the risk of being assaulted by 6.3%.

As indicated in our assumptions and referencing to a good number of other empirical findings, the effect of income is mixed. At the micro-level, the likelihood of victimization of assaults is positively related to individual income while income negatively impacts on the probability of being victimized of thefts. That finding exhibits the key role of income in crime control policies. It shows that a sustained growth of the GDP per capita is necessary but not enough to deter crime; reduction of inequalities does matter. Inequality, captured by the Gini concentration index in our

simultaneous equation model, is significantly and positively related to thefts. We also found that the likelihood of victimization increases with education. Individuals with secondary and higher education levels are the most exposed to assaults and to aggregate crime.

In addition, while the population size is found to deter any kind of crime at the macro- level, the likelihood of victimization of assaults, thefts, and aggregate crime is found to be positively associated with the neighborhood in micro-data. Precisely, while the residential neighborhood is likely to be exposed to any type crime, a populated neighborhood is likely only to increase victimization of thefts. This finding is quite obvious since it is in accordance with economic motivation of crime, making residential areas the best targets of offenders where the expected return of crime is higher than elsewhere.

As far as exogenous shocks are concerned, we have found that devaluation of the CFA franc explains positively only aggravated assaults, while the military coup d'état is found to have positively and significantly affected both aggravated assault and aggregate crime. The effect of the civil war is mixed. On the one hand, we found a positive and significant relationship between civil war and the incidence of thefts or larcenies, and on the other hand a negative and significant relationship between civil war and the prevalence of aggravated assaults and homicides. While the positive impact of civil war on property crime could be associated with worsening economic conditions consecutive to the conflict, the deterrent effect of the civil conflict on violent offenses could be linked to a temporary "crackdown" policing resulting from a massive presence of armed forces in the streets.

Finally, in order to take into account the specificity of the case of Abidjan, two variables have been included in the analysis: at the macro-level, we have checked the effect of illegal firearms and at the micro-level the fact of being a displaced individual. We found that the proliferation of illegal light weapons has positively and significantly influenced the incidence of aggravated assaults. Also, there is a positive link between the probability of victimization and the fact of being displaced due to the civil conflict.

From these findings, it appears that policies that are likely to perform economic growth and inequality reduction and combined with those which are prone to increase the probability of arrest need to be implemented. Particularly, to effectively control crime in Abidjan, we suggest to:

- Increase police resources by equipping police forces with gears that cope with the nature of violent crime.
- Increase the share of public investment in security.
- Increase the number of police stations.
- Accelerate the poverty reduction programs of the government so to reduce inequality.
- Intensify the control of light weapons proliferation.

In addition, for that policy to actually reduce illegal behavior, the issue of the quality of the police resources needs to be addressed mainly in a framework of the lack of democracy and high level of corruption.

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Appendix: Specification tests

A.1 Nakamura–Nakamura endogeneity test for the probability of apprehension

The Nakamura–Nakamura test can be performed to check whether a set of explanatory variables are endogenous. In our model, all the coefficients of the residual of the first regression are significantly correlated to the dependant variable, indicating that the probability of arrest is endogenous to crime rate.

Table 8 Results: test for endogeneity

	Endogenous dependant variable			
	Homicides	Assaults	Thefts	Aggregate crime
Coefficient of the residual of the first equation	1.098407**	0.0041383***	2.001***	1.359906***

** significance at 5%, *** significance at 1%

A.2 Specification error test: the Ramsey reset test

H0: model has no omitted variables

Table 9 The Ramsey reset test

	Variables: fitted values of			
	Thefts	Assaults	Homicides	Aggregate crime
F(3, 15)	0.45	0.23	0.66	0.14
Prob > F	0.7235	0.9924	0.5893	0.9724

From the respective probabilities (prob > F), we cannot reject the null hypothesis at the level of 10%

In conclusion, our econometric models of supply for offenses are well specified.

A.3 Normality tests

Table 10 Skewness/kurtosis tests for normality

Equation of supply for	Variable	Pr(Skewness)	Pr(Kurtosis)	Joint	
				adj chi2(2)	Prob>chi2
Assaults	Residual	0.412	0.558	1.08	0.5817
Homicides	Residual	0.161	0.544	1.03	0.5235
Thefts	Residual	0.689	0.554	0.53	0.7674
Aggregate Crime	Residual	0.529	0.681	0.59	0.7456

The probabilities of the tests are respectively 0.58, 0.52, 0.76, and 0.74; we cannot therefore reject the null hypothesis of normality of the error term of the different equations of supply for offense.

A.4 Breusch–Pagan/Cook–Weisberg test for heteroskedasticity

H0: Constant variance

Table 11 Results: Breusch–Pagan/Cook–Weisberg test for heteroskedasticity

	Variables: fitted values of			
	Thefts	Assaults	Homicides	Aggregate crime
chi2(1)	0.19	0.90	0.82	0.96
Prob > chi2	0.6621	0.3431	0.3654	0.3278

With the values of the probability (Prob > chi2), the null hypothesis cannot be rejected.

A.5 Chow stability test

H0: stability of the coefficients in the two periods

Table 12 Results for the Chow stability tests

	1994: devaluation	1999: coup d'état	2002: civil war
Assaults	F(13, n-2*13)	F(13, n-2*13)	F(13, n-2*13)
	0.01164324	0.00634295	0.00286143
Thefts	F(13, n-2*13)	F(13, n-2*13)	F(13, n-2*13)
	0.02428191	0.01410153	0.0019446
Homicides	F(13, n-2*13)	F(13, n-2*13)	F(13, n-2*13)
	0.00287397	0.00002654	0.00002361
Aggregate crime	F(13, n-2*13)	F(13, n-2*13)	F(13, n-2*13)
	0.26427835	0.11204641	0.00133399

The probability of the Chow test for each individual crime respectively for devaluation, coup d'état and civil war, indicates that the null hypothesis of stability of the coefficient between the different subgroups can be rejected. In conclusion, these exogenous shocks have affected the incidence of criminal activity in Abidjan.

A.6 Exogeneity test for an explanatory variable: illegal firearms

Table 13 Correlation between the residual and illegal firearms

First difference illegal firearms	Coefficient	Std. Err.	<i>t</i>	<i>P</i> > <i>t</i>
First difference model residual	−0.1496203	0.1627234	−0.92	0.366
Thefts				
First difference model residual	0.250132	0.1974729	1.27	0.216
Homicides				
First difference model residual	0.0670418	0.1393154	0.48	0.634
Aggravated assaults				
First difference model residual	0.057099	0.2518463	0.23	0.822
Aggregate crime				

A.7 Multicollinearity test for explanatory variables

Table 14 Multicollinearity test among explanatory variables

	Single	Married	Dense	Residentia	HH adult	Gender	Age	Age2	Displaced	Prim. Edu	Sec Edu	Higher Edu	Income	Employ	Self- empl	Police	HH size
Single	1.00																
Married	-0.65**	1.00															
Dense	-0.04	0.02	1.00														
Residential	0.01	0.00	-0.45**	1.00													
HH adult	-0.1	0.13**	0.03	-0.013	1.00												
Gender:	0.37**	-0.61**	-0.05**	0.023	-0.09**	1.00											
Age	-0.10**	-0.002	-0.07**	0.06**	-0.002	0.031	1.00										
Age2	-0.13**	-0.02	-0.06**	0.03	-0.04	0.03	0.95**	1.00									
Displaced	0.05**	-0.04	0.02	-0.02	-0.01	0.04	-0.01	-0.03	1.00								
Prim. Edu	0.02	-0.03	0.10**	-0.12**	-0.04	0.03	-0.04	-0.04	-0.01	1.00							
Sec. Edu	0.00	0.05	-0.07**	-0.04	0.02	-0.048	-0.07**	-0.08**	-0.01	-0.32**	1.00						
	0.02	0.06**	-0.17**	0.28**	-0.042	-0.08**	-0.016	-0.035	0.050**	-0.26**	-0.3**	1.00					
High. Edu																	
Income	0.04	0.001	-0.11**	0.18**	-0.28**	0.03	-0.07**	-0.08**	-0.04	-0.08**	-0.05	0.26**	1.00				
Employed	-0.11**	0.20**	-0.001	0.079**	0.055**	-0.28**	-0.15**	-0.21**	0.016	-0.16**	0.04	0.27**	0.101**	1.00			
Self-empl	0.05**	-0.03	0.06**	-0.061**	0.07**	0.04	-0.09**	-0.09**	-0.06**	0.17**	-0.03	-0.2**	-0.07**	-0.60**	1.00		
Police	0.00	0.02	-0.02	-0.11**	0.01	-0.013	-0.02	-0.10**	-0.01	0.08**	-0.01	-0.1**	0.08**	-0.11**	0.1**	1.00	
HH size	0.30**	0.03	-0.04	-0.053**	0.314**	-0.010	0.29**	0.31**	0.013	-0.08**	0.01	-0.01	-0.40**	-0.056**	-0.1**	0.11**	1.00

** Significance at 5% level

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