Crime, Isolation, and Law Enforcement*

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Abstract

This paper investigates the relationship between criminal activity and geographical isolation. Using data from Madagascar, we show that, after we control for population composition and risk factors, crime increases with distance from urban centers and, with few exceptions, decreases with population density. In Madagascar, crime and insecurity are associated with isolation, not urbanization. This relationship is not driven by placement of law enforcement personnel which is shown to track crime but fails to reduce feelings of insecurity in the population. Other risk factors have effects similar to those discussed in the literature on developed countries. We find a positive association between crime and the presence of law enforcement personnel, probably due to reporting bias. Law enforcement personnel helps solve crime but appears unable to prevent it.

Keywords: criminal activity; distance from city; rule of law

JEL: K42, O18

*We thank Bart Minten, Eliane Ralison, and Lalaina Randrianarison for their assistance in collecting and cleaning the commune data. We are grateful to Chris Barrett, Berk Ozler, and Bart Minten for comments. We also thank Berk for graciously sharing his data on poverty and inequality in Madagascar with us. We received comments from the participants to the Oxford conference on spatial inequality in Africa, from conference participants at NEUDC, and from seminar participants at the University of Essex, the University of Aarhus, and the University of Bonn. The support of the Economic and Social Research Council (ESRC) is gratefully acknowledged. The work was part of the programme of the ESRC Global Poverty Research Group

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1. Introduction

Crime and insecurity affect human welfare in many ways. There is the direct cost of crime on victims and the ricochet effect on their friends and relatives. There is also the sense of fear people experience even if they have not been victims of crime. In addition to the direct cost of crime, insecurity generates large economic losses: business and trade are diverted, investment and savings are reduced, and resources are wasted protecting property rights and ensuring personal safety. Insecurity also induces populations to vote for and support strong men who promise security, even at the expense of personal freedom and civil rights. Concerns for security are on the rise everywhere, and most countries experienced increases in crime rates in the 1990s (e.g. Newman 1999, Fajnzylber, Lederman & Loayza 1998). Expenditures on private security personnel and protection equipment are increasing in many countries (Fajnzylber, Lederman & Loayza 2000). As the rich seek to protect themselves and their assets, the poor too often end up bearing the brunt of insecurity (Pradhan & Ravallion 1999).

In both developed and developing countries, the focus has long been on urban crime. By analogy with the US (e.g. Glaeser & Sacerdote 1999, Dilulio 1996, Clinard & Abbott 1973), urbanization is often thought to drive increases in crime in poor countries as well. In Ghana, for instance, much of the increase in crime rates has been attributed to urbanization (Barak 2000). Cities are often ideal places for crime because criminals have a larger number of potential targets and a lower risk of detection than in a small community (Freeman 1996). Crime is frequently found to be correlated with poverty, unemployment, and inequality– all common features of large cities in developing countries (e.g. Ehrlich 1973, Ehrlich & Brower 1987, Fajnzylber, Lederman & Loayza 2000, Bourguignon 2000, Hull 2000). Furthermore, most crime is committed by young men, and since young men account for a large proportion of migrants to cities, one would again expect increases in crime rates there (Clinard & Abbott 1973). Finally, cities in poor countries harbor a large foot-loose population freed from the social pressure found in many small, rural communities, and hence more prone to express its criminal tendencies (e.g. Glaeser, Sacerdote & Scheinkman 1996, Sah 1991, Lederman, Loayza & Menendez 2000). One exception is cattle theft which is more likely in rural areas where cattle are raised.

The focus on urban crime leaves one to believe that crime is rare or even non-existent in rural areas. Little is known about rural crime and insecurity in the developing world. Gugler (1991), for instance, argues that Nigerian parents living in large cities often send their children back to the village to be raised where it is safer. The plight of the rural poor is thought to be more easily bearable because what little property they have is safe.

This paper investigates the relationship between crime and isolation. Using a commune census undertaken in Madagascar immediately prior to the 2001 presidential election, we examine the incidence of various types of crime – cattle theft, burglary, homicide, vehicle theft, and rape – as a function of population density and distance to the nearest major city. We test whether crime is primarily an urban phenomenon driven by proximity to other people and favored by ease of transportation.

The choice of Madagascar as study country is quite propitious. Madagascar has high crime rates. The rate of homicides is as high if not higher than it was in the US in the early 1990s. Other forms of criminal activity are similarly high, especially cattle theft. Yet, unlike other parts of the developing world, Madagascar has known relatively little political violence and has witnessed no guerilla activity in recent memory. In 2002, for instance, contested election results led to a temporary partition of the country between its two main politicians. Both parties, however, refrained from arming militias and the conflict was ended in June 2002 with little bloodshed. This enables us to study crime in isolation from political conflicts which are now thought to be related to crime (e.g. Collier 2000, Collier & Hoeffler 1998).

We find that, contrary to the US, crime in Madagascar is negatively related with population density and positively related with isolation, even after we control for various risk factors. Except for vehicle theft, other categories of criminal activity are more prevalent in areas with low population density and a long way from the nearest city. Much of the rural crime in Madagascar is typically blamed on the *Dahalo*, which can be described as organized rural crime gangs. What the data suggest is that *dahalos* are not a folk legend; they are a sad reality of rural life. While these results contrast Madagascar with, say, the US, it may be in line with other African countries.[1] Examples of a high incidence of rural crime in Africa can be found, for instance, in the works of Andre & Platteau (1998), Smith, Barrett & Box (2001), and Poewe (1989). Whether a high incidence of rural crime is specific to Madagascar, Africa as a whole, or all poor countries remains an open question for further investigation.

An analysis of crime would be incomplete without factoring in the role of law enforcement (Becker 1968). The incidence of crime is usually affected by the presence and effectiveness of the police (e.g. Ehrlich 1996, Rasmussen, Benson & Sollars 1993, Barak 2000, Levitt 1997, Levitt 1998). While not much is known about police and crime control in the developing world, police forces are generally urban-based and under-funded (Hills 2000). Lack of policing in isolated area may thus account for higher crime rates. Before we can conclude that isolation by itself is associated with more crime, we need to control for law enforcement.

The difficulty is that law enforcement personnel is often posted in areas worst affected by crime, thereby generating endogeneity bias. We therefore need to instrument law enforcement. Finding suitable instruments is often difficult. Fortunately, in the case of Madagascar we find that law enforcement personnel prefer to be posted in cities where amenities are better. As

[1] In South Africa, however, Demombynes & Ozler (2002) find a significant and positive correlation between all crimes and population density. Given that South Africa is much more developed than other sub-Saharan countries, it may be that rural crime is characteristic of poor countries – or it may be that South Africa is different, because of its unusual history. This issue deserves more research.

amenities have no independent effect on crime once we control for poverty and inequality, they can be used as instrument.

Results show that the observed relationship between isolation and crime is not due to a bias in policing. As anticipated, law enforcement personnel tend to locate in communes that are close to schools and hospitals. But after we correct for endogeneity in police placement, we still find that crime incidence is higher is isolated, less populated communes, even when they have more law enforcement personnel. If anything, police presence raises crime incidence, probably because of a reporting bias: more crimes are reported in areas where law enforcement personnel are present and active. This suggests that the actual incidence of rural crime is likely to be even higher than reported.

We also investigate subjective the insecurity ranking of commune residents, an indicator that is free from law enforcement reporting bias. This subjective indicator is strongly correlated with crime incidence. Results again show that feelings of insecurity are highest in low population density, isolated areas. We find that law enforcement personnel tend to locate near crime but their presence has no significant effect on people's subjective feelings of insecurity. Although police presence is not sufficient to make people feel secure, it helps solve crime: communes with more gendarmes have a higher proportion of stolen cattle recovered.

The paper is organized as follows. Section 2 is a brief introduction to the conceptual framework. The data is presented in Section 3, together with descriptive statistics. Simple regressions on crime incidence are discussed in Section 4. Police placement and its effect on crime are examined in Section 5. Regression results using subjective measures of insecurity are presented in Section 6.

2. Conceptual framework

Crime is a natural tendency of human beings (e.g. Becker 1968, Ehrlich 1973). In any population, some people are predisposed to crime. If the conditions are 'right', this predisposition expresses itself and crime occurs. On the basis of this simple observation, we expect the average number of crimes $E[c_i]$ committed in location i to be roughly proportional to population P_i in that location.

Different segments of the population have different propensities toward crime. Men, for instance, especially young men, are more prone to violent crime (e.g. Grogger 1997, Clinard & Abbott 1973). Consequently, we expect $E[c_i]$ to increase with the share S_{Mi} of men in the population of location i. Similarly, we expect migrants S_{Ii} to be more crime prone because they live outside the boundaries of social control: crime is less likely to be noticed by neighbors and relatives, and less likely to result in social sanctions (e.g. Glaeser, Sacerdote & Scheinkman 1996, Sah 1991, Lederman, Loayza & Menendez 2000). In contrast, because the sedentary nature of agriculture favors social sanctions, we would expect the proportion of men engaged in farming S_{Ai} to reduce crime. The only exception is when social customs call for young men to prove their courage by stealing cattle.

Crime rates are usually thought to be affected by poverty and inequality (e.g. Ehrlich & Brower 1987, Blau & Blau 1982, Doyle, Ahmed & Horn 1999, Imrohoroglu, Merlo & Rupert 2000, Morgan 2000, Bourguignon 2000, Demombynes & Ozler 2002, Fafchamps & Minten 2002, Fajnzylber, Lederman & Loayza 2001). For poor people, monetary gains from crime are higher relative to non-crime income, hence raising the attractiveness of criminal activity. By reducing the opportunity cost of time, poverty reduces the deterrence effect of jail sentences. Stigma costs are also lower for poor people (Rasmusen 1996). For these reasons, we expect locations with a higher proportion of poor people U_i to incur more crime. Inequality I_i is also thought to have an effect on crime that is distinct from that of poverty. Controlling for poverty, more inequality means more wealth to be stolen. Furthermore, inequality engenders envy and potentially reduces guilt for stealing from the rich.

Crime incidence also depends on the intensity of social interaction. Child upbringing matters. Glaeser & Sacerdote (1999), for instance, show that there is more crime in US cities with a larger proportion of female-headed households H_i. If we regard the criminal as a predator and the victim as the prey, the number of committed crimes should increase with the number of encounters between a prospective criminal and his or her potential victims. For this reason, we expect crime to increase with population density N_i: the less dense population is, the fewer opportunities for theft, rape, and murder (Hull 2000). For the same reason, we expect road links R_i to increase crime because they facilitate human interaction and thus create a greater likelihood of an encounter with the violent and the criminally inclined. This is, for instance, the interpretation given by Rephann (1999) who finds that US rural counties closer to highways have more crime. For all these reasons, we expect isolated populations to be less subjected to crime.

Other risk factors, such as alcohol or drug consumption, are also expected to play a role (Grogger & Willis 1998). Although we cannot measure consumption directly, we suspect it is correlated with the presence of bars and, thus, of electricity V_i. Ethnic diversity is also expected to increase crime if it reduces social bonds and guilt (e.g. Glaeser, Sacerdote & Scheinkman 1996, Easterly & Levine 1997). Using international comparison of country-level data, Fajnzylber, Lederman & Loayza (2000) find a strong effect of ethnic diversity on crime. We therefore expect more crime where ethnic fractionalization F_i is more acute. Certain types of criminal activities, such as cattle theft, are by definition more likely in areas with abundant livestock (Smith, Barrett

& Box 2001). To summarize, we expect the following:

$$E[c_i] = P_i h(P_i, U_i, I_i, H_i, N_i, F_i, R_i, V_i, S_{Mi}, S_{Ii}, S_{Ai}, D_R) \tag{2.1}$$

where D_R are region or ethnic effects capturing location-specific factors, including thieving customs.

Crime statistics are count data. It is therefore natural to assume they follow some kind of Poisson process – or generalization thereof. In our analysis, we posit a generalized negative binomial distribution for crime. This formulation has the advantage of allowing for overdispersion, that is, for the fact that the Poisson density is too restrictive for most count data (see (Greene 1997), Chapter 19). Formally, we assume that the number of crimes c_i is distributed as a Poisson($\nu_i \mu_i$) with

$$\mu_i = P_i \exp(X_i \beta) \tag{2.2}$$

where X_i stands for all the variables entering $h(.)$ in equation (2.1) and where ν_i is an unobserved individual effect with a $\Gamma(1/\alpha_i, 1/\alpha_i)$ density. Premultiplication μ_i by P_i (called an offset) corrects for differences in population across locations and is equivalent to estimating the model in terms of crime rate. The model is further generalized by letting the variance of individual effects ν_i vary across observations, i.e., by assuming $\ln(\alpha_i) = Z_i \gamma$ with Z_i a vector of variables thought to affect the variance. In our analysis, we normally set $Z_i = X_i$. With these assumptions, the unconditional likelihood for the ith observation is:

$$\begin{aligned} l(c_i) &= \int_0^\infty f(c_i|\nu) g(\nu) dv \text{ with} \\ f(c_i|\nu_i) &= \frac{(\nu_i \mu_i)^{C_i} e^{-\nu_i \mu_i}}{\Gamma(c_i + 1)} \\ g(\nu) &= \frac{\nu^{(1-\alpha_i)/\alpha_i} e^{-\nu/\alpha_i}}{\alpha_i^{1/a_i} \Gamma(1/\alpha_i)} \end{aligned} \tag{2.3}$$

Equation (2.1) does not allow for law enforcement personnel and deterrence. In general, we expect the police to catch and punish (some of the) criminals (e.g. Levitt 1997, Levitt 1998, Fajnzylber, Lederman & Loayza 1998). Let the punishment be J_i and let the probability of being caught be an increasing function of the number of law enforcement personnel $p(L_i)$: The gain from crime is written G_i; it is enjoyed only if not caught. The expected gain from crime is $p(L_i)J_i + (1 - p(L_i))G_i$. Since $p(L_i)$ increases in L_i, we see that police presence reduces the expected gain from crime. To the extent that criminals weigh punishment against the instant gratification crime provides, we expect L_i to have a deterrent effect on crime: the higher L_i is, the higher G_i must be to make crime profitable (Becker 1968). Of course, the deterrence effect of police presence assumes that criminals are rational.

If G_i varies across locations – for instance because of population density – then achieving a similar level of criminal activity requires a higher level of policing. Let $g(L_i)$ be the threshold level of G_i required to induce crime when law enforcement personnel is L_i. In any population, some proportion of individuals have a $G_i > g(L_i)$ and thus commit crime. This means that the expected number of crimes $E[C_i]$ is a decreasing function of L_i. We write this as:

$$\mu_i = P_i \exp(X_i\beta - \tau \log L_i) \tag{2.4}$$

where parameter τ measures the deterrence effect of police presence.

For β and τ in equation (2.4) to be estimated consistently, we must account for the possibility that government locates more law enforcement personnel where G_i is highest. In this case, regressing crime on police presence would yield spurious results: L_i is correlated with G_i and thus unobserved factors that affect crime incidence also affect police presence. It is therefore necessary to instrument L_i. To this effect, we need factors that affect police presence but have no anticipated effect on crime. In general, such variables are difficult to come by. Thankfully, the specific situation of Madagascar suggests possible candidates. Because law enforcement personnel are skilled civil servants, they expect a certain level of public amenities. For instance, they probably wish for their families to be located reasonably close to schools and health facilities, to face a reasonably low cost of living, and to enjoy access to electricity and running water. These factors are thus likely to affect police placement. At the same time, they are unlikely to have a direct effect on crime – at least on the types of criminal activity for which we have data. In a country as poor as Madagascar, differences in public amenities between locations are so large that they can serve as instrument. Once police placement has been properly instrumented, we expect its effect on crime to be negative or, in case of no deterrence, zero.

So far we have reasoned that isolation and low population density reduce crime incidence. It is also conceivable that they encourage crime. Lack of roads makes it difficult for law enforcement personnel to pursue criminals. Low population density makes it hard to find witnesses. Put differently, it is possible that bad roads and dispersed human settlements reduce $p(L_i)$ and the deterrence effect of police presence. If this effect on deterrence is strong enough, it would generate a lower τ in isolated and less densely populated areas. But it would not, by itself, generate a negative relationship between crime and isolation in equation (2.2) where we do not control for L_i.

For such a relationship to arise, other assumptions are required. One possibility is that low population density reduces the probability of detection so much that any form of punishment – legal or informal – is unlikely. If this were the case, the effectiveness of law enforcement and of social sanctions would be lower in isolated areas, contrary to what happens in developed countries. Another possibility is that isolation may foster strong identification within a small group but relatively conflictual relations with other groups. When people from different isolated groups come into contact, the likelihood for conflict and crime may increase (Diamond 1997). In this context, we would expect violence to erupt between neighboring groups. This is consistent with findings in the northern Kenyan and southern Ethiopian rangelands, where households living close to hostile ethnic groups had higher expectations of crime and violence (Smith, Barrett & Box 2001). Other possibilities exist as well, such as alcohol abuse or cultural factors. Since our data does not enable us to distinguish between these alternative explanations, these issues are left for further research.

Having clarified our conceptual framework and testing strategy, we now turn to empirical implementation.

3. The data

The data for this study come from three sources: a commune-level survey conducted in 2001, the 1993 national population census, and estimates of poverty and inequality constructed by Mistiaen, Ozler, Razafimanantena & Razafindravonona (2002) on the basis of the 1993 census. Our unit of analysis is the commune, a geographically defined administrative unit in Madagascar, roughly equivalent to a county. Madagascar has six provinces (or faritany), which are divided into fivondronana. The fivondronana are made up of communes – the smallest administrative units with direct representation from the central or provincial government. Rural communes are further divided into fokontany, which essentially represent individual villages. Each commune has a locally elected mayor and a délégué appointed by the province. As of late 2001, there were approximately 1390 communes in Madagascar, but the exact number remains unclear due to the existence of conflicting "official" lists. This confusion is the result of changes in the boundaries and composition of some communes in the mid-1990s. This means that approximately 20 percent of the communes surveyed in 2001 did not have an exact equivalent in the 1993 census.

The commune survey used in this research was conducted over a three-month period in 2001 in a collaboration between Cornell University, Oxford University, and the Malagasy agricultural research institute (FOFIFA). The remoteness of some communes and the general lack of national data on certain subjects meant that little was known about the spatial distribution of public goods and services, economic activity, or crime prior to this study. The commune survey gathered statistics such as the number of gendarmes and police, crime figures, and educational enrollment, from the relevant government offices in the commune. More subjective questions, such as those concerning local prices, transportation, access to various goods and services, major economic activities, and community perceptions of existing conditions, were answered by a focus group composed of residents of the commune. The survey was conducted at the commune's administrative center. A total of 1385 communes were surveyed, all but 9 currently functioning communes.[2]

The 1993 population census is the most recent government census currently available in Madagascar. Information from this census includes population figures by gender and various age groups, literacy rates, employment figures, and percent of the population with amenities such as electricity and running water. Because this information is available by commune based on the 1993 territorial divisions, we are only able to match 86 percent of the communes in the population census with the 2001 commune survey. After combining the three data sets and eliminating observations with missing data, we are left with a little less than 1000 observations.

A map of Madagascar with provincial and communal boundaries is shown in Figure 1. Population density is depicted in shades of grey. We see that population is densest in the Central highlands around the main cities of Antananarivo (the capital city) and Antsirabe. The Eastern highlands and coast between Toamasina and Fianarantsoa are also heavily populated. This largely reflects climate patterns that make these areas more productive for agriculture. Other

[2] The 9 communes in question were missed in the first round of surveys, but the political crisis following the 2001 presidential elections made the work impossible to complete.

major cities such as Toamasina, Mahajanga, Toliara, and Antsiranana are coastal port cities with a small rural hinterland surrounding them. The Western and Southwestern parts of the country are more arid and much less populated.

Descriptive statistics on crime and law enforcement personnel from the commune census are presented in Table 1. All figures are reported per 100,000 inhabitants. Crime statistics are averages over the three year period 1999-2001. Of the five types of criminal activity recorded in the commune survey, cattle rustling is the most common. An average of 80 or so head of cattle are stolen on average each year in each commune – an average of 1500 or so head of cattle per 100,000 inhabitants. This figure is influenced by a number of a small number of very large outliers where cattle rustling takes place at an 'industrial' level. But the median is still 62 head of cattle reported stolen each year per 100,000 inhabitants. The high incidence of cattle rustling may be related to traditional practices of certain ethnic groups. The Bara, one of the dominant ethnic groups in Southwestern Madagascar, are known cattle thieves because young men are supposed to prove their manhood by stealing cattle . When they have done so, they are ready to get married (Ramiarantsoa 1995). The Sakalava have similar customs. Cattle rustling is more common in the western part of the island. This largely reflects the fact that this drier part of the island is most suitable for extensive livestock production, which naturally facilitates cattle rustling (Smith, Barrett & Box 2001).

Burglaries are the next most common type of crime, with some 43 burglaries on average per year per 100,000 inhabitants. The average number of reported homicides is higher than the high US national average from the early 1990's: 8.5 homicides per 100,000 inhabitants (Fox & Zawitz 2000). This number is a bit higher than the 1994 national average of 6.4 intentional homicides reported in Fajnzylber, Lederman & Loayza (1998). The median number of homicides is much lower, suggesting that crime is concentrated in certain communes. The geographical distribution of murder rates is shown in Figure 2. We see that the highest rates are by and large found in less densely populated areas.

A high proportion of perpetrators of homicides are found, with a median probability of 67%. The mean is lower, however, suggesting that finding murderers is more difficult in communes where the number of homicides is high. The incidence of rape appears low, with less than three reported cases on average per 100,000 inhabitants. This is likely due to under-reporting bias. Vehicle theft is extremely rare, reflecting the low number of personal vehicles on the island and the fact that few people know how to drive.

The summary statistics on law enforcement personnel are presented in the second half of Table 1. Law enforcement personnel are divided into three categories in Madagascar: *gendarmes, police,* and *quartiers mobiles* (literally, 'mobile quarters'). *Gendarmes* and *police* are responsible for public security (Ministere de la Justice 1999). The former are primarily posted in rural communes while the latter are posted in urban areas. Both deal with major crimes like the ones discussed in this paper. The police are under the State Secretary while the gendarmes are part of the Ministry of the Armed Forces. The majority of communes have neither *gendarmes* nor *police* and must rely on law enforcement assistance from neighboring communes. *Quartiers mobiles* are more numerous and more broadly distributed but their mandate is focused on smaller crimes and misdemeanors. They nonetheless may play a preventive role. Regular army units sometimes assist the gendarmes in the pursuit of bandits or cattle thieves. The data shows that military forces are extremely concentrated geographically.[3]

Figure 3 shows the geographical distribution of law enforcement personnel per 100,000 inhabitants. Except for a large pocket of low law enforcement density in the Southwest, there

[3] In some areas, groups organized at the village level enforce traditional laws called *dina* (U.S. State Department 2002). In our analysis, we also experimented with a *dina* dummy, but its effect on crime and insecurity is never significant. These results are omitted here.

does not seem to be strong evidence that law enforcement is concentrated in and around cities.

Table 2 provides information on the make-up of Malagasy communes in terms of population, isolation, public services, and risk factors. The population variables (Table 2, Part A) as well as the percentage of households with running water, electricity, pump water and toilet (Table 2, Part B) are from the 1993 census data. The remaining variables are from the commune survey.

We see that median population density is low – 26 inhabitants per square Km. The proportion of migrants in the male population is high – 12% on average. Most active males are involved in agriculture. Overt unemployment is essentially non-existent. The proportion of female-headed households is quite high, with an average of 19%.

Table 2 presents summary statistics estimated by Mistiaen et al. (2002) for all communes of Madagascar. The figures are obtained in two steps. Using a detailed household survey, the authors first estimate the relationship between household income and various indicators, such as housing quality, durables, and the like. The authors then apply the estimated parameters to population census data and derive a variety of poverty and inequality statistics for each commune. This method has now been used in numerous countries and has been shown to yield reliable predictions (e.g. Elbers, Lanjouw & Lanjouw 2003, Elbers, Lanjouw & Lanjouw 2002). In this paper, we use three statistics: the average household income in the commune; the poverty headcount index; and the poverty gap. The latter two correspond to the Foster-Greer-Thorbecke index with $\alpha = 0$ and $\alpha = 1$, respectively, and hence are denoted FGT0 and FGT1.

The majority of the population is considered poor or very poor, with roughly 73% of the population behind the poverty line. Less than 10% is regarded as rich according to Madagascar standards. There are also large income difference across communes: the coefficient of variation of average household income is 0.59. The poverty gap is reported as well. It measures the depth of poverty. Mistiaen et al. (2002) also report a Gini coefficient for each commune. Inequality within communes is moderate, with an average of .36 and a standard deviation of .05. We only use the first three in the regression analysis.

Table 2 also reports the available information on isolation and the provision of public services. The average travel time to a major city is high: 29 hours, with a median of 14 hours. This includes travel time as well as waiting time for public transportation, and is an average of dry and rainy season. This measure is a more useful measure of isolation than either cost or distance, which fail to account for the often long distances that must be covered on foot to reach a road with public transportation. A third of surveyed communes are located 6.5 hours or less from a major city; one third is located 25 hours away or more. The average commune is located 5 hours from the nearest hospital and 2.4 hours from the nearest secondary school. Medians, however, are much smaller. The percentages of households with electricity or running water are quite low. Less than one fourth of households have a toilet. We also report the average beer price in the communes. Malagasy beer is produced at a single location in the central highlands, near the city of Antsirabe, and is transported from there to all parts of the country. We use it as a yardstick to measure the cost of living in terms of manufactures.

Risk factors and other characteristics are listed in the third panel of the table. Crime may go up when climatic events force people to abandon their homes. The occurrence of cyclones is fairly high: over the three year period 1999-2001, on average, communes experienced a cyclone 0.6 years. This means that in any single year, the probability of being hit by at least one cyclone is 20%. The likelihood of bridges and roads being washed out during at least part of the year is twice as high, with a 40% probability in any single year. Such occurrences constitute another measure of isolation as it hinders movements by law enforcement personnel.

Using the data at hand, we construct an index of ethnic fractionalization. The literature has indeed suggested that conflicts of all nature – including crime – may be related to ethnic diversity (e.g. Easterly & Levine 1997, Collier & Hoeffler 1998, Smith, Barrett & Box 2001). Let the share of ethnic group j in the population of commune i be written σ_{ij}. The fractionalization index F_i is simply a Simpson index based on the population shares of various ethnic groups:[4]

$$F_i \equiv 1 - \sum_{j=1}^{N} \sigma_{ij}^2$$

The fractionalization index is also the polarization index proposed by Duclos, Estaban & Ray (2002), equation (6), with their parameter $\alpha = 1$. If the whole population belongs to the same ethnic group, $F_i = 0$. If the population is equally divided into many tiny groups, F_i tends to 1. The average index is 0.32, which corresponds to a moderate degree of fractionalization. We also record the presence of Bara or Sakalava in the commune. As discussed earlier, these two ethnic groups have a tradition of cattle rustling. One fourth of the communes have some Bara or Sakalava.

Other risk factors include a history of political violence. Crime and violence indeed tend to display a fair degree of inertia (Blume 2002). Some 6% of communes have experienced riots or looting since independence. We suspect these communes to be less secure as the population might be against the authority and more willing to harbor criminals. The mining of precious stones and minerals and the presence of non-native residents provide easily identifiable targets for crime. We follow Rephann (1999) and include tourism as a possible draw for criminals and risk factor. The presence of large numbers of livestock in the commune similarly may attract cattle theft. We see that Madagascar is well stocked in zebu cattle, with a median of 2500 heads of cattle per commune. Variance is quite large, and some communes have massive herds. The

[4]The survey records ethnicity into 19 distinct categories. Like all definition of ethnicity, these categories are based on a somewhat arbitrary combination of phenotype, dialect, and place of origin. There is also a residual category 'other'. For the sake of constructing the index, we assumed that the 'other' population is divided equally into three distinct ethnic groups.

number of sheep and goats is smaller but also heavily concentrated geographically.[5]

To summarize, the variables listed in Table 2 cover essentially all major determinants of crime identified in the literature: proportion of males and of migrants in the population; poverty and inequality; crime opportunities measured by the number of livestock, the mining of precious stones, tourism, and the percentage of non-Malagasy population (Becker 1968); labor participation measured by the unemployment rate and the proportion of population engaged in agriculture and livestock (e.g. Ehrlich 1973, Tauchen, Witte & Griesinger 1994); literacy as a proxy for education (Ehrlich 1975); the percentage of female-headed households (Glaeser & Sacerdote 1999); the history of violence and criminal inertia measured by the riot dummy (Glaeser, Sacerdote & Scheinkman 1996); social interactions measured by ethnic fractionalization (e.g. Dilulio 1996, Lederman, Loayza & Menendez 2000, Glaeser, Sacerdote & Scheinkman 1996); and social practices measured by the Bara/Sakalava dummy. We also have data on law enforcement personnel (e.g. Fajnzylber, Lederman & Loayza 1998, Levitt 1997).

In addition to these standard explanatory variables, we have information about distance to the nearest town and the incidence of cut roads. Together with population density, these three variables constitute our measures of isolation. The main objective of the remainder of this paper is to ascertain whether isolation has an effect on crime independent of all the standard explanations for crime.

4. Empirical analysis of crime incidence

Now that we have a better idea of the area under study, we turn to the determinants of criminal activity. We begin with univariate non-parametric regressions between crime rate and distance

[5] regional customs which forbid raising or eating these animals.

to the nearest city, measured in hours of travel time.[6] Results are displayed in Figure 4, together with 95% asymptotic confidence intervals. Results show that crime rates tend to increase with distance from the nearest city. The effect is particularly strong for cattle theft and homicides. For rapes and burglaries, the regression curve cannot be estimated at low distances, probably because the effect of distance is compounded by other factors. We repeat the exercise for crime rates and population density. The results, presented in Figure 5, indicate a generally negative relationship between the two: communes with more people per square km have less crime. The effect is again strongest for cattle theft and homicides. For rapes and burglaries, the relationship cannot be estimated precisely at high levels of population density. While indicative, these results need to be confirmed by multivariate analysis.

We now turn to a relatively sparse multivariate specification that includes only travel time to the nearest city, population density, and controls for poverty, inequality, and location. Latitude and longitude are included as regressors to control for North-South and East-West differentials.[7] The estimator is generalized negative binomial regression with $Z_i = X_i$. The dependent variable is the total number of crimes in the three years prior to the survey. Population is controlled for as an offset variable, so that estimated coefficients measure the effect on the crime rate.

Results are presented in Table 3 for five categories of crime. Because there are very few cases of vehicle theft reported in the commune survey, we can only estimate the model with a reduced number of regressors. Results show that, except for vehicle theft, crime rises with distance from the nearest city. In Madagascar, vehicle theft is the only form of urban theft recorded in the survey. We also find that cattle theft and homicides are more frequent in communes with a

[6]We use an Epanechnikov kernel with a bandwidth of 0.6. In the Figures, we trim the 5% of observations with the lowest kernel frequency in order to improve readability. Without trimming, graphs tend to be dominated by very large confidence intervals at either end of the regression curve.

[7]Latitude and longitude enter in decimal degrees. The West and South of the island are drier. Western communes tended to be settled by populations from the African mainland while Eastern communes were settled primarily by Malays. The Northern tip of the country was, for a while, ruled by pirates.

low population density and hence where people live further apart from each other. In contrast, burglaries and vehicle theft occur in more densely populated areas (the effect is not significant for burglaries, however).

Poverty and inequality variables are often significant, but their effect is different depending on the type of crime. A similar finding is reported by Fafchamps & Minten (2002). We find that the crime rate is higher in communes with a higher average income and a higher poverty gap, i.e., in communes with more inequality. Cattle theft shows a different pattern, with less crime when the poverty gap is large.[8] Location variables are also shown to be important determinants, with more crime in the North and West and strong differences across provinces regarding the incidence of various types of crime.

Results regarding the effect of distance to the nearest city are extremely robust. We obtain similar results if we use alternative definitions of distance. Table 4 reports results obtained using transport cost or physical distance instead of travel time. Other regressors are as in Table 3. With the exception of rapes where the coefficient is no longer significant, results are similar to those reported in Table 3. Virtually identical results are also obtained if some of the regressors are dropped or if alternative estimators (e.g., OLS, Tobit) are used.

It is conceivable that our results are due to omitted variable bias: determinants of crime that are not included in the regression could be correlated with distance. To address this possibility, we reestimate the model with additional controls. The first set of additional regressors controls for population composition, particularly the proportion of men and migrants in the population. The next set of controls focuses on living conditions, such as sanitation and electricity. From the discussion in the introduction we suspect that livestock plays an important role in crime

[8] In regressions not reported here, we also experimented with alternative measures of poverty and inequality. These measures are based on focus group responses to 2001 questions regarding the proportion of commune residents falling in different income groups. These variables are always jointly significant. They confirm that crime is higher when the proportion of poor residents is higher.

because of cattle rustling. We therefore control for livestock population as well as the presence of specialized herders. The third set could be described as 'attractive nuisance', that is, magnets for criminal activity, such as the extraction of precious stones or metals or the presence of tourists. Finally, we include measures of shocks faced by the population either recently (cyclones, cut roads), or in the more distant past (riots). We also allow the crime rate to vary with population and area separately, rather with population density which is the ratio of the two.[9]

The results, presented in Table 5, show that, if anything, adding more controls reinforces the role of isolation, poverty, and inequality. We also add the number of years in which roads or bridges were cut by weather conditions. This regressor can be construed as capturing isolation shocks. We find that it is significant for homicides.

Contrary to expectations, none of the crime measures is found to be proportional to total population: communes with a larger population have a significantly lower crime rate in all four categories. The effect is strongest for cattle theft.[10] We also find that, for three of the four crime categories, the crime rate increases with the area of the commune. Together, these results confirm that larger, less populated communes have higher crime rates. This constitutes further evidence that the concentration of population is not driving crime in Madagascar. Crime is thus more prevalent in areas with low population density and located further away from a major city. These results confirm that, in the case of Madagascar, crime is associated with low population and rural isolation, not with urbanization.

Many of the standard explanatory variables have the expected sign and are significant in at least some of the regressions. Communes with proportionally more migrants have more homicides and cattle theft. As Glaeser & Sacerdote (1999) find in US cities, a higher percentage

[9] But population continues to enter the regression as offset variable.

[10] For cattle theft, the coefficient of population is less than -1, suggesting that the *absolute* number of cattle theft falls with the *absolute* number of people in the commune.

of female headed households is associated with more homicides. Cattle rustling is higher in communes with more cattle. Communes with tourism or mining of precious stones have more crime. Electricity is associated with more rapes while the proportion of households equipped with a toilet is associated with a reduction in cattle theft. Ethnic fractionalization has a positive effect on cattle rustling and homicides. Many of the forces driving crime elsewhere in the world are thus at work in Madagascar.

5. Deterrence

As discussed in Section 2, the negative relationship we find between crime and isolation may be due to insufficient law enforcement and hence to low deterrence. To investigate this possibility, we turn to equation (2.4) and include the number of law enforcement personnel as an additional regressor. Results, partly shown at the bottom of Table 7, indicate that the presence of law enforcement personnel is associated with more crime, not less. (The effect is just below 10% significance for cattle theft.) We also find that controlling for law enforcement does not alter our main conclusion that crime is higher in more isolated areas.

These results are nevertheless suspect because of possible endogeneity between law enforcement L_i and unobservables in the crime regression (Ehrlich & Brower 1987). To correct for this bias, we instrument L_i using variables measuring the attractiveness of the commune to police personnel and their family. Instruments include: distance to nearest school and hospital and average beer price (an indicator of cost of living for manufactures).[11] These variables are likely to affect the placement of law enforcement personnel, but should have no direct effect on crime once we include all the additional controls appearing in Table 5.

[11] The price of a standard-size beer bottle was chosen as indicator of the price of manufactures because it is a perfectly homegeneous commodity that can be found in all communes of the country. In Madagascar, all bottled beer originates from a single manufacturing plant in the Central highlands.

Table 6 reports the results from various endogeneity and exogeneity tests.[12] We apply two separate endogeneity tests: a standard Hausman test and a Davidson-MacKinnon test. Surprisingly, we see that, except for burglaries, we cannot reject the assumption that law enforcement is exogenous. Given the risk of incorrect inference, we nevertheless instruments law enforcement. To test the validity of our instruments, we first use a Wald overidentification test. We cannot reject the hypothesis that instruments are exogenous in all the crime regressions.[13] Secondly (second part of Table 6), we test that the instruments explain enough of the variation in law enforcement. Results show that, with the exception of *quartiers mobiles,* our instruments are jointly significant determinants of law enforcement. Moreover the R^2 statistics of the instrumenting equations are reasonable without being so high that they would suggest overfitting.

We then reestimate the full model, including instrumented law enforcement as additional regressor. By analogy with the method proposed by Rivers & Vuong (1988) for binary data and by Smith & Blundell (1986) for censored data, we follow Wooldridge (2002) and instrument L_i by including the actual variable as well as the estimated residuals from the reduced-form instrumenting equation of L_i. Experimenting with various categories of law enforcement personnel, we find consistent results throughout. Here we only report estimates obtained using total law enforcement.[14] Results, presented in Table 7, show that, contrary to expectations, law enforcement has a significant *positive* effect on crime in two regressions and is positive albeit non-significant in the other two. We also find that law enforcement has an even higher effect on crime after instrumentation: to the extent that endogeneity is present, it tends to underestimate

[12] In the Hausman test, the two covariances used in the test are based on a common estimate of the disturbance variance, that of the fully efficient estimator.

[13] This tests is conducted by first estimating the crime regressions using 2SLS to instrument law enforcement. The residuals from this regression are then regressed on all the instruments and a joint significance test is performed (Wooldridge 2002).

[14] This variable is constructed as the number of gendarmes and policemen plus the number of quartiers mobiles divided by 5. Since there are many more quartier mobiles, if we do not divide quartiers mobiles by 5, they swamp other categories. Very similar results are obtained if we simply sum all law enforcement personnel but we feel there results present a more accurate picture of actual law enforcement effort.

the positive impact of law enforcement personnel on reported crime.

This is an unusual result. Other studies typically find a negative relationship between law enforcement and crime (e.g. Barak 2000, Demombynes & Ozler 2002, Ehrlich 1996, Fajnzylber, Lederman & Loayza 1998, Levitt 1996, Levitt 1997, Levitt 1998). Most of these studies, however, come from developed countries where a minimum level of law enforcement is provided everywhere and crime reporting is reasonably accurate, even in isolated areas. This is unlikely to be the case in Madagascar: police presence may have a strong effect on the reporting of crime. If, in addition, policing has little or no effect on crime itself, the reporting effect will dominate. In this case, more crime is reported where law enforcement personnel is present.[15] This is our favored explanation for our results. Instrumentation does not eliminate this possibility because the instruments chosen are associated with the presence of law enforcement personnel net of the effect of crime itself – and thus with more reporting. Why the Malagasy law enforcement personnel does not have a more pronounced effect on crime prevention is unclear. Ministere de la Justice (1999) presents ample circumstantial evidence that the Malagasy police is notoriously ineffective at preventing crime. Bribing policemen appears to be required for them to investigate crimes. Prisons are also alledgedly porous, with many criminals bribing their way out of jail. Rasamoelina (2000) provides evidence that law enforcement personnel occasionally collude with criminals, or choose not to intervene. We revisit some of these issues below.[16]

Including law enforcement weakens distance coefficients somewhat: travel time remains pos-

[15] A cynical view of policing may ascribe excess criminality to the presence of ill-disciplined law enforcement personnel. Although lack of discipline has been documented in a few cases (Ministere de la Justice 1999), it is unlikely that the small numbers of law enforcement personnel be responsible for very large increase in crime implied by the coefficients.

[16] As pointed out by one referee, it is possible that the number of gendarmes and police does not provide an accurate picture of law enforcement effort. Law enforcement personnel operating in more remote areas may be less effective because of the difficulty involved in policing a very large area. If true, this would mean that law enforcement is less effective in isolated communes.

We do not dispute this idea. Given the log form of our regression (both law enforcement, area, and population appear in logs), these effects are already captured in the regression presented in Table 7. A complete treatment of this important issue is beyond the scope of this paper, however.

itive in all regression but is significant only in two. However, the relationship between crime rate and population becomes even more negative. If under-reporting is the correct explanation for the positive association between police presence and crime, then the fact that more isolated, less densely populated areas are more crime prone cannot be due to under-reporting: if anything, isolation and low population density should reduce crime reporting. The fact that isolation variables by and large remain significant suggests that the association between isolation and crime is not an artifact of incorrect reporting.

6. Subjective insecurity

The results presented thus far indicate that law enforcement personnel have no identifiable effect on crime prevention. One possible explanation is that Malagasy law enforcement is ineffective. This claim is made, for instance, by Ministere de la Justice (1999), Root (1993), and The World Bank (1999) who argue that Malagasy law enforcement personnel are unmotivated and corrupt. A gentler interpretation is that the beneficial effect of law enforcement is entirely obscured by crime under-reporting in communes without policing. To investigate this possibility, we turn to a subjective measure of insecurity collected in the commune census.

Respondents to the census questionnaire – a focus group of commune residents – were asked to rank the level of insecurity in their commune on a scale from 1 to 5.[17] Half the communes were ranked as average; 19-20% were ranked either moderately bad or moderately good, and the rest were ranked as either very bad or very good. A high ranking means the commune is very insecure. The geographical distribution of the subjective rankings suggests that Western communes with low population density feel the most insecure.

Although subjective, this ranking offers the advantage that it is not subject to crime under-

[17] If we regress the insecurity variable on (instrumented) crime statistics, we find that insecurity responds mostly to cattle theft (t-ratio of 6.32) and burglaries (t-ratio of 2.82).

reporting. Using ordered probit, we regress it on the same set of regressors as in Table 7. Results are reported in Table 8. Law enforcement is again instrumented using the Smith and Blundell (1986) method. Results show no relationship between the presence of law enforcement personnel in the commune and the feeling of insecurity of residents. This is true whichever law enforcement category we use. This confirms that law enforcement personnel has little or no effect on crime prevention.

Regarding population and isolation variables, results are by and large consistent with earlier findings. Travel time to the nearest town has a strong positive effect on subjective insecurity. Commune area and population have the expected sign but are not significant.[18] This further confirms that isolation and low population density are strongly associated with a deep sense of insecurity. The proportion of men in the population and the proportion of migrants among males are strong determinants of insecurity. The presence of Bara or Sakalava in the commune also raises insecurity.[19]

7. Determinants of law enforcement

We have accomplished our main objective, which was to test the relationship between isolation and crime. In so doing, we have come up with puzzling evidence of a positive link between law enforcement and crime. Because this is an important issue in its own right, we also examine the factors that determine the effectiveness of Malagasy law enforcement in fighting crime. We do so in two steps. In this section we investigate whether law enforcement personnel locates where crime is more prevalent. Failure to do so would indicate that the government is not responsive

[18] They become significant if the additional controls are dropped.

[19] Strangely, we find that communes with a high literacy rate feel more insecure, possibly because literacy makes people long more for security. Another possible explanation is failed expectations. Literacy raises expectations, especially among young people. When these raised expectations are not met by real economic opportunities, some turn to crime. Yet another possible interpretation is that literacy is correlated with income and higher incomes attract more crime. This issue deserves more investigation.

to local crime levels in its geographical allocation of gendarmes and police. In the next section we investigate whether law enforcement personnel has a significant impact on crime resolution. If the police does not catch criminals, its deterrent effect is unlikely to be strong.

Regarding geographical placement, we examine the three categories of law enforcement personnel separately and together.[20] Because of censoring at 0, we rely on censored least absolute deviation as our estimator. To improve efficiency, we adjust the quartile depending on the amount of censoring in the data (higher quartile if more censoring). Crime incidence is instrumented to control for possible endogeneity bias. By analogy with other limited dependent variable estimators, we correct for endogeneity by including actual crime figures together with residuals from the instrumenting equations. Instruments include: the proportion of males in the population; the proportion of migrants and agricultural workers in the male population; the proportion of female headed households; and various risk factors such as livestock, tourism, ethnic fractionalization, and the presence of Bara and Sakalava. These variables can reasonably be thought to affect police placement only through their effect on crime.

The validity of instruments is tested in Table 9. First, we find that crime variables test endogenous in all four regressions. Second, in all cases, we cannot reject the hypothesis that the instruments are exogenous in the law enforcement regressions. Finally, instruments are jointly significant in three of the four crime regressions. We do not have suitable instruments for rape. Consequently, rape is omitted from the placement regressions. As the reported R^2 values indicate, we are able to explain a sizeable share of the variation in crime. We also see that overfitting is not a concern in spite of the relatively large number of instruments. Instrumenting the three main categories of crime should be sufficient to control for crime incidence.

Table 10 summarizes the regressions of police placement. Two political factors are included

[20] In the joint regression, we give quartiers mobiles a lower weight (0.2) to reflect their low involvement in fighting crime.

in the regressions: a history of riots in the commune and the proportion of non-Malagasy in the population (e.g. Blanchy 1995, Fafchamps & Minten 2001). At least one instrumented crime variables is significant in each regression, but their effect varies across types of law enforcement personnel. Homicides raise the number of *gendarmes* but only have a negative, non-significant effect on policemen and *quartiers mobiles*. Burglaries, in contrast, raise the number of policemen and *quartiers mobiles* but lower that of *gendarmes*. Cattle theft, in contrast, only raises the number of *gendarmes*. Because the effects of homicides and burglaries on *gendarmes* and policemen tend to cancel each other, cattle theft is also the only form of crime to have a significant effect on the combined placement of law enforcement personnel.

Isolation has a significant effect on policing. We find that isolation tends to raise the number of *gendarmes*. This was expected since they are in charge of rural law and order. As predicted by our model, law enforcement presence is an increasing function of population, albeit less than proportionally in all cases. It also increases with commune area. Taken together, these results imply that isolated communes and communes with a lower population density have a larger number of law enforcement personnel per inhabitant: the positive relationship between crime, isolation, and population density is therefore unlikely to be due to underpolicing.

Attractiveness variables are jointly significant in all cases but the sign and significance of individual controls is not very robust in the sense that they are sensitive to small changes in the list of regressors. For this reason, we do not discuss them further.

Perhaps the placement of law enforcement personnel responds not to actual crime but to feelings of insecurity. To investigate this possibility, we repeat the analysis controlling for the sense of insecurity instead of crime. As before, insecurity is instrumented to control for endogeneity. The list of instruments is the same as for crime. Results are not reported here to save space. We find that the placement of gendarmes is quite responsive to feelings of insecurity. The placement of other categories of law enforcement personnel, however, is not.

8. Solving crime

We have seen that law enforcement personnel does, to some extent, locate where they are most needed to fight crime. We have also seen that their deterrent effect on crime itself is non-existent and their effect on feelings of insecurity is not significant. Does this imply that Malagasy law enforcement personnel has no deterrence effect because they are ineffective at fighting crime?

To investigate this possibility, we examine whether policing has an effect on crime resolution. Our two measures are the proportion of recovered cattle and the proportion of captured murderers. Given that these two measures are only available in communes where a crime was perpetrated, we estimate a Heckman selection model. Because the information content of the dependent variable is less, we estimate a sparse version of the model.[21] The variables affecting the occurrence of crime are those reported in Table 5. We are primarily interested in the effect of law enforcement on the probability of resolution, conditional on a crime having taken place.

Some of our results are shown in Table 11; others are omitted to save on space. We find that the effectiveness of law enforcement varies between the different branches. The presence of quartiers mobiles has no effect on the resolution of cattle theft and murder. These findings are consistent with their subsidiary role. Police and gendarmes help solve homicides, although Table 11 the effect is not significant. Only gendarmes have an effect on the recovery of stolen cattle.

These results suggest that law enforcement personnel is not entirely useless: it does locate partly in response to crime and it apprehends some of the criminals. But we find no evidence that law enforcement personnel either deter criminals or increase the sense of security among

[21] Adding more regressors would reduce the likelihood of omitted variable bias but is also biased towards finding no effect of law enforcement on crime resolution.

residents. These findings are in line with the critiques of Malagasy police presented in Ministere de la Justice (1999) and Root (1993)

9. Conclusion

Using data from a commune census in Madagascar, we investigate whether crime incidence is associated with urbanization or isolation. Theory predicts that areas of large human concentration should have more crime because of more potential victims and more opportunities to gain from crime. For similar reasons, areas with better transport to urban centers should suffer more crime. A few forces operate in the opposite direction, however, such as the capacity to avoid detection and the lack of trust among neighboring communities that results from being insulated from the rest of the world.

Results show a strong positive association between crime, the feeling of insecurity, isolation, and low population density. Communes that are the least populated and furthest away from major cities harbor the most criminal activity. This finding stands in stark contrast with the common perception that urbanization drives crime (e.g. Glaeser & Sacerdote 1999, Grogger & Willis 1998, Fajnzylber, Lederman & Loayza 2000).[22] Our results suggest that, in the case of Madagascar, the construction of roads to remote areas may reduce crime and insecurity, not the contrary. They also invite researchers to question the nature of guerilla uprisings and their relationship with crime and isolation (Collier 2000): if isolated regions have more banditry, they are also more likely to harbor armed insurgent and terrorist groups, especially if crime is used to finance insurgency.

Why crime and isolation are correlated remains unclear. One possibility is that isolation pro-

[22] It also differs from the work of Demombynes & Ozler (2002) who find a positive correlation between crime and population density in South Africa. However, Madagascar may be more representative of underdeveloped countries than South Africa.

vides safe harbor and passage for criminals, hence reducing the effectiveness of law enforcement. Another possibility, suggested by the work of Smith, Barrett & Box (2001), is that isolation nurtures distrust among different ethnic groups. This distrust then manifests itself by raiding cattle and property (shops, granaries), occasionally accompanied by homicide and rape. Yet another possibility is that the dearth of entertainment alternatives makes alcohol consumption higher in isolated area, with a by-product of brawls, homicides, and rape. These issues deserve further research.

Regarding other determinants of crime, our results confirm many findings obtained using either US data or international comparisons. The presence of males and migrants in the population increases crime. So does the proportion of female-headed households (Glaeser & Sacerdote 1999). Ethnic fractionalization is associated with more crime as well (e.g. Fajnzylber, Lederman & Loayza 2000, Dilulio 1996, Glaeser, Sacerdote & Scheinkman 1996). Crime opportunities, such as tourism or a large livestock population, raise crime. Rephann (1999) finds a similar effect of tourism in US counties. Put differently, the Madagascar data used here behaves like other data sets except for the effect of isolation. The positive correlation observed between crime and urbanization in the US may have to do with the different nature of crime, primarily the drug trade. To avoid easy detection and be close to demand, dealers must be located in urban centers.

There is, however, an important way in which our results differ from other studies: the lack of deterrent effect from policing. We find that law enforcement personnel tends to be placed in areas of high crime incidence and that it solves a significant proportion of reported crimes. But we also find that law enforcement has no effect on perceptions of insecurity and that the presence of law enforcement personnel has a positive effect on reported crime. We attribute this effect to under-reporting of crime in communes without police presence. It remains unclear why Malagasy police has no discernible effect on crime prevention and deterrence, albeit some authors have suggested that law enforcement in Madagascar is particularly corrupt and ineffective (e.g. Ministere de la Justice 1999, Root 1993). This issue deserves more attention.

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Table 1. Descriptive statistics on crime and police

All figures reported per 100,000 inhabitants

A. Crime incidence (average 1999-2001)	**Mean**	**Median**	**Std. dev.**
Number of stolen cattle	1496.0	62.0	5754
Number of stolen cattle found	323.2	6.1	1074
Proportion of recovered catte (if stolen)	33%	22%	38%
Number of stolen vehicles	0.2	0.0	2
Number of burglaries	42.8	7.9	97
Number of homicides	8.5	2.1	20
Number of murderers found	7.0	0.0	27
Proportion of murderers found (if murder)	56%	67%	44%
Number of rapes	2.9	0.0	10
B. Law enforcement personnel			
Gendarmes	46.2	0.0	105
Police	12.9	0.0	83
Quartier mobiles	478.1	362.9	609
Total	537.1	413.7	613
Military	25.0	0.0	271

Table 2. Characteristics of communes	Data source	Mean	Median	Std. dev.
A. Population characteristics				
Total population	pop. census	10532	7873	23965
Population density	pop. census	131	26	754
Percentage of men in total population	pop. census	50%	50%	1%
Percentage of migrants in male population	pop. census	12	8	11
Percentage of men in agriculture or livestock	pop. census	70	75	19
Percentage of female headed households	pop. census	19	18	6
B. Poverty and inequality				
Average household income in the commune (1993)	Mintian et al	324880	295181	190491
FGT0 (number of poor) in commune (1993)	Mintian et al	72.6%	75.4%	15.3%
FGT1 (poverty gap) in commune (1993)	Mintian et al	0.338	0.329	0.120
Gini coefficient	Mintian et al	0.3615	0.3648	0.0518
C. Isolation and public services				
Travel time to nearest city (in hours) (*)	commune	28.7	14.0	45.0
Travel time to nearest hospital (in hours)	commune	5.3	2.0	10.3
Travel time to nearest secondary school (in hours)	commune	2.4	0.0	8.3
Percentage of households with electricity	pop. census	2.4	0.0	7.8
Percentage of households with running water	pop. census	0.9	0.0	3.6
Percentage of households with pump water	pop. census	5.6	0.2	12.9
Percentage of households with toilet	pop. census	22.7	7.4	28.4
Average beer price (an indicator of cost of living)	commune	5244	5000	1317
D. Other characteristics				
Number of years with cyclone in last three years	commune	0.6	0	0.8
Number of years road was cut in last three years	commune	1.2	1	1.3
Ethnic fractionalization index	commune	0.32	0.29	0.25
Presence of Bara or Sakalava	commune	24%	0%	
Commune had riots since independence	commune	6%	0%	
Precious stones or gold mined in commune	commune	20%	0%	
Tourist attraction present in commune	commune	43%	0%	
Percentage of non-Malagasy population	commune	0.06%	0.01%	0.29%
Number of zebu cattle	commune	6644	2588	31974
Number of sheep and goats	commune	1718	6	8615
D. Province				
Antananarivo		21%		
Fianarantsoa		27%		
Toamasina		14%		
Mahajanga		13%		
Toliara		16%		
Antsiranana		10%		

(*) Travel time to nearest urban center includes waiting time. Average of dry and wet season times.

Table 3. Determinants of the crime rate

(estimator is generalized negative binomial regression)

		Cattle theft		Burglaries		Homicides		Rapes		Vehicle theft (1)	
Isolation	**Unit**	**Coef.**	**z-stat.**	**Coef.**	**z-stat.**	**Coef.**	**z-stat.**	**Coef.**	**z-stat.**	**Coef.**	**z-stat.**
Travel time to nearest major city	log	0.284	**3.70**	0.194	**2.41**	0.168	**3.03**	0.202	**2.58**	-0.575	**-2.75**
Population density	log	-0.554	**-8.02**	0.124	1.52	-0.155	**-2.42**	-0.119	-1.17	0.310	**1.68**
Poverty and inequality											
Average household income in commune	log	-0.900	-0.63	3.176	**2.56**	3.162	**2.47**	4.465	**2.52**	n.a.	
Headcount index (FGT0) in commune	share	3.174	1.33	0.671	0.28	2.920	1.46	-0.481	-0.12	n.a.	
Poverty gap (FGT1) in commune	index	-6.271	**-2.38**	7.225	**2.01**	3.597	1.13	11.456	**2.22**	n.a.	
Location and province dummies (Fianarantsoa is omitted province)											
Antananarivo	yes=1	-2.729	**-5.65**	0.550	1.30	-1.181	**-3.76**	1.182	1.62	n.a.	
Toamasina	yes=1	-3.234	**-5.46**	1.664	**4.31**	-0.392	-1.14	0.928	1.50	n.a.	
Mahajanga	yes=1	-2.970	**-4.67**	1.832	**2.75**	-1.084	**-2.27**	0.982	1.07	n.a.	
Toliara	yes=1	-1.039	**-2.74**	-0.250	-0.81	-0.647	**-2.52**	1.391	**1.66**	n.a.	
Antsiranana	yes=1	-3.059	**-3.50**	2.463	**3.75**	-0.676	-1.39	-0.500	-0.58	n.a.	
East	degree	-0.594	**-7.94**	-0.106	-1.49	-0.412	**-5.82**	-0.015	-0.14	n.a.	
North	degree	0.507	**5.19**	-0.064	-0.75	0.253	**4.45**	0.324	**2.59**	n.a.	
Population (offset variable)	log	1.000		1.000		1.000		1.000		1.000	
Intercept		-0.295	-0.01	-46.661	**-2.78**	-53.784	**-3.12**	-84.210	**-3.27**	-12.343	**-10.67**
Number of observations		980		984		986		986		1003	
Pseudo R-squared		0.0556		0.024		0.055		0.045		0.0676	
		test stat.	*p-value*	*test stat.*	*p-value*	*test stat.*	*p-value*	*test stat.*	*p-value*		
Joint test of the poverty and inequality variables		25.800	0.000	26.270	0.000	27.010	0.000	34.150	0.000		

Since all regressions correct for population size as an offset variable, coefficient estimates measure the effect of regressors on the crime rate.
All regressions allow for the dependence of the variance of the negative binomial distribution on all the regressors.
(1) Due to the very small number of non-zero observations (3% of the sample) we can only estimate a very reduced form equation.

Table 4. Alternative distance measures

(estimator is generalized negative binomial regression)

		Cattle theft		Burglaries		Homicides		Rapes		Vehicle theft (1)	
		Coef.	**z-stat.**	**Coef.**	**z-stat.**	**Coef.**	**z-stat.**	**Coef.**	**z-stat.**	**Coef.**	**z-stat.**
Travel time to nearest major city (Table 3)	log	0.284	**3.70**	0.194	**2.41**	0.168	**3.03**	0.202	**2.58**	-0.575	**-2.75**
Transport cost to nearest city	log	0.171	**3.82**	0.195	**4.40**	0.090	**2.53**	0.177	1.57	-0.544	**-2.41**
Distance in Km. to the nearest city	log	0.217	**3.14**	0.201	**3.19**	0.187	**3.57**	0.031	0.40	-0.549	**-3.10**

Table reports only the coefficient and z-statistic of the distance variable. Other regressors are the same as in Table 3.
Other coefficients not reported here to save space.
(1) Due to the very small number of non-zero observations (3% of the sample) we can only estimate a very reduced form equation.

Table 5. Determinants of the crime rate with additional controls

(estimator is generalized negative binomial regression)		Cattle theft		Burglaries		Homicides		Rapes	
Isolation	**Unit**	**Coef.**	**z-stat.**	**Coef.**	**z-stat.**	**Coef.**	**z-stat.**	**Coef.**	**z-stat.**
Travel time to nearest major city	log	0.155	**1.97**	0.154	**2.04**	0.167	**3.36**	0.254	**2.88**
Area	log	0.306	**3.88**	-0.191	**-2.47**	0.177	1.59	0.293	**2.20**
Population	log	-1.376	**-10.06**	-0.445	**-3.67**	-0.694	**-5.72**	-0.491	**-2.97**
Poverty and inequality									
Average household income in commune	log	2.043	1.38	3.903	**3.34**	1.892	1.11	-0.017	-0.32
Headcount index (FGT0) in commune	share	5.916	**3.10**	5.500	**2.61**	2.270	0.95	-0.778	-0.24
Poverty gap (FGT1) in commune	index	-0.633	-0.21	4.323	**1.65**	3.051	1.32	7.707	**2.70**
Location and province dummies (Fianarantsoa is omitted province)									
Antananarivo	yes=1	-1.690	**-4.44**	0.188	0.47	-0.538	-1.09	0.430	0.72
Toamasina	yes=1	-2.180	**-4.20**	1.520	**4.22**	0.143	0.51	0.808	1.53
Mahajanga	yes=1	-1.957	**-3.71**	1.163	**2.33**	-0.495	-0.69	0.822	1.06
Toliara	yes=1	-0.963	**-2.68**	-0.672	**-2.12**	-0.736	-1.41	1.405	**1.84**
Antsiranana	yes=1	-3.051	**-4.37**	2.336	**4.13**	-0.227	-0.51	-0.208	-0.26
East	degree	-0.368	**-4.85**	-0.210	**-2.82**	-0.203	-1.17	0.086	0.79
North	degree	0.342	**4.57**	0.036	0.54	0.067	0.65	0.249	**1.74**
Additional controls									
Percentage of men in total population	%	-3.925	-0.42	-0.092	**-2.23**	0.009	0.24	3.818	0.35
Percentage of migrants in male population	%	0.023	**2.75**	-14.891	**-1.69**	19.818	**2.07**	0.019	1.38
Percentage of men in agriculture or livestock	%	0.007	1.40	0.010	1.06	0.016	**2.23**	-0.012	**-1.77**
Percentage of female headed households	%	-0.003	-0.16	-0.015	-0.93	0.031	**2.43**	2.008	1.28
Percentage of households with running/pump water	%	0.017	**2.38**	-0.008	-1.32	0.000	0.06	-0.016	**-2.19**
Percentage of households with toilet	%	-0.015	**-3.49**	-0.001	-0.29	-0.005	-1.30	0.004	0.76
Percentage of households with electricity	%	0.002	0.09	0.017	1.30	0.050	1.16	0.057	**2.96**
Number of zebu cattle	log	0.189	**4.03**	-0.004	-0.71	-0.002	-0.26	0.022	0.55
Number of sheep and goats	log	0.037	1.55	0.092	**3.15**	0.034	1.11	0.211	1.19
Ethnic fractionalization index	index	1.076	**2.71**	-0.382	-1.00	0.484	**1.81**	0.347	1.42
Presence of Bara or Sakalava	yes=1	0.188	1.22	-0.160	-0.88	0.215	0.79	0.018	0.75
Precious stones or gold mined in commune	yes=1	0.597	**2.92**	0.097	0.57	0.222	1.50	0.181	0.82
Tourist attraction present in commune	yes=1	0.178	1.27	0.296	**2.18**	0.080	0.54	-0.629	-1.18
Percentage of non-Malagasy population	%	-0.017	-0.10	-0.305	-1.19	0.533	0.10	-0.496	.
Commune had riots since independence	yes=1	0.074	0.25	0.451	**1.93**	0.127	0.52	-0.630	**-1.89**
Number of years road was cut in last 3 years	# years	-0.005	-0.08	0.072	1.15	0.083	**1.70**	0.071	0.94
Number of years with cyclones	# years	0.111	1.13	0.112	1.43	0.122	1.12	-0.103	-0.63
Population (offset variable)	log	1.000		1.000		1.000		1.000	
Intercept		-31.083	-1.47	-46.649	**-2.99**	-40.135	**-1.92**	-49.937	**-2.12**
Number of observations		971		975		977		977	
Pseudo R-squared		0.071		0.038		0.085		0.080	

Since all regressions correct for population size as an offset variable, coefficient estimates measure the effect of regressors on the crime rate.
All regressions allow for the dependence of the variance of the negative binomial distribution on all the regressors; results not shown to save space.

Table 6. Endogeneity and exogeneity tests for law enforcement

A. Crime regressions		**Cattle theft**		**Burglaries**		**Homicides**		**Rapes**	
Test that law enforcement is endogenous:	*test*	*test stat.*	*p-value*	*test stat.*	*p-value*	*test stat.*	*p-value*	*test stat.*	*p-value*
Hausman test	Chi-sq(9)	11.92	0.2911	**24.78**	0.0098	12.25	0.3453	16.65	0.1188
Davidson MacKinnon test	t	-0.88	0.3770	**-1.73**	0.0840	-1.6	0.1100	-0.75	0.4560
Wald test that instruments are exogenous in the crime regressions (overidentification test)	Chi-sq(2)	0.5721	0.7512	4.2630	0.1186	4.2650	0.1185	3.4400	0.1785
B. Instrumenting regressions		**Gendarmes**		**Police**		**Quartiers mobiles**		**All three (1)**	
F-test that instruments are jointly significant in		*test stat.*	*p-value*	*test stat.*	*p-value*	*test stat.*	*p-value*	*test stat.*	*p-value*
instrumenting regressions for law enforcement	F(3,N)	**2.82**	0.0378	**6.33**	0.0003	1.89	0.1296	**5.17**	0.0015
R-square		0.256		0.288		0.266		0.266	

(1) When combining all three law enforcement personnel, 'quartiers mobiles' are given a weight of 0.2 to capture their lesser involvement in solving crime.
(2) Testing total law enforcement personnel. Similar results are obtained for other categories of law enforcement personnel.
(3) Using total law enforcement.

Table 7. Determinants of the crime rate, controlling for law enforcement

(estimator is generalized negative binomial regression)		Cattle theft		Burglaries		Homicides		Rapes	
Law enforcement	**Unit**	**Coef.**	**z-stat.**	**Coef.**	**z-stat.**	**Coef.**	**z-stat.**	**Coef.**	**z-stat.**
Number of law enforcement personnel	log	1.859	**3.35**	1.160	**2.20**	0.433	0.97	0.878	1.14
Residuals from instrumenting equation		-1.738	**-3.13**	-0.949	**-1.78**	-0.348	-0.78	-0.731	-0.92
Isolation									
Travel time to nearest major city	log	0.067	0.87	0.098	1.14	0.146	**2.58**	0.194	**1.86**
Area	log	0.174	**1.92**	-0.355	**-3.58**	0.121	1.64	0.215	1.17
Population	log	-2.268	**-7.84**	-1.039	**-3.80**	-0.880	**-3.69**	-0.888	**-2.19**
Poverty and inequality									
Average household income in commune	log	-2.915	-1.42	1.200	0.62	0.652	0.39	-0.328	-0.12
Headcount index (FGT0) in commune	share	3.854	**1.98**	5.156	**2.27**	1.864	1.07	-1.722	-0.53
Poverty gap (FGT1) in commune	index	-9.659	**-2.53**	-1.644	-0.41	0.676	0.21	3.341	0.65
Location and province dummies (Fianarantsoa is omitted province)									
Antananarivo	yes=1	-2.121	**-5.26**	-0.308	-0.71	-0.628	**-2.19**	0.300	0.49
Toamasina	yes=1	-1.293	**-2.20**	1.806	**4.61**	0.329	1.01	1.144	**1.88**
Mahajanga	yes=1	-2.253	**-4.35**	0.678	1.26	-0.516	-1.34	0.618	0.75
Toliara	yes=1	-0.399	-1.01	-0.362	-0.99	-0.598	**-1.95**	1.412	**1.92**
Antsiranana	yes=1	-1.473	**-1.85**	2.920	**4.47**	0.141	0.25	0.538	0.51
East	degree	-0.385	**-5.27**	-0.241	**-3.11**	-0.215	**-2.84**	0.048	0.39
North	degree	0.271	**3.72**	0.039	0.54	0.044	0.74	0.216	1.25
Additional controls									
Percentage of men in total population	%	1.954	0.21	-10.763	-1.23	0.015	**1.97**	6.726	0.54
Percentage of migrants in male population	%	0.026	**3.02**	0.010	1.09	0.001	0.13	0.020	1.30
Percentage of men in agriculture or livestock	%	0.015	**2.82**	0.001	0.08	-0.004	-0.12	-0.010	-1.32
Percentage of female headed households	%	0.011	0.56	-0.009	-0.52	0.033	**2.58**	0.021	0.81
Percentage of households with running/pump water	%	0.015	**2.38**	-0.006	-1.01	0.001	0.10	-0.013	-1.51
Percentage of households with toilet	%	-0.020	**-4.54**	-0.005	-1.40	-0.006	**-1.85**	-0.001	-0.10
Percentage of households with electricity	%	0.030	**1.71**	0.032	**2.26**	0.059	**2.64**	0.065	**2.85**
Number of zebu cattle	log	0.113	**2.34**	-0.095	**-1.93**	23.171	**3.13**	-0.056	-0.83
Number of sheep and goats	log	0.024	0.98	0.100	**3.37**	0.034	1.41	0.026	0.62
Ethnic fractionalization index	index	1.020	**2.56**	-0.416	-1.07	0.548	**2.11**	-0.653	-1.19
Presence of Bara or Sakalava	yes=1	-0.055	-0.33	-0.295	-1.46	0.149	0.95	0.226	0.83
Precious stones or gold mined in commune	yes=1	0.315	1.50	-0.007	-0.04	0.171	1.23	0.030	0.14
Tourist attraction present in commune	yes=1	0.147	1.05	0.292	**2.19**	0.075	0.68	0.204	1.18
Percentage of non-Malagasy population	%	-0.400	**-2.07**	-0.539	**-2.23**	0.756	0.58	-0.768	-1.32
Commune had riots since independence	yes=1	-0.265	-0.98	0.191	0.80	0.110	0.52	-0.612	**-1.71**
Number of years road was cut in last 3 years	# years	-0.008	-0.14	0.073	1.18	0.078	**1.70**	0.064	0.85
Number of years with cyclones	# years	0.130	1.35	0.096	1.23	0.130	**1.89**	-0.181	-1.14
Population (offset variable)	log	1.000		1.000		1.000		1.000	
Intercept		41.142	1.39	-8.340	-0.31	-22.876	-0.95	-15.106	-0.38
Number of observations		962		965		967		967	
Pseudo R-squared		0.072		0.041		0.087		0.082	
Selected parameters from uninstrumented regression									
Number of law enforcement personnel	log	0.120	1.64	0.184	**2.48**	0.108	**1.98**	0.181	**2.02**
Travel time to nearest major city	log	0.147	**1.93**	0.162	**2.07**	0.161	**3.51**	0.253	**2.80**

Since all regressions correct for population size as an offset variable, coefficient estimates measure the effect of regressors on the crime rate.
All regressions allow for the dependence of the variance of the negative binomial distribution on all the regressors.

Table 8. Determinants of sense of insecurity, controlling for law enforcement
(Estimator is ordered probit)

Law enforcement (instrumented)	**Unit**	**Coef.**	**z-stat.**
Number of law enforcement personnel	log	0.313	0.96
Residuals from instrumenting equation		-0.299	-0.91
Isolation			
Travel time to nearest major city	log	0.140	**3.42**
Area	log	0.064	1.16
Population	log	-0.190	-1.11
Poverty and inequality			
Average household income in commune	log	1.393	1.11
Headcount index (FGT0) in commune	share	1.740	1.32
Poverty gap (FGT1) in commune	index	2.223	0.92
Location and province dummies (Fianarantsoa is omitted province)			
Antananarivo	yes=1	0.070	0.33
Toamasina	yes=1	0.399	**1.74**
Mahajanga	yes=1	0.548	**2.00**
Toliara	yes=1	0.022	0.10
Antsiranana	yes=1	0.938	**2.36**
East	degree	-0.155	**-3.13**
North	degree	0.012	0.32
Additional controls			
Percentage of men in total population	%	10.523	**2.18**
Percentage of migrants in male population	%	0.011	**1.98**
Percentage of men in agriculture or livestock	%	0.005	**1.73**
Percentage of female headed households	%	0.012	1.29
Percentage of households with running/pump water	%	0.001	0.29
Percentage of households with toilet	%	0.000	0.08
Percentage of households with electricity	%	0.004	0.39
Number of zebu cattle	log	-0.022	-0.81
Number of sheep and goats	log	-0.015	-0.92
Ethnic fractionalization index	index	0.061	0.31
Presence of Bara or Sakalava	yes=1	0.229	**1.99**
Precious stones or gold mined in commune	yes=1	-0.098	-0.99
Tourist attraction present in commune	yes=1	0.017	0.22
Percentage of non-Malagasy population	%	-0.124	-0.85
Commune had riots since independence	yes=1	0.173	1.08
Number of years road was cut in last 3 years	# years	0.022	0.69
Number of years with cyclones	# years	0.001	0.02
Number of observations		969	
Pseudo R-squared		0.0730	

Table 9. Endogeneity and exogeneity tests for crime variables

A. Law enforcement regressions		**Gendarmes**		**Police**		**Quartiers mobiles**		**All three (1)**	
Test that crime is endogenous:	*test*	*test stat.*	*p-value*	*test stat.*	*p-value*	*test stat.*	*p-value*	*test stat.*	*p-value*
Hausman test	Chi-sq(7)	**24.94**	0.0008	**47.56**	0.0000	**22.94**	0.0017	**15.83**	0.0267
Davidson MacKinnon test	F(3,N)	**4.57**	0.0012	**3.91**	0.0037	**4.73**	0.0009	1.92	0.1052
Wald test that instruments are exogenous in the law enforcement regressions (3)	Chi-sq(6)	6.9396	0.3264	3.5320	0.7399	4.7440	0.5769	5.1321	0.5282
B. Instrumenting regressions		**Cattle theft**		**Burglaries**		**Homicides**		**Rapes**	
F-test that instruments are jointly significant in the instrumenting regressions for crime	*test* F(11,N)	*test stat.* **3.13**	*p-value* 0.0002	*test stat.* **1.99**	*p-value* 0.0269	*test stat.* **4.09**	*p-value* 0.0000	*test stat.* 1.22	*p-value* 0.2632
R-square		0.230		0.170		0.186		0.126	

(1) When combining all three law enforcement personnel, 'quartiers mobiles' are given a weight of 0.2 to capture their lesser involvement in solving crime.
(2) Testing total law enforcement personnel. Similar results are obtained for other categories of law enforcement personnel.
(3) Using total law enforcement.

Table 10. Presence of law enforcement officers, controlling for crime

(Estimator is censored least-absolute deviation)		Gendarmes		Police		Quartiers mobiles		All three	
Crime (instrumented)		**Coef.**	**z-stat.**	**Coef.**	**z-stat.**	**Coef.**	**z-stat.**	**Coef.**	**z-stat.**
Cattle theft	log	0.310	**6.85**	0.005	0.13	0.025	0.86	0.061	**2.83**
Burglaries	log	-0.219	**-2.19**	0.098	**1.66**	0.093	**2.22**	0.033	1.10
Homicides	log	0.362	**2.04**	-0.218	-1.34	-0.095	-1.09	-0.015	-0.17
Residuals from instrumenting equation for cattle theft		-0.000	-0.35	-0.000	-0.14	-0.000	-0.64	-0.000	-0.61
Residuals from instrumenting equation for burglaries		0.004	0.75	-0.002	-0.98	-0.001	-0.50	0.000	0.10
Residuals from instrumenting equation for homicides		0.001	0.02	0.063	**1.66**	-0.001	-0.05	0.023	0.92
Isolation									
Travel time to nearest major city	log	0.307	**2.89**	-0.007	-0.13	-0.052	-1.24	0.064	1.50
Area	log	0.556	**6.32**	0.089	1.31	0.042	0.76	0.108	**2.56**
Population	log	0.561	**2.88**	0.468	**3.82**	0.532	**7.42**	0.536	**6.76**
Location and province dummies (Fianarantsoa is omitted province)									
Antananarivo	yes=1	0.268	0.78	-1.773	**-3.06**	0.348	**2.52**	0.078	0.59
Toamasina	yes=1	-1.550	**-3.23**	0.042	0.16	-0.977	**-4.57**	-0.642	**-3.45**
Mahajanga	yes=1	-0.322	-0.75	-0.415	-1.07	-0.019	-0.07	-0.240	-1.00
Toliara	yes=1	0.554	**1.73**	-0.323	-0.96	-0.326	-1.27	-0.532	**-2.64**
Antsiranana	yes=1	-1.145	**-1.77**	-2.169	**-3.71**	-0.742	**-2.07**	-0.730	**-2.30**
East	degree	0.004	0.04	0.125	1.43	0.193	**3.25**	0.033	0.65
North	degree	0.094	1.45	-0.013	-0.22	-0.051	-1.01	-0.015	-0.45
Additional controls									
Mean income in the commune (1993) (1)	log	-0.552	**-1.75**	0.643	**2.33**	0.377	**2.36**	0.436	**3.98**
Percentage of households with running/pump water	%	-0.003	-0.37	0.029	**2.83**	-0.008	-1.32	0.005	1.06
Percentage of households with toilet	%	0.024	**5.00**	-0.000	-0.17	0.003	**1.93**	0.003	**1.95**
Percentage of households with electricity	%	0.087	**4.83**	0.007	0.44	-0.018	**-2.23**	0.011	1.28
Number of zebu cattle	log	0.030	0.55	-0.008	-0.27	0.036	0.88	-0.006	-0.21
Precious stones or gold mined in commune	yes=1	-0.092	-0.58	0.198	1.57	0.182	**1.96**	0.084	1.11
Percentage of non-Malagasy population	%	0.734	**2.14**	0.153	0.18	0.048	0.07	0.155	0.61
Commune had riots since independence	yes=1	0.044	0.16	0.422	1.14	0.214	1.17	0.067	0.40
Number of years road was cut in last 3 years	# years	0.051	0.76	-0.029	-0.66	-0.053	**-1.66**	0.006	0.21
Number of years with cyclones	# years	-0.246	**-2.26**	0.154	**2.15**	0.056	1.15	0.024	0.64
Travel time to nearest hospital	log	-0.132	-1.22	-0.212	**-2.42**	0.129	1.54	0.010	0.16
Travel time to nearest school	log	-0.016	-0.12	0.007	0.11	-0.056	-0.99	-0.134	**-2.76**
Average beer price (an indicator of cost of living)	log	-0.962	-1.50	1.148	**2.84**	0.523	**1.90**	0.649	**2.57**
Intercept		1.333	0.20	-23.642	**-3.41**	-12.816	**-3.46**	-14.341	**-4.38**
Quantile used in estimation		0.718		0.739		0.536		0.518	
Pseudo-Rsquare		0.230		0.191		0.137		0.184	

The dependent variable is log(# law enforcement personnel+1)

Table 11. Solving crimes

(estimator is maximum likelihood Heckman selection model)		Recovering stolen cattle		Finding murderers	
A. Proportion of cases solved		**Coef.**	**z-stat.**	**Coef.**	**z-stat.**
Number of law enforcement personnel	log	0.090	**2.95**	0.060	1.26
Residuals from instrumenting equation		-0.072	**-2.13**	-0.068	-1.27
Isolation					
Travel time to nearest major city	log	0.005	0.42	0.016	0.83
Population density	log	-0.011	-0.86	-0.007	-0.38
Location and province dummies (Fianarantsoa is omitted province)					
Antananarivo	yes=1	-0.130	**-2.67**	0.009	0.11
Toamasina	yes=1	-0.037	-0.54	0.300	**3.22**
Mahajanga	yes=1	-0.105	-1.43	0.272	**2.35**
Toliara	yes=1	-0.058	-1.19	0.044	0.52
Antsiranana	yes=1	-0.005	-0.05	0.471	**3.04**
East	degree	-0.006	-0.44	0.005	0.19
North	degree	-0.002	-0.18	-0.036	**-1.83**
Intercept		0.411	0.85	1.716	**2.29**
B. Selection equation					
Isolation					
Travel time to nearest major city	log	0.001	0.01	0.117	**2.95**
Population density	log	-0.002	-0.03	-0.001	-0.03
Poverty and inequality					
Average household income in commune	log	0.539	0.54	3.498	**3.90**
Headcount index (FGT0) in commune	share	3.478	**2.03**	2.746	**1.90**
Poverty gap (FGT1) in commune	index	-0.690	-0.33	5.765	**3.11**
Location and province dummies (Fianarantsoa is omitted province)					
Antananarivo	yes=1	0.308	1.34	-0.197	-1.01
Toamasina	yes=1	-0.152	-0.61	0.407	**1.88**
Mahajanga	yes=1	1.032	**2.51**	0.112	0.37
Toliara	yes=1	-0.354	-1.58	-0.346	**-1.90**
Antsiranana	yes=1	0.407	0.93	-0.056	-0.15
East	degree	-0.413	**-6.02**	-0.218	**-4.33**
North	degree	0.167	**3.57**	0.104	**2.65**
Intercept		-7.394	-0.53	-48.374	**-3.88**
Number of observations		978		978	
of which uncensored		709		513	

The dependent variable is the number of cattle (murderers) found over the number of cattle stolen (murders).

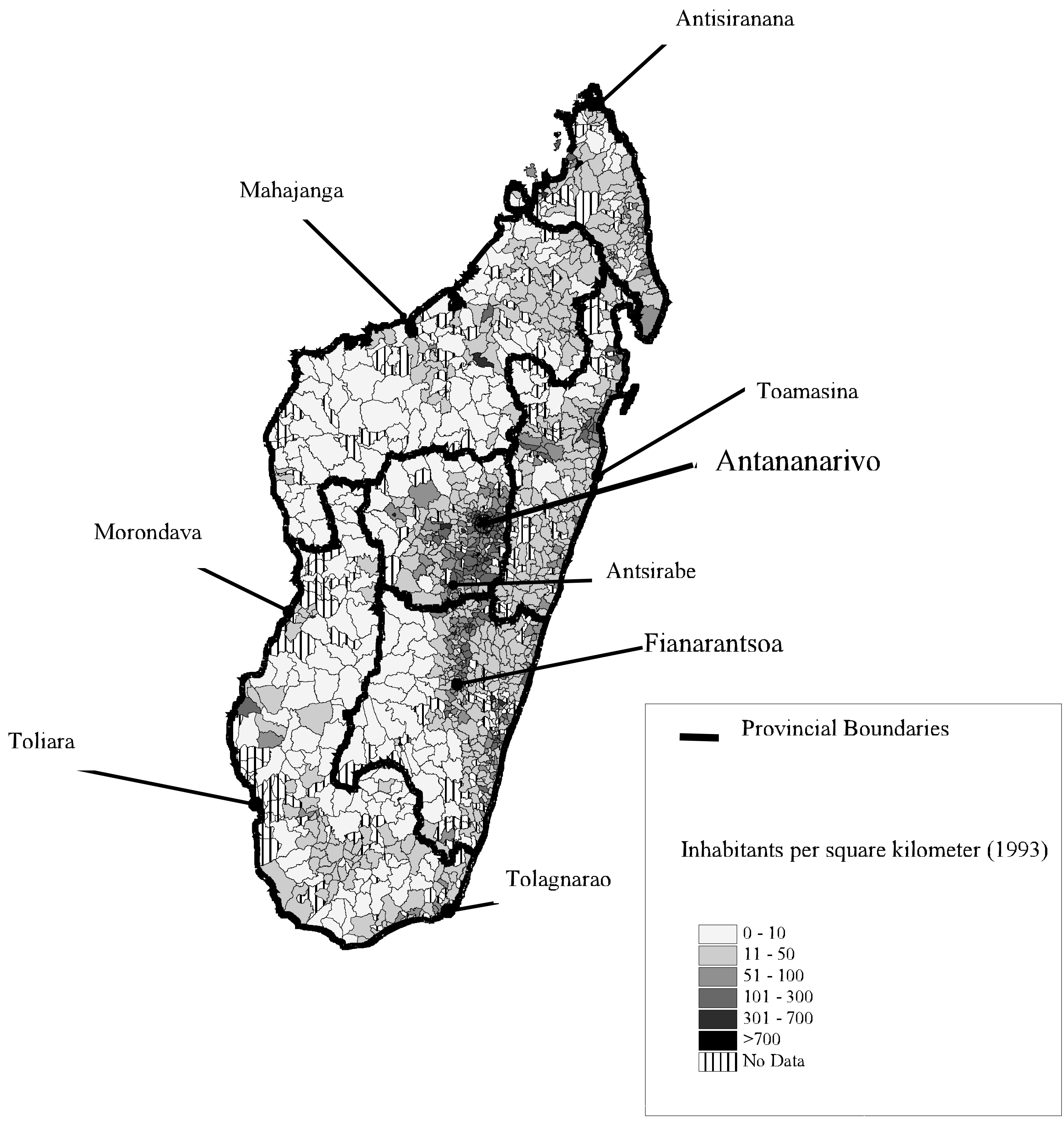

Figure 1. Population density and major cities of Madagascar

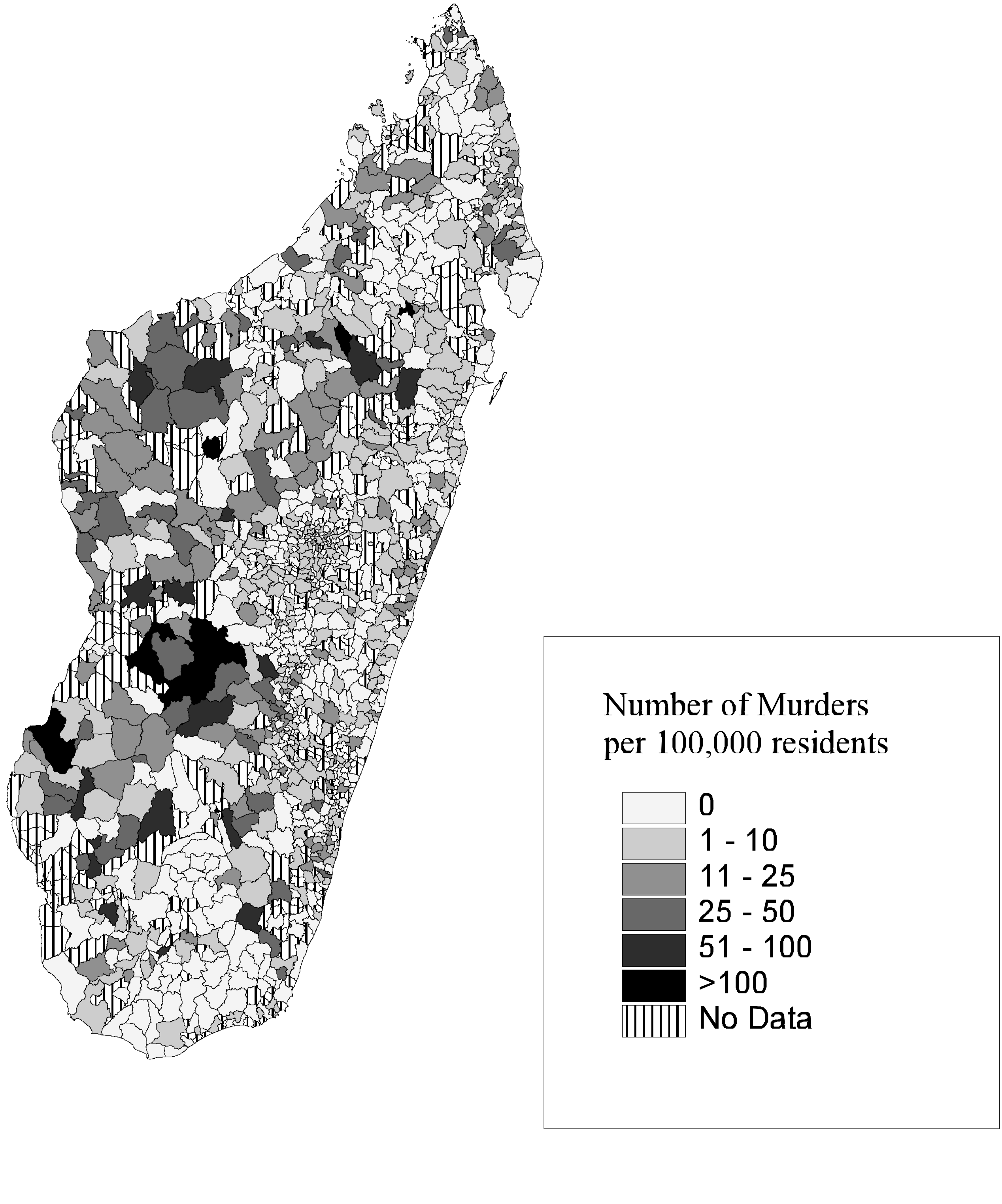

Figure 2. Average Number of Murders per 100,000 inhabitants 1999-2001

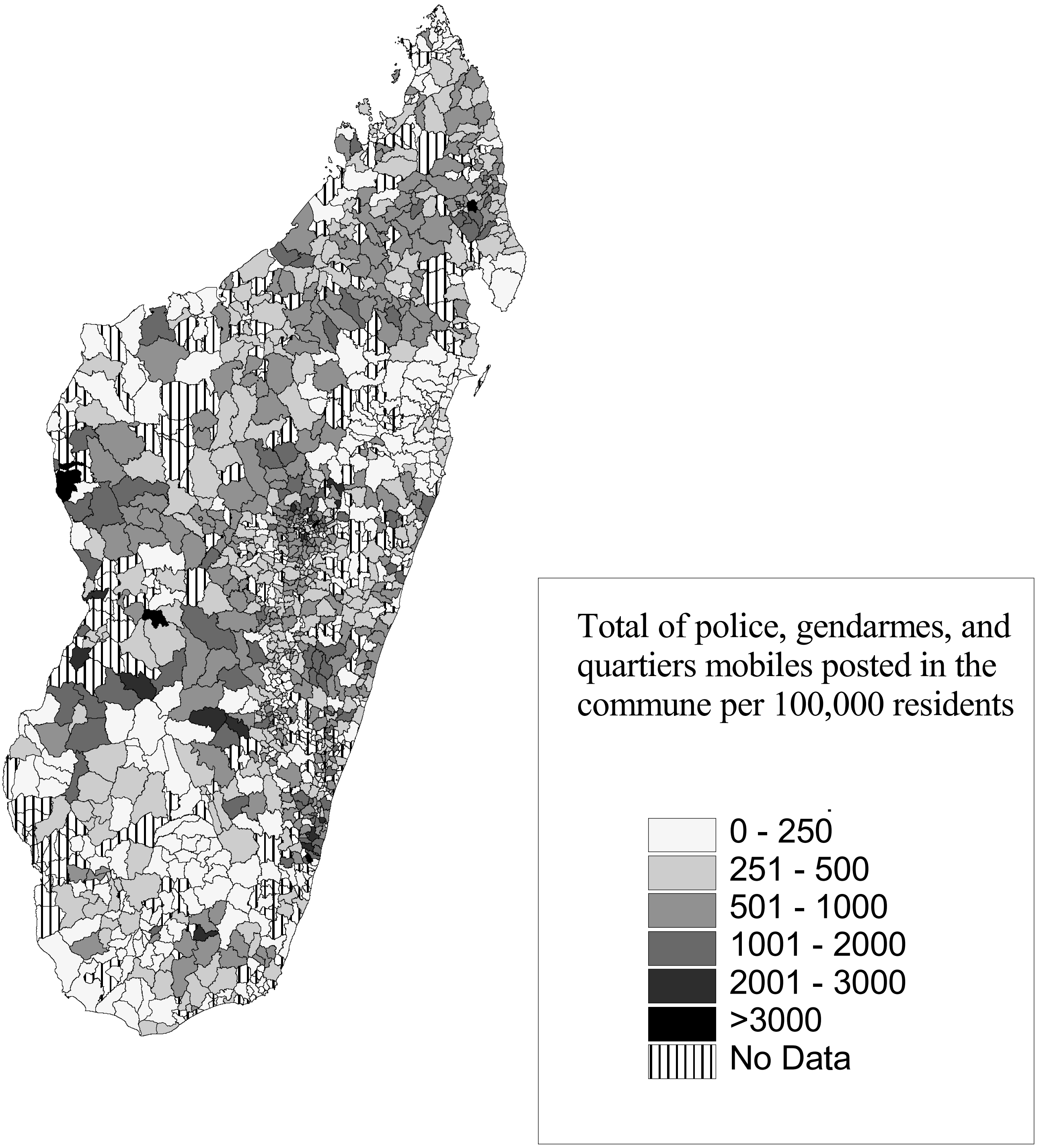

Figure 3. Number of law enforcement personnel per 100,000 inhabitants

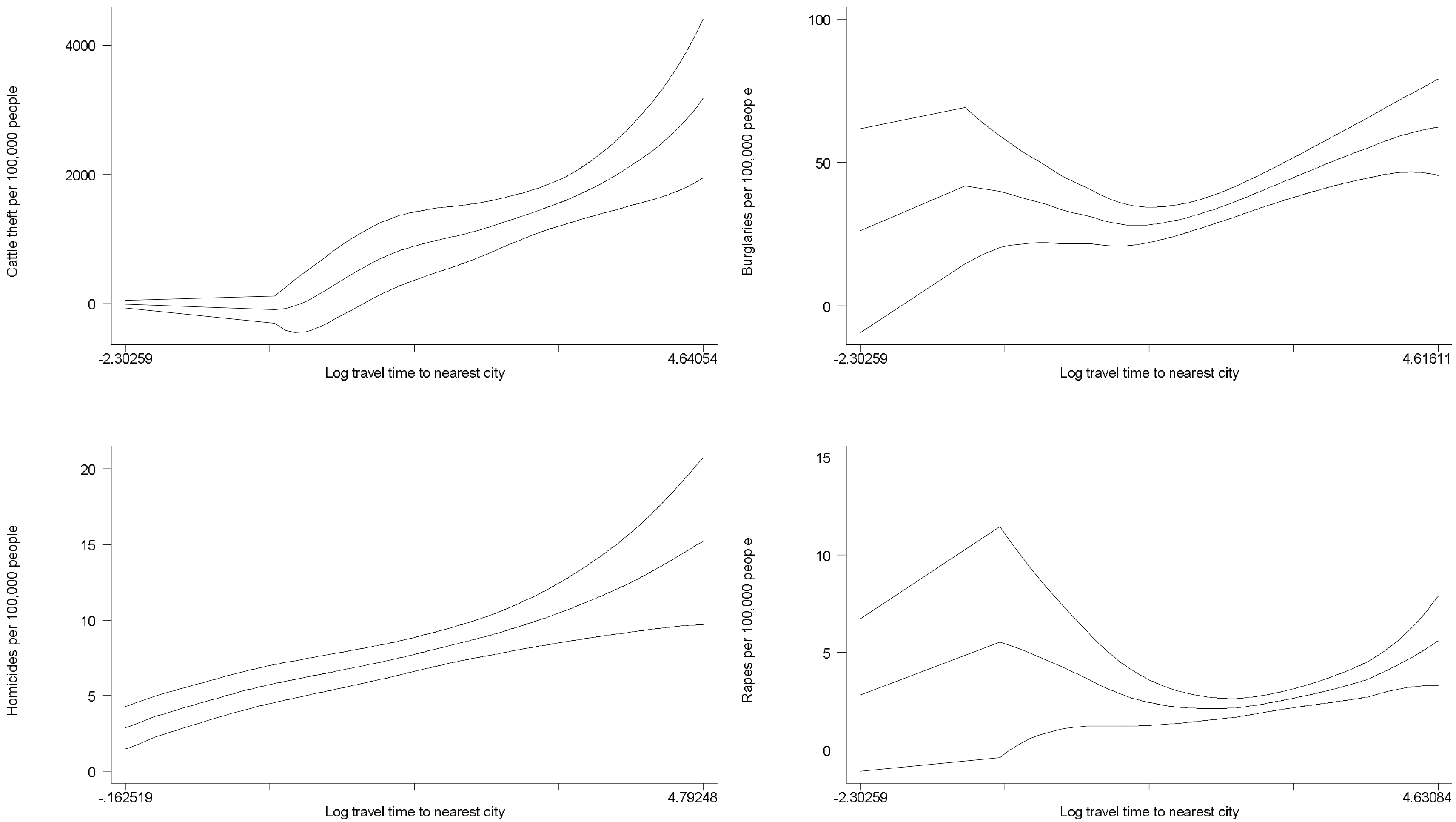

Figure 4. Crime Rate and Cost of Travel to Nearest City

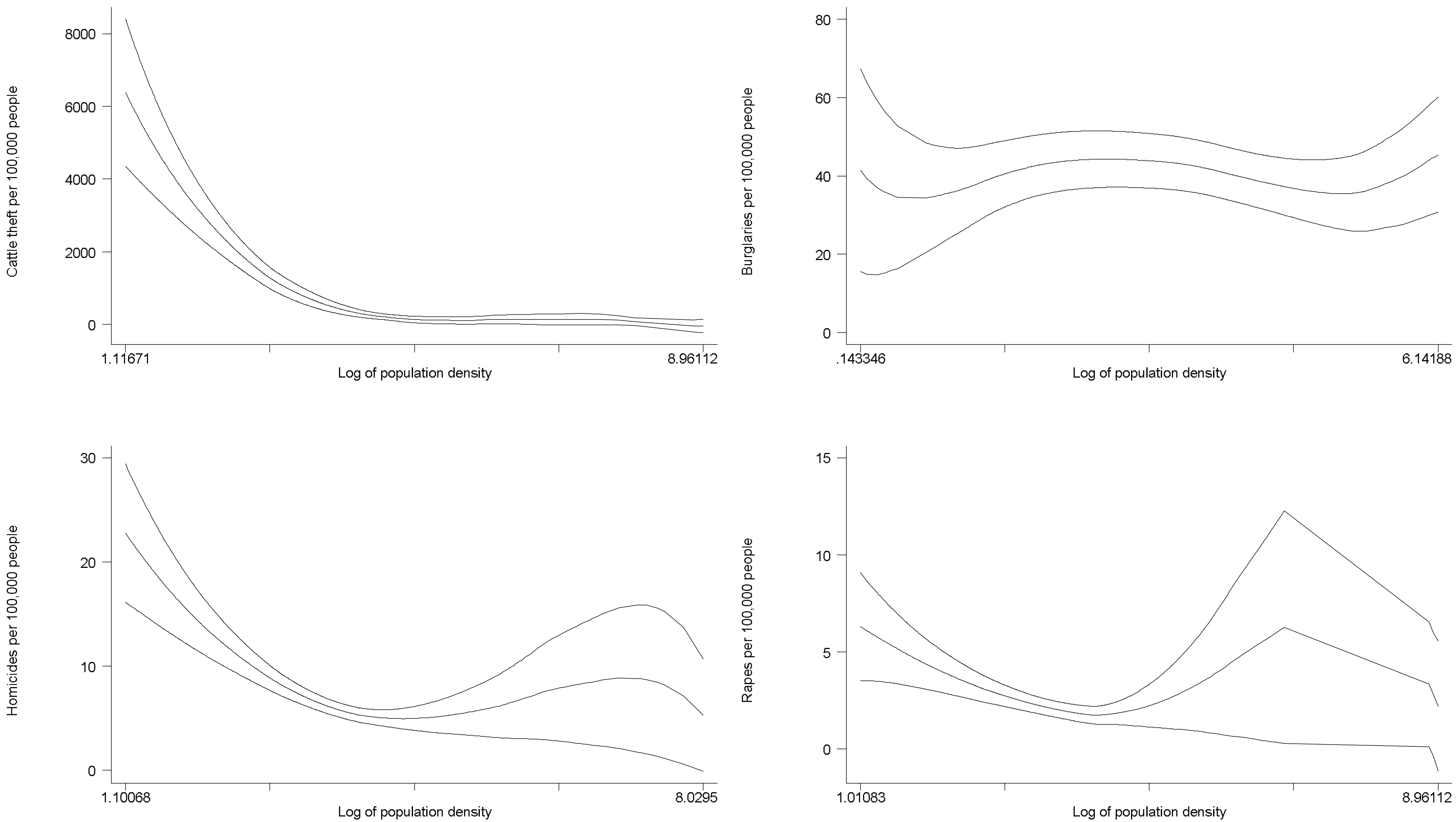

Figure 5. Crime Rate and Population Density