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Determinants of Crime Rate: The Case from Regions of Mindanao, Philippines

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Abstract: This study examines the factors influencing crime rates across various regions in Mindanao, Philippines, from 2009 to 2022, addressing its economic and security challenges. Like many developing countries in Asia, the Philippines faces disparities in economic growth, with Mindanao lagging behind other areas in terms of development. This issue is further intensified by travel advisories from foreign governments, such as the United States, United Kingdom, Canada, and Australia, impacting tourism and foreign investment. By analyzing GRDP per capita, mean years of education, unemployment rate, urban population, police operating expenses, and police visibility, the research uses panel regression analysis to determine significant crime predictors. Results show that mean years of education have a considerable positive relationship with crime rates, suggesting that higher education levels may be linked to increased crime, particularly through the involvement of educated individuals in sophisticated crimes, such as white-collar crime or drug-related activities. Meanwhile, police visibility has a significant negative relationship with crime rates, indicating that a higher police presence is an effective deterrent, as criminals are reluctant to engage in criminal activities when a strong police presence is evident. Other variables, such as GRDP per capita, unemployment rate, urban population, and police operating expenses, were insignificant. These findings underscore the complexity of crime factors and the necessity for strategic police allocation and education reforms, providing insights for policymakers in addressing crime. The study's implications extend beyond the Philippines, offering insights for other countries facing similar challenges in balancing economic growth and crime prevention.
Keywords: crime rates; education; panel regression analysis; police visibility
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Introduction

Crime remains a significant challenge in the Philippines, undermining national security and economic development. Despite government efforts, recurring incidents continue to threaten public safety, highlighting the need for more effective crime reduction strategies (Leikuma-Rimicane et al., 2022). Moreover, crime is not confined to specific areas, as it is prevalent across Luzon, Visayas, and Mindanao, which represent the major islands of the Philippines. However, Mindanao is often identified as a high-risk destination, with travel advisories from the UK, Australia, and Canada warning against elevated crime rates, terrorism, and kidnappings (Sablad, 2017). These concerns continue to be reported by various media outlets

and remain unrevoked (Government of Canada, 2024; Foreign, Commonwealth & Development Office, 2023; Australian Government Department of Foreign Affairs and Trade, 2023). As a result, Mindanao lags behind Luzon and Visayas in economic development, as potential investors are dissuaded by security concerns (Lameda, 2018). This indicates that the crime problem in Mindanao requires immediate attention because it significantly impacts the Philippine economy.

Existing studies, exemplified by the works of Northrup and Klaer (2014), Rathie et al. (2016), Wang and Hu (2022), Sabroso et al. (2023), and Di Matteo (2014), primarily focused on analyzing national-level data, overlooking specific regional factors influencing crime trends. Despite extensive research on national-level crime factors, there is a notable lack of understanding regarding regional influences, particularly in Mindanao. Limited attention has been devoted to examining the effects of GRDP per capita, mean years of education, unemployment rate, urban population, police operating expenses, and police visibility on crime rates in Mindanao's island regions. Addressing this gap is vital for evidence-based policies to reduce crime and enhance safety in Mindanao, prompting a comprehensive panel regression analysis in this study.

Existing studies, exemplified by Northrup and Klaer (2014), Rathie et al. (2016), Wang and Hu (2022), Sabroso et al. (2023), Di Matteo (2014), and Padrick (2021), primarily focused on national or urban-level data from developed or more centralized contexts, often overlooking specific regional dynamics that influence crime rates. For instance, Northrup and Klaer (2014) found a positive relationship between GDP per capita and violent crime in the United States, suggesting that increased wealth may paradoxically contribute to higher crime levels. Meanwhile, Rathie et al. (2016) demonstrated a significant negative relationship between average years of education and crime, highlighting education as a protective factor across 73 countries. Wang and Hu (2022) analyzed city-level data in China. They found that unemployment had varying effects on crime depending on the local context. In the Philippine setting, Sabroso et al. (2023) revealed a positive correlation between urban population growth and crime, implying that urbanization may intensify criminal activity. Di Matteo (2014), examining Canadian data, reported that greater police visibility measured through police per capita corresponded to lower crime rates. However, Padrick (2021) found that police spending had an inconsistent and insignificant effect on U.S. cities' crime rates, citing budget inefficiencies and structural constraints.

Despite these valuable contributions, there remains a lack of empirical studies addressing how variables such as GRDP per capita, mean years of education, unemployment rate, urban population, police operating expenses, and police visibility relate to crime rates in regional contexts with unique socio-political conditions. Specifically, Mindanao, with its island provinces and history of conflict, represents a distinct case where crime may be influenced not only by socio-economic conditions but also by the presence of insurgency and armed groups. This study seeks to fill this research gap by conducting a panel regression analysis tailored to the context of Mindanao's regions. Understanding how these variables operate within such a setting is essential for crafting effective, evidence-based crime prevention strategies.

Establishing the relationship between these factors and crime rates, which is the objective of this study, enables the implementation of strategies to address or enhance related issues. This proactive approach will strengthen Mindanao's economy and prevent it from falling behind. As Finance Secretary Benjamin Diokno pointed out in 2023, Mindanao is poised to drive the Philippines' economic advancement. Its unique geographical advantages and abundant natural resources position Mindanao to propel the country's economic growth significantly. By strategically investing and collaborating across various sectors, Mindanao has the potential to emerge as a key player in the nation's transformative journey (Department of Finance, 2023).

Research Method

Sources of data

The study utilized secondary data from various sources, including the Philippine Statistical Yearbook (PSA), Global Data Lab (GDL), Department of Budget and Management (DBM), and the Philippine National Police (PNP). The dataset encompassed all regions in Mindanao, Philippines, spanning fourteen years (2009–2022). Panel data methodology was employed to analyze this data, accounting for the cross-sectional and time-series dimensions. The cross-sectional component represents the number of regions included in the study. In contrast, the time-series component reflects the periods covered for each area. The analysis begins in 2009, as this year marked the introduction of a new crime reporting system by the PNP, which established a consistent baseline for the dependent variable, making data before 2009 incomparable due to changes in reporting parameters (Philippine Statistics Authority, 2012).

However, while the study offers meaningful insights, it faced several limitations. Firstly, the analysis may be constrained by the limitations of the statistical techniques, such as assumptions underlying regression models. Additionally, the study was limited by excluding certain external factors, such as cultural, social, and political influences, which could also have impacted crime rates in the region. It is also important to note that the study utilized unbalanced panel data due to the absence of data for the independent variable, police visibility, in 2009 and 2022. Furthermore, while recent data is relevant, 2023 information is unavailable online, limiting its inclusion. Despite this, the researchers proceeded with the analysis as an exploratory effort to uncover initial insights into potential relationships among the study's variables, laying the groundwork for future studies once the missing data is accessible. Lastly, although the survey offers valuable insights into the determinants of crime rates in Mindanao, its findings may not be directly applicable to other regions, limiting the generalizability of the results.

Method of Estimation

The study employed panel regression analysis to explore the factors influencing crime rates across Mindanao's regions from 2009 to 2022, focusing on variables such as GRDP per capita, mean years of education, unemployment rate, urban population, police

operating expenses, and police visibility. Due to missing data for police visibility in 2009 and 2022, an unbalanced panel data approach was utilized, which still provides significant insights into the relationships among these determinants and crime rates. Diagnostic tests were conducted, including stationarity tests, normality and skewness analysis, and assessments for multicollinearity using the Variance Inflation Factor (VIF). The Hausman test confirmed the suitability of the fixed effects model, leading to further diagnostic evaluations such as the testparm that include time-fixed effects through dummy time variables. Moreover, the Pesaran's Test for Cross-Sectional Independence indicated that unobserved factors can be shared between regions, similarly affecting outcomes, thus revealing cross-sectional dependence in the model.

Furthermore violations of constant variance assumptions are identified through heteroscedasticity tests. Lastly, the autocorrelation test indicated first-order autocorrelation in the residuals, leading to biased and inefficient estimates. Feasible Generalized Least Squares (FGLS) was applied with dummy time variables to address these issues, enhancing model robustness.

Empirical Model

Equation 3.1 presented the empirical model of this study, which was based on the previous empirical studies of Bahtiar and Nurhayati (2023), Rathie et al. (2016), Wang and Hu (2022), Sabroso et al. (2023), Borjas (2019), and Kizilgol and Selim (2017).

The model estimated whether GRDP per capita, mean years of education, unemployment, urban population, police operating expenses, and police visibility can affect the crime rate of each region in Mindanao from the period 2009 to 2022, as modeled:

$$C_{it} = \beta_0 + \beta_{1_{it}}GPC_{it} + \beta_2 MYE_{it} + \beta_3 UN_{it} + \beta_4 URB_{it} + \beta_5 POE_{it} + \beta_6 PV_{it} + \varepsilon_{it}$$
(3.1)

Where:,
C is the crime rate of the regions in Mindanao from 2009 to 2022;
β_0 is the intercept;
β_1, β_2, β_3, β_4, β_5, β_6 are the slope coefficients of GPC, MYE, UN, URB, POE, and PV, respectively.
GPC_{it} is the GRDP per capita, which represents the average economic contribution per person for each region of Mindanao from 2009 to 2022. It is calculated by dividing a region's GDP by population according to the PSA.
MYE_{it} is the average number of years of education completed by adults aged 25 and older in each region of Mindanao from 2009 to 2022, according to GDL;
UN_{it} is the percentage of the total number of unemployed persons to the total number of persons in the labor force of each Mindanao region from 2009 to 2022, according to PSA.
URB_{it} is the percentage of the population living in urban areas of each Mindanao region from 2009 to 2022, according to GDL;

POE_{it} is the total operating expenses of PNP of each region in Mindanao from 2009 to 2022;

PV_{it} is the number of police officers per 100,000 inhabitants in each region of Mindanao from 2010 to 2021;

ε is the error term;

i is the indicator for each region in Mindanao;

t is the indicator for each year from 2009 to 2022.

Result and Discussion

Table 1 provides a descriptive overview of the study's variables, presenting summary statistics such as the mean, standard deviation, minimum, maximum, and the number of observations for each variable. The data spans from 2009 to 2022 across six regions in Mindanao, with 84 observations for most variables. However, police visibility has only 72 observations due to missing data for 2009 and 2022. Crime rates show substantial variation, with the highest value reported at 1,617.9 and the lowest at 24.9. The average crime rate is 373.03, with a standard deviation of 301.0893, reflecting considerable fluctuations.

Regarding Gross Regional Domestic Product (GRDP) per capita, the highest value is Php 182,351, while the lowest is Php 41,177. The average GRDP per capita across regions is Php 101,477.6, with a standard deviation 37,673.5. Concerning mean years of education, the highest value is 9.76 years, and the lowest value is 5.78 years, with an average of 8.4273 years and a standard deviation of 1.0358. Regarding unemployment rates, the highest rate is 9.9%. The lowest rate is 2.3%, with an average unemployment rate of 4.9071% and a standard deviation of 1.4883. The urban population's highest rate is 60.4%, while the lowest is 8.72%. The average urban population across regions is 36.255%, with a standard deviation 12.5432. About police operating expenses, the highest value is Php 427,970,000.

In contrast, the lowest value is Php 69,909,000, with an average of Php 196,586,511.9 and a standard deviation of Php 108,144,481.5. Finally, police visibility is highest at 353.3666, while the lowest value is 95.1435. The average police visibility across regions is 168.9365, with a standard deviation 38.5172.

Table 1 Descriptive Statistics of the Variables

Variable	N	Mean	Std. Dev.	Min	Max
Crime Rate	84	373.03	301.0893	24.9	1617.9
Gross Regional Domestic Product per capita	84	101,477.6	37,673.5	41,177	182,351
Mean Years of Education	84	8.4273	1.0358	5.78	9.76
Unemployment Rate	84	4.9071	1.4883	2.3	9.9
Urban Population	84	36.255	12.5432	8.72	60.4
Police Operating Expenses	84	196,586,511.9	108,144,481.5	69,909,000	427,970,000
Police Visibility	72	168.9365	38.5172	95.1435	353.3666

Panel Data Model Specification

A Hausman test was conducted to determine whether to use a Fixed Effect (FE) or Random Effect (RE) model. If the Hausman test is statistically significant, the FE model is appropriate; otherwise, the RE model is more suitable. As shown in Table 2, the Hausman test results indicated statistical significance, confirming that the FE model was more appropriate than the RE model.

Table 2 Hausman Test

Test Summary	Chi-sq. Statistic	Df	Prob>chi-sq	Remark
Cross-section random	28.76	5	0.0000	FE is appropriate

As shown in Table 3, the Testparm test validated the Fixed Effects model by assessing the significance of year dummies. With an F-statistic of 16.32 and a p-value of 0.0000, the results confirmed that time-fixed effects significantly influence the dependent variable, justifying their inclusion in the model.

Table 3 Testparm

F- Statistics	Prob>F	Remark
16.32	0.0000	Time effects should be included in the model.

Assumptions of Ordinary Least Squares for Panel Analysis

The Variance Inflation Factor (VIF) was examined to evaluate the multicollinearity of the variables in the model. Following the rule of thumb, multicollinearity is not considered severe if the VIF values are below 10. As shown in Table 4, the model does not exhibit severe multicollinearity, with a mean VIF of 1.98.

Table 4 Multicollinearity Test

Independent Variables	VIF	1/VIF	Remark
Gross Regional Domestic Product per capita	1.55	0.643890	The model does not suffer from serious multicollinearity.
Mean Years of Education	2.83	0.353494	
Unemployment Rate	1.48	0.675738	
Urban Population	3.05	0.327886	
Police Operating Expenses	1.26	0.795382	
Police Visibility	1.72	0.581644	
Mean VIF	1.98		

The Pesaran test revealed a test statistic of -2.441 and a p-value of 0.0146, rejecting the null hypothesis of no cross-sectional dependence. This indicates significant correlation across panel units, suggesting shared unobserved factors that affect outcomes similarly. Cross-sectional dependence is present in the model.

Table 5 Pesaran's Test of Cross-sectional Independence

Pesaran's Test of Cross-sectional Independence	Prob>F	Remark
-2.441	0.0146	There is a cross-sectional independence.

The Modified Wald test for groupwise heteroskedasticity indicated a chi-squared value of 25.45 and a p-value of 0.0003, leading to the rejection of the null hypothesis of homoscedasticity. This confirms the presence of heteroskedasticity, suggesting that the variance is not constant across groups.

Table 6 Modified Wald test for groupwise heteroskedasticity

Chi-square Statistics	Prob>F	Remark
25.45	0.0003	The model is suffering from Heteroskedasticity.

Moreover, the study also checks if the model suffers from serial correlation. The test showed an F-statistic of 21.672 with a p-value of 0.0056, indicating significant first-order autocorrelation in the residuals. This suggests that error terms are correlated over time, which can bias estimates if unaddressed.

Table 7 Wooldridge test for autocorrelation in panel data

F-Statistics	Prob>F	Remark
21.672	0.0056	There is first-order autocorrelation.

Final Model

Table 8 presents the final results of the panel regression following a series of diagnostic tests. FGLS regression was employed to address heteroskedasticity, autocorrelation, and cross-sectional dependence. The model comprises a total of 62 observations. The Wald chi-square statistic of 605.18, with a p-value of 0.0000, confirms that the model fits the data significantly at the 1% level.

Among the independent variables, mean years of education and police visibility are significant at the 1% level and align with the 5% significance threshold used in the analysis. Specifically, mean years of education demonstrates a positive and significant relationship with crime, with a coefficient of 4.2874, indicating that a 1 percent increase in education is associated with a 4.2874 unit rise in the crime growth rate. This finding is consistent with Ummah and Rahani (2022), suggesting that higher education is related to increased criminal activity. In Mindanao, educated individuals, including leaders of groups like the New People's Army (NPA) and Moro Islamic Liberation Front (MILF), utilize their knowledge to organize and execute complex criminal activities (Director of National Intelligence, 2022). For example, a graduate involved in illegal activities was reported (International Network for Philippine Studies, 2022).

Table 8 FGLS Regression Result on the effect of GRDP per capita, Mean Years of Education, Unemployment Rate, Urban Population, Police operating Expenses, and Police Visibility on Crime rate in the regions of Mindanao, Philippines

Independent Variable	Coefficient
GRDP per capita	-0.0000243
Mean years of education	4.2874***
Unemployment Rate	-0.1206
Urban Population	0.0037
Police Operating Expenses	0.1421
Police Visibility	-0.6583
Year	
2012	-0.1932
2013	1.2835***
2014	0.8107***
2015	0.8999***
2016	0.2633
2017	-0.1517
2018	-0.3649**
2019	-0.6290**
2020	-0.7092**
2021	-0.3542
Constant	-2.4596
Prob > chi2	0.0000
Number of Observations	62
Number of groups	6
Obs per group	min = 9 avg = 10.33333 max = 11
*Level of significance: 1%***, 5%***	

Furthermore, criminal involvement extends to public officials, such as a mayor implicated in drug-related crimes (Al Jazeera, 2017), as well as teachers in Region 12 and Davao del Sur connected to drug trafficking (Estabillo, 2009; Pilapil, 2017). Even police officers have been arrested for drug offenses (Fuerzas, 2021). Additionally, cybercrime has become prevalent in Mindanao (PNP, 2021), with research indicating that cybercriminals often possess higher intellectual capabilities than traditional criminals (Schiks et al., 2021). These are just a few examples of reported criminals with high educational attainment. Still, there are many more articles online that highlight this concerning issue. Similarly, police visibility exhibits a negative and significant relationship with crime, with a coefficient of -0.6583, suggesting that a 1 percent increase in police visibility reduces the crime growth rate by 0.6583 units. This aligns with the findings of Di Matteo (2014), Kizilgol and Selim (2017), and Chalfin et al. (2022), which emphasize the deterrent effect of larger police forces on crime rates. The Philippine National Police recognizes the importance of enhanced police presence in crime reduction, as outlined in the National Economic and Development Authority (2017), which stresses the need to increase visibility and personnel to strengthen law enforcement.

On the other hand, several variables, including GRDP per capita, unemployment rate, urban population, and police operating expenses, were found to have statistically insignificant relationships with crime rates. However, their potential influence on crime dynamics should not be overlooked. The negative relationship between GRDP per capita and the crime rate (coefficient = -0.0000243) is consistent with the study of Perez (2022), which reported a similar result. Likewise, the negative relationship between the unemployment rate and crime (coefficient = -0.1206) contrasts with expectations. Still, it aligns with the study of Armin and Idris (2020), which found a similar negative but insignificant relationship. The positive relationship between urban population and crime (coefficient = 0.0037) corresponds with the findings of Kizilgol and Selim (2017), Oyelade (2019), Rivera (2015), Sabroso et al. (2023), and Zaman and Khan (2021). However, statistical insignificance was observed in the context of Mindanao. Finally, the positive but statistically insignificant relationship between police operating expenses and crime (coefficient = 0.1421) aligns with the study of Padrick (2021), which reported a positive but insignificant relationship. This outcome aligns with the findings of Padrick (2021), who emphasized inefficiencies in law enforcement budgeting. Substantial portions of police budgets are frequently allocated to administrative and logistical costs, including utilities, vehicle maintenance, and office operations, which do not directly impact crime deterrence.

In contrast to police visibility, which showed a significant negative relationship with crime, police operating expenditures alone do not guarantee enhanced public safety outcomes. This highlights a potential misalignment between spending priorities and actual crime prevention effectiveness. Therefore, government policy must focus not merely on increasing law enforcement budgets but also on evaluating the operational efficiency and targeting expenditures. Strategic allocation toward activities with proven deterrent effects, such as patrolling, investigative capability, or community policing, should be prioritized to ensure that public resources translate into measurable security improvements. In addition, according to Prud'homme et al. (2017), over 95% of the Philippine National Police (PNP) budget is centrally controlled, limiting effective local resource deployment. Despite adequate police-to-population ratios in regions like ARMM, high crime rates persist (Ranada, 2016, cited in Madanlo et al., 2016). The lack of formal training for many police investigators (Sison Jr. & Felipe, 2011) and persistent corruption within the force (Buan, 2017; COMMONER, 2021) continue to weaken crime prevention. These issues help explain the positive but statistically insignificant relationship between police operating expenses and crime rates, highlighting the need for accountability and resource use reforms. While these variables did not exhibit statistical significance in this analysis, their potential impact on crime rates cannot be ruled out.

Regarding the year dummy variables, data for 2009, 2010, and 2022 were excluded due to specific analysis methods. First differencing was applied for 2010, and rows with missing values were automatically excluded during the analysis, with 2011 as the baseline year. The regression analysis shows that crime rates in 2013, 2014, and 2015 were significantly higher than in 2011, mainly due to improved record-keeping (PNP, 2013), the activation of the Anti-Cybercrime Group (PNP, 2021), increased violent incidents like bombings (United States Department of State, 2014), and the Mamasapano clash in 2015

(Castillo, 2018). Conversely, a downward trend in crime began in 2018, with rates significantly lower than in 2011, continuing through 2019 and 2020. This decline is attributed to the success of the war on drugs (Caliwan, 2020), the declaration of Martial Law in 2017, and the impact of COVID-19 lockdowns (Santos, 2020). In contrast, 2012, 2016, 2017, and 2021 showed no significant difference in crime rates compared to 2011. Crime rates fluctuate significantly, with notable peaks and declines relative to the 2011 baseline.

Conclusion

This study contributes to the understanding of crime determinants by analyzing key factors influencing crime rates in the regions of Mindanao, Philippines. The research advances knowledge by revealing that educational attainment and police visibility significantly predict crime rates. In contrast, other socio-economic factors like GRDP per capita, unemployment rate, urban population, and police operating expenses exhibited statistically insignificant relationships. These findings provide critical insights into crime dynamics and the effectiveness of policies in regions facing economic and security challenges.

The implications of these findings are particularly relevant for policymakers and law enforcement agencies. The positive relationship between mean years of education and crime highlights the need to reform the educational framework. Policymakers in the education sector should focus on strengthening values formation, ethics, and critical thinking within curricula to foster intellectual and moral development, thereby reducing the likelihood of individuals using their knowledge for unlawful purposes. Furthermore, the significant negative relationship between police visibility and crime emphasizes the importance of increasing police presence. Optimizing deployment strategies, enhancing police visibility, and investing in community-based policing initiatives can effectively deter criminal activities. Building and strengthening trust between law enforcement and local communities is equally crucial for public safety.

Furthermore, several recommendations are proposed for future researchers to enhance the understanding of crime determinants in areas where violent crime persists. First, incorporating other variables such as government welfare program budgets and mental health factors could provide a more detailed understanding of crime dynamics. Moreover, variables capturing military operations or visibility should be considered, given the prevalence of crimes related to anti-government movements, such as insurgency activities involving rebel groups and other armed factions. This could explain how military presence and counterinsurgency efforts influence crime patterns. Exploring the role of local governance and its impact on crime rates could also provide valuable context, particularly given the diverse political landscape in Mindanao. In addition, employing qualitative methods such as interviews or focus groups with community members and law enforcement officials could enrich quantitative findings and offer deeper insights into the underlying causes of crime. Finally, expanding the geographical scope to include comparisons with other regions in the Philippines may help identify unique and common

trends that could inform targeted interventions. By considering these aspects, future research can contribute to a more comprehensive understanding of the complex factors influencing crime rates in Mindanao.

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