# The Relationship Between Crime Levels and Spatial Accessibility to Police Services: The Case of Paraguay

Luis Recalde Ramírez
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September 13, 2022

**Abstract**

Spatial Accessibility to police services is a measure of police presence and visibility, and is therefore central to assessing overall access to justice and the status of the rule of law. Its impact on crime levels is not straightforward. Previous research shows diverging outcomes of police presence over crime levels. One major reason for this is *reporting bias*, which is a systematic measurement error that occurs when higher accessibility creates incentives for higher crime reporting. Unlike other types of less serious crimes, murder is assumed to be immune to reporting bias due to the severity of the offense, as it cannot go unreported. A set of OLS regressions of crimes on the spatial accessibility index, controlling for population size and variables of police efficiency shows that an increase of a 1-index point in spatial accessibility (roughly a decrease of 2km in the average minimum distance to the nearest police station and an increase of 1 additional police station within a 5km radius) is associated with a 32 percent decrease in homicides. All other types of crimes exhibited reporting bias, and under the strong assumption that they are all impacted by higher accessibility in the same extent as murder is, it can be observed that theft, robbery, and bodily harms are the crimes with the highest magnitude of reporting bias. Overall, greater spatial accessibility to police stations deters murders significantly, and at the same time creates incentives for higher crime reporting.

**Keywords:** spatial accessibility, justice services, police stations, crime, reporting bias, Paraguay

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# The Relationship Between Crime Levels and Spatial Accessibility to Police Services: The Case of Paraguay

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# Introduction

*Accessibility* to a public service has been defined as the spatial relationship between the service and the population, measured mainly by distance (Penchansky & Thomas, 1981). As such, it is considered one fundamental aspect of the broader concept of *Access*, which may also include other dimensions, such as, for instance, the quality of the services. *Accessibility* on its own, however, may have powerful implications in the analysis of the presence of the government over social dynamics. When it comes to the geography of justice, previous studies have shown that traditionally marginalized groups, such as women, migrants, rural population, poor people, suffer the largest degree of "isolation" from such services (Birghin & Kohen, 2006). When additional variables are introduced into the equation, such as crime levels, not only does the analysis become more interesting, but it becomes necessary.

Targeting the spatial accessibility to police stations, one of the most important primary justice fora, this paper will intend to uncover the relationship these services have with crime levels. The role of police organizations in the modern world are of utmost importance in the maintenance of well-functioning law and order within a country (Stassen & Ceccato, 2019). Beyond that, they can also be considered as a "symbol" of government authority and the rule of law, thus their proximity can create a certain sense of trust in the institution (Millie, 2012). Analyzing the impact of geographic accessibility to police stations on crime under the light of these premises could help answer relevant questions about (a) the crime-deterring effect of police presence and (b) the social behavioral responses of greater police visibility.

The specific question this research intends to answer is: *what is the relationship between spatial accessibility to police services and crime levels in Paraguay?* This question broadens the possibility of exploring accessibility with more open expectations rather than hypothesizing on

"what the results should be". As a matter of fact, much research has been done to evaluate the impact of police presence (be it size or other features), and not always do they prove that an increase in policing efforts help reduce crime levels. Cameron (1988), Marvell and Moody (1996) and other authors spoke about how more often than not there is little evidence of strong negative correlation between police and crime.

Levitt (1998) conducted his analysis not trying to measure the impact of the police on crime, but rather evaluating why in some cases there was a positive correlation between them. He identified that crimes may often be affected by *reporting bias*, which can be defined as a measurement error that occurs when the crime reporting or recording (here used interchangeably) behavior is systematically affected by the policy being analyzed. A central argument of this paper, *reporting bias* implies that a higher spatial accessibility to police stations leads to an increase in the reporting of crimes that would otherwise go unreported. This may be caused, as mentioned above, by the increased confidence people have of crimes being solved when the police are closer and more visible. The one exception to reporting bias are homicide cases, since regardless of how far police stations are from where a murder happened, due to the severity of the crime it can hardly be ignored and go unreported.

The methodology applied in this paper are OLS regressions of spatial accessibility to police stations on crime levels, controlling for relevant observable variables, such as arrest statistics or police efficiency measures. One major assumption that guides this analysis is that murders are immune to reporting bias, which means that conditional on the inclusion of control variables, the obtained coefficient represents the actual effect of accessibility on true murder numbers. Other types of crimes, however, are believed to be affected by reporting bias.

The data on spatial accessibility to police stations was obtained from the working paper *"Rule of Law and Access to Justice: Construction of an Accessibility Index of Primary Justice Fora in Paraguay"* (Recalde, 2022), which introduces a methodological approach to combining two main GIS measures to create the index: (a) average minimum distance to police stations from households, and (b) average count of services available for households within a radius of 5km. Crime and policing related data were obtained from Paraguay's National Police Statistics Department, and population data was retrieved from the National Statistics Institute (INE). The analysis is conducted at the department level.

Ultimately, the policy implications of the results may arise through two different channels. The first is a depiction of the *true* desired effect of accessibility on crime, seen through the unbiased coefficients on murder. The second one, a bit more complex to grasp, is the behavior and decisions of people who benefit from increased accessibility to police stations in the face of a nonmurder crime, as opposed to those with less accessibility.

The first section of this paper introduces background review on police presence and its impact on crime, including the definition and explanation on *reporting bias* and its implications. After this section, the data used for the analysis is presented, immediately followed by the methodology. Results are then presented before the last section, which concludes.

## Police Presence and its Impact on Crime

The analysis of police presence on crime using GIS tools is a promising innovation. For example, Fondevila et al. (2021) rely on spatial data of criminal activity to model criminal behavior in the city of Buenos Aires. The authors found that police stations seem to "have a deterrent effect on crime", as crimes tended to increase exponentially as distance from the

nearest police station up to 500-600 meters, past which it began to decrease again. A similar conclusion was reached by Weisburd (2021), who evaluated the location of police patrol cars in Dallas (USA). The main finding was that in locations where police presence decreased by 10 percent, crime increased by 4.6 percent. More traditional line of research, such as the one conducted by Lin (2009) relying on USA state tax rates as an instrumental variable for local police size, show with statistically significant results that police presence does reduce crime.

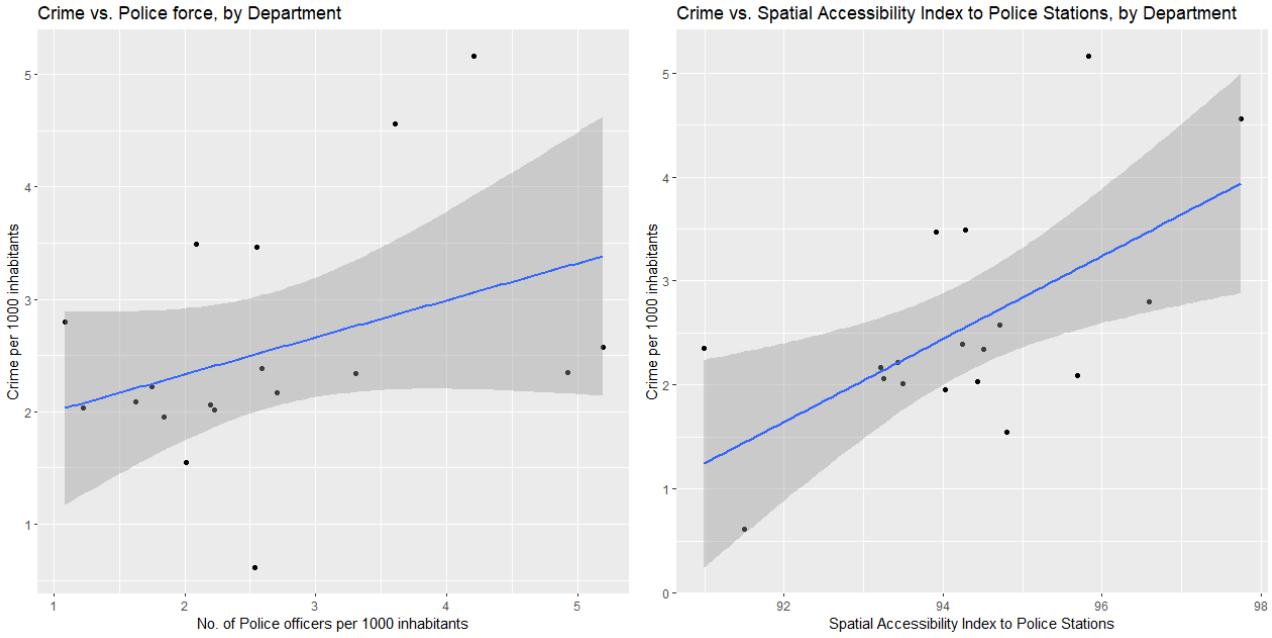
However, as logically unambiguous as it may seem to be, finding the effect of police presence on crime levels is not as straightforward. Eck and Maguire (2000), for instance, reached the conclusion that there is insufficient evidence that changes in police presence can deter crime. Years before that, Cameron (1988), as well as Marvell and Moody (1996), showcased a large body of literature in which an increase in the number of police is reported as being associated with an increase in crime rates, or as having no effect at all. Diagnoses for the causes of such often-counterintuitive results range from endogeneity, omitted variable bias, reverse causality, and even poor data. Here, in the context of spatial accessibility to police services and crime reporting, one more explanation seems suitable to be introduced: *reporting bias.*

## Reporting Bias

The work of Steven D. Levitt (1998) focuses on explaining the concept of "reporting bias", built on previous research that consistently failed to show a strong negative correlation between police and crime. Reporting bias is defined as a measurement error that is systematically related to the policy being evaluated; in this case, an increase in the crime levels is a consequence of an intrinsic relationship between crime reporting behavior and the changes in police presence. Levitt further explains that that the size of police force may systematically affect the "willingness of victims to report a crime or a police department's propensity to

officially record crimes". In other words, "victims may be more likely to report crimes to the police when the perceived likelihood of a crime being solved is high."

**FIGURE 1. Crime per 1000 inhabitants in Paraguay vs. Police size and Accessibility Index**




*SOURCE:* Author's own elaboration using crime reporting data and police force size data from the National Police of Paraguay, and the Spatial Accessibility Index (Recalde, 2022)

At this point it is important to highlight that, in the case of Paraguay, the size of the police force has a high correlation with the spatial accessibility index to police stations (*r=0.81*), both being measures of police presence (the data used for this paper are introduced in detail in a later section). As observed in Figure 1, the number of total crimes per 1000 inhabitants is similarly an increasing function of the number of police officers per 1000 inhabitants and of the accessibility index to police services, which might be anticipating the presence of reporting bias.

As pointed out by Levitt (1998), dealing with reporting bias is not an easy task. Nevertheless, if there is one factor that may make crime immune from reporting bias is the severity of the offense. In other words, serious crimes such as murders are "virtually always reported to the

police", thus eliminating reporting bias. The logic behind this is that the majority of homicides are difficult to ignore or hide, let alone go unreported, regardless of whether the perpetrator is known or not. This clearly contrasts with less grave crimes, such as robbery or theft, which have a higher probability of being under-reported and under-recorded.

In the context of an analysis where spatial accessibility to police stations is the main independent variable, the presence of reporting bias may have interesting policy implications, as it could serve as an opportunity to understand the dynamics that come into play between society and the geography of justice services, beyond their crime-deterrent basic purpose. The existence of crimes that are systematically affected by this phenomenon may be a signal that higher spatial accessibility serves as an incentive for people to report crimes when they occur or for the police to record them, as opposed to leaving them undeclared.

# Data

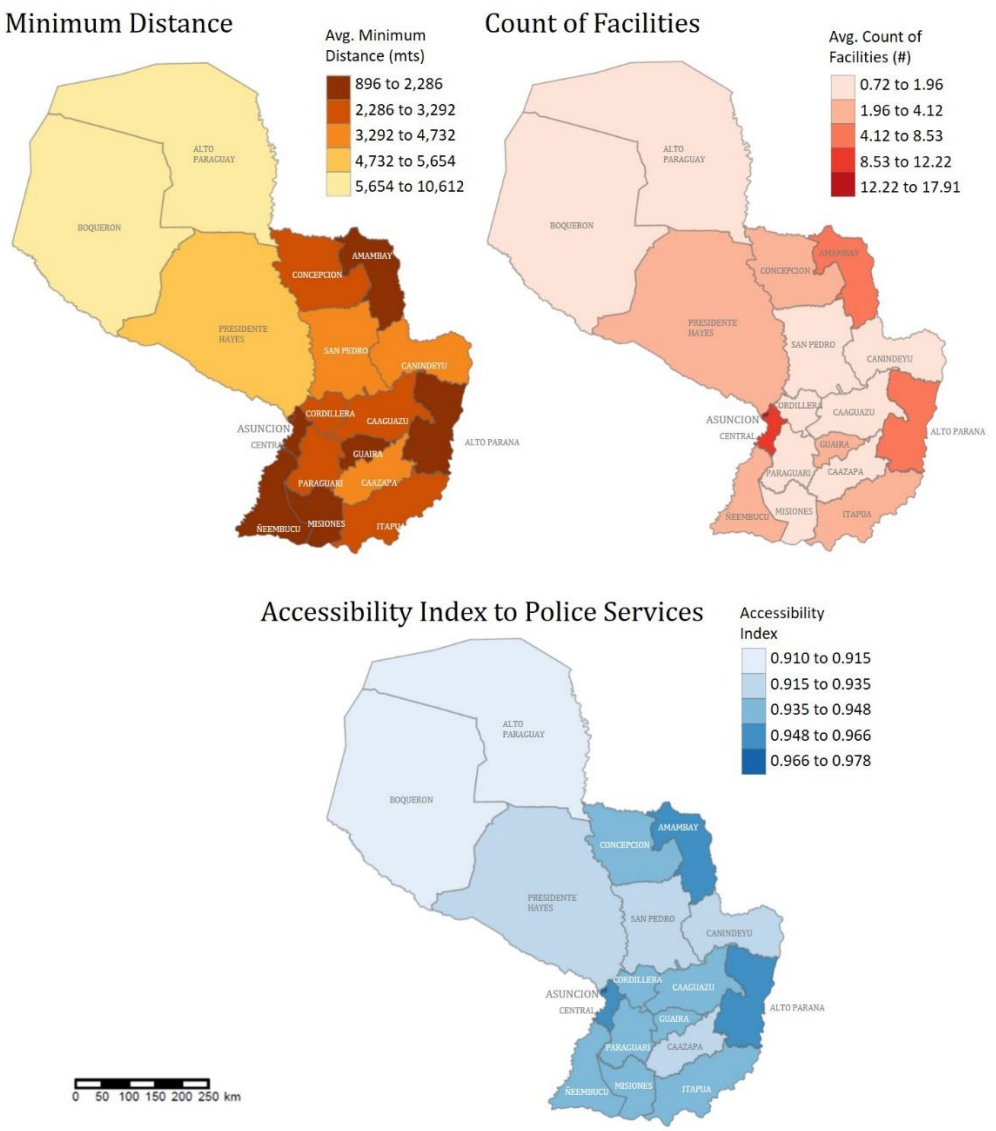
## Accessibility Index to Police Services

**TABLE 1. Spatial Accessibility Index to Police Stations in Paraguay**

| Department | Accessibility Index | Department | Accessibility Index |
|---|---|---|---|
| ASUNCIÓN | 0.978 | CONCEPCIÓN | 0.942 |
| CENTRAL | 0.966 | CAAGUAZÚ | 0.940 |
| ALTO PARANÁ | 0.957 | PARAGUARÍ | 0.939 |
| AMAMBAY | 0.956 | CANINDEYÚ | 0.935 |
| GUAIRÁ | 0.948 | SAN PEDRO | 0.934 |
| ÑEEMBUCÚ | 0.947 | CAAZAPÁ | 0.933 |
| MISIONES | 0.945 | PRESIDENTE HAYES | 0.932 |
| ITAPÚA | 0.944 | BOQUERÓN | 0.915 |
| CORDILLERA | 0.943 | ALTO PARAGUAY | 0.910 |

*SOURCE:* Spatial Accessibility Index to Primary Justice Fora, by Department, Paraguay (Recalde, 2022)

**FIGURE 2. Paraguay's Spatial Accessibility to Police Services, by Department**




*SOURCE:* Spatial Accessibility to Police Services, by Department, Paraguay (Recalde, 2022)

The working paper *"Rule of Law and Access to Justice: Construction of an Accessibility Index of Primary Justice Fora in Paraguay"* (Recalde, 2022) introduces a methodological approach to combining two main GIS measures to create the index: (a) estimation of minimum distance to the nearest justice service and (b) point proximity buffer analysis. In simple words, the index, which was estimated at the household level before aggregation at the district or department levels, reflects not only how close on average Paraguayans live to justice services (police

stations, Peace Courts, and Prosecutor's Offices), but also the number of service facilities to which they have access within a determined radius (5km for police stations). Table 1 shows the accessibility index to police stations by department in Paraguay.

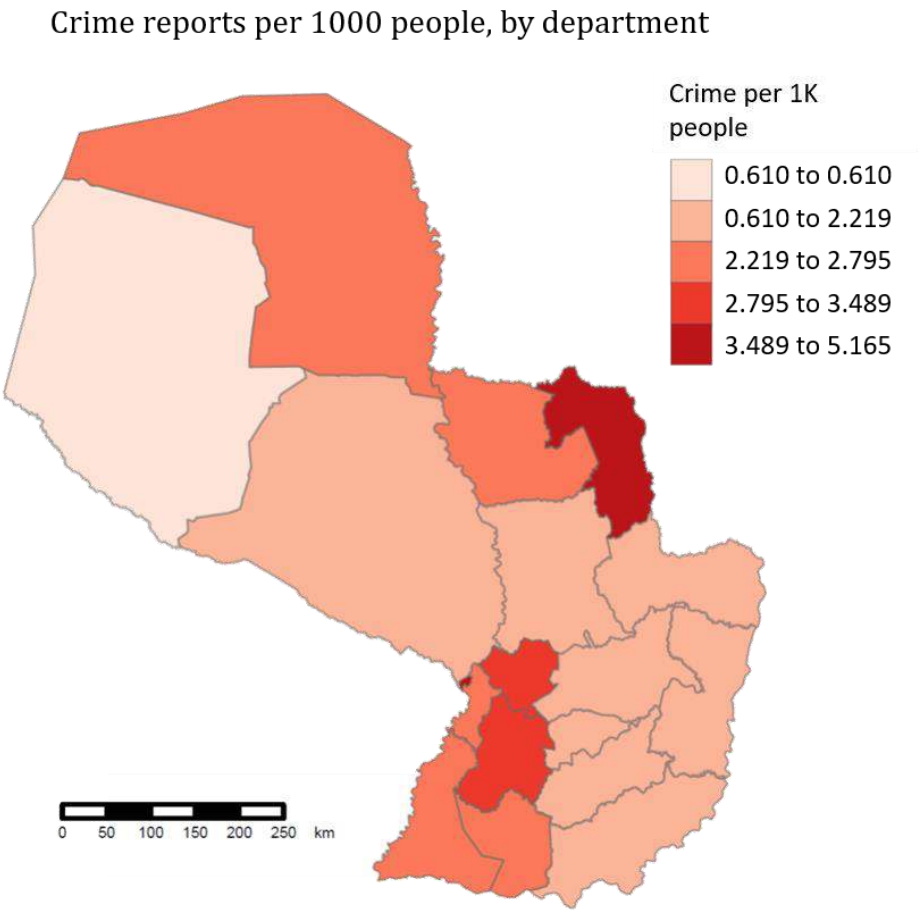
The data the index is built upon is geospatial household data from the 2012 Census in Paraguay, as well as the location of justice service facilities (police stations data from 2016, data for the Public Prosecutor's Offices and for Justices of the Peace Courts, both from 2021).

The analysis conducted in this paper relies on the assumption that accessibility to police stations at the department level remained constant over time, mainly on the grounds that first, the bulk of households and justice services physically remain at the same geographic location as when they were registered, and second, evolution in population size over time should exert only minimal impact over the configuration of the final aggregated index.

## Crime Data

The initial goal of this paper was to conduct an analysis at the district (city/town) level, given the availability of spatial accessibility data. Unfortunately, the only official crime data provided by the National Police Statistics Department in Paraguay was at the department level. Further iterations of this research could certainly expand the analysis featuring more granulated data. For now, the data covers all 17 departments plus the capital city, Asuncion, and it includes report statistics of the following crimes: cattle raiding, sex offense, homicide, theft (including burglary), robbery, and bodily harm (including battery and traffic incidents)

**FIGURE 3. Map of Reported Crimes per 1000 inhabitants, by District**




*SOURCE:* Author's own elaboration with 2019 crime data from the National Police of Paraguay

## Other Variables of Interest

*Population.* As show in Recalde (2022), there is an expected positive correlation between *population size* and spatial accessibility to justice fora, including police stations. This is also expected to be the case with crime data, where the number of crimes is expected to be higher in more densely populated areas. For this reason, population size is also taken into consideration. Population values from 2019 were used and the data was obtained from official population projections by the National Statistics Institute of Paraguay (INE).

**TABLE 2. Summary Statistics of Variables of Interest**

| Variable | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|
| Police accessibility index | 0.942 | 0.016 | 0.910 | 0.978 |
| Avg. minimum distance (km) | 3.68 | 2.61 | 0.90 | 10.61 |
| Avg. count of facilities (in 5km) | 4.08 | 4.68 | 0.72 | 17.91 |
| Number of reported crimes | 1051.78 | 1382.68 | 40.00 | 6033.00 |
| Cattle raiding | 47.67 | 48.48 | 1.00 | 186.00 |
| Sex offense | 40.61 | 68.36 | 0.00 | 296.00 |
| Murder | 78.33 | 69.38 | 6.00 | 268.00 |
| Theft | 198.06 | 290.61 | 3.00 | 1217.00 |
| Robbery | 373.28 | 646.54 | 3.00 | 2732.00 |
| Bodily harm | 313.83 | 338.20 | 11.00 | 1481.00 |
| Dept. Population (x 1000) 2019 | 397.37 | 488.88 | 17.89 | 2158.22 |
| Number of arrests | 900.44 | 1367.10 | 15.00 | 5685.00 |
| Police efficiency (clearance rate) | 45.31 | 9.88 | 34.10 | 76.35 |

*SOURCE:* Accessibility variables are drawn from Recalde (2022),. Crime data, as well as data on arrests, and clearane rates were obtained from Paraguay's National Police Statistics Departement. Population data was obtained from the National Statistics Institue (INE) of Paraguay.

*Arrests.* Considering the traditional role of the police, when analyzing the impact of spatial accessibility to police services on crime the expected outcome is that of a negative, decreasing trend. Besides the mere police presence through accessibility, one important channel through which deterrence may occur is the number of arrests, which is therefore included in the analysis. Data was obtained from the National Poli ce Statistics Department in Paraguay for the year 2019.

*Police efficiency.* Modelling police efficiency and all it may entail (such as trust in the institution, for instance), is not an easy task. Replicating the data published by the Rule of Law Observatory in Paraguay (2022), a measure of the "clearance rate" as proxy for police efficiency is introduced into the analysis. These values are estimated by dividing the total number of

"cleared" or solved cases over the total number of reported crimes for each department of Paraguay, using data from the National Police Statistical Department.

The inclusion of arrest data and a measure of police efficiency into the analysis may also be a way to indirectly account for other dimensions of "access" to justice that are not reflected in the geographic accessibility to these services, such as the quality of services or the mutual acceptability of both the supply and demand sides.

## Methodology

Similar to an approach introduced by Levitt (1998), one of the major assumptions of the applied model is that murder crimes are immune to reporting bias. Therefore:

$$\ln(r\_murder_i) = \ln(t\_murder_i) \quad (1)$$

where *r_murder* denotes reported crime, *t_murder* the true number of homicides, and *i* represents each department. However, in the case of other crimes:

$$\ln(r\_nonmurder_i) = \ln(t\_nonmurder_i) + \ln(report_i) \quad (2)$$

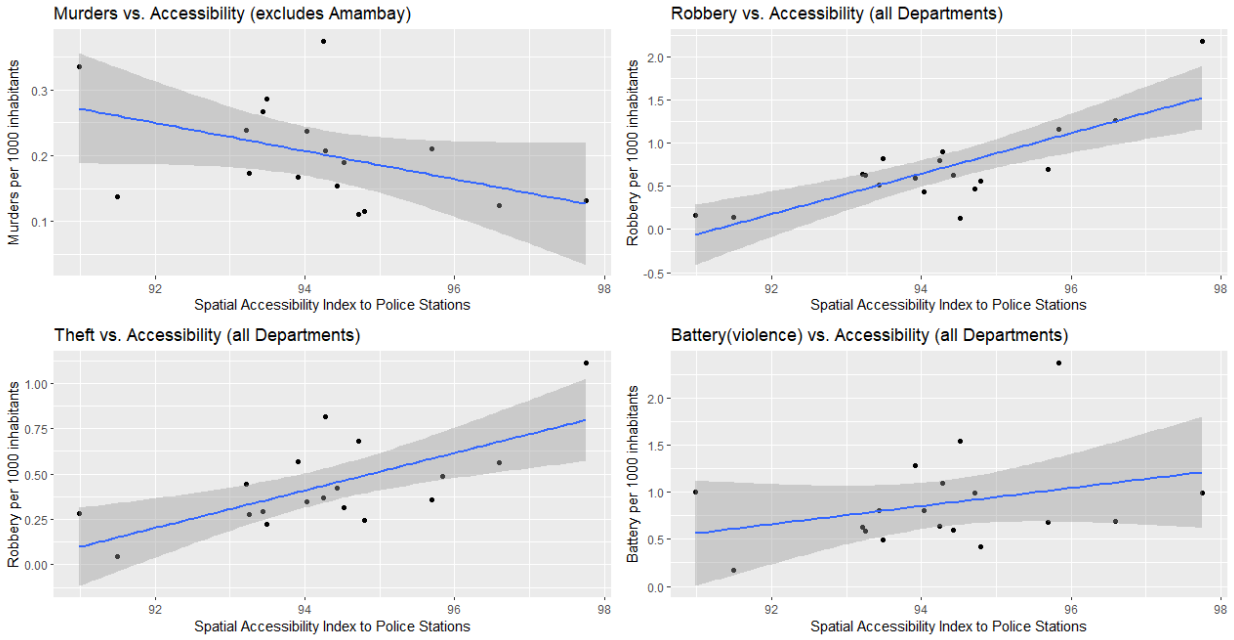
$$\ln(report_i) = \delta \ln(accessibility_i) + u_i \quad (3)$$

where *report* is the actual rate of crime reporting to the police, and is a function of *accessibility* to police stations as well observable and unobservable variables *u* that impact reporting behavior at a rate $\delta$, which is assumed to be reporting bias.

Given that murder crimes are believed to not suffer from reporting bias, it can be expected that, with the correct specifications, a regression model would yield a near-unbiased estimation of the impact of accessibility to police stations on homicides. Similarly, because the error term

*u* in (3) may contain unknown, unobservable factors that cannot be accounted for in the model, and which could better explain crime reporting behavior, coefficients are expected to be consistently biased. As mentioned before however, while the causes of this bias can hardly be explained beyond mere hypotheses, it can shed light on the effects that the presence of public judicial institutions have over social crime reporting conduct.

**FIGURE 4. Major Crime Types per 1000 People vs. Accessibility Index to Police Stations**




*SOURCE:* Author's own elaboration using crime reporting data from the National Police of Paraguay, and the Spatial Accessibility Index to police services (Recalde, 2022)

Figure 4 shows four graphs depicting a simple trend of reported murder, robbery, theft, and bodily harm plotted against the accessibility index to police stations. In the case of murder graph, the department of Amambay was excluded, since it appears as an unfortunate outlier where the homicide rate per 1000 inhabitants reached 0.91, whereas the department with the second highest rate (Concepcion), landed far below at 0.37. Amambay, located right in the border with Brazil, has had a history of rising violence linked to illegal drug trafficking and organized crime, which explains this outcome. Once Amambay is excluded, a negative correlation can be seen between murders and spatial accessibility to police stations, in clear

contrast with the other types of crime. It is worth mentioning that excluding Amambay did not sway the upward trend for these crimes.

With all this into account, a set of OLS regressions is run, following the following basic model:

$$\ln(crime_i^c) = \alpha_0 + \alpha_1\, accessibility_i + \alpha_{2\ldots n} X_i + \omega_i \qquad (4)$$

where:

$\ln(crime_i^t)$: is the natural logarithm of the number of crimes; *c* denotes the type of crime selected, and *i* indexes the departments

$accessibility_i$ measures of spatial accessibility where *s* denotes the selected measure, which could be the s*patial accessibility index to police station*. For ease of interpretation the accessibility index to police station is transformed from a scale of 0 to 1, to a scale of 1 to 100.

$X_i$: is a set of control variables that includes:

- *ln(population 2019)*
- *isamambay* - a dummy for the department of Amambay, to account for it being an outlier
- *ln(arrests)* – number of arrests
- *ln(efficiency)* – the log of the clearance rate

The identification assumption here is that, conditional to controlling for these variables it will be possible to obtain an unbiased coefficient for the impact of spatial accessibility to police

stations on murders. Similarly, it is assumed that these controls will help remove some types of bias from the coefficient on other types of crimes, except for reporting bias.

# Results

## Impact on Murders

Table 3 shows the results of the regression with reported murders as the dependent variable and the spatial accessibility index to police services as the independent variable. As expected, the relevance of population size is clear. Then, when adding a dummy for Amambay to account for it being an outlier when it comes to homicides, a negative relationship begins to emerge, just like it was shown above in Figure 4.

As for arrests, including it into the equation shows that increased numbers are correlated with a further decrease in murders. The final specification, which includes the clearance rate as a proxy for police efficiency shows that, everything held constant, an increase in the spatial accessibility index to police stations by 1 index point (in a scale from 0 to 100), is associated with a 32.1 percent decrease in murders on average. This result is statistically significant ($p<0.01$). It can also be seen that the $R^2$ increases as controls are added.

A 1 index point increase in spatial accessibility implies not only a significant decrease in the distance that the population needs to travel to reach the nearest police station, but also in the number of services that are available within a 5km radius. A quick calculation regressing the components of the index on the final index itself (at the district level for greater precision) shows that a 1 index point increase implies a decrease of about 2.1 kilometers in the average minimum distance to the nearest police station, and an addition of 1 police station within a 5km radius.

**TABLE 3. Regression Outputs: Accessibility Index on Reported Murders**

| | *Dependent variable:* | | | | |
|---|---|---|---|---|---|
| | ln(Reported Murders) | | | | |
| | (1) | (2) | (3) | (4) | (5) |
| Accessibility index | 0.426*** | 0.0004 | -0.151* | -0.294** | -0.321*** |
| | (0.129) | (0.116) | (0.082) | (0.098) | (0.097) |
| ln(population 2019) | | 0.893*** | 1.091*** | 0.491 | 0.333 |
| | | (0.175) | (0.121) | (0.296) | (0.310) |
| Amambay dummy | | | 1.823*** | 1.330*** | 1.178** |
| | | | (0.389) | (0.414) | (0.416) |
| ln(arrests) | | | | 0.580** | 0.698** |
| | | | | (0.267) | (0.273) |
| ln(clearance rate) | | | | | -0.573 |
| | | | | | (0.423) |
| Constant | -36.195*** | -7.197 | 4.520 | 22.062** | 27.986** |
| | (12.170) | (9.499) | (6.630) | (9.988) | (10.622) |
| Observations | 18 | 18 | 18 | 18 | 18 |
| $R^2$ | 0.404 | 0.782 | 0.915 | 0.938 | 0.946 |
| Adjusted $R^2$ | 0.367 | 0.753 | 0.897 | 0.918 | 0.923 |
| Residual Std. Error | 0.857 (df = 16) | 0.536 (df = 15) | 0.346 (df = 14) | 0.308 (df = 13) | 0.298 (df = 12) |
| F Statistic | 10.866*** (df = 1; 16) | 26.892*** (df = 2; 15) | 50.225*** (df = 3; 14) | 48.889*** (df = 4; 13) | 41.997*** (df = 5; 12) |

*Note:* *p<0.1;**p<0.05;***p<0.01

*SOURCE:* Regression outputs of the natural logarithm of reported murders as the dependent variable, the accessibility index to police stations (scale of 0 to 100) as the main independent variable, and controls.

These results obtained when isolating murder reports as the dependent variable, given its nature as a serious offense that is rarely under-reported and under-recorded, shows that higher spatial accessibility to police stations is associated with lower homicide levels. Determining how this translates to other types of crime is not easy, mainly due to reporting bias. However, they are explored below, including all the same controls for comparison purposes.

## Impact on Other Crimes

As seen in Table 4, and as expected, except for murder most of the coefficients have a positive sign, and most are not statistically significant. It is clear that reporting bias is present and is contaminating the *true* effect of spatial accessibility on crime levels. In other words, higher

spatial accessibility to police stations shapes the crime reporting and recording behavior. While finding the causes for this phenomenon is outside the scope of this paper, it can be hypothesized that the reasons may range from a decreased opportunity cost of filing a report stemmed from greater accessibility, all the way to enhanced knowledge of the process due to closer police presence, and even an increased trust in the institution.

**TABLE 4. Regression Outputs: Accessibility Index on Reported Crimes**

| | *Dependent variable:* | | | | | | |
|---|---|---|---|---|---|---|---|
| | ln(all crimes) | ln(murder) | ln(cattle raid) | ln(sex offense) | ln(theft) | ln(robbery) | ln(bodily harm) |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Accessibility index | 0.066 | -0.321*** | -0.514 | -0.010 | 0.193 | 0.087* | 0.061 |
| | (0.105) | (0.097) | (0.359) | (0.148) | (0.158) | (0.048) | (0.162) |
| ln(population 2019) | 0.254 | 0.333 | 1.758 | 1.001* | 0.002 | 0.523*** | 0.260 |
| | (0.336) | (0.310) | (1.145) | (0.472) | (0.506) | (0.153) | (0.518) |
| Amambay dummy | -0.055 | 1.178** | 1.057 | 0.609 | -1.036 | -0.140 | 0.400 |
| | (0.451) | (0.416) | (1.537) | (0.635) | (0.679) | (0.206) | (0.695) |
| ln(arrests) | 0.567* | 0.698** | -0.683 | 0.185 | 0.729 | 0.530*** | 0.540 |
| | (0.296) | (0.273) | (1.007) | (0.416) | (0.445) | (0.135) | (0.456) |
| ln(clearance rate) | -0.855* | -0.573 | -0.986 | 0.284 | -1.331* | -2.662*** | 0.112 |
| | (0.458) | (0.423) | (1.561) | (0.644) | (0.689) | (0.209) | (0.706) |
| Constant | -3.206 | 27.986** | 37.716 | -10.743 | -12.998 | -2.853 | -7.465 |
| | (11.514) | (10.622) | (39.237) | (16.193) | (17.330) | (5.257) | (17.749) |
| Observations | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| $R^2$ | 0.953 | 0.946 | 0.471 | 0.920 | 0.922 | 0.994 | 0.882 |
| Adjusted $R^2$ | 0.934 | 0.923 | 0.251 | 0.887 | 0.890 | 0.992 | 0.832 |
| Residual Std. Error (df = 12) | 0.323 | 0.298 | 1.102 | 0.455 | 0.487 | 0.148 | 0.498 |
| F Statistic (df = 5; 12) | 49.201*** | 41.997*** | 2.140 | 27.686*** | 28.468*** | 423.156*** | 17.853*** |

*Note 1:* *p<0.1;**p<0.05;***p<0.01

*Note 2:* To deal with zero values present in data of sex offense for log conversion, all observations for this crime were added 1 ($x_i$+1). The coefficient of adding 1 and omitting the observation were not significantly different.

*SOURCE:* Regression outputs of the natural logarithm of reported crimes as the dependent variables, the accessibility index to police stations (scale of 0 to 100) as the main independent variable, and controls.

While the actual magnitude of reporting bias for each crime may be hard to estimate, introducing the assumption that accessibility has the exact same impact on nonmurder crimes

that it has on murders, an interesting comparison among them can be made. That is, if in the absence of reporting bias all crimes behave like murders do with greater accessibility, then it must be the case that the difference between the coefficients on each of the crimes and the coefficient on murders will be a measure of reporting bias. Therefore, the larger the coefficients in the regressions shown in Table 4, the larger will the reporting bias be. This idea was also presented in Levitt's paper (1998), when he used the ratio of nonmurder crimes to murders as the dependent variable.

With that exercise in mind, it can be seen that theft is a crime that tends to go under-reported if accessibility is low, followed by robbery, and bodily harm. Consequently, an increase in police presence creates an incentive for reporting crimes that would otherwise remain unreported. Cattle raid poses a particular issue: the negative correlation is like to be because the bulk of such crimes occur in rural areas where spatial accessibility to police services tends to be low. Sex offenses lean more towards being a more severe crime compared to the others (with the exception of murder), which could explain it slight negative coefficient, hence lower reporting bias.

## Conclusions

As the first research conducted using the Spatial Accessibility Index to Primary Justice Fora (Recalde, 2022), in this case to police stations, this paper proved that the index is a robust measure of police presence that can be reliably used for a myriad of analyses. Because accessibility to justice services is a central dimension of access to justice, more broadly speaking, this index can contribute to a deeper understanding of the current status of the rule of law in Paraguay.

The central objective of this paper was to measure the *relationship* between spatial accessibility to police station and crime levels. Thanks to the existing literature, ahead of the implementation of the methodology, it was understood that such relationship was not going to be straightforward or homogenous for all types of crimes. In other words, although the intuition may indicate that greater accessibility will result in fewer crimes, which would satisfy the "goal" of the police as a public institution, multiple authors have found diverging results on the effect that police presence has over crime, which ranged from negative correlations, positive correlations, to no correlation at all.

The structure of the data used for this study made it easy to agree with the study of Levitt (1998), whose work extensively analyzes a phenomenon called *reporting bias*. This "measurement error" was caused by a systematic correlation of crime with police presence. That could be, for example, in the case of this study, a counterintuitive increase in the reported crimes as the accessibility index to police stations increases. While there might be multiple explanations for this, one of the most convincing ones is that greater police presence or visibility creates an incentive (e.g. increased confidence that the crime will be resolved, more comprehensive knowledge on the reporting process, etc.) to report crimes that would otherwise end up unreported. There is one crime, however, that is assumed to be immune to reporting bias due to the severity of the offense: murder. This means that reported murders is virtually the same as the true number of murders.

With all this information, OLS regressions were run, controlling for population size, number of arrests, and police response efficiency (through the clearance rate). Results show that, everything else constant, an increase in 1 accessibility index point (scale from 0 to 100), is associated with a 32.1 percent decrease in the number of reported murders (and therefore,

actual murders). A 1 index point means roughly having the nearest police station 2.1 kilometers closer on average, and having at least 1 additional police station within a 5-kilometer radius.

Also as expected, most other crimes exhibited a positive correlation with accessibility, with the exception of cattle raid and sex offense, which were not, however statistically significant. It is therefore assumed that they suffer from reporting bias. Through these coefficients, and under the very strong assumption that all nonmurder crimes are impacted by spatial accessibility to police stations in the exact same way as murders are, the approximate magnitude of the reporting bias can be observed. Thus, theft is the crime that showed the highest reporting bias, followed by robbery, and bodily harm. These are crimes that would remain greatly underreported unless a strong incentive to report them comes around, such as a greater geographic accessibility to police stations.

To sum up, two important conclusions can be drawn from the analysis:

(a) *Higher spatial accessibility to police stations deters crime – or at least murders:* the results obtained when isolating murder as the dependent variable, given its nature as a serious offense that does not suffer from reporting bias, shows that increased police visibility and proximity can actually prevent these crimes from occurring. While it is not possible to conclusively state that the same applies to other crimes, it is very likely that in the absence of reporting bias many of the crime types will exhibit a similar outcome.

(b) *Higher spatial accessibility to police stations creates an incentive for more crime reporting/recording:* reporting bias shows that crime reporting for some of the crimes increases significantly with higher accessibility. There is a clear behavioral response to greater police visibility that is worth mentioning. Finally, the public policy implications

of this last conclusion are worth exploring further: what is the social cost of crime under-reporting and could increasing police presence through more police stations be the answer? Further studies down this road would be a great contribution to exploring these questions.

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