THE DETERMINATION OF THE VIOLENT LIFE-RELATED CRIMES AS AN EXTESION OF THE BROKEN WINDOW THEORY APPLIED OVER THE CRIME RATES OF THE BIGGEST BRAZILIAN CITY.

Thyago Celso Cavalcante Nepomuceno
Universidade Federal de Pernambuco
Av. Prof. Moraes Rego, 1235 – Cidade Universitária, Recife – PE
thyago.nepomuceno@yahoo.com

Victor Diogho Heuer da Carvalho
Universidade Federal de Pernambuco
Av. Prof. Moraes Rego, 1235 – Cidade Universitária, Recife – PE
victorheuer@gmail.com

Ana Paula Cabral Seixas Costa
Universidade Federal de Pernambuco
Av. Prof. Moraes Rego, 1235 – Cidade Universitária, Recife – PE
apcabral@hotmail.com

ABSTRACT

The determination of violent crimes, those related to the citizens' life, is viewed in this study as a function of the property crime, those related to the public and private property, and the policing enforcement. Through a monthly crime's dataset provided by the Department of Public Safety of the State of São Paulo, Brazil, we developed a multiple regression analysis for the years of 2011-2014 in order to validate the relationship between these two kinds of crimes. A mathematical model is also proposed as a framework that could explain this reality. We conclude, as in the Broken Windows Theory, that once the offenses are committed in the majority by the same people, when the feeling of impunity arose due a low policing enforcement over the property crimes, these property crimes begins to decrease, and the violent crimes to increase, a relationship which may provide a good forecast for the violent crimes in a later period.

KEYWORDS. Public Safety. Crimes Determination. Broken Windows Theory.

DEA - Data Envelopment Analysis, EST – Statistics, OA - Other applications in OR

1. Introduction

The relationship among types of criminal offenses has been widely discussed along the past decade, mainly brought by the Broken Windows Theory (Wilson & Kelling, 1982) which claims that small crimes lead inevitably to more serious criminal conduct, if those small offenses were not suppressed by the police enforcement. When a window is broken and remains unrepaired it sends a message of impunity, a sign that property is not important, and soon dozens of other windows will be broken as an inevitable consequence. This approach has been subject of numerous studies, researches and applications related to the association of minor offenses like disorders with severe crimes and it has been viewed as a source of value on law enforcement policy (Corman & Mocan, 2005; Funk & Kugler, 2003; Jang & Lawton, 2008; Skogan, 1988). For instance, according to Kelling & Bratton (1998) there is a link between disorder, fear and crimes that has the following relation: *disorder → citizen fear → withdraw (physical and social) → increased predatory behavior → increased crime → spiral decline*. This model demonstrate that the intervention occurs when is too late, and a small crime becomes a motivation for worst crimes.

Hinkle & Yang (2014) intended to extend the current literature on perceptions of disorders using initially streets segments as the unit of analysis. They consider these units as the most relevant parameter to understand the residents' perception of disorder in the local environment. The analysis contrasts the perceptions of property damages and disorders with a perceived disorder measure developed on these streets and it additionally includes observational measures of both social and physical disorder. As results, the authors reported that there is a little correspondence with the residents' perception to the researchers' observational measures, suggesting that the crescent social disorder is a social construct, rather than a concrete phenomenon. So, the idea the Broken Windows claims that a crime is inextricably linked to a social order consciousness more generally, such as the work of Engel et al. (2014) which pointed out that the first impressions and the early punishment for social disorders are independent and the first impressions are more important than the early vigilance due mostly because, in the long term, the effects of early vigilance fades away, while the effects of first impressions remains stable. Jang & Lawton (2008) collected data from the thirty-five largest municipal police agencies of Texas from 1990 through 2004 and applied a hierarchical multivariate linear modeling analysis to capitalize the longitudinal characteristics of the data, allowing the analysis of the influence of the broken windows enforcement across a wide spectrum of agencies over a long period. Their analysis demonstrated that broken windows enforcement in prevent minor offences also had a positive impact on the clearance rates for burglaries and a marginal impact on auto theft clearance rates.

Based on the current literature we intended to analyze whether the same relationship could be verified in a wider scenario with the interaction not only between minor serious crimes but also among several type of different crimes and offenses. Through a multiple regression of a dataset of property crimes such as burglaries, armed robberies, bank robberies, thefts of cargoes, vehicles theft and related and violent crimes such as homicide, attempted homicide, aggravated assault and rape from de city of São Paulo, the Brazilian most populous city with a population about 12 million inhabitants, between the years 2011 and 2014, we validate a relationship between these two variables in the sense that in months which the size of the property crimes are minor, the violent crimes are increased and months where property crimes are high implies an opposite effect on the violent crimes. Once the growth rate of criminals remains untouched in the short run or with a little variation from one month to the other, the crimes in a given society are committed by the same people, then, the increase in the violent crimes means the migration from the property crimes. A mathematical model for the determination of crimes is also proposed as a framework that could explain this reality towards the variation of violent related crimes in function of the property crimes, the police force and the entry of new crimes unrelated before.

2. The Violent Crimes' Determination Model

We assume the total crimes committed in a given society (C) consist in three instances: the property crimes (*Cp*), the violent crimes (*Cv*) and the crimes of trafficking (*Ce*).

$$C = \sum_{i=1}^{n} Cp_{m;t} + \sum_{i=1}^{n} Cv_{m;t} + \sum_{i=1}^{n} Ce_{m;t} \quad (1)$$

Where:

$\sum_{i=1}^{n} Cp_{m;t}$ is the sum of the property crimes relative to the year *t* for the community *m*, composed by car burglaries, robberies, armed robberies, bank robberies, thefts of cargoes and premises, vehicle theft and related, without taking into consideration the crimes of extortion with deprivation of liberty and the crimes of embezzlement.

$\sum_{i=1}^{n} Cv_{m;t}$ is the sum of the violent crimes of the reference year *t* for the community *m*, composed by intentional homicide, attempted homicide, aggravated assault, rape, without taking into consideration the crimes of culpable homicide and also the crimes and traffic accidents.

$\sum_{i=1}^{n} Ce_{m;t}$ is the sum of the crimes related to trafficking of the reference year *t* for the community *m*, such as crimes related to drug trafficking, narcotics crimes, arms smuggling and illicit substances or products.

In order to make it simple, we disregard the crimes of trafficking of drugs, weapons and narcotics crimes, $Ce_{m;t}$, so that the crimes committed in a given society can be summarized by the sum of the property and violent crimes:

$$C = \sum_{i=1}^{n} Cp_{m;t} + \sum_{i=1}^{n} Cv_{m;t} \quad (2)$$

We assume the determination of the property crimes is related to a *k* factor, the marginal propensity to commit a property crime by a society. The marginal propensity to property crimes has endogenous and exogenous components related to either objective nature of the individuals, such as those related to the income or education, and to the subjective nature, such as greed, apathy, euphoria, which directly affects their propensity to the commission of crimes of economic motivations. The propensity *k* focuses on the total commission of crime in a given period of time, *k*C. Also, we assume the property crimes has an independent variable from the objective or subjective factors of the human nature that influence the crime and it is related to the opportunities that arise to favor the commission of a crime: the crimes of opportunity, *O*. It refers to the situations where an honest individuals or a group of honest people with a little or no propensity to commit a property offence subject themselves to the illegal action by the reason of the opportunity being too favorable. Finally, the determination of property crimes includes a ƥ variable relative to the police action in reduce the property crimes. Thus, the determination of property crimes is given by:

$$Cp_{m;t} = (O^{\alpha} + kC) - ƥ^{\beta} \quad (3)$$

Where the opportunities have a positive non-linear relationship with the amount of property crime, represented by the exponent $\alpha > 1$ in equation (3), which means that an increase in the amount of opportunities to commit a certain property-related delict increases the number of property crimes ($\partial Cp / \partial O > 0$) and it is steadily increasing ($\partial^2 Cp / \partial O^2 > 0$) . The exponent $\beta < 0$

has a similar interpretation, it also emphasizing a non-linear relationship for the police action implying that an increase in the policing causes a decrease in the number of property crimes (∂Cp / $\partial \mathfrak{p} < 0$) and that decline is increasing ($\partial^2 Cp$ / $\partial \mathfrak{p}^2 > 0$). Isolating the equation (2) as a function of the violent crimes, $Cv_{m;t}$, and substituting the ratio of property crimes, $Cp_{m;t}$, present in (3) in the equation (2) we have:

$$Cv_{m;t} = \mathrm{C} - Cp_{m;t}\text{, or}$$
$$Cv_{m;t} = \mathrm{C} - [(O^{\alpha} + k\mathrm{C}) - \mathfrak{p}^{\beta}] \quad (4)$$

In order to predict the violent crimes for one period after, $Cv_{m;t+1}$, we determine two components that affects the increase or decrease in those crimes compared to the period before. The first one is an autonomous component, the independent life-related crimes, *I*, which has the meaning of be representing the violent crimes that were not related somehow to the historical series murders or injuries committed by the present criminals. The independent crimes arise from the emergence of new criminals which were absent in an earlier period, like bodily injuries committed in protests. The second component is the police enforcement working in the next period *t +1*. Thus, a good prediction for the violent crimes in the next month may take into consideration those crimes committed one month before, $Cv_{m;t}$, summed to the independent crimes, *I*, and discounted by the police enforcement in *t +1*, $\mathfrak{p}_{t+1}$, resulting in the determination of violent crimes for a forward period:

$$Cv_{m;t+1} = I + \mathrm{C} - Cp_{m;t} - \mathfrak{p}_{t+1}\text{, or}$$
$$Cv_{m;t+1} = I + \mathrm{C} - [(O^{\alpha} + k\mathrm{C}) - \mathfrak{p}^{\beta}] - \mathfrak{p}_{t+1} \quad (5)$$

Equation (5) tells us that, given that crimes in the short term are constant (or at least do not vary radically from one month to the other), the amount of violent crimes that will be committed next period, *t + 1*, is precisely the amount of violent crimes committed in a previous period, $\mathrm{C} - [(O^{\alpha} + k\mathrm{C}) - \mathfrak{p}^{\beta}]$, plus the independent crimes that was not foreseen before, *I*, minus the police force in the forward period, $\mathfrak{p}_{t+1}$. When the police performance improves and the independent crimes does not suffer a considerable increase, the overall$Cv_{m;t+1}$, decreases, going the opposite otherwise.

Also, the model reveals that the variation in the crime rate in the community *m* in the short run from a period *t* to another *t* + 1 $\Delta Cv = Cv_{m;t+1} - Cv_{m;t}$, is explained by the police activity one period after, $\mathfrak{p}_{t+1}$, and by the number of the independent violent crimes, *I*. The interpretation of this model is such that when there is a greater ease to the commission of property crimes or when the scenario in which the community is set is conducive to impunity, the amount of the opportunities to commit crimes increases, increasing the number of violent crimes ΔCv. When the police action in a later period is high compared to a period before, the amount of crimes in the current period will be lower, or even negative, since a more effective police action $\Delta\mathfrak{p}$ coming by increasing the number of police or by the increase in the productivity prevents the spread of crime in the community both because those criminals no longer will be on the streets to commit more crimes in the subsequent periods, or because the police action should intimidate those who were not punished yet.

3. Determination of violent crimes in the city of São Paulo

In order to validate the model on the dataset provided by the *Secretaria de Segurança Pública do Estado de São Paulo* (São Paulo Department of Public Safety) the equation (5) must

been reordered to explicit the variation on the police enforcement and what we previously called property crimes as it shows in equation (3), we must consider ${}^{*}Cp_{m;t} = (O^{\alpha} + k\mathrm{C})$, which results:

$$Cv_{m;t+1} = I + \mathrm{C} - (O^{\alpha} + k\mathrm{C}) + (\mathfrak{p}^{\beta} - \mathfrak{p}_{t+1}) \tag{6}$$

For the dataset of crimes of the city of São Paulo the model also disregard the effects of *I*, so that we are declaring in the short run (one month to another) it should not be a significant the input or output of criminals in a given society. Given that the total number of the criminal offenses in the short run is a constant, the prediction for the violent life-related crimes for the following month can be seen as a negative function of the property crimes and the variation of policing.

$$Cv_{m;t+1} = -(O^{\alpha} + k\mathrm{C}) + (\mathfrak{p}^{\beta} - \mathfrak{p}_{t+1}), \text{ or}$$

$$Cv_{m;t+1} = -{}^{*}Cp_{m;t} - \left(\mathfrak{p}_{t+1} - \mathfrak{p}^{\beta}\right) \tag{7}$$

We obtained data of violent crimes, composed by the sum of murder, attempted murder, rape and aggravated assault, and also a set of data about the property-related crimes: thefts, robbery of vehicles, bank robbery, cargo theft, widespread thefts and thefts of vehicle, for the years 2011 to 2014 of the city of São Paulo. Also, we obtained a more restricted sample of data related to the police production for the period of 2013 and early 2014. The data of police production aggregates the sum of occurrences recorded for postage or trafficking of narcotics, illegal possession of arms seized in flagrant, offenders apprehended by mandate, the number of arrests made and the number of repossessed vehicles. Since the lack of data relating to police production for previous years limited us to a set of 13 elements, the period from February 2013 to February 2014, we modeled two regressions: The first involving the crime data from three years prior to 2014 and the second adding the police action, using only the monthly data of 2013 and early 2014. The first regression aimed to confirm the negative relationship between the two types of crimes and how the decrease of one should influence an increase in the other in a subsequent period, and the second regression aimed to validate our model described in (7). Table 1 summarizes the values corresponding to the database of crimes provided by São Paulo's Department of Public Safety (SSP/SP).

Table 1 - Data of crimes and police activity in the city of São Paulo, between the years 2011 and 2014.

Monthly Period	Property Crimes	Violent Crimes	Violent Crimes (t + 1)	Police Production
mar/11	32837	3491	3547	---
apr/11	32939	3547	3419	---
may/11	35058	3419	3180	---
jun/11	33532	3180	3252	---
jul/11	33026	3252	3718	---
aug/11	35230	3718	3633	---
sep/11	34645	3633	3699	---
oct/11	33401	3699	3722	---
nov/11	33505	3722	4175	---
dez/11	31597	4175	3771	---
jan/12	30319	3771	4065	---
feb/12	30719	4065	4510	---
mar/12	36499	4510	3905	---
apr/12	35182	3905	3793	---
may/12	38111	3793	3488	---
jun/12	32663	3488	3568	---
jul/12	32723	3568	4022	---
aug/12	35259	4022	3708	---
sep/12	32364	3708	4198	---
oct/12	34882	4198	3682	---
nov/12	32523	3682	4161	---
dez/12	32611	4161	3631	---
jan/13	34087	3631	3652	10390
feb/13	31351	3652	3997	9107
mar/13	35955	3997	3597	10036
apr/13	36478	3597	3538	11083
may/13	36630	3538	3334	10861
jun/13	35928	3334	2873	10058
jul/13	37214	2873	3176	9695
aug/13	37704	3176	3366	9843
sep/13	35305	3366	3071	8951
oct/13	39013	3071	3215	9135
nov/13	35853	3215	3345	9376
dez/13	36209	3345	3378	8519
jan/14	39004	3378	3256	9849
feb/14	37341	3256	3169	9753

In order to validate the relationship $Cv_{m;t+1} = -Cp_{m;t}$in the equation (6) we selected the 36 monthly samples of violent crimes at t + 1 (one month after the occurrence of the property offenses) as the dependent variable and the 36 monthly samples of property crimes as the independent variable. The multiple regression by the method of ordinary least squares resulted in a high significance for the parameter with an intercept of approximately 7327.646 and coefficient b_1 = -0.107 for the property crimes variable, and a substantial descriptive power (R approximately 45%) which suggests that the behavior of the violent crimes (the dependent variable) is somehow explained by the behavior of the property crimes. Table 2 summarizes the main results.

Table 2 - Summary statistics derived from the multiple regression between property crimes and violent crimes.

Statistics	Values
R	0.672834486762158
R^2	0.452706246576496
Adjusted R^2	0.436609371475805
F (1, 34)	28.1238590561627
P-Value	0.0000069385578172
Std. Error	273.109554614602

The negative sign in the variable property crimes implies an inverse relationship between this variable and the dependent variable in the sense that in months where the amount of incidents recorded as property crimes were high, the next month we expect that the amount of violent related crimes will be small. Also, the conclusion was reinforced by the positive increasing in the violent crimes for the same month of the property crimes occurrence, which assumes in a migration of the criminals from the less risky crimes of property to the most dangerous life-related crimes within one month to the next.

Table 3 compares the occurrences of violent crimes effectively registered with the values predicted by the regression model taking into account the influence of the property crimes. The difference between the estimates generated by the model and the actual values of the incidents recorded varies with an average around 212.05 and that the greatest difference between the predicted and the registered is 487.72 seen in June 2011 and the lowest has the value of 18.51 seen in January 2012.

Table 3 - Comparison between the recorded occurrences of violent crimes and the estimates derived from the model between the years 2011 and 2014.

Monthly Period	Property Crimes	Violent Crimes (t + 1)	Estimated $Cv_{m;t+1}$	Difference
mar/11	32837	3547	3814.087	267,087
apr/11	32939	3419	3803.173	384,173
may/11	35058	3180	3576.440	396,440
jun/11	33532	3252	3739.722	487,722
jul/11	33026	3718	3793.864	75,86404
aug/11	35230	3633	3558.036	-74,964
sep/11	34645	3699	3620.631	-78,369
oct/11	33401	3722	3753.739	31,73904
nov/11	33505	4175	3742.611	-432,389
dez/11	31597	3771	3946.767	175,767
jan/12	30319	4065	4083.513	18,51304
feb/12	30719	4510	4040.713	-469,287
mar/12	36499	3905	3422.253	-482,747
apr/12	35182	3793	3563.172	-229,828
may/12	38111	3488	3249.769	-238,231
jun/12	32663	3568	3832.705	264,705
jul/12	32723	4022	3826.285	-195,715
aug/12	35259	3708	3554.933	-153,067
sep/12	32364	4198	3864.698	-333,302
oct/12	34882	3682	3595.272	-86,728
nov/12	32523	4161	3847.685	-313,315
dez/12	32611	3631	3838.269	207,269
jan/13	34087	3652	3680.337	28,33704
feb/13	31351	3997	3973.089	-23,911
mar/13	35955	3597	3480.461	-116,539
apr/13	36478	3538	3424.500	-113,5
may/13	36630	3334	3408.236	74,23604
jun/13	35928	2873	3483.350	610,35
jul/13	37214	3176	3345.748	169,748
aug/13	37704	3366	3293.318	-72,682
sep/13	35305	3071	3550.011	479,011
oct/13	39013	3215	3153.255	-61,745
nov/13	35853	3345	3491.375	146,375
dez/13	36209	3378	3453.283	75,28304
jan/14	39004	3256	3154.218	-101,782
feb/14	37341	3169	3332.159	163,159

In a second analysis, we intended to include the variable that represents the difference between the police production from one month to another and observe how the results from a more limited set of data could change. Just 13 cases were included in the multiple regression by the method of ordinary least squares, resulting a weak significance for the parameter relating to the police production due mainly to the restricted dataset provided. Even so, the substantial descriptive power of this model remained (R statistical approximately 64% and R^2 41%), the regression model intercept was approximately 6113.25 and the coefficients b_1 = -0.64225 for the property crimes variable, *Cp*, and b_2 = 0.1475 for the production of the police.

Table 4 - Summary statistics derived from the multiple regression between property crimes, violent crimes and change in police productivity.

Statistics	Values
R	0.643696048
R^2	0.414344602
Adjusted R^2	0.307861803
F (2, 11)	3.8911881
P-Value	0.0527268499
Std. Erro	231.044707

Table 5 abstracts the information according to the values of the partial correlations for each variable.

Table 5 - Partial correlations of the variables related to the crimes and policing.

Variables	*b*	Partial Correlation	Semipartial Correlation	Tolerance	P - Value
Property Crimes	-0,642249	-0.640752	-0,638694	0,988959	0,018292
Changes in Police Production	0,147575	0,188338	0,146758	0,988959	0,537766

The high P-value for the variable Police Production implies that the strength of this sample did not significantly explain the reality that we initially modeled. The partial correlation of this variable with the dependent variable represents a positive value of 0.146758, as shown in Table 5, which leads us to perceive a signal reversal from the previously explained in the model by the equation (7), possibly caused by the low explanatory power that a few cases of that parameter had on prior findings.

4. Conclusion

We propose a model that could explain the determination of the violent crimes in the society by its relation to the increase or decrease in the property related crimes. The model was tested by multiple regressions through a database of crimes of the city of São Paulo, the Brazilian most populous city, and attested the validity of the relationship between the behaviors of these two types of crimes.

The model described by the equation (6) is based on the assumption that in the short run the crime rate does not vary considerably by radical increase (or decrease) of criminals in a society, and therefore the total crimes can be considered as constant being committed by the same offenders. Thus, the determination of the violent crimes is drawn as follows: when the property crimes are small and the police production in a given month *t* is small, it means that the feeling of impunity will increase and some of the criminals will become more risky and begin to commit

bolder violent crimes and continue a month later. If the police action is more effective in the current period, the sense of impunity retracts, the risk of committing irregularities increases and criminals will require a greater reward in order to increase the intensity of their crimes. Given the police activity, the reward remains the same (or decreases as the police activity in predicting opportunities for crimes increases) and so the violent crimes falls and the property crimes in the current period increases because these are less risky and thus less costly for criminals, if the police action remains unchanged.

Some limitations of this model could be verified, such as the absence of data about the independent violent crimes, the segregation of the property crimes in crimes of opportunity and the marginal propensity to crimes and also the police production for longer periods, which did not invalidate the main purpose of the analysis: the existence of a relationship between those different types of crimes and how one may increase the other. Just as in the broken window theory, which first investigated the relationship between small crimes into the more rigorous ones, the findings we have been drawn may add value to the current discussion of the public safety in municipal levels and provide the police officers with innovative strategies in this regard.

References

Corman, H., and Mocan, N. (2005). Carrots, sticks, and broken windows, *Journal of Law and Economics*, 48, 235-266.

Engel, C., Beckenkamp, M., Glöckner, A., Irlenbusch, B., Hennig-Schmidt, H., Kube, S., Kurschilgen, M., Morell, A., Nicklisch, A., Normann, H. T., Towfigh, E. (2014), First impressions are more important than early intervention: Qualifying broken windows theory in the lab, *International Review of Law and Economics*, 37, 126-136.

Funk, P. and Kugler, P. (2003), Dynamic interactions between crimes, *Economics Letters*, 79, 291-298.

Hinkle, J. C., & Yang, S. M. (2014), A New Look into Broken Windows: What Shapes Individuals' Perceptions of Social Disorder?, *Journal of Criminal Justice*, 42, 26–35.

Jang, H., Hoover, L. T., and Lawton, B. A. (2008). Effect of broken windows enforcement on clearance rates, *Journal of Criminal Justice*, 36, 529-538.

Kelling, G. L., & Bratton W. J. (1998), Declining Crime Rates: Insiders' Views of the New York City Story, *Crim. L. & Criminology*, 88, 1217-1232.

Skogan, W. G. (1988), *Disorder and Crime*: Crime and the Spiral of Decay in American Neighborhoods, Free Press, New York, 1988.

Wilson, J. Q., and Kelling, G. L. (1982), Broken Windows: The police and neighborhood safety, *The Atlantic Monthly*, 249, 29−38.