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MEASURING EFFICIENCY USING DATA ENVELOPMENT ANALYSIS: APPLICATION ON 12 POLICE PRECINCTS IN DAVAO CITY, PHILIPPINES

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Abstract:
Public security plays a vital role in a developing country. It brings positive externalities. This means that it is the function of government to ensure the protection of citizens, persons in their territory, organization, and institutions against threats. The main purpose of this study is to determine the efficiency of 12 Police Precincts in Davao City, Philippines. The inputs and outputs for police performance measurement were first identified. Data Envelopment Analysis and Multiple Regression Analysis were used to measure efficiency and changes to overall services between 2015-2017. We use window analysis and output-oriented DEA models to sharpen our efficiency estimates with both constant and variable returns to scale. The problem of the presence of non-discretionary input variables is explicitly treated in the models used. Potential improvements in the technical efficiency of police precincts are examined by readjusting the output/input indicators. The analysis indicates that some differences in operating environments, especially socioeconomic factors such as residents and young people's population, significantly influence the efficiency of police precincts.

JEL: H11; H50; H76

Keywords: police efficiency, performance measurement, police precincts, data envelopment analysis, Philippines

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1. Introduction

Public security plays a vital role in a developing country. It brings positive externalities. This means that it is the government's job to safeguard citizens, people in their area, organizations, and institutions from dangers to their well-being and community prosperity. Responsible public institutions and organizations can successfully use their intelligence to address possible threats in advance to meet the expanding problems in public security. They are responsible for enhancing their internal structures, interacting and working together, and carefully equalizing the costs and benefits of their measures (Defense Research and Development of Canada, 2013; Alberts and Hayes, 2003).

Providing security for the people is an essential role of the government, and as a result, they created a criminal justice system securing the public citizens against crime (M2 Presswire, 2004). Law enforcement agency plays a vital role in the public security against crime via the criminal justice system. Their active roles and visible presence in preventing and suppressing crime are incredibly important. The government's primary capability is to improve the police force's operational efficiency and effectiveness in preventing and suppressing crime, as well as to strengthen the police force's responsibility and self-governance, which is crucial in shaping the justice of equality as an administrative command (Bailey and Dammert, 2006).

The determination of public security expenditures, according to Kopp and Fenoglio (2003), is an important indication for evaluating the government's efforts to prevent crime. Many governments have been under pressure to cut spending and execute budgetary improvements due to very high and rising public security costs, which points to performance measurement and economic output, and outcome evaluation (Alibegovic and Slijepcevic, 2015).

As a result, taxpayer money is spent on public security institutions and organizations, primarily police operations, which is vital for the Police Department to ensure cost-effective, efficient, and effective delivery of police services. Due to the limitations of most police operations, conventional performance methodologies have not been very effective in identifying and allocating best practices within the police force (Moore and Braga, 2003; Coelho, 2013; Arie et al., 2008). This raise triggered among policymakers and official leaders, as excellent police forces operation is expected to provide public security measures and positive economic development impacts (Tiwana, Bass, and Farrell, 2015).

The study seeks to examine the relative performance of Davao City police precincts from 2015 to 2017 using a two-stage technique. In the first stage, data envelopment analysis (DEA) is used to provide a scalar measure of efficiency for all police precincts (Charnes et al., 1978). In the second stage, multiple regression is utilized to look at the external operating factors that could explain the technological inefficiencies between police precincts. The outcomes of the survey are being utilized to determine how effective Davao City police precincts are in providing better and more efficient services to the general population (Sun, 2002).

According to the Philippines Population Census (POPCEN) 2015, Davao City's annual population growth rate increased from 1,449,296 to 1,632,991, a 2.30 percent increase, on average, from 2010 to 2015. The population increased by 183,695 compared to the previous five years of 1,449,296 in May 2010. (Philippine Statistic Authority, 2019). Despite its growing population, Davao City remains one of the safest cities in Southeast Asia, according to "numbeo.com," an online user-contributed survey site, with a low crime index rate of 27.50 percent and a high safety index rate of 72.50 percent in 2019, up from fourth place last year with a safety index rate of 71.21 percent, contributing to the region's 7.11 percent economic growth. (Macapagat, 2019; Limit).

The efficiency and effectiveness of the police forces in Davao City are some of the biggest factors that drive the region's positive economic growth. Davao City Police Office (DCPO) recorded a 66 percent decrease in crime rate for 4 years at 2,311 in the first half of 2019 compared to 2018, 2017, 2016, and 2015 with 6,869 crime volume. Crime volume has decreased based on the statistics gathered from police blotters across the region totaled 12,622 in 2018. In 2015, the highest number of index-crime was at 2,218 incidents and decreased progressively in 2019, with the lowest number of focus crimes at 432. In 2019, Davao City had the highest crime clearing efficiency (CCE), or the proportion of cases cleared out of total criminal events, with 96.71 percent. Meanwhile, the crime solution efficiency (CCS) was 75.88 percent in 2015, and it gradually increased to 90.31 percent of solved cases out of the total number of crime occurrences in 2019 (Revita, 2019; Alama, 2018).

According to the Philippine Statistics Authority (2018), the City's population would double in 30 to 49 percent yearly if the current annual growth rate persists. Among Davao City's 182 barangays, three have the highest population ranks: [1] Barangay Bucana ranks first with 83,964 people, or 5.14 percent, followed by [2] Barangay Buhangin Poblacion with 65,461 people, or 4%, and [3] Barangay Ma-a with 59,803 people, or 3.63 percent, accounting for about 12.81 percent of the total population (Philippine Statistics Authority, 2018).

Furthermore, Senior Supt. Alexander Tagum, the city police director, was quoted in a press release from the City Information Office as saying, "*The expansion of the police force and precincts is necessary because the city is underserved with an estimated ratio of 1 policeman per 864 individuals*," and that "t*he DCPO needs 1,700 additional police personnel*," according to the DCPO. The DCPO proposes to virtually triple its current workforce of 1,890 to 3,497. As a result, the surviving strongholds will not be sufficient to assure the efficiency of police operations, the resolution of crimes, and the security of the growing population and economic prosperity in Davao City and the Davao Region (Colina IV; Carillo, 2018).

The Davao City government, specifically the City Mayor's Office, requested that the City Council pass a resolution to the National Police Commission (Napolcom) and the Philippine National Police (PNP), as well as sign the proposal in the Davao City Police Office (DCPO) Director, in the hopes of realizing the expansion of the City's police forces and additional police stations to provide more efficient and effective security measures

to protect the president's inauguration (Carillo; Colina IV, 2018). As a result, improving crime management and policymakers' efforts would benefit from a study of police performance efficiency. Currently, none of the studies conducted by the police precincts has aided officers in evaluating how management systems should be tweaked to improve elements that drive the efficiency of our police operations. The Davao City Police Department must ensure that police services are performed economically and effectively because police activities use a significant amount of taxpayer dollars (Sun, 2002; Colina IV, 2018). This research will look into these issues. The principles of Data Envelopment Analysis can be used to assess the relative effectiveness of police precincts in Davao City. A police precinct is a group of police officers in a certain Davao City administration district that is responsible for preventing and investigating crime. This is the first Data Envelopment Analysis study on police precincts in Davao City to the best of our knowledge.

Data Envelopment Analysis has a lot of appropriate qualities that's why it is applied to measure the relative efficiency of the 12 Davao City police precincts: [1] DEA proposes a single aggregate measure of the relative efficiencies of these police precincts in terms of their input factors to construct required outputs, also [2] it can handle several non-comparable outputs, and numerous input factors, [3] DEA can manage for feature outside the control of the DMU's being assessed, [4] it is independent on a set of previous weights for the inputs or the outputs, [5] it also required objectives for expanding outputs and/or safeguarding inputs for an inefficient police precinct to turn out to be efficient, and [6] DEA uphold fairness in performance assessment.

DEA is also a theory-driven, transparent, and repeatable analytical method. Traditional methods such as ratio analysis and regression analysis have a few advantages (Sherman, 1986). Data Envelopment Analysis has been empirically proven numerous times, which gives it a substantial advantage. According to Golany (1988), DEA is emerging as the primary tool for evaluating police precincts' efficiency in multiple research studies and applications to real-world challenges. The researcher assumes some familiarity with DEA throughout this work. Readers unfamiliar with DEA are directed to (Charnes et al., 1994) and (Charnes et al., 1994). (Cooper et al., 1994).

2. Framework of the Study

This study is attached to the following theories: Performance measurement, Decision-making units in DEA.

2.1 Performance Measurement

The foundation for conducting a performance evaluation is performance measurement. It can be used to assess a police precinct's, program's, or activity's success. The term "performance" refers to anything that has to do with completing the job, including the outcomes (Otley, 1999). The attainment of the authorized objectives is not the only criterion for measuring performance. It does, however, take into account how efficient it

is in producing high-quality police services, the comparison of actions and aims, and the efficacy with which it achieves its objectives. The police precinct's performance measurement is an important tool or device. Management should use it to make decisions and analyze performance management in each unit of the organization. One of the performance indicators is productivity. According to Frisch (2010), productivity is defined as a human-directed transformation that some people find desirable. Meanwhile, according to Sealey and Lindley (1977), transformation occurs when the input process (police resources) produces a new type of output (efficient police services). Comparing the number of outputs generated with the number of inputs consumed is the primary basis for determining productivity.

$$\text{Productivity} = \frac{\text{Outputs}}{\text{Inputs}}$$

In order to boost productivity, three key variables must be considered: labor, capital, and management. In most cases, the production process has multiple inputs and outputs. If the number of inputs is large, a method must be used to determine the total value of all inputs. As a result, a single index that can be used to quantify productivity can be created. When several outputs are in a production process, the same procedures are followed (Heizer and Render, 2009).

2.2 Decision-making Units in DEA

The business divisions in the DEA composition are particularly suited to the public sector or non-profit organization, which is made up of many "decision-making units" that perform a homogeneous function to be predictable with the DEA results, such as police precincts, schools, hospitals, or other "unit-based" public sector organizations (Charnes et al., 1978). A decision-making unit in DEA, according to Van Vliet, V. (2011), is a unit that converts inputs (police resources) to outputs (police services) and is used to study and evaluate the performance (efficiency) of homogeneous decision-making units.

2.3 Preliminary Data Analysis

According to this study, the first step in controlling Data Envelopment Analysis is to gather the input and output measurements that are important to the analysis. The purpose is to develop a statistically represented collection of essential inputs and outputs for performance measurement. From this perspective, knowledgeable police chief officers or previous studies can supply the required variables. When data is available, a multivariate statistical evaluation is required to determine the following: first, which inputs or outputs are intercorrelated; second, which inputs and outputs are associated; and last, the direction of the relationship (i.e., positive or negative).

2.4 Conceptual Input/output Measures

The following inputs and outputs for police precincts should be considered in our research, according to past research on police performance: number of various criminal activities recorded (i.e., number of burglaries);

Input measures:

- number of police officers employed;
- number of civilian employees;
- level of budget for a police precinct;
- capital equipment used for police activities (i.e., number of police cars, computers, and police vehicle radio stations); and
- other inputs (i.e., the number of civilian employees, number of posts occupied, work station, violations of public order regulations, and road accidents)

Output measures:

- number of various crime clear ups;
- number of various non-crime activities recorded, (i.e., activities for traffic control, road accidents involving serious and minor injury, the average response time of police patrols (in minutes), use of instruments of restraint and warning shots, and emergency first aid care);
- level of costs for a police precinct;
- number of police activities to prevent crime and investigate criminal cases (i.e., patrol and official inspection); and
- other outputs (i.e., quality of services).

2.5 Available Input/output Measures

The researcher fantasizes of a world where data isn't constrained to their personal possession. The Data Envelopment Analysis measurement of police precincts includes all of the inputs and outputs that a police precinct consumes and produces in order to offer service to the inhabitants of Davao City. Since it's difficult to find available second-hand data of police statistics records on the DCPO website. The researcher requested to conduct a study and obtained first-hand data in the Davao City Crime Registrar Office (barracks) and used the gathered crime statistics record as input and output indicators in the study. The Davao City Government places a great premium on maintaining law and order. As a result, the police precinct has established several goals for its services:

- to prevent crime;
- to enforce the law; and
- to protect, help and reassure the public.

The Police Precinct, in particular, strives to protect Davao City inhabitants by preventing crime and reducing high crime rates. As a result, the number of crimes reported and solved is an important input and output variable in the study. However, there is a wide spectrum of crimes, from multiple murders to vandalism. Many crime categories would muddy the study, making it difficult to get a clear picture of each precinct's performance. To develop a simple yet adequate image of crime levels and clear-

up at each precinct, the researcher uses group crimes as indicators and decides each sub-type as categorized and provided by the Davao City Crime Registrar Office in their police crime statistics data:

Group crimes are of two types:

- index crimes;
- non-index crimes.

Index crimes are of two sub-types:

- against the person (i.e., offenses including murder, homicide, physical injury, and rape);
- against property (i.e., burglaries including robbery, theft, motor napping, carnapping, and cattle rust).

Non-index crimes are of three sub-types:

- reckless imprudence (i.e., reckless homicide, physical injury, and damage to property);
- violation of special laws;
- 'others'.

There is no information on the number of civilian employees, the number of posts occupied, workstations, public order violations, road accidents, capital equipment used, and various non-crime activities recorded (such as traffic control activities, road accidents involving serious and minor injury, the average response time of police patrols (in minutes), use of restraint and warning shots, and emergency first aid care). On the other hand, because obtaining this information is specifically prohibited in their individual departments, the cost of police services and the amount budgeted for an included police precinct are not provided. As a result, the DEA model does not include this critical input and output variables.

A crime is considered "cleared up" if it has been reported in a summons, charge, caution, no further action judged appropriate, or is regarded to have been taken into consideration with another cleared up the offence. On the other hand, the following variables are established to quantify the performance efficiency of police precincts in Davao City using these two crime categories and available crime statistic data as input.

The research is based on data from the years 2015, 2016, and 2017. The Davao City Crime Registrar Office (Barracks) keeps track of total input and output statistics throughout the year. The researcher did not use data for 2018, 2019, or 2020 since annual statistical data and some crucial information for our study for these police precincts supplied by the Davao City Government were not available. As a result, the DEA model does not include these factors.

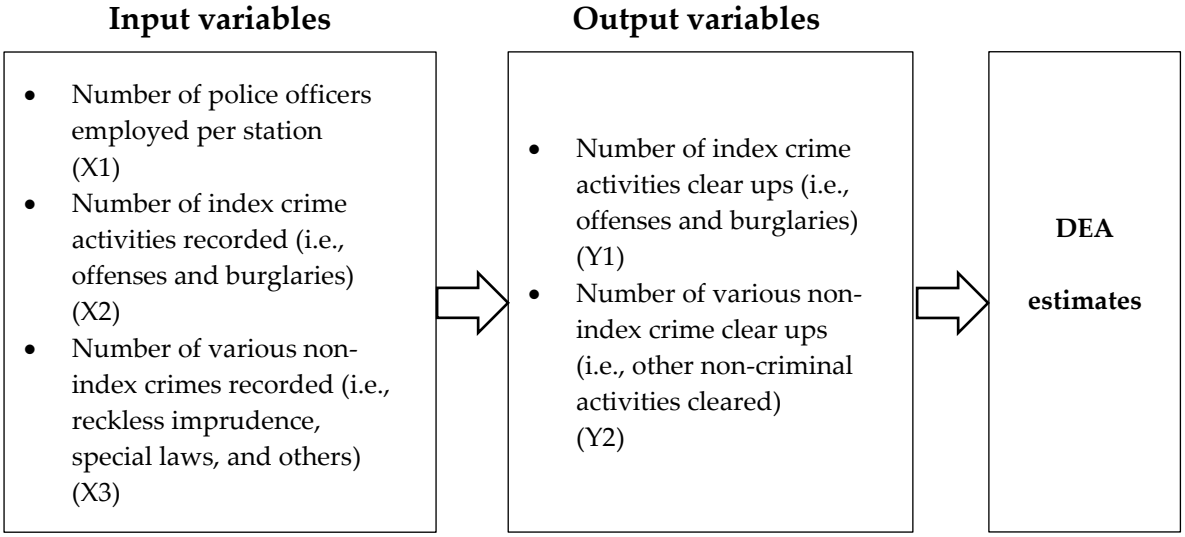

Figure 1: Conceptual Framework of the Study using DEA Model

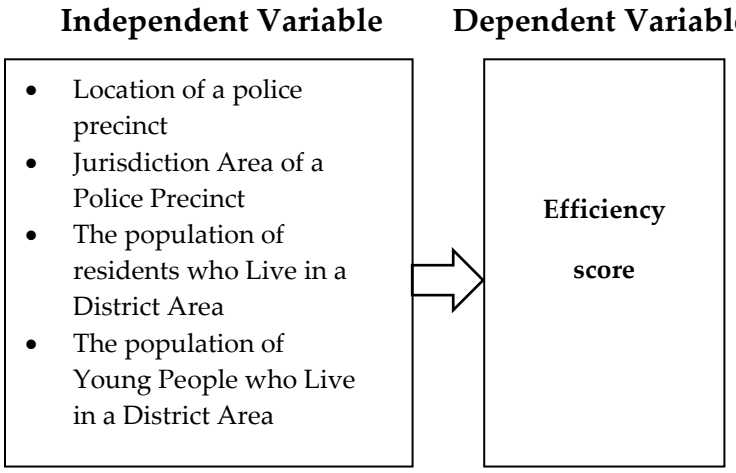

Figure 2: Conceptual Framework for Multiple Regression Model

3. Objectives of The Study

The general objective of this study is to measure the efficiency of 12 Police Precincts in Davao City, Philippines, using Data Envelopment Analysis. Specifically, the study aimed to:

a) To identify the plausible input and output variables in measuring the performance efficiency of police precincts in Davao City.
b) Measure the performances and identify the most efficient and inefficient police precincts.
c) To provide recommendations for inefficient police precincts in Davao City to improve their efficiency.
d) Determine the external elements or operating conditions that have a substantial impact on the efficiency of police precincts, such as geography and socioeconomic considerations.

4. Materials and Methods

4.1 Research Design

This study adopts a non-parametric research design. According to Salkind (2010), a non-parametric research design refers to techniques of measurement that do not rely on evidence that the data are drawn from a specific distribution. A non-parametric research design is used to make a statistical conclusion. This study will probe the efficiency of Police Precincts in Davao City, Philippines.

In practice, when the regularity of evidence on the analysis is not satisfied, a parametric research design might give misleading results. Conversely, a non-parametric research design makes less strict distributional evidence on the analysis (Salkind, 2010). On the other hand, the non-parametric research design is also cited as an "order test" or "ranking test." Numerous non-parametric tests use as their data the orders of the observations (i.e., classificatory data), while others are useful with data for which even ranking is impossible.

4.2 Research Subject

The research motive for this study conduct to include the 12 selected police precincts in Davao City. Table 1 shows the decision-making units or Police Precincts that meet the criteria to qualify for the study. Police Precincts are in Davao City, Philippines, and the Police Precinct is homogenous in inputs and outputs.

4.3 Decision-making Units

Table 1: Lists of DMU's subjects for the 12 Police Precincts studied (36 observations)

#DMU	Police Precincts
DMU01	Police Station 1
DMU02	Police Station 2
DMU03	Police Station 3
DMU04	Police Station 4
DMU05	Police Station 5
DMU06	Police Station 6
DMU07	Police Station 7
DMU08	Police Station 8
DMU09	Police Station 9
DMU10	Police Station 10
DMU11	Police Station 11
DMU12	Police Station 12

4.4 Research Instrument

The researcher developed three instruments for the study: first, he gathered first-hand crime statistics from the Davao City Crime Registrar Office; second, he adapted parts of the first-hand data's input and output indicators from a prior study (Thanassoulis 1995, Aristovnik et al. 2014 and Carrington et al. 1997). Second, use the DEA model's important

extensions to improve our performance efficiency estimates, especially the three-year window analysis to determine which areas an inefficient unit needs to improve, and output-oriented DEA models with both constant and variable returns to scale to determine the efficiency scores obtained from solving DEA model linear programming problems. Third, multiple regression analysis is used to determine the significant relationship between technical efficiency scores and operating environmental parameters.

4.5 Research Procedures

The following are the steps done to gather the data that is utilized in the study:

4.5.1 Permission to Conduct a Study

The researcher asks permission from the City Police Director to request a first-hand copy of the City's Crime Statistics Data that include each asset and expenditure of the 12 selected police precincts in Davao City.

4.5.2 Collect Data

The first-hand data are manually gathered through the Davao City Police Office (DCPO), Barracks. The data have been collected, tabulated, and analyzed using appropriate statistical tools.

4.5.3 Analysis and Interpretation

After retrieving the results, these have been analyzed and interpreted with the help of the statistician.

4.6 Statistical Treatment of Data

The statistical tools employed in treating and evaluating the data are the following:

a. Window Analysis

The research was limited to the performance of police officers assigned to a police station. From a technological aspect, the study made use of several key extensions to DEA models. They evaluate 12 precincts/decision-making units utilizing 5 measures/variables using the window approach (Charnes et al. 1985) to deal with degrees of freedom problems (DMUs). The researcher will utilize three years to do the efficiency analysis. For each of the three consecutive years in a window (2015, 2016, 2017), each DMU will represent a separate DMU, as well as an examination of the 36 (= 312) DMUs. Window analysis can be used to assess trends and potential stability difficulties, as Klopp (1985) points out, which will be taken into account in the study.

b. CCR and BCC Model Analysis

In some circumstances, non-discretionary input variables are used. There are two types of criminal activity: (1) index criminal activities (such as burglary and offenses) and (2) non-index criminal activities (i.e., reckless imprudence, special laws, and other crimes). The only element that may be adjusted is the number of police officers in each precinct. The researcher uses Banker and Morey's modified DEA model for these (1986). The

researcher uses CCR and BCC models to quantify overall, technical, and scale efficiency for these precincts. Calculate the sum of all lambdas for each precinct to understand what type of scale efficiency an impact on these precincts has, in terms of increasing or decreasing returns to scale. According to Banker and Thrall (1992), if the sum of all lambdas for a DMU is greater than 1.0, there is a falling return to scale (DRS); if the sum of all lambdas for a DMU is less than 1.0, there is a rising return to scale (IRS) (IRS).

When the sum of lambdas for a DMU is 1.0, the constant return to scale (CRS) occurs. Cooper et al. provide a single source for all of the above sources (1994). Although the efficiency scores obtained from solving linear programming problems for DEA models show management's ability to convert inputs into outputs at the current scale of operation, additional external factors beyond management's control may impact.

c. Multiple Regression Analysis

The efficiency ratings for the Data Envelopment Analysis model developed by researching linear programming challenges, on the other hand, show police management's ability to change input elements into output factors at the current scale of operation. Other external elements or environmental indicators beyond police management's control may impact efficiency. The researcher wants to know which external factors have a major impact on technical efficiency variations between police precincts and in which direction. Multiple regression analysis is used to determine the relationship between technical efficiency ratings and operating environmental parameters. The following model is examined by the researcher:

$$TE = ð + Zß + u$$

Where:

TE is a vector (Jx1) of technical efficiency for J police precincts. The scalar ð and the (Rx1) vector ß are unknown parameters to be estimated, Z is a (JCR) matrix of environmental factors, and u is a (Jx1) vector of residuals.

d. Production Model Analysis

Based on the preliminary investigation, the researcher considers a production model that includes all three inputs and two outputs to evaluate the relative efficiency of police precincts in Davao City. The collection of input-output variables will be used if the precincts are to perform and locate the best precincts, so that the efficiencies obtained will reflect the extent to which clear-ups in a precinct will rise given its crime levels and workforce. Data on computers, automobiles, and other items were excluded because the capital equipment utilized by all police precincts is extremely uniform. In addition, these statistics were not available. The evaluation will be outcome-oriented, based on the assumption that crime levels will be largely outside the police's control, and that efficient operations will, at the very least, result in greater clear-ups rather than reduced crime levels.

The study's assessment of police precinct performance is comparable to those of other studies (Thanassoulis 1995, Aristovnik et al. 2014 and Carrington et al. 1997). The researcher is especially intrigued by the obvious increases in crime that occur during every police operation. The researcher assumes continuous returns to scale when converting crimes to clean-ups. As Thanassoulis (1995) points out, if there is no reason to believe that the proportion of harder-to-clear instances depends on the actual percentage of cases cleared, this assumption is likely to be safe. As the percentage of criminal cases cleared rises, the number of difficult-to-clear cases may rise as well.

e. Data Envelopment Analysis Tool

Throughout the examination, the researcher relied on output-oriented DEA models. The CCR model is used to calculate technical and scale efficiencies, whereas the BCC model is used to measure relative efficiency. For mathematical computations, Banxia Software Ltd's Frontier Analyst, a DEA-based software tool, is used.

f. This is a Sample Map

Our sample comprises 12 randomly chosen police precincts in Davao City, Philippines, and represents all of the City's police precincts. The location of these precincts is depicted in Figure 3 on a map of Davao city. Other police agencies will be excluded from the study because they are separate individual police forces, such as the Police Operations Branch, Police Commission Relations Branch, Police Intelligence Branch, Police Invest and Det Mgt Branch, City Mobile Force Company, Police Mobile Patrol Group, Police Foot Patrol Section, Tourist Police Unit, and Traffic Police Group.

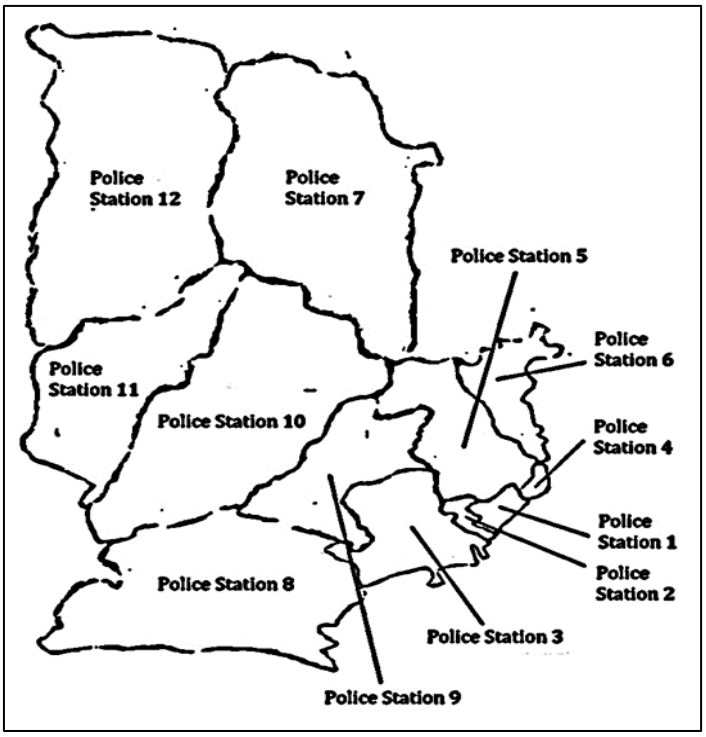

Figure 3: A map of Davao city showing the locations of the 12 police precincts studied

5. Results and Discussion

Table 2 shows the RTS results for the 12 precincts analyzed and a window analysis of overall, technical, and scale efficiencies. Note that (1) nearly 53% of the 36 DMUs are overall inefficient, with an average overall efficiency score of 96.62; (2) approximately 61 percent are technically inefficient, with an average technical efficiency score of 97.64; (3) 47% are scale inefficient, with an average scale efficiency score of 98.91; and (4) the returns to scale categories for IRS, CRS, and DRS are 19, 17, and 0 DMUs, respectively. Police Station 1, Police Station 7, and Police Station 8 received overall efficiency ratings of 100, 100, and 100 for three independent DEA assessments, indicating that they are overall efficient across the three research years. These three precincts are also technically and scale-efficient; Police Stations 11 and 12 have been operational for three years.

Our DEA studies indicated that 17 of the 36 DMUs have a 100 percent overall efficiency score. Police Stations 1 (2015-2017), 2 (2017), 5 (2015), 6 (2015), 7 (2015-2017), 8 (2015-2017), 10 (2015), 11 (2015, 2017), and 12 (2015, 2017) were among them (2015, 2017). The other precincts are inefficient in general, with efficiency scores below 1.0. The technical efficiency of 22 of the 36 DMUs is 100 percent. Police Station 1 (2015-2017), Police Station 2 (2015, 2017), Police Station 3 (2016, 2017), Police Station 5 (2015), Police Station 6 (2015), Police Station 7 (2015-2017), Police Station 8 (2015-2017), Police Station 10 (2015), Police Station 11 (2015-2017), and Police Station 12 (2015-2017) are the most efficient police precincts (2015-2017). The other precincts are deemed to be inefficient in terms of technology.

Table 2 also shows that the average scale efficiency was 98.91 percent. If a police precinct can run at constant returns to scale, this predicts a further potential output improvement of 1.09 percent. Table 5 shows that 19 DMUs operate at the appropriate scale: Police Station 1 (2015-2017), Police Station 2 (2017), Police Station 4 (2015), Police Station 5 (2015), Police Station 6 (2015), Police Station 7 (2015-2017), Police Station 8 (2015-2017), Police Station 9 (2015), Police Station 10 (2015), Police Station 11 (2015, 2017), and Police Station 12 (2015, 2017). (2015, 2017). 17 DMUs, on the other hand, are seeing rising returns to scale. This means that if present operating output levels are increased, the performance of the last-mentioned precincts could improve.

Table 2 is ideal for examining patterns and potential issues within the window. Take, for example, Police Station 9's overall efficiency score of 99.3 from 2015. This number differs significantly from the efficiency scores of 93.4 (-5.9%) and 93.5 (-5.8%) from the 2016 and 2017 examinations. More inquiry should be explored given the poor and decreasing relative efficiency scores for Police Station 9. In 2015, Police Station 2 was discovered to have 97.2 overall efficiencies. However, this figure differs significantly from the efficiency ratings of 97.5 (+.003%) and 100 (+2.8%) found in the 2016 and 2017 evaluations, respectively. Overall efficiency ratings for Police Station 2 show an improving tendency, particularly in the last year of the three-year research period, which could be beneficial in analyzing its performance.

Table 2: The efficiency of the 12 police precincts for the period 2015-2017

			Efficiency measures (%)			RTS
Precinct	**Term**	**DMU Code**	**Overall**	**Technical**	**Scale**	
Police Station 1	2015	1-15	100	100	100	CRS.
	2016	1-16	100	100	100	CRS.
	2017	1-17	100	100	100	CRS.
Police Station 2	2015	2-15	97.2	100	97.2	IRS
	2016	2-16	97.5	97.6	99.9	IRS
	2017	2-17	100	100	100	CRS.
Police Station 3	2015	3-15	90.8	90.9	99.9	IRS
	2016	3-16	89.8	100	89.8	IRS
	2017	3-17	98.7	100	98.7	IRS
Police Station 4	2015	4-15	92.3	92.3	100	IRS
	2016	4-16	96.2	96.5	99.7	IRS
	2017	4-17	98.5	98.7	99.8	IRS
Police Station 5	2015	5-15	100	100	100	CRS.
	2016	5-16	75.4	80.1	96.1	IRS
	2017	5-17	93	93.2	99.8	IRS
Police Station 6	2015	6-15	100	100	100	CRS.
	2016	6-16	92.1	92.4	96.6	IRS
	2017	6-17	95.3	95.6	99.7	IRS
Police Station 7	2015	7-15	100	100	100	CRS.
	2016	7-16	100	100	100	CRS.
	2017	7-17	100	100	100	CRS.
Police Station 8	2015	8-15	100	100	100	CRS.
	2016	8-16	100	100	100	CRS.
	2017	8-17	100	100	100	CRS.
Police Station 9	2015	9-15	99.3	99.3	100	IRS
	2016	9-16	93.4	94.4	98.9	IRS
	2017	9-17	93.5	93.7	99.8	IRS
Police Station 10	2015	10-15	100	100	100	CRS.
	2016	10-16	94.3	94.9	99.4	IRS
	2017	10-17	95.3	95.5	99.8	IRS
Police Station 11	2015	11-15	100	100	100	CRS.
	2016	11-16	88.3	100	88.3	IRS
	2017	11-17	100	100	100	CRS.
Police Station 12	2015	12-15	100	100	100	CRS.
	2016	12-16	97.5	100	97.5	IRS
	2017	12-17	100	100	100	CRS.
		Mean	96.62	97.64	98.91	
Number of DMUs: 12 x 3=36.						

Similarly, utilizing the technical and scale efficiency ratings acquired for these precincts, one can assess trends and potential stability issues.

Table 3 summarizes the data of Table 2 in yet another way that we believe is beneficial. For example, despite having the lowest overall mean efficiency score (89.47), Police Station 5 has a quite high variance. Part of the reason for the last mention could be the DMU's very low overall efficiency rating of 75.4 in the 2016 review. As a result, we

recommend that this DMU be placed aside for further investigation. In Table 6, on the other hand, low means are frequently accompanied by significant variances. The mean technical efficiency values of Police Station 3, Police Station 5, and Police Station 6 are all found to be high (96.97, 91.1, and 96, respectively). In addition, each of these precincts has a wide range of overall efficiency scores. The low ratings of 90.9 for Police Station 3 (2015), 80.1 for Police Station 5 (2016), and 92.4 for Police Station 6 (2016) evaluation of these DMUs may explain the wide variation in their efficiency ratings.

5.1 Multiple Regression Analysis

As previously mentioned, regression is utilized in the second-stage analysis to explain the variation in DEA technical efficiency scores from the first stage. We found numerous environmental variables or non-controllable inputs that may affect the efficiency of a police precinct based on prior police reports of crime statistic data from 2015 to 2017. The majority of offenders, according to police, are young persons between the ages of 15 and 29. A police jurisdiction with a larger population of young people is more likely to respond to more occurrences than one with a smaller population. In addition, a precinct with a larger population of residents in its jurisdiction is more likely to respond to more crime than one with a smaller population.

Table 3: Mean-variance analysis across windows

	Overall efficiency			Technical efficiency		
Precinct	**Mean**	**Variance**	**Group**	**Mean**	**Variance**	**Group**
Police Station 1	100	0	I	100	0	I
Police Station 2	98.23	2.36	II	99.2	1.92	II
Police Station 3	93.1	23.77	IV	96.97	27.6	IV
Police Station 4	95.67	9.82	IV	95.83	10.57	IV
Police Station 5	89.47	160.65	IV	91.1	102.31	IV
Police Station 6	95.8	15.79	IV	96	14.56	IV
Police Station 7	100	0	I	100	0	I
Police Station 8	100	0	I	100	0	I
Police Station 9	95.4	11.41	IV	95.8	9.31	IV
Police Station 10	96.53	9.26	IV	96.8	7.77	III
Police Station 11	96.1	45.63	IV	100	0	I
Police Station 12	99.17	2.08	II	100	0	I
Group: (I) very low; (II) low; (III) medium; (IV) high						

A precinct covering a bigger jurisdiction area necessitates more police officers than the services they give to the community justify. Due to a lack of staff, a precinct with a larger jurisdiction is more likely to respond to more offenses than a smaller one. Finally, a police precinct in a downtown area is more likely to respond to more crime than one in a suburban area.

The jurisdiction areas of the police precincts covered here and their populations and populations of young people are based on statistical data collected between 2015 and 2017. A dummy variable is used to define the location of a police precinct, with a value

of 1.0 indicating that it is located downtown and 0.0 indicating that it is located in the suburbs. Because they respond to more crime, police precincts with a higher population of young people or residents are projected to be more inefficient than those with lower populations of similar socioeconomic circumstances (i.e., they have less indolent time). Nonetheless, we predict downtown police precincts have greater measured outputs than their suburban counterparts because they are generally more closely supervised. Precincts with bigger jurisdictions are less efficient than those with smaller jurisdictions since providing an effective service requires more inputs (i.e., officers).

Table 4: Results of multiple regression

Variables	Regression coefficient	Significant	Decision
LOC	-0.496	0.790	Not significant
YOU	-5.586E-5	0.010*	Significant
AREA	0.000	0.897	Not significant
YOU	0.000	0.038*	Significant
CONSTANT	101.019		
R^2	0.740		
[a]AREA: jurisdiction areas of police precinct; LOC: location of a police precinct; RPOU: population of residents who live in a district area; YPOU: population of young people who live in a district area.			

Technical efficiency scores are regressed against the location, the jurisdiction area, the population of residents, and the population of young people who live in a police jurisdiction to see if environmental factors affect the efficiency of police precincts. Table 7 shows that the population of residents and young people who live in a police jurisdiction region are significant at P = 0.05, explaining nearly 74% of the difference in technical efficiency scores. The location of a police precinct and the jurisdiction areas of police precincts, on the other hand, are irrelevant. Furthermore, we find that several of these environmental variables impact the effectiveness of the police precincts investigated.

Our findings support Carrington et al. 1997's conclusion that changes in operating conditions, such as location and jurisdiction area, are insignificant. Since police-to-population trust has risen empirically and conceptually, several socioeconomic elements, such as the population, either young people or residents who live, especially in urbanized regions, have a considerable influence on the efficiency of police patrols, according to Roche et al. 2020. The public's faith in the police force can be defined in two ways on an empirical scale: diffuse support and specific support. The people's agreement on the policeman's mission, which is related to their opinion and trust, is the source of widespread support. Following that, the specific support examines the efficiency with which police officers perform their tasks. Their effectiveness in reducing crime and ensuring public safety are two examples. However, as compared to other regions, the EU has a 20% lower rate of specific trust.

The IPCAN paper also looked at the police's "discriminatory effectiveness" towards minorities. According to a survey, minorities, particularly the black adult

minority, are subjected to more frequent police checks. Discrimination is seen to be a factor in police-community relations (Roche et al. 2020).

Furthermore, over the last 25 years, uncontrolled global urbanization has resulted in deplorable living conditions, contributing to a progressive deterioration of quality of life and urban social fabric, as well as contributing to an increase in crime in all forms and posing a threat to individual security and city social and economic development (Chalom et al. 2001). As a result, in communities where a growing percentage of the population is excluded from the educational system or the labor market, many people, particularly young people, see themselves as destined for alternative models of success and peer recognition, which can include illicit and criminal activities or lead to violent behavior. Aside from the impact of uncontrolled urbanization, the political and economic climate and culture and customs all have a role in establishing a social atmosphere conducive to violence (Vanderschueren, 1996).

6. Conclusion

The following conclusion is drawn in relation to the gathered data:

1. Police stations can be rated based on their relative efficiency. The overall technical and scale performance of police stations is assessed by comparing their clear-up levels to their crime and workforce numbers. The evaluation looked at the performance of possibly weak and strong police stations, their efficient peers, and the clear-up levels that would make inefficient police stations efficient. Particularly, Police Station 1, Police Station 7, and Police Station 8 are already functioning at a high level. Other police stations are seeing greater returns to scale and may increase their output levels to become more efficient.
2. In their analysis of DEA, the researchers discovered that having higher and larger manpower levels is associated with higher and better output performance efficiency. This discovery is in line with Thanassoulis' findings from 1995. Nonetheless, they state in their analysis that various variables in operational settings, particularly socioeconomic criteria such as inhabitants and the population of young people, have a substantial impact on the effectiveness of police precincts (Roche et al. 2020; Chalom et al. 2001; and Vanderschueren, 1996).
3. The researchers point out highly aggregated output and input components metrics as a few reminders. Some crucial qualitative output measurements, such as the quality of employees' labor and police budget and cost, are not considered. It would be preferable to treat these desirable results in the models utilized here explicitly. Nonetheless, our straightforward technique would be valid. Finally, it is important to recognize that the researcher's findings are indications of relative efficiency (or inefficiency), which are merely a means to an end, namely, efficient operations, rather than an end in and of themselves. Finally, the gathered data will guide the Davao City Police Stations to conduct additional investigations and improve their police station's performance efficiency.

6.1 Recommendations

The researchers recommended the following based on the results and conclusions given.

1) To Philippine National Police, the researchers recommend forming a method to rationalize the police force's operation to bolster police precincts or departments which lag in DEA standards. Additionally, the Philippine National Police should strengthen their relationships with their communities by setting up public or virtual fairs (more cost-efficient) to bolster the people's awareness of this noble job, leading to stronger barangays.
2) To Police Precincts, the researchers recommend that the precincts that are found to be inefficient can improve their efficiency by allowing themselves to mimic their efficient peers' processes, methods, and techniques. Excellent police precincts are born out of a good role model. If each precinct imitated the excellent practice of their peers, soon the community will follow the positive example. This sociological strategy is free. We hope all the precincts will start by becoming a positive example.
3) To City Mayor's Office, the researchers recommend City Mayor's Office develop policies to backup police precincts or departments for continuous improvement in overall efficiency. We further recommend City Mayor's Office increase the police population ratio of 1 to 500 per police officer to 3 to 500 per police officer. Additional police stations can be established in preparation for the growing economic development that is recently happening in the City of Davao.
4) To Future Researcher, the researchers recommend that future analysts direct further research on police precincts considered inefficient based on DEA principles. An example to aid them in this further research is to obtain the number of employees per police precinct, cost, budget per precinct, and the cost for police equipment since these data are confidential and unavailable.

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Conflict of Interest Statement

The authors declare no conflicts of interests.

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