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Governmental (In)Efficiencies on Detriment of Crime

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Governmental (In)Efficiencies on Detriment of Crime
A Spatial Autorregresive Study

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WORKING PAPER

Abstract

By using data from the Ministry of Security of the Argentine Republic for the year 2017, this paper aims to estimate the degree of substitution between public and private spending, placing in the core of study the relationship between the level of government efficiency and private spending on security. With information about the 24 Argentine jurisdictions, this work uses an autoregressive spatial model (SAC), to control for presumed autocorrelation in the residuals, in order to achieve consistent and unbiased estimations. In this line, the discrepancy between reported crimes and the number of convicts jailed under the respective sentence is taken as an efficiency measure of the government. In this way, the results show the expected signs, except for threats, for which the measure of efficiency takes the opposite sign (i.e. as greater the public spending is, greater private expenses), denoting an inefficiency of government spending. We attribute this finding to the fact that individuals perceive governmental action upon threats as insufficient, hence inducing private spending to cover the public inefficiency.

JEL: C54 D12 H23 H53 K40

1 Introduction

The main purpose of governmental investment on security services relies in saving such expenditure to individuals. Due to positive externalities upon security services, it is wide accepted that States should be the main actors in investing resources in detriment of crime. However, even when many countries dedicate significant efforts (and resources) on the matter, contributors are still investing large amounts of money in security. This behavior exposes, therefore, dissatisfaction regarding the degree of efficiency of the public sector upon dissuading criminal tendencies.

Intuitively, in absence of government supply, the private sector will provide the market with the demanded goods by its own. Police, lighting, prevention and punishment are examples in which this point can be seen. When private companies do not perceive the State's expenditure on security as efficient, they tend to "fill the missing efficiency" by their own expenses. Therefore, it is expected that individuals begin to spend on services such as private security, lighting, weapons, insurance, and alarms, among others. Expenses that, theoretically, could have turned into consumption (that generate direct utility) if only the Government had been efficient in providing public security. In this way we can illustrate this "substitution" that exists between public and private spending on security in function of the efficiency that the former possesses, and of the aversion to crime that the latter has.

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Throughout the literature one can find a vast discussion about the nature of "public good" that security can adopt (see, for example, Clotfelter 1977); that is, assuming a nature of non-rivalry and non-exclusivity in the provision of security and justice, the allocation by the private sector would then be insufficient, and given this, the government should take charge of its supply. This and other aspects of the Public Finance bibliography serve to clarify the **"magnitude"** of the relationship between public and private spending regarding crime, but not about the relationship between the level of government **"efficiency"** with respect to crime control, and the private spending on security.

Our paper aims to delve into this last point. For this, we propose to model the interaction between the public sector (government) and the private sector (agents/consumers) as a game with complete and perfect information with an unique Nash equilibrium; in which the private sector is understood in its entirety by consumers, who have to choose between the consumption of goods for their own pleasure, and an expense in security against crime. On the other hand, the government collects taxes from individuals, and invests in security and justice. This last point is crucial for our analysis since the public sector has an associated measure of efficiency that will be the focal point of our interest. After developing the theoretical framework, our work aims to evaluate this relationship between government efficiency and private spending in an empirical way. Based on data from the Ministry of Security of the Argentine Republic (SNIC and SNEEP 2017 reports), together with an official survey on household expenditure (Household Expenditure Survey - ENGho INDEC), we evaluated the relationship of interest for the 24 Jurisdictions of Argentina, for the year 2017.[1] In turn, it is common throughout the empirical crime literature to discuss the presence of "spatial correlation" in crime models. That is, since crime is not usually distributed "randomly" in an area, but is concentrated in certain areas, then econometric methods must be adjusted to capture this effect. In this way, our paper will evaluate alternatives considering spatial correlation, and compare the results with those obtained by traditional methods.

This paper is organized as follows: Section 2 presents a review of the literature; Section 3 reports the theoretical model; Section 4 develops the empirical model and its procedures; Section 5 presents results and discussion; and finally, Section 6 presents the conclusions.

2 Literature Review

Already from the first advances outlined in the seminal work of Gary Becker (Becker - 1968), the use of economic analysis for the study of crime has been advancing by leaps and bounds over the years. The great contribution of Becker in this field has to do with the premise that the tools generally used in economics (namely, the cost-benefit analysis) can be applied to decisions of prevention and punishment of crime. In this way, both individuals and governments face a trade-off between the cost of combating delinquency and the marginal reduction of the crime that such spending can generate. In other words, agents in an economy face a difficult decision about which alternative "results more expensive": to avoid being a victim of a crime -after spending a huge amount of money in prevention-, or to be a *low cost* victim. As can be sensed, from Becker's approach, the mere presence of crime in a society already involves the expenditure of resources that, if not, could have been invested in any other purpose.

Also, after this great contribution to literature, the *economics of crime* has developed articles dedicated to study various aspects of this field. In line with this, we can find papers like Chiu & Madden (1998), which are mainly dedicated to model the behavior of agents in the presence of crime, and associate it with the relationship between theft and inequality. On the other hand, another large branch of crime economics is devoted to studying the mechanisms by which agents "valuate" security. In this way can be found great contributions of environmental economics in papers such as Thaler (1971), Bishop et al (2011), Bartley (2000), Cohen (2004), Clotfelter (1977), among others; hence, these papers study the way in which agents lose utility before the uncertainty of being victims of a crime, and therefore, they are willing to allocate resources in order to reduce

[1] Last updated data until the production of this paper.

crime.

From the empirical point of view, the methods to deal with the study of crime vary considerably. Firstly, it is well known that when dealing with crime issues, especially in the sphere of public policy, care must be taken in the implementation of the models. For example, the classic case refers to the study of the crime rate as a function of the number of policemen. In this regard, there is a double-causality problem: does the number of police officers determine the number of crimes? Or is it the number of crimes that determines the number of police officers? In this sense, the econometric management has been changing and evolving depending on the question to be addressed. Moreover, we can find papers that work with instrumental variables (Clotfelter - 1977); hedonic valuation (Bishop - 2011); contingent valuation (Thaler - 1971); spatial models (Anselin - 2000), just to name a few. On this last point we focus our work. The spatial models start from the premise that the crime responds to a correlation caused by the geographical area, factors such as an increase in the probability of committing a crime if one resides in a dangerous neighborhood, the presence of mafias and robberies clustered near hi-crowded urban areas (among others), are some examples of factors that are difficult to measure, which generate that the criminal acts (and their implications) are distributed non-randomly with respect to the different geographical areas.

Specifically, our work is based on the article by Clotfelter (1977) but gives another theoretical approach and applies econometric refinements that contribute to the existing literature. In his article, Clotfelter analyzes the relationship between public and private expenditure regarding security from a Public Finance point of view, studying security spending as a good with two components: a part of public good, and another part private. Thus, developing a theoretical and empirical model, this paper studies this relationship from the point of view of the allocation of resources to the production of this compound good. In this way, the focus of our work is on taking the motivation of Clotfelter's paper, but giving it a more microeconomic theoretical approach. Starting from the interaction between consumers and the government, our article gives a twist to Clotfelter taking the study between public and private spending to control crime at another level. Hence, the final objective of this paper is to study this relationship between agents through government efficiency in the fight against crime, and not so much as merely the allocation of resources between agents. Likewise, our paper proposes to implement the advances in economics of crime with respect to the econometric treatment of spatial models in order to give extra rigor to our conclusions.

3 Theoretic Framework

In this framework we will consider usual "legal" citizens who maximize their expected utility, subject to some budject constraint. Formally, the utility function adopts this form:

$$U_{i,t} = \mathbb{U}\Big[\mathbb{E}(c_{i,t})\Big] \tag{1}$$

Where $c_{i,t}$ denotes the consumption of individual i, at the moment t. Under this approach, individuals maximize their expected utility under the probability of being victims of a crime. This probability (φ_t) is taken as an ex-post parameter which citizens do not control directly, but indirectly through their investment in security services and/or taxes paid to the State. Therefore, the maximization problem of individuals is summarized as follows:

$$U_{i,t} = \mathbb{U}\Big[(1-\varphi_t)\times c_{i,t}\Big]$$

As can be noted, for simplicity we assumed that costs of victimization imply the overall reduction of consumption for the current period.[2] That said, private investment in security services is one of the two weapons

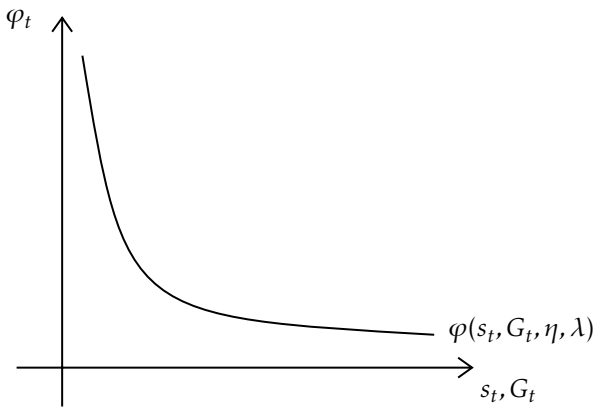
[2] Without losing generality we label this as the *all or nothing assumption*. The introduce of an average percentage of stolen goods do not add further rigor into the model, since conclusions derived from the simplified version are broad enough to cover cases in with the costs of victimization imply a partial reduction of consumption. The evaluation of alternative frameworks including loss-aversion features in the expected utility (See Kanneman and Tversky (1979)) is left for further research.

individuals have for minimizing the probability of victimization, both with public security provision. Formally, the probability of victimization is defined as a decreasing function of private and public investment in security, weight by the corresponding *degree of efficiency* of each kind of security provision. From now on, for simplicity we dispense the individual sub-script i just by assuming a "representative consumer" whitout loosing further generalization. Then, the probability of victimization (φ_t) is defined as follows:

$$\varphi_t = \varphi(s_t, G_t, \eta, \lambda)$$

Where s_t and G_t denote the private and public spending in security services, while η and λ measures the private and public efficiency degree in detriment of crime. [3] Regarding the relationship between private and public investment in security with the probability of victimization, function $\varphi(s_t, G_t, \eta, \lambda)$ must hold certain characteristics. Precisely, $\varphi(s_t, G_t, \eta, \lambda)$ must be decreasing and convex to s_t and G_t, as shown in the chart below:

Figure 1: Investment in Private - Public Security and Probability of Victimization



As can be seen, the efficiency parameters (i.e.η and λ) define the slope and convexity of $\varphi(s_t, G_t, \eta, \lambda)$). That said, in general terms the overall conditions for $\varphi(s_t, G_t, \eta, \lambda)$ will imply that $\frac{\partial \varphi}{\partial s_t}; \frac{\partial \varphi}{\partial G_t} < 0$ and $\frac{\partial^2 \varphi}{\partial^2 s_t}; \frac{\partial^2 \varphi}{\partial^2 G_t} \geq 0$.

Hence, due to the negative relation between utility and probability of victimization (φ_t), a positive relationship between investment in private (and public) security upon expected utility can be derived. In sum, we drew the following conditions regarding the utility function:

$$\frac{\partial \mathbb{U}}{\partial c_t} > 0; \qquad \frac{\partial \mathbb{U}}{\partial s_t}; \frac{\partial \mathbb{U}}{\partial G_t} > 0; \qquad \frac{\partial \varphi_t}{\partial s_t}; \frac{\partial \varphi_t}{\partial G_t} < 0$$

$$\frac{\partial^2 \mathbb{U}}{\partial^2 c_t} < 0; \qquad \frac{\partial^2 \mathbb{U}}{\partial^2 s_t}; \frac{\partial^2 \mathbb{U}}{\partial^2 G_t} \geq 0; \qquad \frac{\partial^2 \varphi_t}{\partial^2 s_t}; \frac{\partial^2 \varphi_t}{\partial^2 G_t} \geq 0$$

Then, the consumer's problem will consist in maximizing (1) subject to the budget constraint:

$$c_{i,t} + s_{i,t} = y_t - \tau_t \tag{2}$$

As can be noticed from equation (2), since we do not specify any productive process beyond y_t we assume, for simplicity, an endowed economy. Additionally, individuals must pay a lump-sum tax (τ_t) to the government. As we shall further develop in depth, since taxes serve to finance governmental spending, this represent an alternative mechanism of investment in crime detriment.

In line with this, we incorporate the government as a new agent with its own maximization problem. Then, by strategical interaction with citizens in a sequential-game setting, we draw a general equilibrium scheme to

[3] It is worth recalling that, despite individuals do not control public invesment in security, they internalize the relationship beyond $\varphi(s_t, G_t, \eta, \lambda)$ by knowing *ex-ante* that their taxes are used to finance public security spending.

analyze public-private investment in security. Furthermore, the governmental problem consists in minimizing the following loss function:

$$L_t = \Xi\Big[\varphi_t(s_t, G_t, \eta, \lambda)\Big] \tag{3}$$

Where, as mentioned above, φ_t denotes the probability of crime victimization, with public investment in security (G_t), and its associated efficiency measure (λ) being the variables associated with governmental maximization problem. As can be seen, the efficiency measure do not represent a control variable for the government, but refers to an exogenous magnitude linked to public expenses. Further research is reserved to intrinsic specifications of the efficiency measure as a control variable in governmental maximization problem.[4] The specifications beyond $\Xi(\varphi_t)$ are the common loss-function specifications regarding the crime victimization probability (i.e. increasing and convex upon φ_t). As usual, governmental spending is constrained by its financing streams (i.e. collected taxes). That said, the problem of the government will consist in minimizing (3) subject to a simple budget constraint:

$$G_t \leq \tau_t \tag{4}$$

Where τ_t denotes taxes collected from individuals. Put simply, the right hand of equation (4) refers to the total mass of taxes, representing an upper bound for governmental spending. This equation represents a "fiscal balance condition", which simply implies that the government cannot spend more money that comes from individuals' taxes. Recall that since we assume a representative agent framework, we do not loose generality by assuming that total mass of taxes is simply represented by taxes collected from this single consumer.

Once specified both individual's and governmental optimization problems, the last specification has to do with the events' timeline on which agents (government and citizens) interact. In this line, we assume a sequential game framework which citizens move first by allocating their income between consumption and investment in security services, and then the government take the rest as tax collection to invest in public security. As usually done with sequential games with perfect information, the solution is achieved by backward-induction: individuals deduce government's optimal tax scheme (internalizing the public crime-detriment efficiency), and then they determine their optimal investment in security services. The rationale behind is quite straightforward: citizens first observe the governmental efficiency implied in the tax bill, and then they decide their optimal allocation of security expenses.

Analytic Solution

In our simplified model, the interaction between the consumer and the government will be the following:

As stated above, we solve this sequential game by backward induction: Since consumers move first, they must know the optimal governement response to their set of strategies. Such is determined by minimizing the governmental loss function (eq.3), subject to its budget constraints (eq.4), taking as control variable the amount of taxes (τ). By finding the optimal taxation as function of s_t, λ, and η; individuals internalize this information to maximize its expected utility (according to its respective constraints) and derive the optimal level of private security spending as a function of public efficiency (λ). We focus special attention to this last result to perform our further econometric estimations.

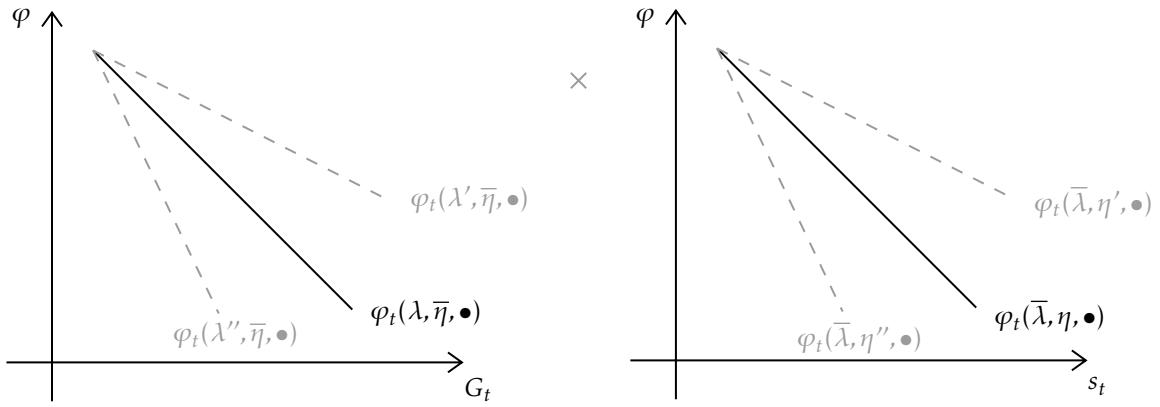
As general scheme, we assume that the probability of victimization follows a linear relationship upon private and public investment in security (i.e. G_t and s_t), each weighted by its corresponding efficiency measure (i.e. λ and η). This simplified specification goes in accordance with the set of conditions listed above, and allows an easy interpretation of the mechanics behind the scope of this paper. Formally:

[4] Another placeholder for further research is given by specifying an alternative scenario in which the governmental problem consits in minimizing a loss function with two crime-associated variables: the usual direct crime victimization probability (φ_t), and an additional crime variable associated with *indirect costs of crime* (e.g. prisons maintenance costs, wages not-earned by prisoners, etc.). Such additional costs would not be internalized by private spending since do not imply a direct increase of consumer's expected utility; but its absence would derive in a social efficiency loss.

$$\varphi_t = 1 - \lambda G_t - \eta s_t \tag{5}$$

By assuming a linear specification for φ_t, the relationship between the probability of victimization and the corresponding efficiency measures is simple and straigthforward. Schematically, all else equal, and assuming $\eta' < \eta < \eta''$, and $\lambda' < \lambda < \lambda''$ the probability of victimization (φ_t) adopts the following shape:

Figure 2: Linear Probability of Victimization



Practical Solution

The Government

To start formally drawing our study upon on private-public substitution of crime spending, we will assume the following governmental loss function:

$$L_t = \varphi_t^2 \tag{3'}$$

Then, given equations (4) and (5), the optimal level of taxation (τ_t) is the following:

$$\tau_t^* = \frac{1}{\lambda}\left(1 - \eta s_t\right) \tag{6}$$

As can be noted from the equation above, the relationship between government efficiency and the amount of taxes is clear and intuitive: as more efficient the government is regarding its efforts to deter crime, less will be the need for taxes; or, from other perspective, the more efficient the government is, greater will be the available income for the private sector to derive in consumption. Conversely, can be noticed that as private efficiency increases, there's no need for additional governmental efforts to fight against crime.

As already mentioned, with the optimal government solution, individuals internalize the public efficiency measure through the taxes requirement (τ_t^*), and determine their optimal level of investment in private security (s_t). Hence, by using eq.6, now it's individuals time to maximize.

The Consumer

In accordance with the set of conditions detailed in the theoretic section, we assume a quadratic expected-utility function for individuals:

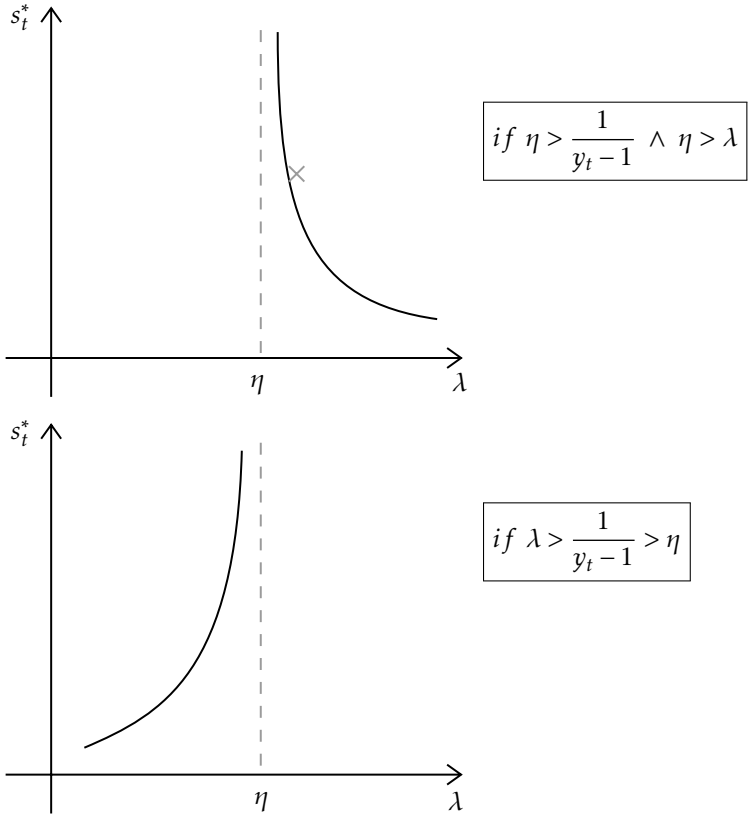
$$\mathbb{U}_{i,t}(c_{i,t}, s_{i,t}) = \left[(1 - \varphi_t) \times \ln(c_{i,t})\right]^2 \tag{7}$$

Then, by taking into account the budget constraint (eq. 2), the probability of victimization (eq. 5), and the optimal level of taxation (eq. 6), individuals maximizes their utility function specified in eq. 7, to reach at the optimal level of private spending in security:

$$s_t^* = \left(\frac{\lambda}{\lambda - \eta}\right) \times y_t - \left(\frac{1+\lambda}{\lambda - \eta}\right) \tag{8}$$

Eq. 8 then presents a series of interesting implications behind the interaction among private spending (i.e. s_t^*), efficiency measures (i.e. λ and η), and total income (i.e. y_t). Firstly, it is interesting to point out that the optimal private spending is not always decreasing in λ. We will demonstrate that this is a shared problem between public and private efficiencies. Formally, for certain combination of non-negative values of η, λ, and y_t, the private spending in security services can increase in parallel with public efficiency. As can be seen from the figure below, when the public efficiency (λ) exceeds private efficiency (η), but the latter lies below an specific cut-off point (in this simplified model denoted by $\frac{1}{y_t - 1}$), private spending must boost governmetal's efficiency levels with a greater amount of private spending. Intuitively, this only happens when $\lambda > \frac{1}{y_t - 1} > \eta$ and reflects that when the public efficiency is not enough to minimize the probability of victimization, and individuals' endowed efficiency is low as well, citizens internalize λ as an "inefficiency" parameter. Due to this inefficiency, the private sector must compensate this "empty slot" generated by the government, in order to reduce the probability of victimization.

Figure 3: Efficient Provision of Private Security - Analysis over Efficiency Measures

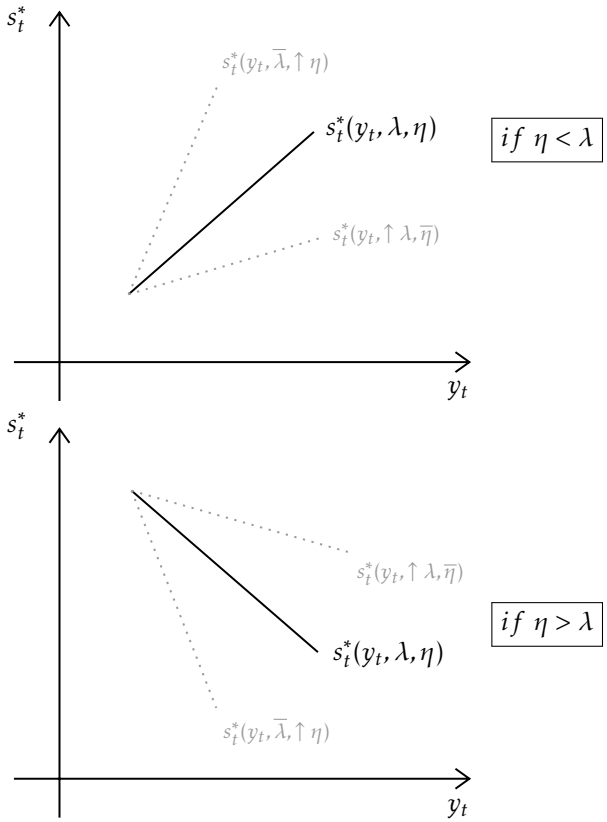


Another interesting feature of the model has to with the interaction between optimal private spending and overall income. As noted, the shape of private spending over income is a straight line with slope $\frac{\lambda}{\lambda - \eta}$, which reflects a positive relationship if the government is more efficient than individuals in security spending. This case is commonly accepted across the literature since it is usually observed that richest families tend to derive more resources in security than poorer households. Nevertheless, from eq.8 above we derive another effect: when individuals are more efficient investors against crime (i.e. $\eta > \lambda$), the relationship between private security investment (s_t) and overall income (y_t) becomes negative. We denote this effect as the *"Income Effect of Efficient Security Investment"*.[5]

[5]This last conclusion has strong implications from the empirical point of view. The presence of the Income Effect of Efficient Security

Also, it is worth noting some features behind the income elasticity of private spending. As can be noted from the figure below, as the private efficiency (η) increases, *ceteris paribus* the s_t^* curve becomes steeper, meaning that less physical resources (y_t) are needed to reduce the same amount crime reduction. The opposite is reflected with increases of the public efficiency measure (λ); meaning that, since individuals are more efficient than the government (i.e. $\eta > \lambda$), increases in λ tend to revert the negative slope of s_t. Put simply, increases of public efficiency (λ) makes s_t flatter, implying greater number of physical resources to service the same level of private spending.

Figure 4: Efficient Provision of Private Spending - Analysis over Overall Income



With all that said, the core of this paper relies on studying the empirical implications of equation (8). More precisely, our interest is focused on the relationship between the private expenditure on security and the efficiency measure of governmental efforts against crime.

4 Empirical Model and Procedures

To construct a measure of public efficiency, we considered the difference between the number of jailed criminals and total complaints, for selected crimes against persons (e.g. homicides, injuries, robberies, threats, etc.). Here jailed criminals include both convicted and non-convicted prisoners,[6] to capture the response time between the report of a crime and private spending on security. In other words, the perception of efficiency of private agents regarding judicial times is taken into account. For example, individuals who perceive that courts are being excessively slow (inefficient), will respond more quickly transforming such feeling of insecurity into private spending.

This time-response makes relevant to perform a correlation analysis between current private spending with several lags of the efficiency measure, to model using the highest-correlated lag.

Investment allows to identify situations of inefficiencies upon detriment of crime.

[6] The latter refers to such prisoners jailed for preventive purposes without formal condemn.

Making use of official databases of the Ministry of Security of the Argentine Republic, we propose to define efficiency as the discrepancies between the number of criminals jailed and total complaints; each for a set of specific crimes. Formally:

$$\eta_t^i \equiv \underbrace{\Lambda_t^i}_{\text{\# convicts}} - \underbrace{\Upsilon_t^i}_{\text{\# complaints}}$$

Then, according to the theoretical model, the empirical specification of equation (8) can be specified as follows:

$$s_t^* = \sum_i \delta_1^i \eta_t^i + \Delta_2 y_t$$

In this simplified setting we expect to find the negative relationship between private spending an efficiency just testing if $\delta_1^i < 0 \ \forall i$,where i denotes the specific crime to be considered, at time t. In line with this, empirically, we obtained the number of convicts from the SNEEP report of the Ministry of Security. This dataset presents specific data about all the convicts, disaggregated by jurisdiction, from 1975 to 2017 for the Argentine republic. From the side of complaints, in this paper we used the so-called SNIC report (also from the Ministry of Security), which relieves information about the complaints of a huge set of crimes, from 2014 to 2017 for all the Argentine jurisdictions. Both reports adopted the feature of census in 2017, fact that makes a huge advantage referred to data manage.

Given that our main purpose is to analyze the effects of public efficiency to the private spending in security, we incorporated this latter data from the National Institute of Statistics and Census (INDEC), using a national-coverage survey about private spending (ENGHo).

Our first difficulty assessing this task refers to the low-dimensionality problem associated with the econometric procedures. In other words, given the 24 jurisdictions taken into account is quite presumable to face issues with the usual assumptions of residuals. More specifically, the problems of non-normality and heteroskedasticity in errors is something that we need to deal with[7]. Even more, among the wide empirical literature of *Economics of Crime* we find vast discussion regarding the problem of auto-correlation in the error term. This comes from the fact that crime rates (and eventually the dis-utility associated with delinquency) are strongly correlated with the mobility of criminals in order to accomplish their criminal activity. In other words, given the fact that "a robber is never a robber in his land", we should take care of this *spatial dependence* of criminal activity. To take care of all these issues, we will proceed to develop our econometric strategy considering different assumptions regarding residuals. More precisely, different distributions and robust standard errors.

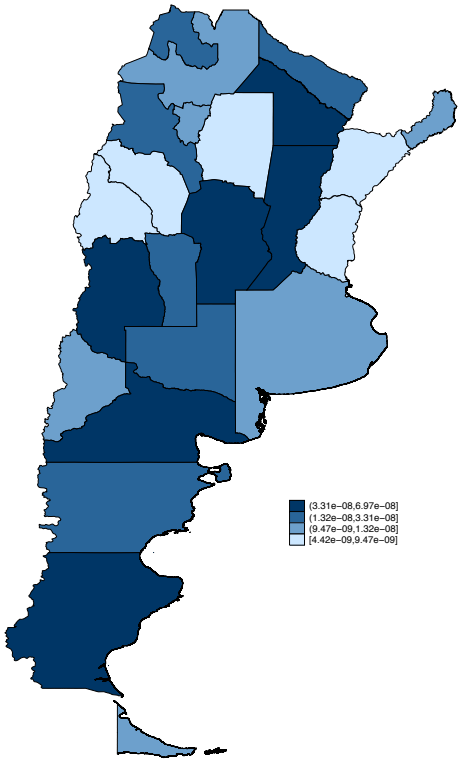
First of all, before we begin with estimations, we will evaluate the presence of spatial autocorrelation on private spending in security services. As a first approximation we begin with the distribution of the ratio between private spending and the Gross Regional Product (GRP)[8] across the jurisdictions of Argentina.

As can be seen from the figure, we can suspect a weak spatial dependence referred to the private spending. As a first sight, the distribution shows four patterns: the south, the center, the east and west. Then, for a more formal analysis, we should incorporate some features of the *Spatial Econometrics* framework. For this we will need to define the *Spatial Weight Matrix*, which basically refers to a matrix that synthesizes the *distances* between observations, given information about latitude and longitude in the data. Formally, for a set of n observations, the spatial weights matrix is defined as follows:

[7] Moreover, considering the difference between two variables as a measure of efficiency we are driving another risk related to the distributions. Basically, regarding the kind of crime being considered, we can face a wide range of distributions, each with its own average, variance and even skewness and kurtosis. For example, one should expect that for several crimes (such as homicides), the difference between complaints and number of convicts will be symmetrically distributed around zero, because of "severity" of the crime itself. But by the other side, we can take the example of threats or small thefts; which are crimes that will be associated with positive-skewed distributions (always referred with our efficiency measure), with mean below zero.

[8] In Spanish *Producto Bruto Geográfico*.

Figure 5: Private Spending over GRP



$$\mathbb{W} = \begin{pmatrix} 0 & w_{12} & \dots & w_{1n} \\ w_{21} & 0 & \dots & w_{2n} \\ \vdots & & \ddots & \vdots \\ w_{n1} & w_{n2} & \dots & 0 \end{pmatrix} \tag{5}$$

With

$$w_{ij} = \begin{cases} 1 \text{ if } d_{ij} \leqslant \bar{d} \ \ \forall i, j \in [1, n] : i \neq j \\ 0 \ \text{ otherwise} \end{cases}$$

Where d_{ij} refers to the euclidean distance between jurisdictions, given their geographic coordinates.

Furthermore, with the definition of the matrix we can proceed to test the presence of spatial autocorrelation in private spending making use of the so-called *Geary's C* test for spatial correlation (Geary - 1954). Formally, the Geary's C is defined as

$$C = \frac{(n-1)\sum_i \sum_j w_{ij}(x_i - x_j)^2}{2\mathbf{W}\sum_i (x_i - \bar{x})^2}$$

Where n is the number of spatial units indexed by i and j; x is the private spending in security services (eventually, $\bar{x}$ refers to the mean of the private spending); w_{ij} is the corresponding spatial weight; and $\mathbf{W}$ is the sum of all w_{ij}.

The value of Geary's C lies between 0 and some unspecified value greater than 1. Values significantly lower than 1 demonstrate increasing positive spatial autocorrelation, whilst values significantly higher than 1 illustrate increasing negative spatial autocorrelation.

The result of this test for our data is the following:

As can be seen from the table, we reject the null hypothesis of non-spatial autocorrelation with a 5% of significance (p-value = 0.026). This weak spatial effect will be the reason why we should also report the

Table 1: Geary's C test

Variables	c	E(c)	sd(c)	z	p-value*
log(private spending)	0.779	1	0.114	-1.942	0.026

estimation results from a Generalized Linear Model (GLM)[9], in addition to the specific spatial model. The latter basically refers to one of the most used models in spatial econometrics, that is called *Generalized Spatial Model* (SAC). This procedure basically consists on estimating the following equation:

$$\mathbf{P} = \rho \mathbb{W}\mathbf{P} + \Lambda\beta_1 + \mathbf{Y}\beta_2 + \epsilon$$

With

$$\epsilon = \lambda \mathbb{W}\epsilon + \mu$$

Where **P** refers to the vector of average private spending on security by province, ρ is the spatial autoregressive coefficient, $\mathbb{W}$ is a $n \times n$ spatial weights matrix which captures the definition of province chosen, Λ denotes the matrix of government efficiency approaches, **Y** denotes the vector of GRP's, and ϵ is a $n \times 1$ vector of independent and identically distributed (iid) error terms.

Regarding the issues of the error distribution we will consider the following: For the GLM the inverse gaussian and the poisson distribution; and for the SAC, we will consider an exponential distribution[10].

5 Results and Discussion

As discussed in the section before, the efficiency measure to be considered for estimations will be selected according to the highest correlation between the private spending in security services and the lags of the differences between convicts and complaints; each for specific crimes against individuals. Categories to be considered are the following: Intentional Homicides, Threats, Intentional Injuries, Robberies and Rapes. The results of the temporal correlations are reported in Table 2:

Table 2: Correlation between private spending and selected crime efficiency measures

year	Intentional Homicides	Threats	Intentional Injuries	Robberies	Rapes
2017	-0.93	-0.87	-0.90	-0.75*	-0.79
2016	-0.94	-0.88	-0.90	-0.74	-0.82*
2015	-0.94	-0.93	-0.94	-0.75	-0.30
2014	-0.95*	-0.94*	-0.95*	-0.75	-0.66

Asterisks denote the highest statistical correlation.

As can be seen from the table below, the following lags will be taken into account for the empirical model: Intentional Homicides → 2014; Threats → 2014; Intentional Injuries → 2014; Robberies → 2017; and Rapes → 2016.

With all this we are now in a position to proceed with the estimations, involving the models (and respective specifications) previously discussed.

[9] The GLM is just a flexible generalization of ordinary linear regression that allows for response variables that have error distribution models other than a normal distribution. Formally, in a GLM, each outcome P of the dependent variables is assumed to be generated from a particular distribution in the exponential family. The mean, μ, of the distribution depends on the independent variables, X, through:

$$E(P) = \mu = g^{-1}(X\beta)$$

Where $E(P)$ is the expected value of P; $X\beta$ is the linear predictor and g is the link function. The unknown parameters, β, are typically estimated with maximum likelihood, maximum quasi-likelihood, or Bayesian techniques.

[10] All this specifications were considered after comparing a set of models with different distributions by the corresponding information

Table 3: Results

VARIABLES	**OLS** log(priv. spending)	**GLM** (Inv. Gaussian) log(priv. spending)	**GLM** (Poisson) log(priv. spending)	**SAC** log(priv. spending)
GRP	-3.38e-12**	-3.86e-12***	-3.53e-12***	-5.27e-12***
	(1.25e-12)	(1.15e-12)	(1.08e-12)	(1.06e-12)
Int. Homicides	-0.00560**	-0.00680***	-0.00595***	-0.00506**
	(0.00203)	(0.00175)	(0.00172)	(0.00224)
Threats	0.000388**	0.000421***	0.000398***	0.000655***
	(0.000148)	(0.000111)	(0.000122)	(0.000104)
Int. Injuries	-0.000332**	-0.000342***	-0.000335***	-0.000615***
	(0.000123)	(9.14e-05)	(0.000101)	(7.88e-05)
Robberies	-8.64e-05***	-0.000100***	-9.07e-05***	-0.000129***
	(2.92e-05)	(3.11e-05)	(2.65e-05)	(1.89e-05)
Rapes	-0.000717	-0.000871	-0.000783	-0.00659***
	(0.00283)	(0.00247)	(0.00245)	(0.00128)
Constant	7.385***	7.329***	7.368***	12.09***
	(0.230)	(0.199)	(0.199)	(2.290)
ρ				-0.641**
				(0.304)
λ				-6.120***
				(0.497)
Observations	24	24	24	24
R-squared	0.666			

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As can be seen from Table 3, empirical results are consistent with the framework drawn in the theoretical section. First of all, it is quite interesting to notice that the relationship between private spending and the level of income (here expressed with the GRP) reflects the "Income Effect of Efficient Security Investment" developed in the theoretical section. This effect is statistically significant regardless the model specification adopted. By the side of public efficiency measures, once discarded the simple OLS alternative, different model specifications derive quite homogeneous results.[11] First, considering the GLM framework we highlight an anomaly upon the sign of "Threats". Despite the fact that every other measure has a negative association with spending -as is intuitively assumed-, the case of Threats makes us suspect that by one dollar invested by the government (in efficiency units) will **increase** the private spending in $\approx 0.04\%$. If were the case, we would be finding an *inefficiency*, rather than an efficiency, measure of governmental spending upon Threats, as specified in the theoretical model. Thus, the private sector would be financing (in certain way) the crime trough taxes and that will require to increase their private spending in order to compensate the dis-utility that crime generates to them and the society itself.

Even when controlling by spatial autocorrelation of residuals, the anomaly persists; moreover, this specification improves the results for the rest of efficiency measures.[12] By the way, the inefficiency regarding Threats can be explained in a fairly intuitive way: given that there are almost no convicts jailed by that kind of crime -at least in Argentina-, the private sector derives more than proportional resources to the detriment of this kind of crime, respect to the public sector. This intuition finds support in the legal definition of "Threats" according to the current Argentine legislation. Article "149 bis cp" of the Argentine Penal Code stipulates that this crime is only subject to imprisonment if weapons are used to threaten [... or] if the threat is anonymous.

criteria tests.

[11] For illustrative purposes we report the OLS results in the first column of Table 3. As can be seen, despite overall conclusions remain, as discussed before, GLM and SAC models are preferable due to their robustness upon residuals' assumptions.

[12] Quite interesting is the that, under the SAC specification, we achieve statistical significance of the variable "Rapes".

[13] This legal framework evidently sets aside a large number of complaints of threats (e.g, that are not anonymous or under the use of weapons), for which the offender will never serve a sentence in prison. In light of the results of this paper, victims of threats internalize this *inefficiency* with respect to this crime and translate it into higher private spending, regardless of the respective public spending. The particular analysis of this conjecture regarding public inefficiency due to the current legal framework is reserved for future research.

6 Conclusions

The main core of this paper was to analyze the implicit relation between private spending on security services and governmental efficiency on detriment of crime. Basically, to understand this relationship is interesting to notice that individuals can protect themselves from crime in two ways: by deriving resources directly in the form of private sending; and paying taxes to the government in order to delegate their power over crime regulation. As we can expect, taking apart the externality effect over crime, both kind of expenditures find an equilibrium for the private agent (i.e both private and public supply of security service finds non-negative solution). Nevertheless, this distinction is not innocuous in the sense that, if we consider the government as a different agent with its own maximization problem, it reflects an efficiency measure associated with the supply of public security. This measure become crucial for the consumer in the sense that the more efficient the government is, the less resources should be derived to private spending (and actually more resources can be derived for consumption). Therefore, the interaction between both agents can be expressed in terms of this efficiency measure on detriment of crime.

The main objective of this paper was to study this relationship between public and private supply of security. For that, we developed a simple model of interaction between two agents (citizens and government) in a *complete and perfect information game* scheme. Thereafter, we arrived to an explicit relationship between private expenditure in security, and the efficiency measure of the government. Then, using data from the Ministry of Security of Argentine Republic and the National Institute of Statistics and Censuses (INDEC), we constructed a couple of empirical models to test and quantify our theoretical premises. Building our own measure of efficiency, defined as the difference between the number of convicts and complaints for specific crimes at a given year, we tested the presence of spatial autocorrelation in the data, and developed a set of models to deal with this and other empirical issues. Finally, we found that the relationship between private spending and governmental efficiency was quite heterogeneous among the different crimes under study. Considering a spatial model (SAC), the results vary from $+0.06\%$ in the case of Threats, to a -0.01% in the case of Robberies; all measured as semi-elasticities respect to private spending on security.

[13] See https: // www.conceptosjuridicos.com/ar/codigo-penal-articulo-149-bis/

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