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Socioeconomic Determinants of the Changes in Homicides over Time: A VAR Analysis

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Abstract

Purpose *– We search for determinants of the change in homicides over time by analyzing the interconnection between a high incidence of murders and the socioeconomic environment, using Puerto Rico as the case study. This case presents intriguing facts that challenge some of the conventional crime hypotheses. For instance, in forty years homicides quadrupled by four times while the population was aging and declining.*

Design/methodology/approach *– First, a new and simple theoretical formalization is exhibited. Then, we applied three vector autoregressions, showed the variance error decompositions, and revised its structural stability.*

Findings *– We found that jobless growth is insufficient to decrease murders. Instead, lower employment, a growing number of families led by a single parent, and higher urbanization have partially caused the increases in homicides. We also found that the homicide incidence partially is a self-propelled phenomenon.*

Research limitations/implications *– The punishment approach is not sufficient in explaining and reducing the high level of homicides. The economic inequality does not map directly onto the changes, though it may explain the level of murders.*

Originality/value *– The homicide incidence is found to be embedded in the socioeconomic structure.*

Keywords: homicides determinants, socioeconomic conditions, crime

JEL Classification: K42, K14, K0

1. Introduction

Many researches use case studies, including relatively small areas such as provinces and cities, to inquire into the causes of crime (Glaeser et al., 1996; Hojman, 2002; Funk and Kugler, 2003; Harcourt and Ludwig, 2006; Buonanno and Montolio, 2008). We chose Puerto Rico as the case study; a jurisdiction where conventional explanations do not completely describe the elevation in homicide incidence. For instance, while it has been proved in cross-country studies such as Fajnzylber et al. (2002a) that economic inequality causes crime and this country has a

very high inequality, inequality does not explain the increase in the murder rate from 7.07 in 1970 to 30.48 in 2011[1].

According to the United Nations Office on Drugs and Crime (UNODC), Puerto Rico is ranked 17th among countries with the highest homicide rate per 100,000 inhabitants. Contrary to conventional wisdom, this increase in homicide incidence occurs at a time when the population is declining and aging.

Researches like Soares and Naritomi (2010) point out that a low incarceration rate is one of the main determinants of high crime. However, Puerto Rico has one of the highest incarceration rates in the world; in the top 30 according to UNODC. Therefore, this cannot fully explain why the crime rate has multiplied by more than four times in 40 years.

A high number of police agents and repressive public policies, such as the "iron fist against crime", are considered insufficient to reduce the homicide incidence and sometimes can have perverse results (Montalvo-Barbot, 1997).

Puerto Rico has one of the highest proportions of police agents, with close to 528 policemen per 100,000 inhabitants (excluding federal and municipal police). This is a number significantly higher than the US, which has 325 agents per 100,000 people (Soares and Naritomi, 2010), or the city of New York, which has around 435 per 100,000 inhabitants. In addition, the Penal Code was reinforced in 2004, but it was not sufficient to reduce the soaring rate in homicides. It would appear that criminals in this country have a high discounting rate (Lee and McCrary, 2005) or that the situation of this country supports the conclusions of Andreoni (1991), where an increase in punishment is not necessarily an optimal solution to reduce crime.

This raises the question: What factors can be at the root of a dramatic change in homicide incidence? We emphasize changes since there are factors that in a cross-sectional analysis can explain the levels (such as inequality and incarceration rates) but cannot completely describe the increases over time. For instance, in the natural sciences there is a theory that links a high temperature with crime (Simister, 2008). However, this cannot explain the multiplication in murder rates, since Puerto Rico had almost the same temperature for the period 1970-2011 (our sample).

Given the challenges with the previous approaches, crime in this country will be studied as a problem embedded in the socioeconomic structure using vector autoregressions (VARs). A few studies before have applied VARs to study crime-related topics in other jurisdictions (Funk and Kugler, 2003; Gkanas and Dritsakis, 2009; Tang, 2009), but it has not been applied in this and many other countries. One of the advantages of VARs over single equation models is that all the variables are endogenous. New as well as standard socioeconomic factors are found to be causing or exacerbating the homicides.

In subsection 1.1, we discuss some of the literature on socioeconomic determinants. One of the contributions is showed in Section 2, where we present a new and simple theoretical foundation and also test many hypotheses using two dynamic econometric models with some new variables. In Section 3, we illustrate the results, and in Section 4, we state the conclusions. The focus will be on quantifying the effect of changes in the socioeconomic environment as an exacerbating factor of the likelihood of homicides, and not on the etiological inquiries of the homicides level.

[1] Because in some supranational organizations (such as the World Bank) Puerto Rico is classified as a country and the legal terminologies are complicated and debatable, for ease of reading, here we refer to Puerto Rico as a country. However, we acknowledge the long and ongoing political debate.

1.1 Related Literature

There is no a clear-cut determinant for the changes in the high incidence of murders. One of the socioeconomic hypotheses is the age effect, which states that the younger population is more likely to commit crime (Nunley et al., 2011). This argument will be tested in the models of the next section.

Another conventional thesis is population growth, namely that the higher the population, the higher the crime (Blau, 1977). Nonetheless, the Census Bureau reports a decline in the population for the period 2000-2010. Given the resonance of this paradigm of criminology, in the next section we will indirectly test the population effect.

Many models use inequality as a regressor (Fajnzylber et al., 2002a). In this paper, there is no attempt to deny that a high level of crime and a high level of economic inequality are intertwined. For instance, the level of economic inequality in this territory is one of the highest in the whole world, with a Gini index of 0.54 in 2011, ranking among the five worst Gini indices in the World Bank. However, economic inequality could explain the level of homicides but not the changes. According to Sotomayor (2004), this country had a Gini coefficient of 0.55 in 1969 and 0.55 in 1999. But in the same period, the homicide rate doubled from 7.07 to 15.6. The same occurred between 1999 and 2011 when the Gini was stabilized around 0.54 but the homicide rate doubled from 15.68 in 1999 to 30.68 in 2011.

It is clear that there is an absence of a one-to-one mapping between the changes in the homicide rates and the changes in inequality or punishment. Other exacerbating factors might be found in the socio-economic environment. For instance, Calvó-Armengol et al. (2007) theorize the interconnections between unemployment and crime, suggesting that in a country where crime is relatively profitable for individuals (e.g., Puerto Rico), the unemployed are more vulnerable to enter into criminal activities. On empirical grounds, Mocan and Rees (2005) and Ihlanfeldt (2007) find an inverse relationship between labor-market access and crime. Raphael and Winter-Ebmer (2001), Weinberg and Mustard (2002), Mocan and Bali (2010), and Altindag (2012), find an inverse association between unemployment and crime.

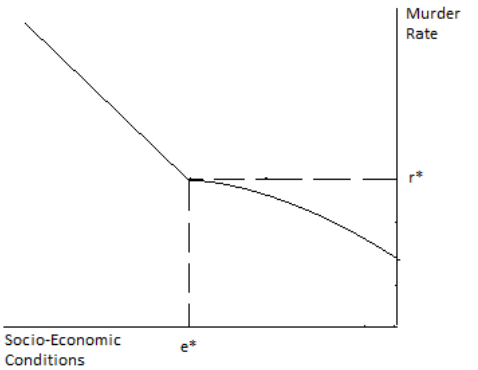
In our specification below, we considered some of these socio-economic variables as well as new determinants that will be justified in the next section.

2. A Model and the Data

The previous discussion can be summarized quickly in Figure 1. Under ideal socioeconomic conditions, there is a "natural" rate of murders or a level of homicides that are due to non-socioeconomic factors; this point is the intercept. There is also a level of murder rate that can be controlled by effective and non-coercive law enforcement. In the graph below, that level is r*.

As the socioeconomic conditions continue to deteriorate, there is a point where law enforcement is insufficient to leash the homicide incidence. This point is e*.

Figure 1. Theoretical Relation between Murder Rate, Socio-Economic Conditions, and Law Enforcement



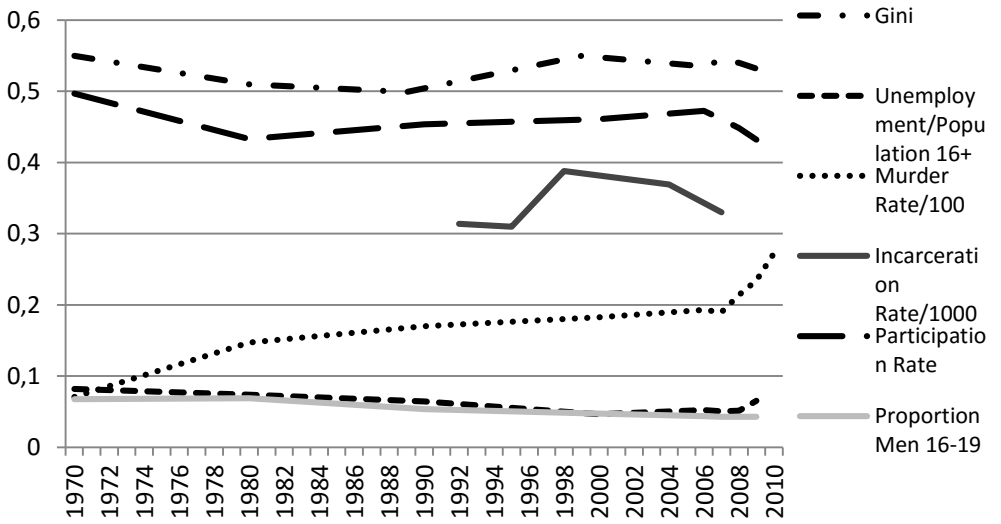
That is, assuming that $\exists\, S \in \mathbb{R}$,

$$\frac{dH}{dS}\Big|_{S<e*} > \frac{dH}{dS}\Big|_{S>e*}$$

where H is the murder rate and S are the socioeconomic conditions. Also note that if S < e*→ $\frac{d^2H}{dS^2} > 0$ and vice versa. Both points can move in time, but in our empirical approach it is assumed that the situation in this country passed the point (e*, r*), which would correspond to a murder rate of a single digit.

Figure 2 illustrates some of the observed data; the source of every variable is in Appendix I. It is important to point out that many series found points of inflection near 1980 and a new pattern started: the ratio of men aged 16-19 to the civilian population 16 and older decreased, the participation rate started to increase and the homicide rate reduced its rate of growth. None of these series had a one-to-one relation with the homicide rate, which suggests that a combination of factors were causing or exacerbating the homicide incidence. Note that in the last decade the homicides increased significantly while the labor market was showing a sharp deterioration.

Figure 2. Patterns of the Homicide Rate and its Possible Determinants, 1970-2010



Note: The incarceration rate was divided by 1000 and the murder rate by 100 to make the graph readable.
Sources: BLS (2012), University of Puerto Rico (2011), UNODC (2012). In the appendix, there is a detailed description of the sources of every variable.

We acknowledge that there is no exhaustive list of homicide determinants. Donohue (1998) states, "With all the random factors that influence the amount of criminal conduct, it is virtually impossible to fully explain or precisely predict the crime rate at any point in time." (p.1423). Based on the literature, we suspect that (the lack of) employment is one of the main determinants. Searching for other exacerbating factors of a high homicide incidence, we first remove the non-statistically significant variables and then assumed that homicides rates can be described by,

$$H_t = \beta_0 + \theta H_{t-1} + \tau L_{t-1} + \gamma A_{t-1} + \rho E_{t-1} - \delta I_{t-1} + \emptyset G_{t-1} - \omega U_{t-1} + \mu_t \quad (1)$$

where β_0 is the constant; H is the homicides rates; L is the ratio employment to population (economically active); A is the ratio of men aged 16-19 to population 16 and older; E is the enrolment in secondary education per 1,000 inhabitants; I is real Gross National Income per capita; G is the employment to population ratio of single head of households (those with absent partner, widow or divorced); U is urbanization rate (proportion of urban

population to total population), and μ is the error term.

As in Funk and Kugler (2003), we chose VARs since it has many advantages over single equation or structural multi-equation models. For instance, there are no exogeneity assumptions over the variables of interest because all regressors are endogenous in the multiple five-dimensional systems to be applied. Pure exogeneity can be a strong assumption because these socioeconomic variables may be determined inside of the system.

Thus, attempting to validate the results without disobeying the parsimonious principle, we estimate different VAR specifications based on Equation (1). The first one is given by,

$$y_t = K_0 + K_1 y_{t-1} + \cdots + K_p y_{t-p} + u_t \quad (2)$$

where $y_t^{'} = (H, L, E, I,)$; K_p are coefficient matrices, and u is an independent and identically distributed vector of disturbances. We refer to Equation (2) as VAR 1.

By analogy, the second and third VAR follows:

$$x_t = A_0 + A_1 x_{t-1} + v_t \quad (3)$$

where $x_t^{'} = (H, G\ , E, L)$ for VAR 2 and $x_t^{'} = (H, U\ , E, A)$ for VAR 3, and v is the respective vectors of innovations. These VARs are first-order by following the Schwarz criterion. The Johansen tests point out that these three VARs have no cointegrating relationships.

Both models passed the Lagrange multiplier test for serial correlation, indicating that there are no misspecification problems at the 95% confidence interval. Since most of these regressors are I(1), we applied first differences to the three VARs. The VARs have all the characteristic roots outside of the unit circle[2].

The effect of young men on crime is represented with the variable *A*, the production per capita with *I*, the labor market with *L*, the education effect with *E*, the urbanization changes with *N*, and the effect of family as an institution with *G*. The last two determinants deserve more explanation since they are part of our innovations.

The employment to population ratio of single head of households was included to study the effects of family instability on homicide incidence throughout the years. *G* can be thought of as an instrument for family stability, which also has a higher correlation with the divorce rate. Family is considered to be a very important institution that affects the attitude and the level of self-control of individuals (Tangney et al., 2004) and reduces the likelihood of crime (Loureiro et al., 2009). We deemed it important to include this variable since there is an upward trend of single-parent households. For instance, according to the Census Bureau, single female householders represented 27% of the total family households in 2000 while in 2010 this segment increased to 31%.

Figure 3. Employment to Population Ratio of Single Head of Household, 1970-2010

Since single householders have a higher probability of poverty, this increasing trend can imply, on average, a higher likelihood of future adults involved in crime. In addition, a single head of household may have, on average, more difficulty teaching self-control to his (or her) offspring. Using other methodology, Sampson and Laub (2006) find a direct relation between marriage and lower crime. In cross-sectional surveys there is the

[2] For in-depth details of these usual regressions, refer to Hamilton (1994) and Johansen (1988). Tests are in the appendix, not necessarily for publication. The data set is available upon request.

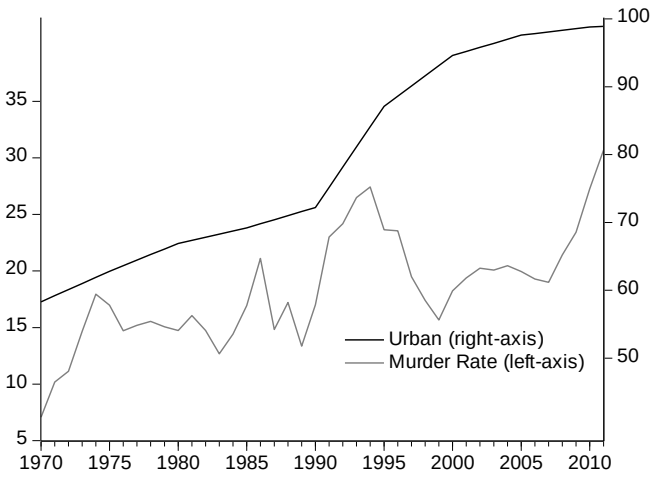
opportunity to study different family influences on crime in one period, but a methodology that does not contain time cannot explain, once again, why the homicide rate has multiplied by four in 40 years. Here *G* is the proposed measurement to study the family (de) composition throughout the years, which has change significantly according to Figure 3 and could indicate some changes in social institutions and social capital.

It is worth mentioning that population growth has, in this case, a negative association with the homicide incidence, but that variable was not included explicitly since it has a very high correlation (about 0.95) with A. In other words, even if it is not our aim, A can be thought of as instrument to total population.

Another interesting point of this research is the inclusion of the proportion of urban population as a determinant. Using other econometric specifications, Buonanno and Montolio (2008) find that urbanization is a determinant of crime for Spanish provinces. In Puerto Rico, more than half of the numbers of homicides are committed in six out of 78 municipalities, namely cities, while many country towns have less than five homicides per year. This is the case at least for the period 2003-2009 when the data segregation is available. As a matter of fact, the capital has a murder rate of 43 while many municipalities have a murder rate close to zero.

As part of its fast modernization, Puerto Rico had a relatively rapid urbanization process. Figure 4 shows that the surge in homicide incidence and the increase in urbanization occurred simultaneously. It is remarkable how the takeoff in 1989 is closely matched by an increase in the total number of murders or vice versa. In the next section, we will report if there is a strong association between urbanization and homicides after controlling for other influences.

Figure 4. Pattern of Urban Population and Homicides, 1970-2010



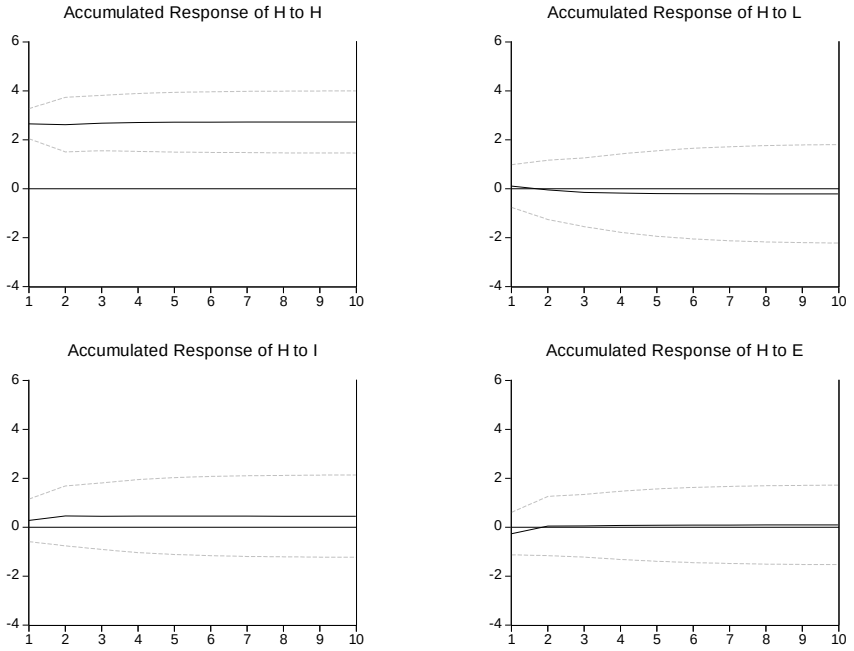
Note: Urban is the urban population divided by total population.
Sources: WB (2012), University of Puerto Rico (2011)

3. Empirical Discussion

There are different procedures to decompose the residuals in a VAR analysis. We selected the orthogonal set of innovations constructed by Pesaran and Shin (1998), which provide generalized impulses that are not dependent on the variables' ordering. We maintained the convention in these models of only presenting the impulse-response

function and the variance decomposition (Stock and Watson, 2001)[3].

Figure 5. Accumulated Homicides Responses to Generalized One Standard Deviation on the Innovations (VAR 1)



Note: Bands are asymptotic confidence intervals based on two standard errors.

When there are both negative and positive responses, the accumulated responses are recommended since they represent series that allow the measurement of impacts in net terms. In Figure 5, we can observe that an unexpected shock in homicides in one period is highly correlated with the homicides of the subsequent periods. This would be very intuitive since the vast majority of homicides are directly linked to drug trafficking (Rodríguez-Madera and Torres-Narváez, 2005): the revenge between groups or gangs produce more homicides in the next periods. In other words, violence generates more violence. Fajnzylber et al. (2002b) find a similar conclusion in this regard.

Another variable that has a direct relation with the murders is the GNI per capita. Holding everything else constant, an unexpected shock in the GNI per capita is associated with an increase in the homicide rates of the next two periods. In other words, an increase in output per capita has a negative effect on murders.

This result, which could be deemed counter-intuitive, is easy to explain given that these results are built on a ceteris paribus (holding everything else constant) assumption: a jobless growth is ineffective to

[3] Referring to these statistics, Stock and Watson (2001) remind: "Because of the complicated dynamics in the VAR, these statistics are more informative than are the estimated VAR regression coefficients or r-squared statistics, which typically go unreported." (p. 104)

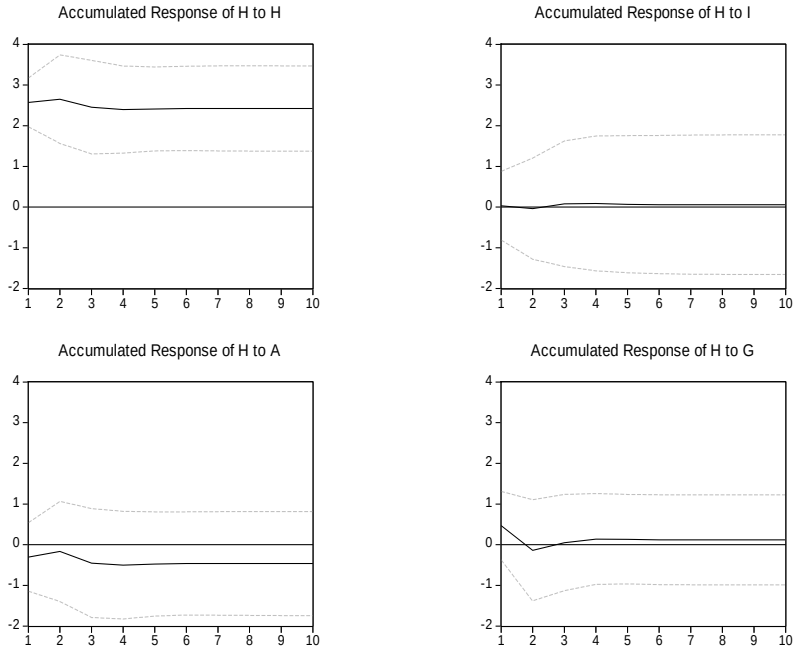
decrease homicide incidence. This is a useful outcome since output growth does not always map the movement in the labor market. In the US, for instance, there is recent literature on the dismissal of Okun's law, which links GDP growth with employment (Gordon, 2010).

On the other hand, employment has long positive effects on murders. In particular, a positive increase in the ratio of employment to population in period t is related with a decrease in total murders for four periods. Clearly, job creation is an effective policy to reduce murders.

Likewise, an unexpected innovation in enrollment creates a dampening effect on the murder rate for two periods. This result will be compared with other specifications such as the system illustrated in Figure 6.

In VAR 2, homicide rates continue to have a long and relatively strong impact on its definite perpetuation. In particular, an unexpected positive shock in homicides today would have a direct correlation with the homicide rates for the following four periods. Another result that is validated in this specification is the consequences of production impulses on the homicide incidence. An unexpected innovation in the GNI per capita does not reduce the homicide rates.

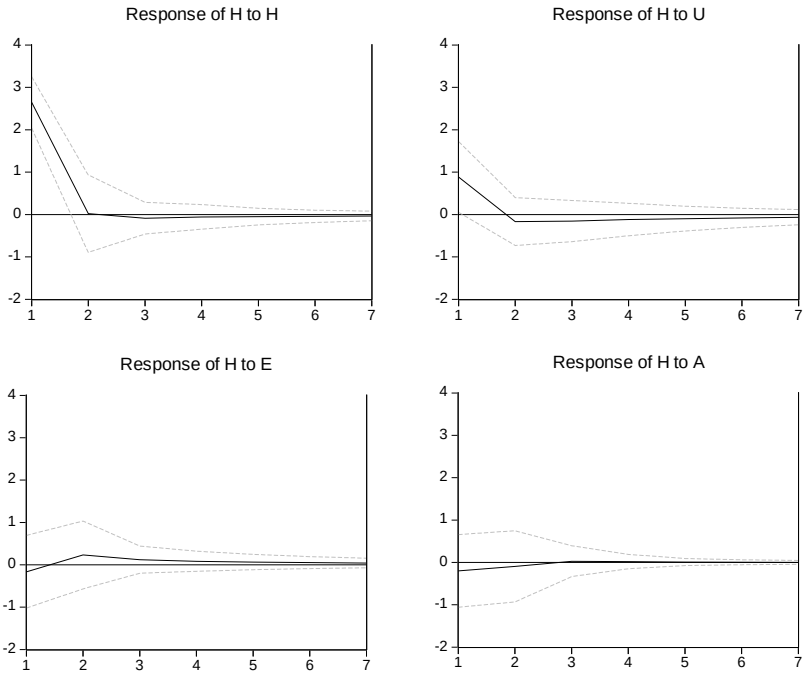
Figure 6. Homicides Responses to Generalized One Standard Deviation on the Innovations (VAR 2)



A higher proportion of young men does not appear to cause an increase in homicide rates. Contrary to some expectations, A is negatively associated with homicide incidence. It would appear that there are other factors playing a more relevant role in this system such as the increase in single head of households. In fact, an unexpected shock in G in period t-1, namely more single head of households in the last year, is related with an

expansion in homicides. This suggests that a lower proportion of single-parent families, or perhaps more stable families, have positive effects in the next generations by declining homicides. As we stated above, a suggested channel might be (on average in the long run) that higher unstable relationships end up in a higher probability of poverty and higher vulnerability of children to attain self-control, which negatively affects the homicide incidence. All the effects combined may have repercussions in the long run that increase the likelihood of being involved in crime.

Figure 7. Homicides Responses to Generalized One Standard Deviation on the Innovations (VAR 3)



In terms of the effect of homicides, the findings reported in Figure 7 are similar to those from the previous VARs: an unexpected shock in the murder rate today has a significant cumulative effect in the murder rate for the following two periods. This would confirm the hypothesis that violence generates more violence.

The responses generated by the proportion of enrollment in secondary education appear to be enigmatic. In this four-dimensional system, on average an unexpected innovation in the enrollment ratio is positively correlated with homicide rates. However, the outcome appears to be relatively small, with a relatively high confidence interval. The contradictory results of these VARs would lead to the conclusion that the role of secondary enrollment does not have a high statistical significance to analyze the evolution of the homicide incidence.

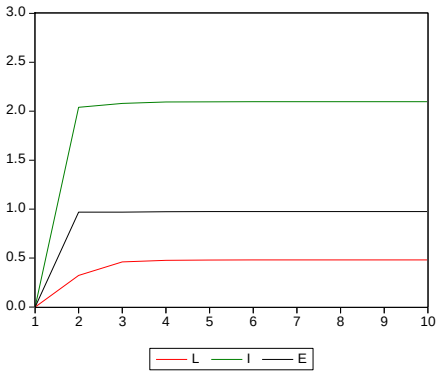
Likewise, based on the results of the last impulse-response function, we conclude that an increase in the proportion of men aged 16-19 has at most no effect on the homicide rate in the long run, dampening also a causality from population growth to homicides since *A* has a correlation of 0.95 with population.

Contrary to Pol and Silvestrini (2004), the proportion of men aged 16-19 is inversely linked to homicide incidence: *ceteris paribus*, one innovation in the proportion of men aged 16-19 produces a small reduction in the murder rate for two consecutive periods. The absence of a positive relation is clear from Figure 2 where the population of men 16-19 is declining while the murder rate inched up steadily. That is another interesting fact: the population is diminishing and aging while the homicide incidence is edging up speedily[4].

Another variable that has a surging effect on the murder frequency is the urbanization rate. In particular, an unexpected innovation in the proportion of the urban population generally enlarges the homicide rate. In the long run, the multiplication in murders appears to be partially embedded in the urbanization process.

What is the relative importance of the determinants of *H*? Can we say that urbanization affects more than lower employment? The error variance decomposition is a widely used tool that can help to answer this type of question. Figure 8 shows the decomposition results for VAR 1.

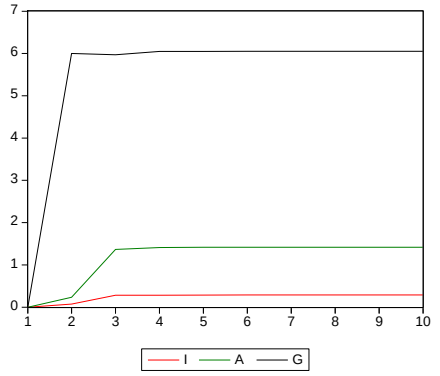
Figure 8. Variance Decomposition of VAR 1



For these three VARs, homicides in the past period are the variable of greatest influence. Thus, we avoid presenting it for ease of presentation. In the first VAR, the second variable of greatest influence appears to be the increases in the GNI per capita followed by the proportion of secondary enrollment. The employment to population ratio appears to have the lowest magnitude in this first specification.

However, in the second system, which is presented in Figure 9, the GNI per capita shows the lowest impact among the socio-economic variables. Both VAR 1 and VAR 2 indicated that what matters for a reduction in the homicide rate is employment performance, not just economic growth. This might suggest that the illegal drugs industry is fuelled by low employment creation, which may attract some individuals that seek high remunerations that are less likely in the legal market.

Figure 9. Variance Decomposition of VAR 2



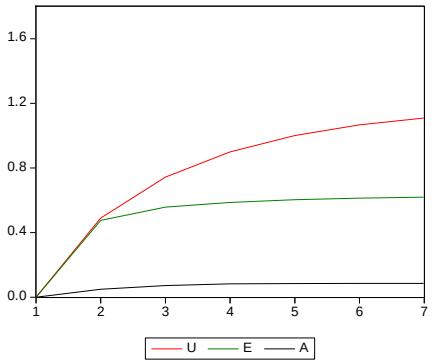
On the other hand, increases in single heads of household represent the second highest impact on the homicide rates, having a relatively higher correlation than other variables. One could infer that a more stable family plays a significant role in reducing the homicide incidence, perhaps by creating a higher probability of attaining self-control for children (future adults).

The proportion of young men has a middle influence in VAR 2 while it represents the variable of least influence in VAR 3, as

[4] There is a wide consensus in Puerto Rico that the population is aging and the population pyramids confirm it, though they were not included here for space considerations.

illustrated in Figure 10. These two error variance decomposition can lead us to reaffirm that the proportion of men aged 16-19 plays a minor role in explaining homicide incidence. The same conclusion applies to the proportion of secondary enrollment, which appears to have the second lowest impact on the homicide rates. On the other hand, urbanization rates create the strongest repercussions on homicide incidence

Figure 10. Variance Decomposition of VAR 3



Are these parameters structurally stable for the whole period? To answer this important question we applied a Chow forecast test, where the Chow forecast statistic is given by,

$$\lambda = \frac{1-(1-R_r^2)^{1/s}}{(1-R_r^2)^{1/s}} * \frac{Ns-q}{Kk^*} \approx F(Kk^*, [Ns-q]) \quad (4)$$

with $s = \left(\frac{K^2k^{*2}}{K^2+k^{*2}-5}\right)^{\frac{1}{2}}, q = \frac{Kk^*}{2} + 1, N = T - k_1 - k^* - \frac{K-k^*+1}{2}$;

$R_r^2 = 1 - \left(\frac{T_1}{T}\right)^K |\widetilde{\Sigma}_{(1)}|(|\widetilde{\Sigma}_u|)^{-1}$; $\widetilde{\Sigma}_{(1)} = T_1^{-1}\sum_{t=1}^{T_1} \hat{u}_t^{(1)}\hat{u}_t^{(1)'}$

where k_1 is the number of regressors), k^* is 23 and equals the forecast periods considered (T - T_1), T is full sample, $\hat{u}_t^{(1)}$ is the residual estimator of T_1 (the excluded periods in the test), and $\widetilde{\Sigma}_u$ is the residual covariance matrix, K are endogenous variables (5 in total). Given that the asymptotic λ can differ from the λ based on small sample (Candelon and Lütkepohl, 2001), we calculated bootstrap p-values that are shown in Figure 11. Since the null hypothesis is that there are constant parameters for the sample considered, it is shown that the model is structurally stable.

Figure 11. Chow forecast test: bootstrap p-values for VAR 3

4. Conclusions

There are a plethora of theories and variables that are imputed as the causes of crime and homicides. Among those are, for example, many psychiatric and biological theories that cannot explain in their own methodologies the changes in homicide incidence over time (e.g., temperature levels).

The punishment approach does not completely account for the high homicide incidence in this country: both the incarceration rate and the variable of police per 100,000 inhabitants are relatively high. The socioeconomic approach appears to be an appropriate framework to map the changes in homicide incidence, especially for countries like this where the social environment has changed significantly in terms of the labor market, economic performance, urbanization, family composition, and population growth.

While the economic inequalities are very high in this country, they cannot monotonically explain the changes in homicide rates. For this high-middle income country, three VARs were applied to test structural socioeconomic determinants that could explain a high change in the homicide rates over time. Based on the empirical tests, we conclude that the population growth and the proportion of men aged 16-19 did not caused the high homicides and that a jobless growth was insufficient to decrease the high level of murders. Instead, a reduction in employment and increases in single heads of households and in urbanization were more correlated with the surge in homicide incidence. Also, there

is some evidence that homicide incidence was also a self-propelled phenomenon, in the sense that past homicides induce more homicides in the following periods.

Although more research is needed, some conclusions to be drawn are that a significant improvement in the socioeconomic environment, especially in job creation, for the whole country is necessary to reduce the high level of homicides and to ensure a low or "natural" rate of crime. The failures of these governments to correctly address their homicide incidence are meaningful for other countries and jurisdictions.

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Appendix I:

VARIABLES	SOURCES
Labor market statistics like participation rate, employment, population 16 and older, G	US Bureau of Labour Statistics and by the Bureau of Labour Statistics, Department of Labour and Human Resources of Puerto Rico
Men in ages 16-19	Bureau of Labour Statistics of the US and in the Department of Labour and Human Resources of Puerto Rico
Homicides data	Police of Puerto Rico, Statistics Division, University of Puerto Rico (2014)
Total Population and GNI per capita	Maddison (2010)