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SIMULTANEITY OF CRIME INCIDENCE IN MINDANAO

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ABSTRACT

The study simulated the predictive relationships of regional monthly crime rates for a period covering January 2009 to July 2013. A six-equation model representing the six regions in Mindanao was estimated using the seemingly unrelated regression (SUR).

The SUR estimation shows that the increase of incidences of crimes in Southern Mindanao Region and SOCCSKSARGEN tended a 1.73% rise and 0.85% reduction in crime incidences in Zamboanga Peninsula. Monthly crime rates in Northern Mindanao increases crime rates in Southern Mindanao (1.1%), SOCCSKSARGEN (1.29%), CARAGA (0.22%) and ARMM (0.96%). Southern Mindanao yielded simultaneous increase in crimes with Zamboanga Peninsula (0.21%) and Northern Mindanao (0.36%); yet a drop in crimes in CARAGA (0.08%) and ARMM (0.29%).

SOCCSKSARGEN's crime rates rise simultaneously by 0.39% in every percentage increase of crime rates in Northern Mindanao yet plunged by about 0.09% and 0.50% when crimes rise by a notch higher in Zamboanga Peninsula and ARMM. CARAGA posted 0.97% increase and 1.07% decrease of crime rates upon the rise of crime rates Northern Mindanao and Southern Mindanao. Lastly, crime rates in ARMM, on the other hand, tend to increase by 0.63% upon the rise of the same in Northern Mindanao and dipped by 0.58% and 1.09% in simultaneity with Southern Mindanao and SOCCSKSARGEN.

Keywords: *panel data, regional crime rates, Mindanao, seemingly unrelated regression, simultaneous effects*

INTRODUCTION

Crimes happen everywhere. Studies revealed that variation in crime rates exists across countries, states, counties, neighborhoods, and even census tracts (Land, McCall, & Cohen, 1990; Rosenfeld & Messner, 1995; Beaver & Wright, 2011). Most research has counted the macro-level differences in socio-environmental factors as attributes of differences in crime rates (Pratt & Cullen, 2005; Sampson, Raudenbush, & Earls, 1997). Also, governance mechanisms are also a strong determinant of crime busting (Ellison, Shirlow & Mulcahy, 2012; Butts & Evans, 2011).

However, a few studies attempted to justify the existence of instantaneous coincidence of crimes across geographic areas. These studies pointed on the possibility that crimes at a macro-level have *spillover effect* on crimes in the nearby regions (LeSage, 2015; Chalfin, 2013). Moreover, seasonal patterns of crime are investigated over time and across regions, presupposing that the movement of crimes in areas within a country or state could be brought by some political, terrorism-related or policy-driven issues and concerns (Coletta, 2011) that have spatial reach. This therefore brings into the greater debate in the characterization of crimes and crime rates are the measures made on some aggregate-level of analysis or in lower levels of aggregation (Beaver & Wright, 2011).

Like other Asian countries, crime in the Philippines is more prevalent in the capital city, Manila. Hill (2002) described the most problematic crime in the Philippines is related to political violence given that there armed groups operating in Mindanao making the island an irony of being the "land of unfulfilled promise" (Turner & May, 1992). These armed groups are responsible for various crimes like kidnapping (Banlaoi, 2005), assault (Rodel, 2004), murder, extortion, and drug and gun trafficking. These crimes can cause high levels of fear in citizens (Khruakham & Lee, 2014) and displacement of civilians (Coletta, 2011).

More so, region-wise, Central Visayas, Northern Mindanao, the Autonomous Region of Muslim Mindanao, the Cordillera Autonomous Region, and Metro Manila saw a steep rise in the number of index crimes. In the ARMM, which consists of Lanao del

Sur, Maguindanao, Sulu and Tawi-Tawi, homicide cases soared by 121%, rape 108%, and robbery 177%. Ironically, ARMM supposedly had enough policemen, being one of only two regions that met the 1:500 police-to-population standard set by the PNP (Philippine Center for Investigative Journalism, 2003). ARMM had one policeman for every 419 population. In contrast, the national ratio was 1:734, with six regions having one cop for more than 1,000 people.

Crime statistics reported by the police are incomplete and does not always paint the real picture (Philippine Center for Investigative Journalism, 2003). The number of reported crimes has been rising, while the ability of the police to solve crimes has decreased. The Philippine National Police, however, had previously explained that the spike in statistics did not necessarily represent a worsening peace and order situation (Ranada, 2016). However, crimes in regions vary, putting the numbers in further scrutiny. The possible speculation on the simultaneity of crime rates across regions has always been neglected as proven by scanty literature and studies.

METHOD

This study utilized the causative research design in a manner of analyzing time-series and panel data estimations. Causative method of research requires a causal inference which was founded on the assumptions of existence of relationship of two events, the time-lag order that cause must precede effect, and finally, that alternative explanation must be ruled out (Marczyk, DeMatteo & Festinger, 2005). In context, causative research design was used such that the study aimed to determine if crime rates of a particular region in Mindanao is simultaneously predictable in the rise or fall of the monthly crime rates of the rest of the regions.

However, note that only six regions of the Philippines (all from Mindanao) were included in the calibration of the system of equations, thus, facing an issue of omitted variables. To solve this problem, the seemingly unrelated regression (SUR) of the family of simultaneous equations model was used to explain the causes of the differences of the fluctuations of monthly crime rates in Mindanao. This paper puts affirmation that the commission of crimes in any region in Mindanao might be caused by its failure to be enacted in another region, or that crimes are done simultaneously in the case of syndicated or coordinated crimes operating within Mindanao.

This paper made use of secondary data in conducting the study, which were readily-available in published or compiled sources. The researchers accessed the published as well as online reports compiled by the Economic Database of the Philippine Institute of Development Studies (PIDS) website[1] for the panel data of monthly crime rates in Mindanao regions for a period of January 2009 to July 2013.

Tests of stationarity and presence of unit root were conducted to check if the monthly crime rates of regions in Mindanao are suitable for time-series estimation. The aim was to determine trend in the occurrence and the characteristics of the trend. A further univariate time-series analysis was done in every regional crime rates. The aim was to determine trend in the occurrence and the characteristics of the trend. The $ARIMA(p,d,q)$ models were used where p is the number of autoregressive terms, d as the number of non-seasonal differences needed for stationarity, and q denotes the number of lagged forecast errors in the prediction equation.

After the series were found made stationary and time-series analyses were done, the researchers developed the simultaneous equations algorithms in Gnu Regression, Econometrics and Time-series Library (gretl) 9.0 to estimate the panel data. The

[1] Accessible at http://econdb.pids.gov.ph/tablelists/table/155

seemingly unrelated regression (SUR) of the simultaneous equations family was used to determine the inter-predictive relationship of the regional crime rates in Mindanao. SUR is a method of estimating panel data models that are long (large T) but not wide (small N). It is used to estimate systems of equations that do not necessarily have any parameters in common, making it look unrelated (Adkins, 2010; Murcia & Tamayo, 2015). Furthermore, in an SUR framework, each equation is parametrically different[2]; each system maintains its own regression function.

In a classical SUR, it was assumed that for each $i = 1,\dots N, x_i = [x_{i1},\dots x_{i\tau}]$ is of full rank of K_i, and regressors $X' = [X_1,\dots X_T]$ the errors u_t are iid over time with mean zero and homoskedastic variance $\sum = E(u_t u_t' \mid X)$. Further assumed that $\sum$ is positive definite and denoted by σ_{ij} the (i,j)th element of $\sum$, that is, $\sigma_{ij} = E(u_{it} u_{jt}' \mid x)$.

In this assumption, covariance matrix of the entire vector of disturbances $U' = [U_1,\dots U_T]$ is given by $E(vec(U)(vec(U))') = \sum \otimes I_t$ (Moon & Perron, 2006). Note that the equations of the system are not totally unrelated, the equations are related by the unobserved factors and SUR requires the specification of the omitted factors being linked in the system's error structure (Moon & Perron, 2006). The system of equations operates within the assumption of contemporaneous correlation. This means that the error of each equation may have own variance, and that each equation is correlated with the others in the same time period (Wooldridge, 2010).

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[2]Algebraically, the SUR model is given by:

$$\mathbf{y}_j = X_j \boldsymbol{\beta}_j + \mathbf{u}_j, \quad j = 1,\dots,m, \qquad \text{[Eq. 1]}$$

with

$$E[\mathbf{u}_i \mathbf{u}_j'] = \begin{cases} \omega_{ij} I \ (i \neq j) \\ \omega_i^2 I \ (i = j) \end{cases}. \qquad \text{[Eq. 2]}$$

Here $\mathbf{y}_j$ and $\mathbf{u}_j$ are $n \times 1$ vectors, X_j is the $n \times p_j$ matrix of rank p_j, and $\boldsymbol{\beta}_j$ is a p_j-dimensional coefficient vector. The equations of the model have different independent variables and error term variances. Also, the model permits error terms in different equations to be correlated.

RESULTS

Trends of monthly crimes are plotted in time-series plots for a period covering 55 months, as illustrated in Figure 1. Generally, crime rates among regions in Mindanao were found to have seasonal patterns; yet posing downward trend movements on the onset of the series. However, sharp spikes were observed in 2013.

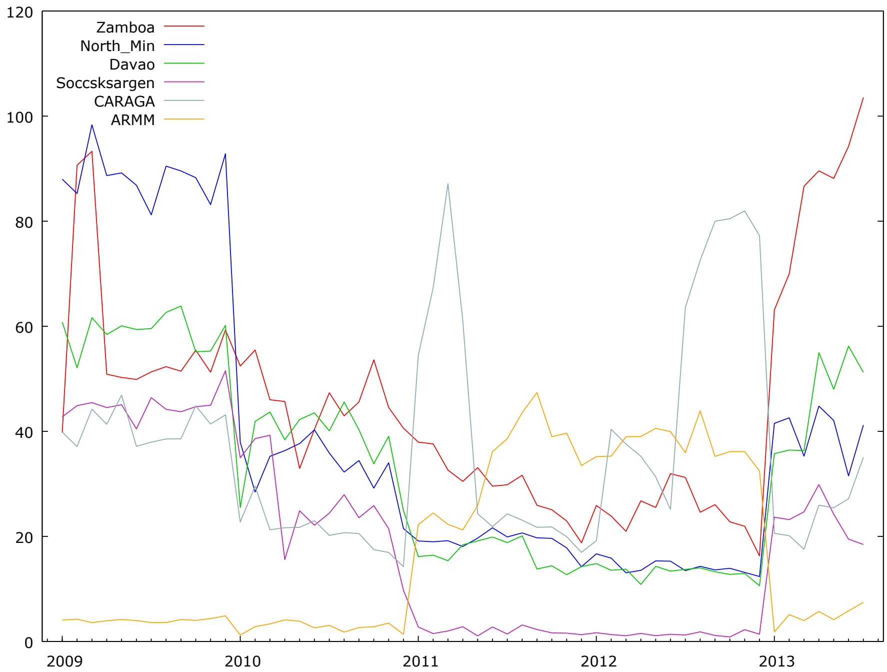

Figure 1. Trends of Monthly Crime Rates of Mindanao Regions from January 2009 to July 2013

Moreover, specific points of the period have noted a simultaneous drop of crimes among the regions particularly in the final months of each year, except in CARAGA and the ARMM where crime rates posted increase. These regions are found to be less-urbanized than the other four regions, which may mean lesser presence of police to address criminality. Lesser presence of anti-crime enforcement agencies would result to higher possibilities of crime occurrences in the area.

The erratic oscillations of crime rates per region might be an indication that the crime rates in Mindanao are non-stationary. Subjecting non-stationary series to immediate analysis would lead to spurious analysis (Tamayo, 2016; Baumohl & Lyocsa, 2009). Moreover, there is the need for testing for unit root because regression results would all be fabricated when non-stationary series with unit root (Mushtaq, 2011). To this effect, the series warranted the use of the Augmented-Dickey Fuller (ADF) test in determining presence of unit root. Table 1 shows the ADF results for the series for level and first difference estimation.

Table 1. Testing for Unit Root (Augmented Dickey-Fuller Test Results) on the Monthly Crime Rates of Mindanao Regions

Series	With Constant		With Constant and Trend		With Constant and Quadratic Trend	
	Level	First Difference	Level	First Difference	Level	First Difference
Zamboanga Peninsula	ns	***	ns	***	ns	***
Northern Mindanao	ns	***	ns	***	**	***
Southern Mindanao	ns	**	ns	***	ns	**
SOCCSKSARGEN	ns	***	ns	***	*	***
CARAGA	**	***	**	***	*	***
ARMM	ns	***	ns	***	ns	***

*** Significant at 99% ** Significant at 95% * Significant at 90% ^{ns} Not Significant

The monthly crime rate data of Mindanao regions were found to be insignificant in the ADF test with constant and with constant and trend in testing the variable at level, except for CARAGA Region. On the other hand, ADF test with constant and quadratic trend revealed that the monthly series for Northern Mindanao, SOCCSKSARGEN and CARAGA were found significant.

The results of the ADF test at level revealed the presence of a unit root on most series is suggestive of non-stationarity of data. Given that the series is non-stationary, any further time-series testing will only lead to spurious or fabricated regression coefficients.

To address non-stationarity of the series, first differences were computed to model the differenced series (Dickey & Pantula, 1987; Dickey, Hasza & Fuller, 1984). After first differencing, the series became stationary.

Henceforth, the stationary series was analyzed to develop a univariate model from identification, estimation and checking (Ong, Huang & Tang, 2005). The model fitting allows understanding the data to predict future. The ARIMA models takes the parameters of (p,d,q) where p denotes autoregressive order, d is for the order of differencing, and q denoting order of moving averages (Spanos, 1990).

Table 2. ARIMA Family Simulation to Characterize Monthly Crime Rates of Mindanao Regions

Regions	Best Model Fit	Coefficients	Schwarz Criterion	Akaike Information Criterion
Zamboanga Peninsula	AR(1)I(1)MA(1)	φ_1=−0.0328842 θ_1=−1.000***	435.2176	427.3365
Northern Mindanao	AR(1)I(1)MA(1)	φ_1=−0.131248 θ_1=−1.000***	410.3347	402.4535
Southern Mindanao	AR(1)I(1)MA(1)	φ_1=−0.378517*** θ_1=−1.000***	381.4341	373.5529
SOCCSKSARGEN	AR(1)I(1)MA(1)	φ_1=−0.220346* θ_1=−1.000***	356.2223	348.3411
CARAGA	AR(1)I(1)MA(1)	φ_1=0.140837 θ_1=−1.000***	449.8088	441.9276
ARMM	AR(1)I(1)MA(1)	φ_1=-0.0362908 θ_1=−1.000***	359.1886	351.3075

As seen in table 2, series of univariate testing for model building indicate that a autoregressive order integrated moving average of order 1 model (AR(1)I(1)MA(1) is a better fit for the six univariate series compared to the rest of the models of the ARIMA family. The choice was based on the power and goodness of fit of the model as indicated by the criteria like the Schwarz and Akaike criteria.

The rule is to observe a decaying value of the mentioned criteria, then compare the statistical power of the coefficients. An AR(1)I(1)MA(2) model implies that the outcome value is linearly influenced both by the mean value of the most previous value of the series and the previous stochastic term of the previous value of the series (Dickey, Bell & Miller, 1986).

Simply stating, the current value of x_t and all previous values are apart from the current value of the outcome variable x (Andersen et al., 2009). Moreover, negative values of the coefficient theta one (θ_1) which is found to be more robust than coefficient phi one (φ_1) suggest that a positive adjacent value of the variable x_t, which means that an above average will tend to be followed by a lower average value. Using the model, it is expected that a decrease in the crime rates across Mindanao will occur in the proceeding one point period.

Lastly, simultaneity of the monthly crime rates in Mindanao was simulated using seemingly unrelated regression (SUR) of the simultaneous equations model. SUR would provide the best estimates for the equations since data were not totally unrelated, the equations are related by the unobserved factors and SUR requires the specification of the omitted factors being linked in the system's error structure, which cannot be addressed by ordinary least-squares procedure (Murcia & Tamayo, 2015). In this paper, the null hypothesis of no correlation was tested using the test statistic $LM = Tr^2{}_{GE,W_d} \underset{\rightarrow}{} \chi^2(1)$ which obtains a value of 48.462, rejecting the null hypothesis of no correlation. Thus, the equations are contemporaneous correlated in their errors.

Moreover, SUR estimation results as seen in Table 3 show that the dynamics of monthly crimes through time have different impact or influence on the crime rates of other regions in Mindanao. Some regions posed decrease of crime rates in the increase of crime rate in the specific region while others pull the crime rate a few notch higher in the increase of crimes, holding other variables constant.

Specifically, the increase of incidences of crimes in Southern Mindanao Region and SOCCSKSARGEN also tended a respective 1.73% rise and 0.85% reduction in Zamboanga Peninsula.

Monthly crime rates in Northern Mindanao soared in the increase of crime rates in Southern Mindanao (1.1%), SOCCSKSARGEN (1.29%), CARAGA (0.22%) and ARMM (0.96%).

For Southern Mindanao, increase of monthly crimes is caused by simultaneous increases in Zamboanga Peninsula (0.21%) and Northern Mindanao (0.36%), yet drop in the increase of crimes in CARAGA (0.08%) and ARMM (0.29%).

SOCCSKSARGEN's crime rates rise simultaneously by 0.39% in the increase of crime rates in Northern Mindanao yet plunged by 0.09% and 0.50% when crimes riseincrease in Zamboanga Peninsula and ARMM. C

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Lastly, crime rates in ARMM, on the other hand, tend to increase by 0.63% upon the rise of the same in Northern Mindanao and dipped by 0.58% and 1.09% in simultaneity with Southern Mindanao and SOCCSKSARGEN.

Table 3. Seemingly Unrelated Regression Estimates for Variables, T=55

Variables	System of Equations					
	Zamboanga Peninsula	Northern Mindanao	Southern Mindanao	SOCCSKSARGEN	CARAGA	ARMM
Constant	21.9516*	−42.8690***	16.7449***	16.7831***	54.2252***	38.9983***
	11.3754	*6.29299*	*3.34609*	*3.58254*	*14.7662*	*3.4326*
Zamboanga Peninsula		−0.106239	0.206432***	−0.0935293**	0.00656298	−0.0996713
		0.0774997	*0.038713*	*0.0431131*	*0.168485*	*0.0618335*
Northern Mindanao	−0.291713		0.360927***	0.38827***	0.969103***	0.629778***
	0.2128		*0.0515838*	*0.0461359*	*0.256496*	*0.0842355*
Southern Mindanao	1.73469***	1.10457***		0.0651831	−1.07429**	−0.576839***
	0.325313	*0.157865*		*0.100697*	*0.471435*	*0.154775*
SOCCSKSARGEN	−0.853135**	1.28983***	0.0707557		−0.797576	−1.08682***
	0.39326	*0.153263*	*0.109306*		*0.497012*	*0.14588*
CARAGA	0.00416876	0.224184***	−0.0812053**	−0.0555402		−0.0400181
	0.107021	*0.0593357*	*0.0356356*	*0.03461*		*0.0517834*
ARMM	−0.418173	0.962282***	−0.288003***	−0.499890***	−0.264324	
	0.259424	*0.128709*	*0.0772756*	*0.067098*	*0.342035*	
Adjusted R^2	0.52	0.88	0.92	0.92	0.09	0.79

Note: All figures in italics are standard errors.

**** Significant at 0.01 level*
*** Significant at 0.05 level*
** Significant at 0.10 level*

CONCLUSION

Crimes were committed in regions at certain points of time where police visibility is low. CARAGA and the Autonomous Region for Muslim Mindanao are exemptions to this; these provinces are conflict grounds of the separatists and insurgent groups. However, data pattern reveal that higher incidences of crimes were observed in the final quarter of each year and dramatically swoops down on the first month of the coming year.

Meantime, an AR(1)I(1)MA(1) of univariate time-series model with negative coefficients point to an expected average decrease in crime occurrence.

In addition, a spillover crime effects was determined. Incidence of crime in one region affects crime occurrence in another. The geographical propinquity of the regions in Mindanao allows for easy spills of reach of the crime rings. They could readily commit crime in one place to hide serious crime activities happening in the proximate region.

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