A Time Series Regression Models and Trends of Drug, Substance Abuse and Index Crimes

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ABSTRACT

It is vital for the Philippines to understand the time series interrelationship of index crimes and drug/substance abuse amidst its mandate on the *"War on Drugs"*. The purpose of this paper is to investigate the best fitting forecasting models of the time series trends of index crimes and drug/substance abuse in the Philippines. The study employed three approaches; (1) delineating time series regression models of index crimes with drug/substance abuse as explanatory variables, (2) describing pure time series analysis by ways of autoregressive integrated moving average (ARIMA) and exponential smoothing, and (3) forecasting the time series trends from 2018 to 2022. These were carried out using IBM SPSS professional. The findings of this study demonstrate an association between drug/substance abuse and index crimes. The regression analyses concluded several associations. For example, variations of the time series data in murder can be predicted by reported new and re-admission cases to various rehabilitation centers and reported cases of marijuana abusers. Rape cases are associated with the admission to rehabilitation centers and reported *Shabu* abusers. Lastly, carnapping is explained by the number of cases of *Shabu* abusers. Although some research on the relationship between crime and drug abuse is yet to be done, this novice idea on model delineation in its time series trends will be of immense help among policymakers.

Keywords: *drug addition, substance abuse, index crimes, crime rates, correlates, time series*

INTRODUCTION

The belief that drug addiction is closely related to crime has been the battle cry of the Philippines' "War on Drugs." Drug addiction in the Philippines became epidemic since the introduction of *Shabu*, the Filipino street word for methamphetamine hydrochloride (PDEA Annual Report, 2013). In response to this, the Philippine government has increased its budget to support the eradication of illegal drugs and to curve criminality.

Crime rates, particularly violence and property crimes, have associations to drug and alcohol abuses (Kirwan et al., 2015; Martin, Maxwell, White, & Zhang, 2004; Dawkins, 1997; and Goldstein, 1985). This paper investigates the relationship between the time series trends of drug/substance abuse and index crimes. The researcher sourced the data from national line agencies.

The framework of drug/substance abuse explaining crime is never out of context for a variety of reasons. The argument may start on a known fact that drug use will alter the person's behavior. For example, economic explanations and deviant lifestyles generate a context of both drug-related violations and crime incidence (Bennett & Halloway, 2006). Martin et al., (2004) stated that efforts to reduce violent crime rates links to regional patterns of problems on drug/alcohol abusers. Corman and Mocan, (1996), using the time series approach, established a causal relationship between drug usage and property-related crimes. Kirwan et al. (2015) revealed that addressing co-occurring poly-pharmaceutical misuse and mental disorder to persons with a history in prison due to drug violations may reduce property crime in this group. There were pieces of evidence that people who inject drugs are reported to frequently engage in crime specifically on property crime and drug pushing (Rosenkranz et al., 2016). The association between drug use and criminal behaviors is due to environmental and social factors, economic motivations and pharmaceutical desired drug effects.

The author anchored the exploration of these relationships in one of the explanations of drug use and crime in the Forsythe and Adams (2009) which suggests that drug use can lead to crime. There were, in fact, inconsistent findings of previous researches along this subject. Dawkins (1997) revealed that adolescent's criminal history and racial identity are relatively more important factors than substance use. In addition to a pharmaceutical effect, the work of (Mocan & Corman, 1998) revealed that drug use might affect criminal behavior because of interaction between drug prices, drug consumption and drug profits. Although a multivariate analysis was done on drug and crime rate in New York City reveals a causal relationship between drug usage and property-related felonies (Corman & Mocan, 1996), pure time series models covering the index crimes and the drugs/substances widely used in the Philippines remained uncovered.

The paper explored the variations of reported cases of drug/substance abuse specifically the methamphetamine hydrochloride (*Shabu*), cannabis

(marijuana), cough/cold preparation, injectable, and inhalants. Inhalants include rugby, solvent, and other volatile substances while injectable refer to morphine, heroin, nubain, ketamine, and others (The Philippines, 2015). The study will delineate the reported drug abuses with the reported index crimes. Index crimes refer to reported cases that are serious and occur with sufficient frequency and regularity. The study will be done threefold. First, it describes the trends and correlations in the number of persons arrested for drug-related violations, reported cases of drug/substance abuse by type of patient confined in various rehabilitation centers, and reported index crimes against persons and property. Secondly, it provides insights into causal relationships between drug use and index crimes. Lastly, it gives a pure time series forecasting model of drug/substance abuse and index crimes.

METHODOLOGY

The data were collected from national line agencies such as the Philippine Statistics Authority (PSA), Philippine National Police (PNP), Dangerous Drug Board (DDB) and Philippine Drug Enforcement Agency (PDEA). The Philippine statistical yearbook (PSY) is the source of most of the data points. The former publisher of the PSY was the National Statistical Coordination Board (NSCB) which is now under the PSA. It noteworthy that the baseline data on crime started only in the year 2009 due to the adoption of the National Crime Reporting System (NCRS) by the PNP. The new system has changed the parameter of the data which makes the old method of crime reporting from the field called Police Regional Office Periodic Report (PROPER) is no longer comparable (The Philippines, 2015).

The study employed the time series trend analysis with applications on pure and causal time series forecasting using IBM SPSS Statistics Professional. Since the dataset was observed yearly, therefore there is less expected periodicity. The researcher generated descriptive statistical analysis, and the tables presented the summaries on correlation coefficients with sequence charts. Inspired with the work of Martin et al., (2004), the annual data points were treated as "individual data," an initial examination of bivariate correlations was done to determine an association between time series data of drug/substance abuse and crime in the Philippines. Lastly, the research generated Causal time series regression and time series analyses by ways of exponential smoothing and ARIMA.

Time Series Regression

The multiple regression equation below specifies the underlying assumption of a linear relationship between dependent and explanatory variables.

$$y_{it} = \alpha_t + b_1(x_1)_t + b_2(x_2)_t + b_3(x_3)_t \ldots + b_n(x_n)_t + \varepsilon_{t\,0p-p} \quad (1)$$

where:
$y =$ the dependent variable
$x_1 =$ the first explanatory variable
$x_2 =$ the second explanatory variable
$x_n =$ the nth explanatory variable
$\alpha =$ the constant term of the linear model
$b_i =$ the various coefficients assigned to the explanatory variables during the regression analysis, and
$\varepsilon =$ the error term or the multiple regression residual.

The final model will utilize only the remaining explanatory variable which was found to be significant at five (5) percent level of confidence. However, if none among the explanatory variables form an excellent regression model in the aggregate, then simple linear regression models one on one between index crimes and drug/substance abuse will be delineated. The null hypothesis (Ho) states that the index crime, for example against a person (murder), is not related to the variation in drug/substance abuse such as the use of *Shabu* (methamphetamine hydrochloride).

Exponential Smoothing

Exponential smoothing is a time series technique that gives a relatively quick way of developing a pure time series forecasting model. This technique is suitable in forecasting the pure time series on the drug/substance abuse or reported indexed crimes. Forecasting models from this technique were used in situations where there are none among the variables may create good causal time series models or when the quality of the data of causal time series models gives poor forecasts. Depending on the time series components and decomposition, the model delineation was done using simple exponential smoothing (SES), double exponential smoothing (Holt's), and triple exponential smoothing (Winters). Winters exponential smoothing is recommended when seasonality of the time series data is observed (Ramasubramanian, 2016).

Autoregressive Integrated Moving Average (ARIMA)

George Box and Gwilym Jenkins introduced the approach of ARIMA in 1976, and for this reason, it is also known as "Box-Jenkins" modeling. Different ARIMA models could fit a particular time series of interest. The type of ARIMA model depends upon the selected orders of autoregression (p), integration (d) and moving average (q). Unfortunately, it is often the case that identifying the p, d, q, combination to give the "best-fit or forecasting" ARIMA model is a process of trial and error (Gill, Murray, Saunders, & Wright, 1986). The primary tool used in this study is the IBM-SPSS® expert modeler.

The autoregressive component of an ARIMA model used lagged values of the dependent variable, and the order autoregression refers to the time difference between the dependent variable and the lagged dependent variable. The integration part relates to whether the time series requires differencing to become stationary. Lastly, the moving average component of the model uses the lagged values of the model error as independent variables (Gill et al., 1986).

Identifying the Best Time Series Models

After the estimation of the models using exponential smoothing and RIMA, the researcher checked each model fit statistics of a particular modeling approach using the available potential tests as follows:

- *Parameter Estimates*. After estimation, all parameter estimates should be statistically significant. One might remove non-significant parameter estimate/s from the model and estimate a simpler model. It was suggested to add tentatively more parameters but these likewise, should be statistically significant.
- *Residual ACF and PACF*. The residual ACF and PACF correlations should be small and nonsignificant. By chance, it was expected to observe significant autocorrelations associated with a random series, but there must be careful attention in autocorrelations at first few lags.
- *Ljung-Box Statistic*. The Ljung-Box statistic is directly proportional to the residual autocorrelations within the specified lag. By default, the SPSS (used in this study) uses lag 18. The Ljung-Box statistic

tests the null hypothesis that there is an association between the autocorrelations from lags 1 to 18 with a white noise process.

- *Model Fit Statistics*. Fit statistics such as the mean absolute error (MAE) are of the same metric measure as the dependent series. Small values of MAE signify better-fitting models.
- *Information Criteria*. There were some information criteria with names such as Akaike Information Criterion (AIC), the Schwartz Bayesian Information Criterion (SBC or BIC), the normalized Bayesian Information Criterion (normalized BIC), and the like.

RESULTS AND DISCUSSIONS

Trends and Correlations

This part presented the exploratory analyses, the time series model delineation and forecasting the trends to 2022. There were two steps in exploratory trend analysis. First was the zero-order correlational analysis (Pearson product-moment coefficients of correlation) to describe associations among index crimes classified as against persons and against properties, the drug/substance abuse reported by cases filed in the court, police blotters and by confinement in various rehabilitation centers and the number of raids and persons arrested for drug-related violations. The second was analyzing the model error on a sequence chart and the determination of heteroscedasticity in a time series. The time series data started from 2009 up to 2014.

Table 1 reveals the different correlation level with both negative and positive or weak and strong ones. It is noteworthy that most of the high positive correlations were most evident in the abuse of *Shabu* (methamphetamine hydrochloride) and marijuana (cannabis). For example, *Shabu* is having the coefficients of 0.87, 0.84, and 0.68 for crimes against persons and property specifically on rape, carnapping, and murder respectively. Likewise, the high positive correlation has also noted the use of marijuana and murder with the coefficient of 0.85. In contrast, the abuse of inhalants showed slightly high negative association with rape and carnapping. This variable was the only with high negative correlations to index crimes. It is also interesting to note that crimes against persons specifically on homicide and physical injuries had weak coefficient to any reported cases of drug/substance abuse.

Table 1
Correlations between Reported Cases of Drug/Substance Abuse and Index Crimes

Reported Cases of Drug/Substance Abuse	Index Crimes							
	Against Person				Against Property			
	Murder	Homicide	Physical Injuries	Rape	Robbery	Theft	Carnapping	Cattle Rustling
Shabu (Methamphetamine Hydrochloride)	0.68	-0.05	-0.01	0.87	0.37	0.52	0.84	-0.09
Marijuana (Cannabis)	0.85	-0.21	0.03	0.49	0.43	0.48	0.46	0.48
Cough/Cold Preparation	-0.04	-0.19	-0.08	-0.41	-0.08	-0.15	-0.34	0.13
Injectable	0.42	-0.15	0.10	-0.19	0.23	0.15	-0.15	0.64
Inhalants	-0.30	-0.02	0.05	-0.67	-0.18	-0.32	-0.68	0.42

The overall strength of association is weak, but it paved the way for further analyses to confine on positive and negative correlations which are beyond the range of -0.50 to 0.50. These were the variables carried out to hopefully construct good regression models on reported cases of drug/substance abuse and crime. Table 2 presented the correlation coefficients between drug/substance abuse as reflected in various rehabilitation centers and index crimes.

Table 2
Correlations between Reported Drug/Substance Abuse Confined in Various Rehabilitation Centers and Index Crimes

Reported Drug/Substance Abuse Confined in Rehabilitation Centers	Index Crimes							
	Against Person				Against Property			
	Murder	Homicide	Physical Injuries	Rape	Robbery	Theft	Carnapping	Cattle Rustling
New Admission	0.65	-0.02	0.00	0.86	0.36	0.51	0.85	-0.11
Re-admission	0.85	-0.21	-0.04	0.72	0.41	0.52	0.72	0.16
Out-patient	0.46	0.23	0.44	-0.06	0.47	0.36	-0.04	0.89

Table 2 revealed some high positive correlations. For instance, new admission to rehabilitation centers has high positive correlations to rape (0.86), carnapping (0.85) and murder (0.65) and has a slightly high positive to theft (0.51). Re-admission to rehabilitation centers also is of high positive correlations to murder (0.85), rape (0.72) and carnapping (0.72) with slightly high positive on theft (0.52). The out-patient cases of drug/substance abuse only make one high positive correlation, and that is to cattle rustling (0.89). All other coefficients are less than the -0.50 to 0.50 range of correlation coefficients. Figures 1 and 2 showed the graphs of these relationships.

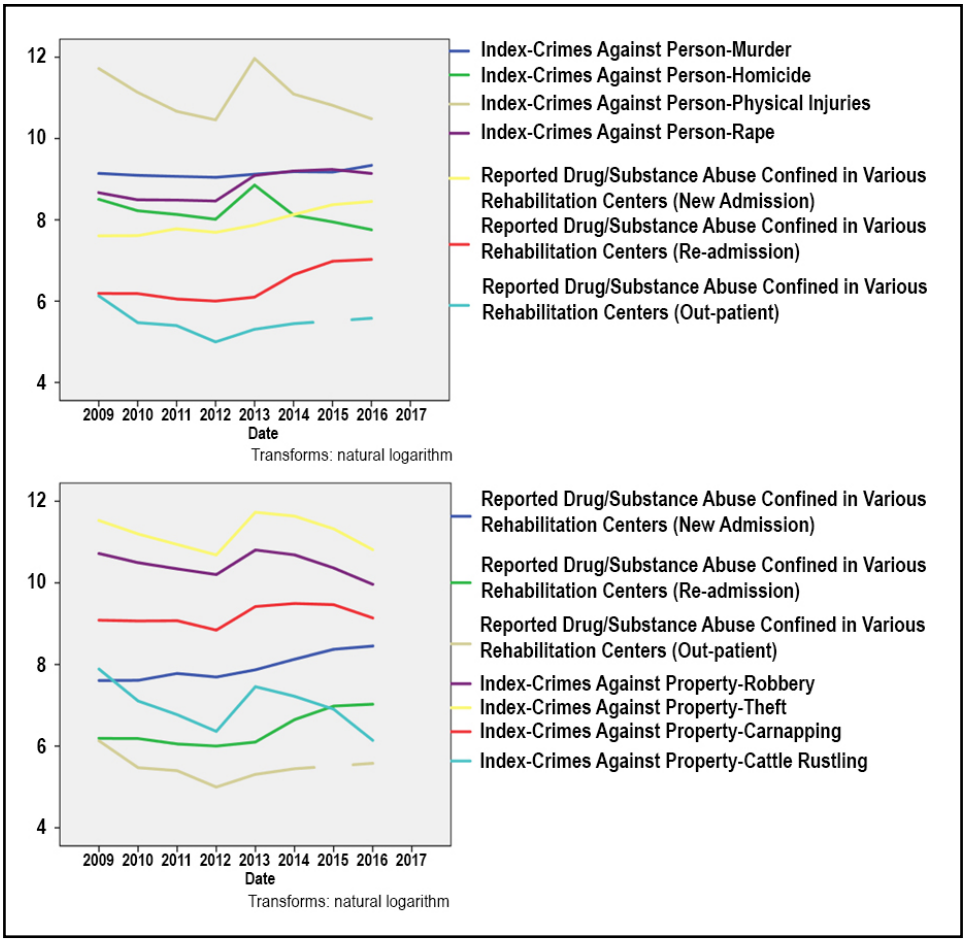

Figure 1
Sequence Charts of Reported Drug/Substance Abuse from Various Rehabilitation Centers with the Index Crimes against Person and Property

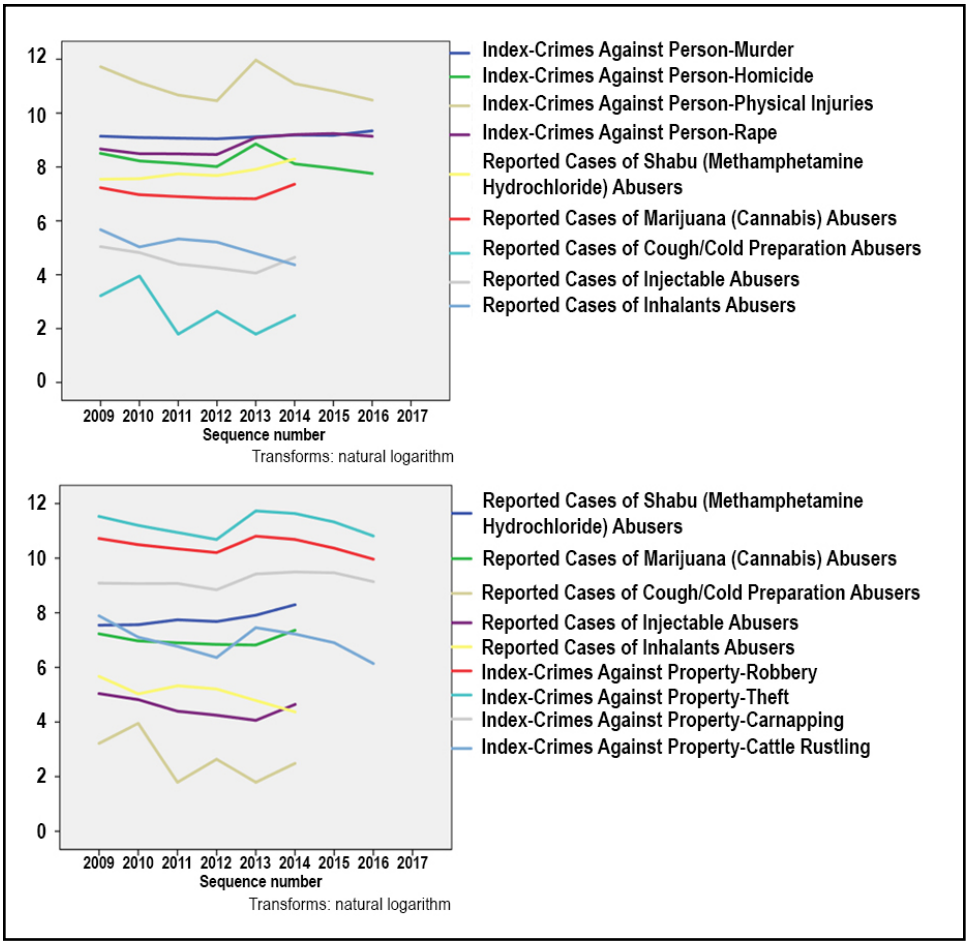

Figure 2
Sequence Charts of Reported Cases of Drug/Substance Abuse with the Index Crimes Against Person and Property

Figures 1 and 2 showed the sequence charts of the time series trends of the variables under study. The logarithmic transformation was done to depict the linear pattern despite the difference on the frequency counts. One of the constraints of the time series is data limitation. This constraint is due to the new method of crime reporting of the PNP which started in 2009. The transition from old reporting called Police Regional Office Periodic Report (PROPER) to the new approach called Unit Crime Periodic Report (UCPER) has changed the parameter and that the time series data points are no longer comparable (The Philippines, 2015). Another constraint is the unavailability of the new records so that most of the last data points were from 2014 to 2016. A good thing to note is that the pure time series forecasting on index crimes is not affected since the data is available until 2017.

The trends revealed residual variations on index crimes against person specifically physical injury and homicide, reported cases on abuse on cough/cold drugs and index crimes against property classified as theft. Results on individual regression analysis conform to the trends depicted in sequence charts and the correlation table.

Regression Models of Drug/Substance Abuse and Index Crimes

The first step was done on developing full regression models to include all the time series data of drug/substance abuse as explanatory variables for (1) total index crimes, (2) total index crimes against a person, and (3) total index crimes against properties. Among these regression analyses, none posed a significant explanatory variable for the index crimes.

The second step was done on looking at significant predictors of index crimes with just one explanatory variable in the different time series data of reported drug/substance abuse.

Results showed that murder, rape, and carnapping have significant predictors from various drug/substance abuse. Table 3 presented the summary of the one predictor variable regression models for murder.

Table 3
Table of Significant Coefficients of the Regression Analyses with the Time Series Trends on Murder as the Dependent Variable

Reported Drug/ Substance Abuse	R Squared	Constant* (Intercept)	Coefficients (Beta)		Sig
			Unstandardized	Standardized	
New Admission to Rehabilitation Centers	0.698	7,293	0.719	0.835	0.010 ***
Re-admission to Rehabilitation Centers	0.719	7,736	0.657	0.848	0.008 ***
Cases of Marijuana (Cannabis) Abusers	0.730	7,365	0.449	0.855	0.030 **

Legend: * *All constants (intercepts) are significant at 0.05 alpha level with p-values of 0.000*
** *Significant at 5% level*
****Significant at 1% level*

Among all the variables in drug/substance abuse, three are significant predictors of the crime murder. It can be gleaned in Table 3 that the R squared values of the models are doing well with that at least these linear models can explain 70 percent of the overall variations of the time series data of incidence of murder. It is empirical that for every unit change in the new admissions to various rehabilitation centers, we add about 0.84 units in the incidence of murder. Also revealed that for every re-admission to a rehabilitation center, about 0.85 would add to the incidence of murder. Lastly, about 0.86 change of murder is attributed to one additional marijuana abusers.

Table 4
Table of Significant Coefficients of the Regression Analyses with the Time Series Trends on Rape as the Dependent Variable

Reported Drug/ Substance Abuse	R-Squared	Constant* (Intercept)	Coefficients (Beta)		Sig
			Unstandardized	Standardized	
New Admission to Rehabilitation Centers	0.686	1,600	1.941	0.828	0.011 ***
Re-admission to Rehabilitation Centers	0.609	3,122	6.449	0.780	0.022 **
Cases of *Shabu* (Methamphetamine Hydrochloride) Abusers	0.757	240	2.502	0.870	0.024 **

Legend: * *All constants (intercepts) are significant at 0.05 alpha level with p-values of 0.000*
** *Significant at 5% level*
****Significant at 1% level*

Table 4 shows three simple linear regression models with the variables new-admission and re-admission to rehabilitation centers and abusers of *Shabu* (methamphetamine hydrochloride) as significant predictors to reported cases of rape.

The models showed that for every unit change in the variables new and re-admission to various rehabilitation centers, and reported cases of *Shabu* abusers would respectively increase by about 0.83, 0.78 and 0.87 in the cases of rape. The R-squared values specified a better model fit with the power of determination of at least 61 percent of the total variations of the time series trends in rape.

Table 5
Table of Significant Coefficients of the Regression Analyses with the Time Series Trends on Carnapping as the Dependent Variable

Reported Drug/ Substance Abuse	R-Squared	Constant* (Intercept)	Coefficients (Beta)		Sig
			Unstandardized	Standardized	
Cases of *Shabu* (Methamphetamine Hydrochloride) Abusers	0.707	3,267	2.604	0.841	0.036 **

Legend: * *Constant (intercept) is not significant at 0.05 alpha level with a p-value of 0.209*
** *Significant at 5% level*

Table 5 depicts that among all other variables of the drug/substance abuse, only the cases of *Shabu* abusers played as a significant predictor to carnapping. The reported cases of Shabu abusers can explain about 71 percent of the part and overall variations of carnapping. The model revealed that for every one additional *Shabu* abuser will correspond to an increase of about 2.604 cases of carnapping.

Pure Time Series Model Delineation

The forecasting model for the reported drug/substance abuse having the best-fit statistics was the Holt's exponential smoothing. Table 6 presented the model description. The Mean Absolute Percentage Error (MAPE) is good at 14.6 percent. MAPE is one of the most popular measures of prediction accuracy which is best at lower values. The worst-case scenario in its model accuracy is about 41.17 percent which is represented by the Maximum Absolute Percentage Error (MaxAPE).

Table 6
Model Description for the Reported Drug/Substance Abuse in Various Rehabilitation Centers

Model Description	Model Fit	R-squared	Ljung-Box
Holt's Exponential Smoothing	MAPE = 14.60	$R^2 = 0.624$	Statistics Q(18)
	MaxAPE = 41.17	Stationary $R^2 = 0.67$	16

The model indicates a slightly high positive R-squared which suggests that the model predicts about 62 percent of the variation of the

time series data. The Ljung-Box statistics is satisfactory when it is close to 15. Another good fit statistic is evident in The Auto-Correlation Function (ACF), and Partial Autocorrelation Function (PACF) as shown in Figure 6a wherein the study did not find significant spikes in the errors.

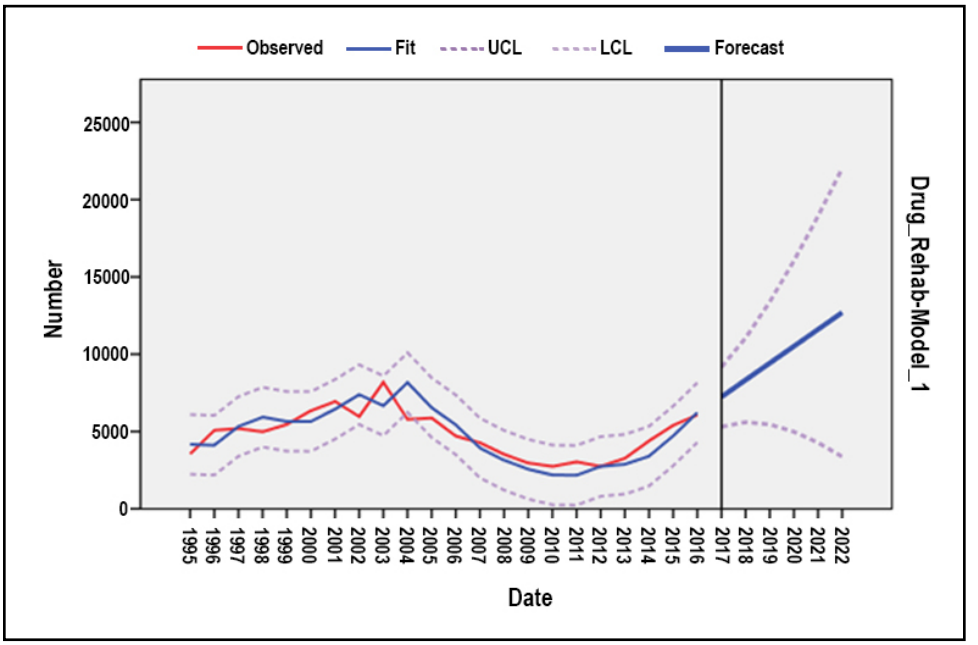

Figure 3
Sequence Charts of the Observed, Fit and Forecasts
of the Index Crimes in the Philippines

The observed values, the model fit, the upper and lower confidence limits, and the 6-year forecast of PSTP were plotted in the sequence chart in Figure 3. The fit was closely following the observed data points with the worst case scenario in 1997 under-predicting by about 2,383 cases of drug/substance abuse. This fit has less effect in the forecast since the exponential smoothing has decreased the impact of distant values exponentially than the near time series observations. Seasonality is not a prominent feature of the data in general. Although there were evident series of upward and downward trends, there were no established seasonal variations as there were no repeated periods in its peaks and troughs.

Table 6 presented the model specification, fits, R-squared and parameters of the ARIMA for the time series trends of index crimes in the Philippines while Figure 5 shows the fit and forecasts.

Table 7
Model Description for the Total Index Crimes in the Philippines

Model Description	Model Fit	R-squared	Parameters
ARIMA(0,0,0)	MAPE = 39.47	$R^2 = 0.00$	$t = 6.55$
	N. BIC = 23.10	Stationary $R^2 = 0.00$	Sig. = 0.00

Table 7 reveals that the coefficient of determination of the ARIMA model is not doing so good, but we cannot classify this as worse than the baseline model since that stationary R-squared value is zero. The noise in the trend of index crimes is an excellent factor affecting model delineation. The order (0,0,0) indicates that the time series model only contains the constant and the white noise. There is no observed seasonality since the data points were annual observations and that the peaks and troughs fail to complete a cycle as observed in Figure 3. The Mean Absolute Percentage Error (MAPE) is quite high at about 39 percent. The MAPE conforms with the accuracy ratio of the residuals against the observed values at 33 percent. This is already a good baseline data since it is wrong to set arbitrary forecasting for policy directions or in any performance goals (Gilliland, 2015). The Normalized Bayesian Information Criterion (N. BIC) is small which indicate that the repeated effects fit the data considerably. The Auto-Correlation Function (ACF) and Partial Autocorrelation Function (PACF) as shown in Figure 5a showed no significant spikes of the errors. Generally, there is a statistical reason to believe that the model is not misspecified. Figure 4 showed that model fit, observed values, forecast, and the confidence limits. Another good indicator is that ACF and PACF showed no autocorrelation at all lags of the index crimes (Figures 6a and 6b). In the pure time series forecasting models, Holt's exponential smoothing and ARIMA were specified as the best forecasting models for drug/substance abuse and index crimes respectively.

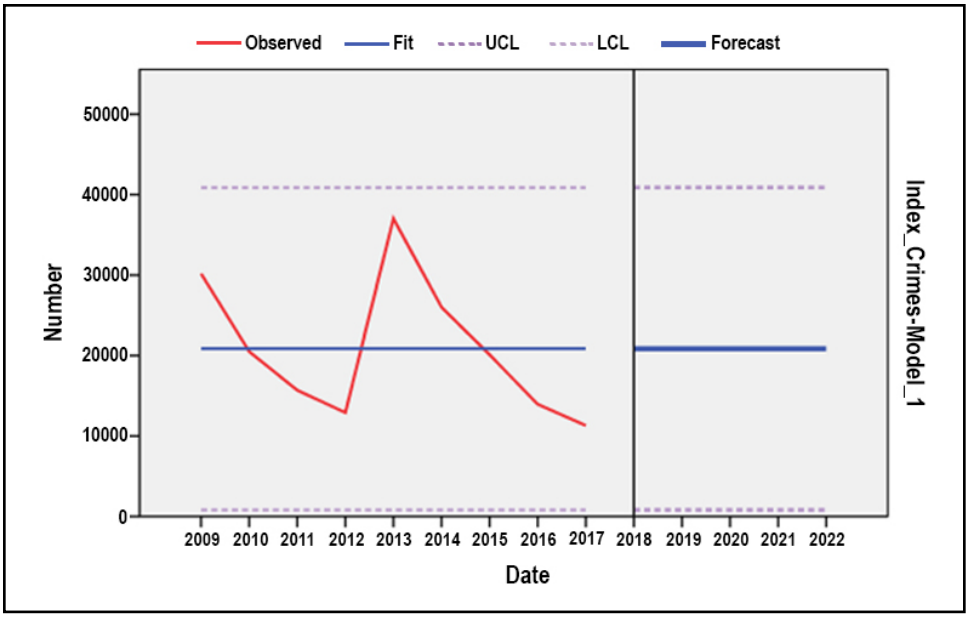

Figure 4
Sequence Charts of the Observed, Fit and Forecasts
of the Index Crimes in the Philippines

The ARIMA model specified zero-order autoregressive, integrated and moving average components. In the estimation of forecasts of the index crimes from 2018 to 2022, the trend is constant at 151,141 per year. The time series trends have changed since the PNP has adopted the National Crime Reporting System (NCRS) in 2009. This model is useful in establishing baseline data and model especially for the new system of reporting.

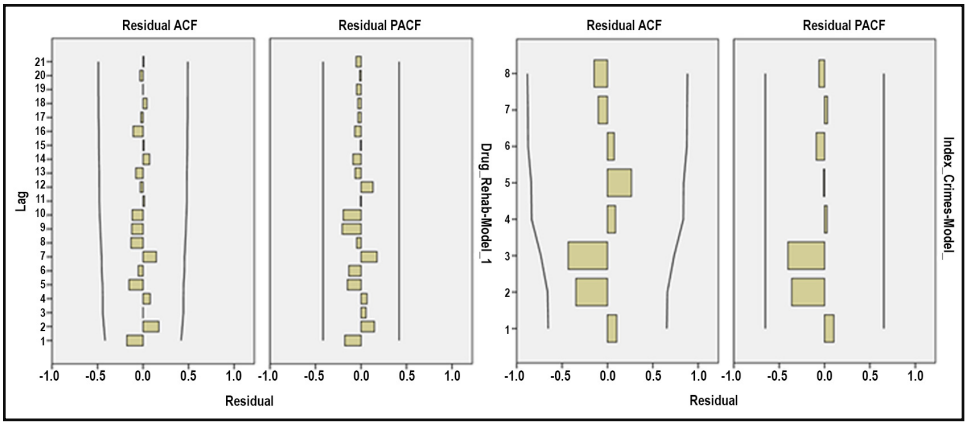

Figure 5
Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) for (a) Holt's Exponential Smoothing and (b) ARIMA

CONCLUSION

The findings of this study demonstrate an association between drug/substance abuse and index crimes. In regression analyses, a conclusion has arrived in several associations. First, the variations of the time series data in murder can be predicted by reported new and re-admission cases to various rehabilitation centers and reported cases of marijuana abusers. Secondly, some part and overall variations of rape cases are associated with new and re-admission cases to various rehabilitation centers and reported cases of *Shabu* abusers. Lastly, carnapping could be explained by the number of cases of *Shabu* abusers.

While there is a need to do much research concerning drugs and criminality in the Philippines, the goal of this research is to establish baseline data on the trends of drug/substance abuse and crime. The outcome of the study may be useful in the evaluation of the Philippines' "War on Drugs" and to "Eradicate Criminality". The models may also serve as a basis for policy directions and recommendations. If these forecasting models and regression equations lead to a more understood effect of drug use to criminality, then, the objective is achieved.

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