ABSTRACT

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Clearance rates have dropped throughout the United States over decades, especially for homicide cases. Clearance is the most common measure by academics and the public to evaluate the ability of police agencies. The declining trend of homicide clearance rates implies the inability of police to protect society. The purpose of this study is to determine what police agencies can do to improve homicide clearance rates. The sample contains homicide clearance rates in the 100 largest U.S. cities in 1987, 1990, 1993, 1997, and 2000. The model estimation for this panel data is the Ordinary Lest Squares regression using Fixed-Effects Lease Squares Dummy Variables approach. The model examines the effect of the number of officers, the percent of officers in investigative functions, operating budgets, and computer use on homicide clearance rates. The findings show that three of the determinants (not including budgets) can significantly improve homicide clearance rates for the 100 departments. No determinants of interest are found from the high-clearance departments to prescribe changes for other departments.

HOMICIDE CLEARANCE DETERMINANTS: AN ANALYSIS OF THE POLICE DEPARTMENTS OF THE100 LARGEST U.S. CITIES

By

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To my parents, Ping-Hui Hsu and Hui-Ming Teng

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CHAPTER ONE: INTRODUCTION

Overview

In recent decades, the rate of closing criminal cases, especially homicide cases, has declined (Wellford & Cronin, 1999). According to the Federal Bureau of Investigation (FBI), the U.S. clearance rate for homicides in 1965 was 91%; however, it dropped to only 62% in 2005 (FBI, 1976, 2005). The declining trend implies an inability of the police to arrest the offenders and to protect society (Riedel & Jarvis, 1999; Wellford & Cronin, 1999).

One of the primary functions of the criminal justice system is to arrest offenders. When an offender has been arrested, charged with the offense, and turned over to the court for prosecution, a police agency can claim a case solved (FBI, 2005). None of the punishments can be performed before a police agency has made any arrest. According to Cesare Beccaria's 1764 treatise, *On Crimes and Punishments,* the criminal justice system should punish wrongdoers with severity, certainty, and celerity, preventing them from committing future crimes, and deterring the public from committing crimes. The decline in clearance rates indicates low celerity and certainty (Wellford & Cronin, 1999), and signals to the public that the offenders are still at large. Public concerns of crimes would be amplified by the widespread perception that law enforcement agencies are incapable of controlling the crime problem. The decline also implies that the criminal justice system is unable to prevent the offenders at large from committing other crimes, and to deter the public from engaging in crime.

The homicide rate doubled from the mid 1960's to the late 1970's; it peaked at

10.2 homicides per 100,000 people in the 1980's and fluctuated afterward. The rate decreased sharply from 1992 to 2000, and then it remained stable (BJS, 2007). Despite increases and decreases in the homicide rate over the past few decades, the clearance rate for homicide declined consistently. Exploring the increase and decrease in the homicide rate trend does not directly explain the declining homicide clearance trend. It would be of interest for researchers and law enforcement officials to know what factors contributed to the decline in homicide clearance rate over those years.

The decline in clearance rates happens not only to homicides cases, but also to cases involving rape, assault, robbery, etc. (Riedel, 1995). However previous studies have focused on homicides for several reasons. First, homicide data are thought to be the most reliable and comprehensive among the Uniform Crime Reporting (UCR) program's Violent Crime Index (Mosher, Miethe, & Phillips, 2002; Riedel, 1995). As stated by the BJS, "At a national level, no other crime is measured as accurately and precisely as homicide cases." Second, homicide is the most severe violent crime, and researchers have noted that uncleared murderers often involve repeat offenders such as robbers and other kinds of felony offenders (Reidel, 1993). Murderers at large are a serious threat to the public safety and cause fear in society. Anything that can suggest solutions to curb homicide rates is welcome. Thus, the present study is focused on homicide cases.

Why did the homicide clearance rate decline over those years? Previous research effort can generally be divided into three categories: 1) the nature of homicide. For example, victim's characteristics and weapons used have been found significant determinants when police are prioritizing investigations (Addington, 2006; Wellford & Cronin, 1999). 2) The behavior of witnesses. Many researchers have recently turned to

study the role of witnesses, and noticed the importance of information they provided (Riedel, 1995; Riedel & Jarvis, 1999; Wellford & Cronin, 1999). 3) The change in the police resources. There has been interest in the officer characteristics such as detectives' experience, workloads (Puckett & Lundman, 2003), skill and training (Greenwood, Chaiken, & Petersilia, 1977). Although previous researchers have noticed these officer characteristics, rather less attention has been paid to the police *resource* characteristics such as department size and computer usage (Wellford & Cronin, 1999). As for policy implications, *it seems more practical to invest in police resources than to change the nature of homicides or the behavior of witnesses*.

One of the famous studies relevant to police resource characteristics and homicide clearance was conducted by Wellford and Cronin in 1999. They noticed that some cities had stably high homicide clearance rates and some had stably lower rates, while the U.S. homicide clearances had been declining for decades. They examined a total of 215 variables which relate to the characteristics of the incidents and its investigation, and evaluated their influences to the status of the cases (solved or unsolved). Their results demonstrated that the allocation of police resources, such as department size and computer use, is a critical determinant for solving homicides. While Wellford and Cronin (1999) examined the characteristics of the incidents and investigative process that led to clearance, the present study focuses on only those variables related to police resources.

However, very few studies have been conducted on the effects of police resource characteristics on homicide clearance rates. The effects of police resource characteristics have been broadly applied to predict total clearances (Greenwood et al., 1977; Stevens, Webster, & Stipak, 1980). Or the effects have been applied to predict clearances of other

types of crimes such as robbery clearances (Greenwood et al., 1977). Clearly, there is a need for a comprehensive study on the effect of these police resource characteristics on homicide clearance rates. The present study will focus on a set of factors relevant to solving homicides in an attempt to suggest ways to improve police effectiveness and to protect the public.

Research Strategy

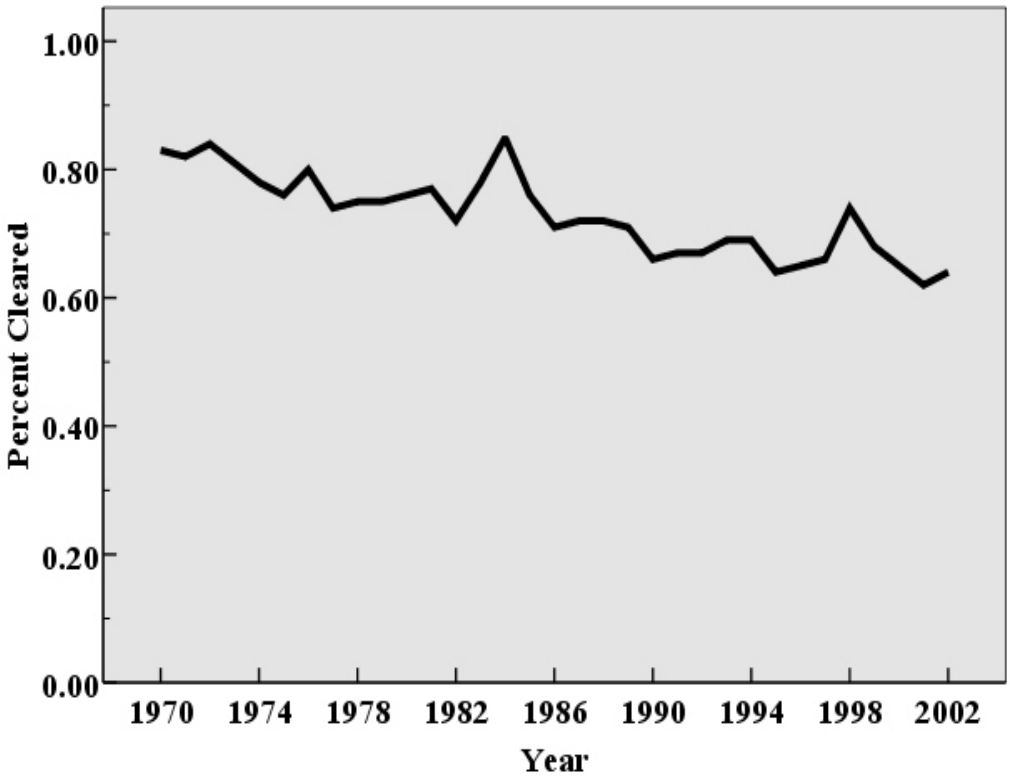
The evaluation of police performance has long depended on crime statistics provided by the UCR program. The UCR is believed to be a benchmark for measuring police performance (Davies, 2003). Thus, this study will analyze clearance data from the UCR program.

Clearance rates have been frequently used to evaluate a police agency's performance (Cordner, 1989; Greenwood et al., 1977; Wellford & Cronin, 1999). A clearance rate is the ratio of solved cases to reported cases (Greenwood et al., 1977). There are disagreements about using the clearance rate to evaluate police efficiency; for example, Cordner (1989) argued that clearance rate is susceptible to manipulability and measurement error, though it is still the most commonly used measure by researchers and the public.

This analysis is based on a pooled cross-sectional time-series sample of homicide clearance rates in the 100 largest U.S. cities in 1987, 1990, 1993, 1997, and 2000. Large cities are selected because of the considerable impacts they made on the homicide problem in the United States (BJS, 2007; Wellford & Cronin, 1999). It was found that changes in U.S. homicide rates have been substantially driven by changes in the homicide

rates in large U.S. cities. For example, over half of the homicides happened in cities with a population of 100,000 or more from 1976 through 2005 (BJS, 2007). Figure 1 was created from utilizing the full sample. The declining pattern in Figure 1 is similar with the pattern of the U.S. homicide clearance rates[1].

Figure 1. The Homicide Clearance Rate in 100 Largest U.S. Cities, 1970-2002

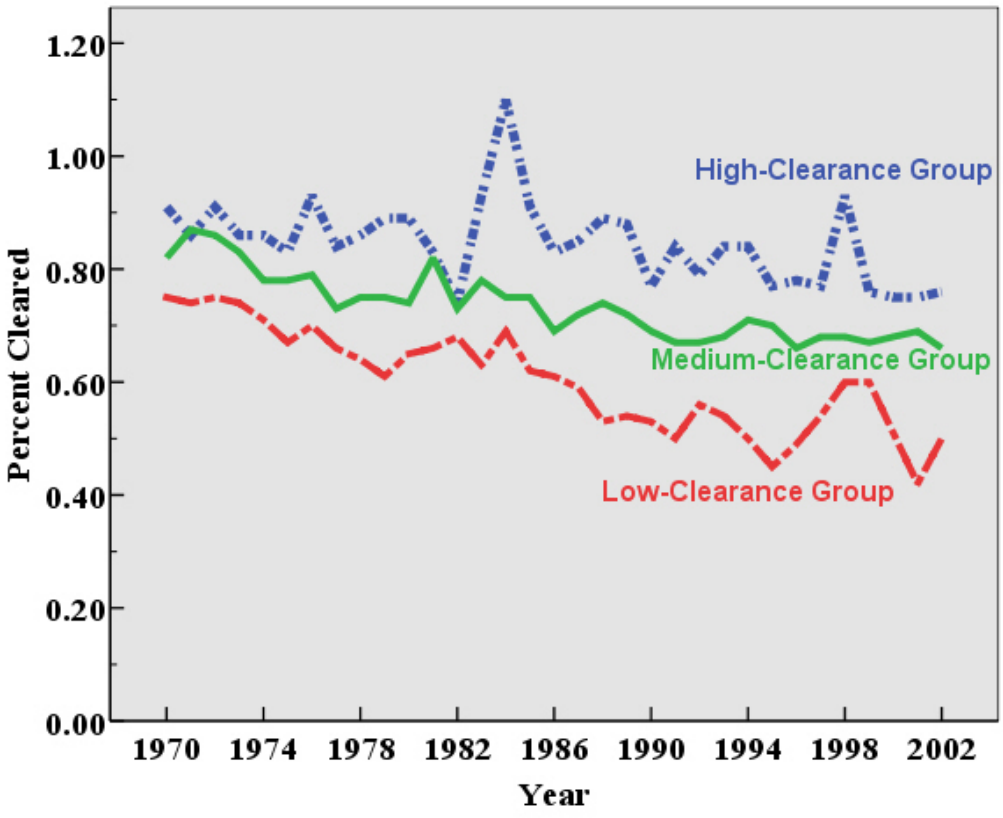


As demonstrated by Wellford and Cronin (1999), homicide clearance rates in some cities remained stably high, while some remained stably low. This suggests that certain factors may exist in those departments that produced their consistently high

[1] In the full sample of the 100 police departments, the correlation between the homicide clearance rate and homicide rate is -0.1975, demonstrating that the two variables are negatively related. Thus the rate of homicide does not explain the rate of clearance during this time period for these cities.

clearance rates. Accordingly, apart from the full sample of the 100 police departments, these departments are ranked and sorted into three groups by their homicide clearance rates. It is anticipated that by understanding what factors account for cities having high homicide clearance rates, we may prescribe changes for other departments to improve their homicide clearances. Figure 2 shows the homicide clearance trends of the three groups.

Figure 2. The Homicide Clearance Rates of the Three Groups, 1970-2002



Data on the dependent variable, homicide clearance rates, were drawn from the dataset provided directly by Professor Charles Wellford; this dataset was collected

annually from the UCR program by Professor Wellford and his staff.

Data of the explanatory variables were drawn from the Law Enforcement Management and Administrative Statistics (LEMAS), which provides a variety of organization and administration data on state and local police departments. Many other police characteristics may affect homicide clearance (e.g., medical evidence, forensic examinations, and witness information); however, because of the data limitation, data relating to budgets, officer statistics, police-officer job functions, and computers[2] were selected for analysis.

The distributional pattern of the dependent variable appears closely normal, thus, Ordinary Least Squares (OLS) regression is used. In addition, fixed-effects least squares dummy variable (LSDV) approach (Hsiao, 2003, p.30) is selected for this panel data analysis in order to control for effects of omitted variables that could violate the OLS assumption.

Contribution to the Field

The results of the present study are anticipated to contribute to the knowledge and understanding of law enforcement personnel, and the large academic research community. To the academics, the present study emphasized the value and importance of the police resource characteristics on clearing homicides, which have been underestimated by previous researchers. For example, Wellford and Cronin (1999) have demonstrated the importance of computer usage on checking the decedent, the suspect, a witness, and a

[2] LEMAS also provides data of digital imaging (fingerprint, mug shot, and suspect composite) and video camera for analyzing technology uses, but only available for both 1997 and 2000. Therefore, they are omitted from the present study.

gun. While certain factors have been found positive to clearing homicides, little follow-up research had been done to support the influence of these findings. Hence, this study will discover what has been studied, extend what is promising, and try to compensate for what has been ignored in the previous research.

For policy makers in the criminal justice system, the present study is anticipated to allow them to better acknowledge how to allocate police resources to improve clearance. One very fundamental goal of the criminal justice system is to protect the society. Clearing crimes is one way to achieve it. Hence, this study will examine several police resource characteristics that are anticipated to be positive on changing the homicide clearance rates, and demonstrates that those factors are significant and promising for the policy.

Subsequent Chapters

This study examined the effect of police department characteristics on homicide clearance. Chapter Two is a literature review of all identified determinants for homicide clearance rate, and the determinants of interest that have been ignored by previous research. Chapter Three introduces the sample-collection processes and model specification. In Chapter Four, statistical results are displayed and interpreted. Chapter Five declares the discussions of the findings, along with the differences between previous literatures. Limitations of the present study, conclusions, and their implications for criminal justice policy and future research will be presented.

CHAPTER TWO: LITERATURE REVIEW

Over the past few decades, the trend for closing homicide cases has been downward (Riedel, 1995; Wellford & Cronin, 1999). A few studies have examined the trend and patterns of homicide rate, but exploring the increases and decreases of homicide rates does not directly explain the declining trend for clearing homicide cases. In any case, studies that directly examine the factors affecting homicide clearance are decidedly limited.

The structure of this chapter is as follows: first, a definition of the terms essential to homicide clearance rate, as well as issues relating to measurement. Then, it identifies the determinants typically addressed in the previous literature of homicide clearance. A separate discussion of the study by Wellford and Cronin (1999) will be displayed because of its significance among the homicide clearance literature. Then based on the findings and suggestions of the Wellford-Cronin study, several important determinants of interest (police resource characteristics) that are relevant to crime clearances will be reviewed in detail. These crime clearances are not limited to homicide cases because of the absence of literature. Finally, a summary of the exiting literature will be displayed, and it will introduce the methodology chapter that follows.

Definition of Homicide Clearance Rate

Homicide

According to the definition by the Uniform Crime Reporting (UCR) program of the Federal Bureau of Investigation (FBI), two types of offenses are classified as homicide: 1) murder and nonnegligent manslaughter, and 2) manslaughter by negligence. Cases such as suicide, accidental deaths, traffic fatalities, assault to murder, and attempt to murder are not defined as homicide cases. When an offender's death is caused by a police officer or by a private citizen during the commitment of an offense, the appropriate term is "justifiable homicide" (FBI, 2004).

Clearance

A clearance is declared when a case is "closed" by the police. According to the UCR program, a case can be reported as cleared as a result of either 1) an arrest, where the suspect is arrested, charged, and actually turned over to the court for prosecution, or 2) "exceptional means," where the case is beyond the law enforcement agency's control—for example, the offender died at the scene, the offender was already sentenced for another offense, or the victim refused to cooperate with the police to prosecute the offender (FBI, 2004; Litwin, 2004; Wellford & Cronin, 1999).

Homicide Clearance Rate

A homicide clearance rate is calculated by dividing the number of homicides cleared in a given year by the number of homicides reported in the same year (FBI, 2004; Greenwood et al., 1977).

Measurement Issues about Clearance

Researchers have tried to evaluate the proper use of clearance. Clearance rate has been the most frequently used measure for evaluating police investigative effectiveness by police, researchers, and the public, although many researchers have considered it a biased measure[3] (Cordner, 1989; Greenwood et al., 1977; Litwin, 2004; Regoeczi, Kennedy, & Silverman, 2000; Wellford & Cronin, 1999). For example, it would be inadequate to claim a case cleared if it was reported in a previous year but solved in the current year (Greenwood et al., 1977; Wellford & Cronin, 1999). Greenwood et al. (1977), therefore, precisely stated the definition of clearance rate as "the number of cases cleared *in a period of time* divided by the number of crimes reported to the police *in that same period*" (Greenwood et al., 1977, p. 32).

Another problem regarding clearance is its manipulability (Cordner, 1989). The police's decision to designate a case as cleared and the time of recording it do vary. Greenwood et al. (1977) suggested that the clearance rate fails to indicate the *overall* quality of clearance. For example, some departments claimed additional clearances when an offender admitted committing another offense while some did not. Additionally, some

[3] Some researchers have suggested an alternate measure for the police's law-enforcing effectiveness rather than clearance rate. For example, Decker (1981) proposed that "the ratio of crimes cleared over total victimizations" could be a better estimate of the "true" clearance rate. However, victimization data does not apply to homicide cases; therefore, it is not relevant to the present study.

departments could neglect to update clearance data if a case is charged and filed but later dismissed (Greenwood et al., 1977).

In addition, Riedel and Jarvis (1999) argued that clearance, as provided by the UCR, does not reflect different *levels of solvability*. They did not take into account the "proportion of felony homicides," because that type of homicide is naturally more difficult to clear and requires more police resources; other types, such as intimate partner homicide, are not. Additionally, they failed to provide whether the investigation of a homicide case suffers impediment, such as having no cooperation from the witness or the community. As Riedel and Jarvis (1999) argued, clearance rates could be more accurate and useful to measure police investigative effectiveness if it provides information such as how and how much resources the police devote to different types of homicide.

Overall, although there are many reasons to question the dependability of clearance rates, it continues to be the most commonly used measure for evaluating police performance (Greenwood et al., 1977; Riedel & Jarvis, 1999; Wellford & Cronin, 1999).

Previous Studies on the Decline in Homicide Clearance

Cardarelli and Cavanagh (1992) examined the homicide trend from 1971 to 1990 using the data from Supplementary Homicide Reports (SHR), demonstrating that the number of murders and nonnegligent manslaughters increased by 33%, but the number of uncleared murders increased by 174%.

Before evaluating police resource characteristics in specific, there is a need to explore all the characteristics that were identified by previous researches. The identified factors are categorized as follows: 1) the nature of homicide, 2) the behavior of witnesses,

and 3) the change in the police resources (Cardarelli & Cavanagh, 1992; International Association of Chiefs of Police (IACP) Murder Summit, 1995; Riedel & Rinehart, 1994[4]). A more comprehensive exploration of each aspect will be displayed respectively in the following.

The nature of homicide has been extensively studied. For example, the characteristics of the individual: the age (Addington, 2006; Regoeczi et al., 2000), gender (Lee, 2005; Regoeczi et al., 2000), and race (Lee, 2005; Liwin, 2004; Wellford & Cronin, 1999) of the victims were found to significantly affect homicide clearance. The relationship between the victim and offender were also examined (Riedel, 1993; Wellford & Cronin, 1999), but they did not find consistent effects influencing homicide clearance. Other studies examined the circumstances surrounding the homicide event. For example, the location of the incident[5] (public or private) was found to be a significant predictor of homicide clearance (Addington, 2006; Regoeczi et al., 2000; Wellford & Cronin, 1999). On the other hand, Borg and Parker (2001) examined city-level data and argued that the social characteristics of the location, such as higher racial inequality in education, employment, and lower residential mobility are positive predictors to homicide clearance. Offenses with weapons used were suggested more likely to be cleared (Addington, 2006; Regoeczi et al., 2000, Wellford & Cronin, 1999), though they did not all have significant findings. And drug-related cases were found significantly influence the likelihood of clearance (Wellford & Cronin, 1999).

[4] Both the studies by Riedel and Rinehart (1994) and Cardarelli and Cavanagh (1992) were presented at the meeting of the Academy of Criminal Justice Sciences, and the IACP Murder Submit (1995) was provided by Mr. John Firman of IACP. I was unable to obtain the original articles; therefore, I used the source provided in the study by Wellford and Cronin (1999, p.4).

[5] However, according to Puckett and Lundman (2003), the visibility of case and the notable importance of clearance make detectives to investigate more aggressively regardless of the location and the characters of victims.

The behaviors of the witnesses have been more recently investigated. There are studies suggesting a significant role of the witnesses on cooperating with the police to improve homicide clearance (Greenwood et al., 1977; Litwin, 2004; Riedel, 1995; Riedel & Jarvis, 1999; Wellford & Cronin, 1999).

The nature of police resources has been an important aspect of clearance. For example, a detective's experience (Puckett & Lundman, 2003), skill, training (Greenwood et al., 1977), or workload (Greenwood et al., 1977; Puckett & Lundman, 2003) were found to have little effect on homicide clearance. Although a number of researches have been devoted to these officer characteristics, rather less attention has been paid to the police resource characteristics. For example, the number of officers and computer were found significant determinants for homicide clearance usage (Wellford & Cronin, 1999).

The Wellford and Cronin Study

Wellford and Cronin (1999) demonstrated that even though the U.S. homicide clearance rates have declined over the years, the clearance rates in some cities have remained stably high, while some remained stably low. They stated:

> *"This stability suggests the existence of persistent factors that affect law enforcement agencies' ability to clear homicide cases."*
> *(Wellford & Cronin, 1999, Executive Summary)*

They examined 798 homicides occurring in four large U.S. cities[6] in 1994 and

[6] These cities are not identified for maintaining their anonymity. They were selected according to their homicide rates from 1980 through 1993 in order to maximize the variation of homicide and aggregate clearance rates. City A had low homicide/low aggregate clearance rates, city B had high homicide/low aggregate clearance rates, city C had low homicide/high aggregate clearance rates, and city D had low homicide/low aggregate clearance rates.

1995 with a total of 215 variables which relate to the characteristics of the incidents and its follow-up investigation. Among those significant variables found significantly associated with solving a case, the proper "allocation of police resources" were found to be very substantial. They then suggested that:

> *"There are few homicide cases that given the right initial response, the right timing, and the right dedication of resources cannot be solved." (Wellford & Cronin, 1999, Executive Summary)*

Unfortunately, there was no systematic study examining the effect of these police resource characteristics on homicide clearance directly, and there were only a few studies examining the effect of these characteristics on *total* clearance rates. Accordingly, a broad review of the literature relevant to these police resource characteristics on clearance rates, but not limited to homicide cases, will be presented in the following.

Police Resource Characteristics Affecting Clearance

This section reviews the literature relating to four elements of police resource characteristics affecting homicide clearance: (1) the size of the police department, (2) the proportion of police devoted to investigation, (3) the department's operating budget, and (4) the computer use.

Few of the exiting studies have focused directly on the relationship between those police resource characteristics and homicide clearance. Most of those studies focused on either the clearance of other types of crime such as robbery, or of total crimes. To more thoroughly examine the impact of such characteristics, the following literature review will cover crimes other than homicide.

Department Size

The size of a police department is strongly associated with the capacity for properly distributing the police force. Larger departments with a large number of police officers have more police force, including more skilled officers, but there is a possibility of having unnecessary police and higher expenditure. On the other hand, smaller departments with a smaller number of police officers obtain less support when needed. There have been a number of studies examining its impact on homicide clearance; however, no consistent statement can be made so far.

In the 1960s, because of the proliferation of small police departments, some researchers argued that small police departments are less effective and less efficient in law enforcement. Underlying those arguments were presumptions such as small police departments were less professional in some specialized tasks, lacked adequate equipment, and were staffed with low-qualified personnel. The National Advisory Commission on Criminal Justice Standards and Goals (1973) accepted the arguments and recommended the elimination of smaller police departments.

Ostrom, Parks and Whitaker (1978) questioned this argument, drawing upon data compiled in a study of police service delivery in small- and medium-sized U.S. metropolitan areas in 1974 and 1975. The police services that they examined were (1) patrol, (2) traffic control, including traffic patrol and accident investigation, and (3) criminal investigation, including burglary and homicide investigation. The researchers concluded that (1) smaller departments are likely to devote a larger proportion of personnel to direct service delivery; (2) smaller departments assign relatively fewer officers to administration and more officers to patrol duties; (3) many smaller agencies

that do homicide investigations receive specialized assistance from larger agencies; and (4) that small- and medium-size police departments perform equally or more effectively than large departments.

The study reduced researchers' doubts about the value of small agencies. The public, however, began to doubt the importance and effectiveness of large agencies. Langworthy (1983) used the data presented by Ostrom et al. (1978) and the data from the Kansas City (MO) Police Department administrative survey of larger police departments in 1977 and concluded that, overall, small and large agencies differ little in the proportion of police that they devote to direct services.

Aside from the above arguments, one of the most well known studies of investigation, *The Criminal Investigation Process*, was conducted by Greenwood et al. (1977) for the RAND Corporation. They surveyed approximately 300 city and county police departments and found three characteristics that correlated strongly with the arrest and clearance statistics[7]: department size (represented by the number of sworn officers and the department budget), the location of the department (for example, the clearance rate is highest in the South Central states.), and the workload (number of cases assigned to each officer. Those three determinants correlate highly with the number of arrests and clearances *per officer*; but there was no significant difference between the clearance *rates* of large departments and small departments.

Cordner (1989) then examined the relationship between department size and its investigative effectiveness (using the aggregate clearance rate as the measure of investigative effectiveness). He drew upon national-level UCR data in 1985 and

[7] The study used two measures: the arrest and clearance. A *clearance* was claimed after the police had *arrested* the offender, had sufficient evidence to charge the offender, and could actually take the person into custody (Greenwood et al., 1977, p.32).

conducted a bivariate analysis, finding a strong negative relationship between them (smaller department is associated with higher clearance rate). Then, he drew upon agency-level data from the state of Maryland (Maryland State Police, 1986) and conducted a multivariate analysis, but it did not produce the same findings. Otherwise, the findings suggested that clearance rates are more affected by: (1) the location of the offense (departments located in rural areas have higher clearance rates than those in urban areas) and (2) the mix of crimes reported to the police (the higher the proportion of reported cases that are property crimes, the lower the clearance rate). Department size had only a minor effect on investigative effectiveness.

Willmer (1970) also found that the effect of department size on clearances is correlated with the environmental characteristics, suggesting that the environmental characteristic has an indirect but strong effect on homicide clearance. From his rational, when a small police department is located in a small community, the residents are more attentive to the neighborhood and more cautious of suspicious activities, and they are more willing to work with the police. The police received more cooperation and information from the residents:

> *When communities were small and people tended to work, live, and spend their money in the same district, the local police were able to obtain a considerable amount of information about all sections of society, both known criminals and otherwise (Willmer, 1970, p.22).*

Willmer claimed that rural areas had fewer crimes and that local (smaller) police departments produced higher clearance rates.

Sanders (1977) suggested that the informal flow of information in smaller departments—those usually located in rural areas with lighter caseloads—is better than in

larger ones, implying that with a lighter workload, the officers in smaller departments spent more time on follow-up investigations (for example, checking fingerprints gathered from the crime scene). The information in case files was found to be more detailed and comprehensive in smaller departments than in larger ones. By this logic, police officers in smaller departments are able to devote more time to investigation and attain higher clearance rates.

Wellford and Cronin (1999) examined the number of detectives assigned instead of department's officer number. They found that the assignment of 3, 4, or 11 detectives to a homicide case is optimal for clearance, compared to one detective. Seemingly, larger departments would have more officers for investigations and would produce more clearances. The researchers conducted another analysis using a dataset containing the 100 largest U.S. cities in 1993, and found only a modest relationship between department size and homicide clearance rates (the results provide a modest relationship by showing that the police per index crime only explain 3% of the variation of homicide clearance). These findings indirectly implied the positive relationship between department size and homicide clearance.

Researchers have disagreed over the proper way to measure department size. Ostrom et al. used the "number of sworn officers," while Langworthy used the "number of total employees," including sworn officers and civilian officers. Moreover, the number of assigned detectives was used as a proxy variable to measure the department size in Wellford and Cronin study. In addition, department size is likely to be correlated with environmental variables. Cordner (1989), Wilmer (1970), and Sanders (1977) suggested

that departments located in rural areas or having small jurisdictions tend to have higher clearance rates.

At this point, the effect of department size on clearance is inconclusive.

Proportion of Police Devoted to Investigation

It has been found that "patrol functions" make a major contribution to clearance, compared to investigative functions. For example, a substantial proportion of clearances were produced by patrol arrests at the crime scenes, or the patrol officers recorded the information gathered from the crime scenes (Greenwood et al., 1977). In general, researchers have focused more on patrol functions than investigative functions (Wellford & Cronin, 1999), and very little research has been conducted to examine the effect of investigative functions.

Greenwood et al. (1977) questioned if (1) many investigative activities contribute little to clearance; and (2) in most cases, some characteristics of a crime itself determine whether or not it will be cleared. They selected samples of cleared cases from six police departments[8] and examined how those cases were cleared. Based on their findings, the clearance rate did not vary substantially according to the organization of investigative units, the selection and training of investigators, their workload, the specialization of the police force, etc. Therefore, they claimed that the role of investigators is not substantial and they make little contribution to clearing crimes[9].

[8] The five departments were Los Angeles, Berkeley, Long Beach (CA), Washington, DC, and Miami (FL). The comparison department was Kansas City (MO).

[9] With the exception of homicide, it was guessed that if the investigators only performed the routine tasks to solve those easy cases, they could solve the majority of crimes.

Greenwood et al. (1977) also examined the relationship between the percentage of police in investigative units and clearances. They found that having a higher percentage of police devoted to investigation yields more clearances *per officer*. It also produces a higher clearance *rate* for burglaries but not other types of crimes.

To date, little information is known about whether or not devoting a higher proportion of police on criminal investigation can make an impact on clearance.

Operating Budget

Wellford (1974) conducted a multiple correlation analysis on a sample of the 21 largest U.S. urban centers, excluding New York City, and assessed the effect of socioeconomic and police characteristics (the number of police and the funds budgeted to police) on both crime rates and clearance rates. Their finding indicated that the number of police and the per capita police budget do not explain the variation in the clearance rates.

Greenwood et al. (1977) examined the annual budgets per department and found that clearances per arrest were higher in larger police departments. There was, however, no consistent relationship between budgets and clearance rates. They also examined the effect of salary per police officer. The results showed that arrests per officer increased as the salary per police officer increased, but clearance rate was negatively related to this variable. The mixed results defy an apparent interpretation.

Cloninger and Sartorius (1979) conducted two time-series models to examine the relationships between police input and output, where the former was represented by department expenditures; the latter, by clearance rate. Presumably, the clearance rate would increase as department expenditures increased. The results, however, showed little

to no relationship in cases where the increase in department expenditures was small. The implication of the study was that there is an insignificant relationship between police input and clearance rate unless the input is considerable.

One indirect study by Wellford and Cronin (1999) discovered that the more time a detective takes to arrive at the crime scene, the lower the possibility of clearance[10]. They were not able to directly measure the variable with their data, but experienced detectives told them that a critical element of quick response was whether they were assigned cars on a 24-hour basis. That finding indirectly suggested the importance of the police resource availability.

Another indirect study by Stevens et al. (1980) observed that:

> *Increasing demands for accountability and productivity from public sector officials have combined with budgetary limitations to produce a need for more efficient uses of resources….While demands for more effective police performance are increasing, so are costs (Stevens et al., 1980, p.210).*

Therefore, they conducted a study to examine how response time is related to clearance, questioning whether shorter response time leads to more clearances. An affirmative answer would imply a need to devote greater department resources for the police. They collected data from the York, Pennsylvania, Bureau of Police in 1976 and found no significant increase in clearance rate after the response time decreased. This suggests that the allocation of more resources to the police may be wasteful. They concluded: "It is unclear whether police administrators should devote great resources to any attempts at reducing response time" (Stevens et al., 1980. p.229).

[10] If a detective's arrival time is between 30-60 minutes, the probability of clearance decreases by 62%, compared to arriving within 30 minutes (Wellford & Cronin, 1999).

It remains unclear whether more operating budgets can help the police achieve higher clearance. According to Greenwood et al. (1977), investing higher salary to police officers seems more likely to improve the efficiency per officer, other than investing on total operating budget. On the other hand, the findings by Wellford and Cronin (1999) demonstrated the importance of resources availability and distribution, suggesting the budget assigned to buying facilities, aside from distributed to police officers, is also substantial. Studies by Wellford (1974), Cloninger and Sartorius (1979), and Stevens et al. (1980) did not demonstrate obvious relationship between budget and clearance.

It would thus be of interest to learn whether or not investing a higher budget to a police department could improve its clearance.

Computer Use

At a crime scene or during investigations, police commonly conduct a variety of computer checks, such as on guns, vehicles, witness, and fingerprints. However, little attention has been paid to examine the relationship between computer use and clearance.

Back to the 1970s, it is understandable that researchers ignored to appreciate the use of computer since the technology was not as well-developed as it is now. However, at least one of the researches has, then, tested the capacity of computer use in criminal investigation (Greenberg, Elliott, Kraft, & Proctor, 1977).

Wellford and Cronin (1999) identified 15 significant clearance determinants. Four of the determinants were related to computer use: a computer check on the decedent, the suspect, a witness, and a gun. The findings strongly suggest the importance of computer checks in investigating various types of crime.

It was difficult to conduct a study on the relationship between the computer use and the clearance rate decades ago, since the technologies were not yet widely applied by the police. To date, the technological facilities are developing and updating, yet little information is available on its effect on clearance.

It would seem, therefore, that further research is needed to find out whether the use of computers makes a significant impact on homicide clearance rates.

Summary

The major problem with the literature on homicide clearance is that most of the studies are out of date. For example, this literature review chapter drew an appreciable amount of findings from Greenwood et al. in 1977, the studies of Willmer, Sanders, Cloninger and Sartorius, and Wellford were conducted in the 1970s. Many of the studies were conducted decades ago, making it inappropriate to generalize and apply their findings to the present. Another problem with the existing literature is its dearth. The research conducted by Wellford and Cronin (1999) is the most comprehensive study on the direct impact of “police resource characteristics” on homicide clearance, and there is no other comparable current study. Most of the current research looks at other determinants of homicide clearances or at police resource characteristics of interest for total clearances. Therefore, there is a need of determining the relationship of these police resource characteristics to homicide clearance.

Moreover, the researchers use different measures for the same factors; for example, using the number of sworn officers or the number of both sworn and civilian officers to measure department size, or using the total department budget or the budget

per officer to measure budgetary input. It is possible that using different measures produces different results. Selecting the most appropriate sample and collection methodology are critical issues. The LEMAS data collection is conducted by the BJS, which provides survey data from more than 3,000 state and local police agencies on a variety of police variables since 1987. It will be utilized in the following analyses, and the strengths and limitations of the sample will be discussed in the next chapter.

CHAPTER THREE: DATA AND METHODOLOGY

Hypotheses

The literature review (Chapter Two) captured many aspects of determinants which have shown evidence of an impact on homicide clearance rates. This study focuses on the police resource characteristics influencing homicide closures that have not yet been examined. The number of sworn officers, total department operating budgets, and computer usage are used in the model to show the impact they make on homicide clearances. The proportion of police force devoted to investigation is used to question whether or not it plays an important role in clearing homicides as the patrol police does. Homicide clearance rates are influenced by many environmental characteristics which the police has no control, and which may affect police performance, for example, the location of the incident and city population. One of the characteristics, the city population, is controlled for in this model. Homicide rates are associated with the number of officers and budgets due to the fact that both of them increase when crime increases. Homicide rate is, therefore, controlled for in the model. Each of the following hypotheses will be tested in this analysis.

> *H1: Homicide clearance rate changes as the number of sworn officers changes (two-tailed test).*
>
> *H2: Homicide clearance rate changes as the percentage of police in investigative functions changes (two-tailed test)*[11].
>
> *H3: Homicide clearance rate changes as the department operating budget*

[11] If there were strong theoretical base, then this hypothesis could be considered using one-tailed. However, there were not strong enough research supports to argue the direction. Therefore, two-tailed test is used for the second hypothesis.

changes (two-tailed test[12]).

H4: Homicide clearance rate increases when a police department uses computers on its criminal investigations (one-tailed test).

Sample

There are two data sources utilized in this study. The first data source came directly from Professor Charles Wellford. It is a pooled cross-sectional time-series data containing police departments of the 100 largest cities in the U.S. from 1970 to 2002 annually (see Table 1), compiled by Professor Charles Wellford and his staff. They compiled these datasets from the Uniform Crime Reporting (UCR) Program under the Federal Bureau of Investigation (FBI). The UCR was established to provide comprehensive crime rates, law enforcement agency statistics, etc. for the nation. Law enforcement agencies around the U.S. voluntarily participate in the UCR program. They report the data monthly to the UCR through the state UCR programs in 46 states and D.C., others in states that do not have state UCR programs forward the data directly to FBI. The dependent variable of this study, homicide clearance rate, and the control variables, the city population and homicide rate, were drawn directly from this dataset.

The second data source was collected from the Law Enforcement Management and Administrative Statistics (LEMAS), provided by the Bureau of Justice Statistics (BJS). The LEMAS provides detailed organizational and administrative variables of state and local police departments (with 100 or more sworn officers), for example, community policing activities and policies, officer's education and training, number of vehicles

[12] If there were strong theoretical base, then this hypothesis could be considered using one-tailed. However, there were not strong enough supports to disagree the fact that the empirical results from previous studies were inconsistent. Therefore, two-tailed test is used for the third hypothesis.

Table 1. Descriptive Statistics for the Homicide Clearance Rates: 1970-2002

Id.	Police Department	State	Mean	Std. Dev.	Minimum	Maximum
1	BIRMINGHAM	ALA	0.55	0.39	0.00	0.97
2	MOBILE	ALA	0.62	0.41	0.00	1.15
3	MONTGOMERY	ALA	0.63	0.36	0.00	1.00
4	ANCHORAGE	ALASKA	0.71	0.20	0.36	1.09
5	GLENDALE	ARIZ	0.77	0.22	0.00	1.00
6	MESA	ARIZ	0.79	0.23	0.22	1.06
7	PHOENIX	ARIZ	0.67	0.14	0.40	0.92
8	SCOTTSDALE	ARIZ	0.72	0.38	0.00	2.00
9	TUCSON	ARIZ	0.76	0.12	0.55	1.09
10	ANAHEIM	CALIF	0.68	0.19	0.26	1.00
11	BAKERSFIELD	CALIF	0.76	0.17	0.41	1.09
12	FREMONT	CALIF	0.83	0.27	0.00	1.33
13	FRESNO	CALIF	0.68	0.14	0.40	0.94
14	GLENDALE	CALIF	0.85	0.42	0.33	2.50
15	LONG BEACH	CALIF	0.60	0.12	0.37	0.82
16	LOS ANGELES	CALIF	0.62	0.09	0.37	0.73
17	OAKLAND	CALIF	0.62	0.13	0.32	0.86
18	RIVERSIDE	CALIF	0.65	0.14	0.31	0.93
19	SACRAMENTO	CALIF	0.80	0.11	0.53	1.10
20	SAN DIEGO	CALIF	0.73	0.18	0.31	1.05
21	SAN FRANCISCO	CALIF	0.55	0.14	0.25	0.88
22	SAN JOSE	CALIF	0.80	0.13	0.52	1.00
23	SANTA ANA	CALIF	0.64	0.28	0.28	1.67
24	STOCKTON	CALIF	0.68	0.13	0.37	0.88
25	AURORA	COLO	0.69	0.32	0.00	1.00
26	COLORADO SPRINGS	COLO	0.78	0.25	0.00	1.18
27	DENVER	COLO	0.63	0.14	0.38	0.84
28	WASHINGTON	DC	0.61	0.20	0.24	1.00
29	HIALEAH	FLA	0.51	0.27	0.00	1.00
30	JACKSONVILLE	FLA	0.64	0.26	0.00	0.93
31	MIAMI	FLA	0.47	0.20	0.00	0.79
32	ST PETERSBURG	FLA	0.68	0.25	0.00	0.94
33	TAMPA	FLA	0.61	0.27	0.00	0.93
34	ATLANTA	GA	0.74	0.16	0.00	0.94
35	RICHMOND	GA	0.57	0.33	0.00	1.00
36	HONOLULU	HAWAII	0.71	0.21	0.22	1.10
37	CHICAGO	ILL	0.37	0.40	0.00	0.92

Id.	Police Department	State	Mean	Std. Dev.	Minimum	Maximum
38	FORT WAYNE	IND	0.74	0.42	0.20	2.67
39	INDIANAPOLIS	IND	0.80	0.19	0.44	1.36
40	DES MOINES	IOWA	0.74	0.24	0.00	1.29
41	WICHITA	KANS	0.50	0.45	0.00	1.13
42	LEXINGTON	KY	0.78	0.31	0.00	1.08
43	LOUISVILLE	KY	0.67	0.27	0.00	0.96
44	BATON ROUGE	LA	0.82	0.18	0.00	1.03
45	NEW ORLEANS	LA	0.54	0.15	0.31	0.91
46	SHREVEPORT	LA	0.82	0.12	0.61	1.08
47	BALTIMORE	MD	0.74	0.13	0.37	0.92
48	BOSTON	MASS	0.56	0.09	0.38	0.72
49	DETROIT	MICH	0.58	0.15	0.00	0.77
50	GRAND RAPIDS	MICH	0.59	0.24	0.00	1.04
51	MINNEAPOLIS	MINN	0.53	0.32	0.00	0.91
52	ST PAUL	MINN	0.60	0.33	0.00	1.00
53	KANSAS CITY	MO	0.69	0.14	0.32	0.95
54	ST LOUIS	MO	0.78	0.13	0.32	1.03
55	LINCOLN	NEBR	0.93	0.24	0.00	1.33
56	OMAHA	NEBR	0.84	0.19	0.00	1.03
57	LAS VEGAS	NEV	0.61	0.13	0.34	0.93
58	JERSEY CITY	NJ	0.73	0.19	0.32	1.19
59	NEWARK	NJ	0.66	0.09	0.52	0.90
60	ALBUQUERQUE	N MEX	0.78	0.18	0.18	1.00
61	BUFFALO	NY	0.67	0.14	0.40	0.92
62	NEW YORK	NY	0.64	0.11	0.29	0.88
63	ROCHESTER	NY	0.71	0.18	0.28	0.97
64	YONKERS	NY	0.76	0.18	0.33	1.11
65	CHARLOTTE	NC	0.80	0.12	0.57	1.06
66	GREENSBORO	NC	0.72	0.20	0.30	1.09
67	RALEIGH	NC	0.92	0.15	0.60	1.20
68	AKRON	OHIO	0.75	0.26	0.00	1.04
69	CINCINNATI	OHIO	0.79	0.19	0.24	1.06
70	CLEVELAND	OHIO	0.74	0.07	0.57	0.92
71	COLUMBUS	OHIO	0.71	0.21	0.27	1.06
72	TOLEDO	OHIO	0.79	0.10	0.57	0.95
73	OKLAHOMA CITY	OKLA	0.84	0.12	0.58	1.03
74	TULSA	OKLA	0.83	0.09	0.67	1.02
75	PORTLAND	OREG	0.54	0.22	0.00	0.83
76	PHILADELPHIA	PA	0.77	0.08	0.60	0.96
77	PITTSBURGH	PA	0.84	0.11	0.59	1.00

Id.	Police Department	State	Mean	Std. Dev.	Minimum	Maximum
78	MEMPHIS	TENN	0.74	0.24	0.00	1.00
79	NASHVILLE	TENN	0.51	0.19	0.00	0.82
80	ARLINGTON	TEXAS	0.84	0.23	0.29	1.43
81	AUSTIN	TEXAS	0.78	0.25	0.00	1.12
82	CORPUS CHRISTI	TEXAS	0.90	0.10	0.65	1.08
83	DALLAS	TEXAS	0.74	0.10	0.52	0.91
84	EL PASO	TEXAS	0.85	0.13	0.60	1.14
85	FORT WORTH	TEXAS	0.74	0.17	0.22	1.09
86	GARLAND	TEXAS	0.99	0.61	0.00	4.00
87	HOUSTON	TEXAS	0.69	0.15	0.00	0.90
88	IRVING	TEXAS	0.80	0.24	0.43	1.40
89	LUBBOCK	TEXAS	0.93	0.09	0.75	1.11
90	PLANO	TEXAS	1.21	1.24	0.25	7.00
91	SAN ANTONIO	TEXAS	0.71	0.17	0.45	1.02
92	CHESAPEAKE	VA	0.75	0.20	0.36	1.29
93	NORFOLK	VA	0.88	0.13	0.53	1.16
94	RICHMOND	VA	0.62	0.15	0.24	0.97
95	VIRGINIA BEACH	VA	0.89	0.16	0.59	1.29
96	SEATTLE	WASH	0.70	0.14	0.37	0.94
97	SPOKANE	WASH	0.81	0.21	0.36	1.33
98	TACOMA	WASH	0.80	0.21	0.25	1.22
99	MADISON	WIS	0.87	0.33	0.25	2.00
100	MILWAUKEE	WIS	0.83	0.08	0.48	0.96

operated, use of video cameras, demographic background of officers, etc. Every three or four years, LEMAS conducts the survey with over 3000 state and local law enforcement agencies and a sample of nationally representative number of smaller agencies. Up to now, they have provided data periodically for the years 1987, 1990, 1993, 1997, 1999, 2000, and 2003. The explanatory variables of this study — the officer statistics, budget, and computer use of the police departments — were directly compiled from the LEMAS program.

While current data of the dependent variable ranging from 1970 to 2002 exists,

the LEMAS has only collected data for the years 1987, 1990, 1993, 1997, 1999, 2000 and 2003. Therefore, there are only 6 years available for this analysis. Moreover, in order to keep the same period (about every 3 years), the year 1999 is excluded from the analysis. As a result, only the data for 1987, 1990, 1993, 1997, and 2000 will be utilized in this analysis.

The five years of data for the 100 police departments were appended into one dataset which now has 500 observations (100*5). Those variables were converted using the formulas described below.

Description of the Variables

Table 2 shows the descriptive statistics of the dependent, explanatory, and control variables.

Dependent Variables

The dependent variable, homicide clearance rate, was calculated from dividing "the total number of homicide cases cleared" by "the total number of homicide cases reported"[13].

Table 2 shows that data ranges from zero to 1.5 with a mean of 0.6541. It is important to note that the maximum of this variable is sometimes more than 1; it has usually been found that a case was reported in one year but was solved during another year. Therefore, it is likely that the number of cases cleared is greater than the number of cases reported in a year (Wellford & Cronin, 1999).

[13] The dependent variable is drawn from the UCR, where police agencies submit data voluntarily. Since the data collection is not mandatory, I have no way to arbitrarily determine the accuracy of data quality.

Table 2. Descriptive Statistics for the Variables: Full Sample

Variable Names	Obs.	Mean	Std. Dev.	Min.	Max.
Homicide Clearance Rate Homicide clearance rate	494	.654	.264	0	1.500
Sworn Officer # of total sworn officers (unit = 100 officers)	496	15.117	35.845	1.510	404.350
Proportion of Police in Investigation Proportion of full-time sworn officers assigned to investigation	495	.210	.039	0	.292
Budget Budget per sworn officer (unit = $1,000)	474	78.219	28.962	.572	223.078
Computer Used Computer used on investigation	497	0.871	.335	0	1
City Population Population of the city (unit = 1,000 residents)	496	538.709	848.322	111.742	7746.511
Homicide Rate Number of homicides per 1,000 residents	499	.160	.135	0	.806

There are 34 observations clustered at zero. No homicides were reported in Plano (TX) in 1987, but eight previous homicide cases were cleared; therefore the homicide clearance rate cannot be calculated. Scottsdale (AZ) had zero homicides reported in 1990. The observations of Hialeah (FL) in 1993, and Akron and Cincinnati (OH) in 1997 are missing. All other police departments were unable to clear any reported homicide cases. Aside from the clustered zeros, the data is closed to being normally distributed.

Explanatory Variables

The first explanatory variable of interest, the number of sworn officers, is to measure the "number of sworn officers in a police department". The original data from LEMAS provides both sworn police officers and civilian officers, divided into both full-time and part-time sworn officers, and full-time and part-time civilian officers. The full-time and part-time sworn officers are combined and used for this variable. In addition, I recalculated the unit to "100" sworn officers instead of "1" officer in order to make the coefficient more tangible for the following interpretation. Table 2 shows this variable ranges from 1.51 to 404.35 with a mean of 15.1167. The mean is much closer to the minimum, indicating the data is skewed to the right.

The second explanatory variable, the proportion of police force in investigation, was designed to represent the "percentage of sworn officers assigned to criminal investigation". The original data from LEMAS provided data in the following way: In 1987, 1990, 1993, and 1997, LEMAS presented the data as assigned to "administration", "field operations[14]", "technical support", "jail operations", "court operations", and "others". In 2000[15], however, LEMAS presented the data as assigned to "patrol", "investigations", "jail", "court security", and "process serving". For the purpose of the present study to evaluate officers assigned to criminal investigation, the 2000 data is more appropriate. In order to exactly match the original five variables into one variable,

[14] Field operations category includes field officers, detectives, inspectors, supervisors, and other employees providing direct services. Traffic, patrol, investigations, and special operations are included (BJS).

[15] With the assistance of Dr. Wellford, I contacted Dr. Matthew Hickman from the U.S. Department of Justice. According to his explanation, the change in 2000 was an attempt to provide more precise data on investigators, so people could distinguish between the sheriffs' offices that primarily do jail operations and those that primarily do law enforcement.

one must adjust the original “percentage of sworn officers assigned to field operation” to the “percentage of sworn officers assigned to criminal investigation.” According to LEMAS, an estimated 75% of these field operation officers are regularly assigned to responding to calls, and the remaining 25% includes supervisors and those who are primarily assigned to investigation (Reaves, 1995). Therefore, I roughly applied the percentage, 25%, to yield the estimated data of the “percentage of sworn officers assigned to criminal investigation” for 1987, 1990, 1993, and 1997. Then they were converged with the 2000 data to yield this variable. Data ranges from zero to 0.292 with a mean of 0.2097. There are two zeros in this variable from Miami, FL and Garland, TX in 2000; in fact, they devoted most of the full-time sworn officers to patrol functions[16].

The third explanatory variable of interest, Budget, is “the annual department operating budget”. The original data from LEMAS had provided “the gross salary”, “overtime payment”, “employee benefit”, “other operation expenditures”, and “capital expenditures” (such as equipments, stationary, and vehicle). The first four of these were converged into a variable to represent the total operating budget. In addition, the department budget is likely to be disproportionately designed according to the size of the department, so I divided the total department budget by the number of total sworn officers (both full-time and part-time) to represent “the department operating budget per sworn officer” for this variable. Moreover, I recalculated the unit to “$1,000” instead of “$1” in order to make the coefficient more tangible for later interpretation. Table 2 shows that the variable ranges from 0.57214 to 223.07783 with a mean of 78.21935.

The fourth explanatory variable of interest, computer use for investigation, was

[16] It was not possible to know whether there was a “zero” entry in other years, since the data in other years was mixed in the “field operation” category.

designed to represent whether or not the police uses any computer on criminal investigation. The original data from LEMAS directly provides the dichotomous variable which was coded as “1” if the police department applies any computer on criminal investigation and “0” if not. This dummy variable ranges from zero to one with a mean of 0.8712.

Control Variables

Table 2 also shows the descriptive statistics of the control variables. This dataset includes two control variables: the city population and homicide rate.

The first control variable, the city population, represents the population of the city. It is designed to be controlled in the model in order to reduce the possible spurious effect from an area being slightly or heavily populated on its homicide clearance rate, suggested by previous literatures. The variable comes directly from the dataset by Wellford et al. The population data of the UCR was drawn from the Bureau of the Census, or was estimated for non-census years. Data ranges from 111.742 to 7746.511 with a mean of 538.708.9 people. Again, I redesigned the unit to “1,000” residents in order to make the coefficient more tangible. Note that there is a serious right skew in the data; approximately 91% of the observations are populated with less than 1,000,000 people.

The second control variable, homicide rate, indicates the number of homicides per 1,000 city residents. The data was drawn directly from the dataset by Wellford et al., calculated as the number of homicide cases divided by every 1,000 residents[17]. This

[17] The homicide rate is put on the right-hand side of the regression equation, and the homicide clearance rate is put on the left-hand side of the regression equation. Since both sides of the equation include the number of homicides, error in estimation could occur. However, since little error in the measure of the number of homicides is assumed here, it should not be a problem that needs serious considerations.

variable ranges from zero to 0.8055 with the mean of 0.16. Data shows a slight skew to the right.

Missing Data Analysis

I performed a missing data analysis, and found there were only a few in the sample. Data is missing for four observations in the sworn officer variable, five missing in the proportion of police in investigation variable, 26 in budget variable as a fact that 24 of them are located in 1987, three in the computer use variable, four in the city population variable, and only one in the homicide rate variable. Nothing significantly influences the model. Therefore, the missing data should not be an issue for this analysis.

Model Specification

The dataset is a panel of data of 100 city police departments, covering five selected years. The distribution of the dependent variable is closed to normal, the Ordinary Least Squares (OLS) method can be applied as the model estimation. The "Fixed-Effects Model: Least-Squares Dummy-Variable (LSDV) Approach," (Hsiao, 2003. p.30) is introduced to this analysis in order not to violate the OLS assumption of constant error term.

In most analyses, it is not possible to include all the relevant factors in the model. All other omitted variables are left out in the error term. When some important factors are omitted from the model, and are correlated with the explanatory variables, the coefficients of those explanatory variables will be biased. Not controlling for such

heterogeneity leads to inconsistent estimates of the explanatory variables and inaccurate inferences. Numbers of models have been developed to control the effect of heterogeneity in panel data, and the most appropriate model for this study is the LSDV approach. It creates dummy variables for each department and year to "allow for the effects of those omitted variables that are specific to individual cross-sectional units but stay constant over time, and the effects that are specific to each time period but are the same for all cross-sectional units." (Hsiao, 2003. p.30) In other words, a dummy variable represents the effect from omitted variables for each department and year specifically, which can be excluded from the error term and absorbed into the intercept term of the regression model. Therefore, 99 additional police department dummy variables (one reference department is excluded in order to avoid perfect linearity) and four additional year dummy variables (one reference year is excluded in order to avoid perfect linearity) are created in the model. In sum, the fixed-effects LSDV model indicates that the slope is the same for every observation, but there are differences among departments and years. Those differences are fixed into their intercept terms.

The error term of the fixed-effect LSDV model is then assumed to be uncorrelated with all the explanatory variables and to be normally distributed. Although the OLS method utilized in panel data yields less efficient estimators, they are still the best linear unbiased estimators (BLUE).

Diagnostics

The number of sworn officers, city population, and homicide rate were identified as heteroscedastic; in other words, the error terms are not constant. As a result, the OLS regression assumption is violated. In order to control for the heteroscedasticity, the model will be run with robust standard errors to make the error terms constant.

Analysis of the Full Sample

First, the regression is run on the full sample (N = 463).

Appendix A shows the correlation matrix for the explanatory and control variables; the number of sworn officers and city population were found highly correlated (r = 0.9591). The high positive correlation between the number of sworn officers and city population is highly likely due to the fact that when a city has more population, its city police department needs to hire more officers. Multicollinearity may result in the variances and standard errors of the estimates very large, and make precise estimations difficult. In addition, multicollinearity produces large confidence intervals of the estimates, leading to Type II error (failing to reject a null hypothesis when it is false). In order to reduce the multicollinearity, I tried to keep only one variable in the model; when I excluded one of them from the model, the sign and significance of the coefficient of the other variable remain unchanged. Therefore, I kept them both in the model. In addition, I created a variable for the “number of sworn officers per resident” by combining them, and another variable for the “number of sworn officers per homicide” from dividing the number of sworn officers by the number of homicides. They both show low correlation

with city population; however, the coefficients are not significant. Since the number of sworn officers is more intuitive in this analysis, I will keep this variable instead of the alternative ones.

Moreover, New York City in 2000 is identified as an apparent outlier. I will run regressions with (N = 463) and without (N = 462) New York City to see which regression is more appropriate.

Analysis of the Three Groups

Second, I run the regression using three separate samples (N = 147, 194, and 153, respectively).

Table 3 displays the police departments in the three groups; they were directly distinguished into the three groups according to their homicide clearance rates from the full sample; as a result, though they were not equally sorted.

Table 3. List of Police Departments in the Three Groups

High-Clearance Group		**Medium-Clearance Group**		**Low-Clearance Group**	
Id.	**Police Department**	**Id.**	**Police Department**	**Id.**	**Police Department**
6	MESA	1	BIRMINGHAM	7	PHOENIX
12	FREMONT	2	MOBILE	8	SCOTTSDALE
22	SAN JOSE	3	MONTGOMERY	13	FRESNO
26	COLORADO SPRINGS	4	ANCHORAGE	14	GLENDALE
39	INDIANAPOLIS	5	GLENDALE	15	LONG BEACH
42	LEXINGTON	9	TUCSON	16	LOS ANGELES
44	BATON ROUGE	10	ANAHEIM	17	OAKLAND
46	SHREVEPORT	11	BAKERSFIELD	18	RIVERSIDE
55	LINCOLN	19	SACRAMENTO	21	SAN FRANCISCO

High-Clearance Group		Medium-Clearance Group		Low-Clearance Group	
Id.	**Police Department**	**Id.**	**Police Department**	**Id.**	**Police Department**
56	OMAHA	20	SAN DIEGO	23	SANTA ANA
60	ALBUQUERQUE	25	AURORA	24	STOCKTON
65	CHARLOTTE	30	JACKSONVILLE	27	DENVER
67	RALEIGH	32	ST PETERSBURG	28	WASHINGTON
68	AKRON	33	TAMPA	29	HIALEAH
73	OKLAHOMA CITY	34	ATLANTA	31	MIAMI
74	TULSA	36	HONOLULU	35	RICHMOND
77	PITTSBURGH	40	DES MOINES	37	CHICAGO
78	MEMPHIS	43	LOUISVILLE	38	FORT WAYNE
80	ARLINGTON	47	BALTIMORE	41	WICHITA
81	AUSTIN	53	KANSAS CITY	45	NEW ORLEANS
82	CORPUS CHRISTI	54	ST LOUIS	48	BOSTON
84	EL PASO	58	JERSEY CITY	49	DETROIT
86	GARLAND	61	BUFFALO	50	GRAND RAPIDS
89	LUBBOCK	63	ROCHESTER	51	MINNEAPOLIS
90	PLANO	64	YONKERS	52	ST PAUL
93	NORFOLK	66	GREENSBORO	57	LAS VEGAS
95	VIRGINIA BEACH	69	CINCINNATI	59	NEWARK
97	SPOKANE	70	CLEVELAND	62	NEW YORK
99	MADISON	71	COLUMBUS	75	PORTLAND
		72	TOLEDO	79	NASHVILLE
		76	PHILADELPHIA	94	RICHMOND
		83	DALLAS		
		85	FORT WORTH		
		87	HOUSTON		
		88	IRVING		
		91	SAN ANTONIO		
		92	CHESAPEAKE		
		96	SEATTLE		
		98	TACOMA		

Table 4 demonstrates the number of observations for each group in each year, and the total number of observations of each group will be later used in the regression (N = 147, 194, 153, respectively). The way I sorted the sample is as follows: In the original dataset by Wellford et al., there are homicide clearance rates for every year from 1970 to 2002. At the beginning, I categorized these departments into having high-, medium-, and low-homicide clearance rates by each year. Then I looked at each department across these years; if the department had more than fifteen years categorized as having high clearance then it was sorted into high-clearance rate group. If the department had more than fifteen years categorized as having low clearance then it was sorted into low-clearance rate group. The rest of the departments, most of them having varying clearance rates, belong to the medium-clearance group[18]. As shown in Table 3 and 4, the full sample was not equally categorized into three groups.

Table 4. Numbers of Observations for the Homicide Clearance Rates: Three Groups

	1987	1990	1993	1997	2000	Total Obs.
High-Clearance Group	29	30	29	29	30	147
Medium-Clearance Group	39	39	39	38	39	194
Low-Clearance Group	31	30	30	31	31	153
Total Obs.	99	99	98	98	100	494

[18] New York City is categorized into low-clearance group.

Table 5 shows the descriptive statistics for the dependent, explanatory, and control variables in the high-clearance group. The dependent variable ranges from zero to 1.5 with a mean of 0.7957. Table 6 shows the descriptive statistics for dependent, explanatory, and control variables in the medium clearance group; the dependent variable ranges from zero to 1.2857 with a mean of 0.6351. Table 7 shows the descriptive statistics for the dependent, explanatory, and control variables in the low-clearance group; the dependent variable ranges and from zero to 1.1667 with a mean of 0.5422.

Table 5. Descriptive Statistics for the High-Clearance Group

Variable Names	Obs.	Mean	Std. Dev.	Min.	Max.
Homicide Clearance Rate Homicide clearance rate	147	.7957063	.2411378	0	1.5
Sworn Officer # of total sworn officers (unit = 100 officers)	149	6.654564	4.219556	1.51	21.51
Proportion of Police in Investigation Proportion of full-time sworn officers assigned to investigation	148	.2107225	.0387287	0	.2755981
Budget Budget per sworn officer (unit = $1,000)	144	70.82743	27.61943	.5721393	223.0778
Computer Used Computer used on investigation	149	.9194631	.2730404	0	1
City Population Population of the city (unit = 1,000 residents)	148	345.7904	166.9825	111.742	888.632
Homicide Rate Number of homicides per 1,000 residents	149	.1021117	.0822865	0	.3489589

Table 6. Descriptive Statistics for the Medium-Clearance Group

Variable Names	Obs.	Mean	Std. Dev.	Min.	Max.
Homicide Clearance Rate Homicide clearance rate	194	.6350613	.2540069	0	1.285714
Sworn Officer # of total sworn officers (unit = 100 officers)	192	12.03187	12.67763	1.7	70.24
Proportion of Police in Investigation Proportion of full-time sworn officers assigned to investigation	192	.2139299	.0335277	.0551627	.2921914
Budget Budget per sworn officer (unit = $1,000)	184	77.73748	26.05548	25.14498	210.2379
Computer Used Computer used on investigation	193	.880829	.3248322	0	1
City Population Population of the city (unit = 1,000 residents)	194	462.5514	379.4981	129.354	1920.35
Homicide Rate Number of homicides per 1,000 residents	195	.172648	.1261685	0	.7053298

Table 7. Descriptive Statistics for the Low-Clearance Group

Variable Names	Obs.	Mean	Std. Dev.	Min.	Max.
Homicide Clearance Rate Homicide clearance rate	153	.542182	.2369221	0	1.166667
Sworn Officer # of total sworn officers (unit = 100 officers)	155	27.07252	60.73234	1.71	404.35
Proportion of Police in Investigation Proportion of full-time sworn officers assigned to investigation	155	.2033301	.0451974	0	.2622021
Budget Budget per sworn officer (unit = $1,000)	146	86.11732	31.77501	24.0787	199.8814
Computer Used Computer used on investigation	155	.8129032	.3912533	0	1
City Population Population of the city (unit = 1,000 residents)	154	820.0498	1413.079	116.001	7746.511
Homicide Rate Number of homicides per 1,000 residents	155	.1998162	.1658704	0	.8055018

I conducted one-tailed t-tests to determine if the difference between the means for the high- and medium-clearance groups is statistically significant, as for the medium- and low-clearance groups, and for the high- and low-clearance groups. The results show that the average homicide clearance rates of the three groups are significantly different from each other.

Appendices B, C, and D show the correlation matrix for the explanatory and control variables for the three groups; the number of sworn officers and city population were found highly correlated (r = 0.8477, 0.9002, and 0.9644, respectively). I did the

same procedures to reduce the multicollinearity; however the models are not improved at all. Therefore the same variables are kept in the models.

In addition, in the high-clearance group, the number of sworn officers is modestly correlated with the homicide rate ($r = 0.5017$). It may be due to the fact that when a police department had a higher homicide rate; it hires more sworn officers accordingly.

CHAPTER FOUR: RESULTS

Analysis of the Full Sample

Table 8 shows the regression results from the full sample (N = 463). The left side of the table is the results of the sample including New York City (NYC); the right side is the results of the sample without NYC. Both the R-Square and adjusted R-Square of the sample with NYC are higher than the ones of the sample without NYC, and the two models differ slightly in the coefficients and significance. Therefore, the sample including NYC is used for the model analysis, and only the regression results of this sample are interpreted below.

As shown in Table 8, the R-square is high (0.5156) for social science research for the fact that those dummy variables take account for a large portion of the variation in the omitted variables. The adjusted R-square is also very high (0.3660)[19].

As the first hypothesis suggests, an increase in the total number of sworn officers could either improve or worsen the homicide clearance. The model result shows a significantly positive relationship. Even though the magnitude of the coefficient is small (0.0021), it is very significant (p-value=0.000); it implies that if a police department adds 100 additional sworn officers, its homicide clearance rate will increase by 0.0021 percentage point.

The second hypothesis states that having more police devoted to investigation will result in a higher homicide clearance rate. Previous studies have suggested that most cases were solved by the evidence found at the crime scene, or that the first-arriving

[19] The R-square is only 0.0636 and the adjusted R-square is 0.0513 if the model is run without those department- and year-fixed effects (see Table 9).

Table 8. Results of the Full Sample (With and Without NYC)

Variables	With NYC 2000 (N = 463) β	With NYC 2000 (N = 463) Robust Std. Err.	Without NYC 2000 (N = 462) β	Without NYC 2000 (N = 462) Robust Std. Err.
Sworn Officer	.0020657***	.000628	.0021949**	.0008373
Proportion of Police in Investigation	.7981605***	.4143526	.8009422*	.4149477
Budget	.0004817	.0006466	.0004789	.0006475
Computer Used	.0608433*	.0384126	.0608488*	.0384252
City Population	-.0002478	.0001621	-.0002417	.0001679
Homicide Rate	.0257259	.1769761	.0265593	.1771191
R^2	.5156		.5154	
Adjusted R^2	.3660		.3653	

Department and year fixed effects are omitted from the table.

* indicates p-value < 0.05 level (1-tailed test)
** indicates p-value < 0.01 level (1-tailed test)
*** indicates p-value < 0.001 level (1-tailed test)

Table 9. Results of the Full Sample (With and Without Fixed Effects)

Variables	With Fixed Effects (N = 463) β	With Fixed Effects (N = 463) Robust Std. Err.	Without Fixed Effects (N = 463) β	Without Fixed Effects (N = 463) Robust Std. Err.
Sworn Officer	.0020657***	.000628	.000318	.0008812
Proportion of Police in Investigation	.7981605***	.4143526	.6890211**	.3167267
Budget	.0004817	.0006466	-.0005426	.0004406
Computer Used	.0608433*	.0384126	.044378	.042089
City Population	-.0002478	.0001621	-.0000232	.0000332
Homicide Rate	.0257259	.1769761	-.4234624***	.0793779
R^2	.5156		.0636	
Adjusted R^2	.3660		.0513	

* indicates p-value < 0.05 level (1-tailed test)
** indicates p-value < 0.01 level (1-tailed test)
*** indicates p-value < 0.001 level (1-tailed test)

patrol officers made a major contribution to clearance. Accordingly, most existing studies have focused on “patrol functions.” This analysis examines the contribution made by “investigative function.” Because of the LEMAS data constraint, only the proportion of *full-time* sworn officers devoted to investigation was available, rather than the total number of sworn officers. The coefficient indicates a significantly positive relationship (0.7982 with the p-value = 0.028), meaning that assigning an additional 10% of full-time sworn officers to investigative functions yields a 7.982-percentage-point increase in homicide clearance. In other words, if the department assigns a higher proportion of full-time sworn officers to criminal investigative function, more homicides will be solved.

The third hypothesis is that a higher operating budget leads to a higher homicide clearance rate. The result shows a positive coefficient, as expected. The variable was defined as the operating budget of each sworn officer, combining the officer’s gross salary, overtime payments, benefits from the employer, and other miscellaneous expenditures. More expenditures budgeted to a police department implies that the officers could earn more money than their stated salary. Therefore, they are more motivated, and they are willing to put forth more effort and time. More expenditures budgeted could also enable a police department to purchase more facilities that the officers could have more sufficient resources to use. However, the coefficient is insignificant (p-value = 0.229), suggesting that investing additional budgets does not improve the department’s homicide clearance rate.

The fourth hypothesis claims that if a police department conducts any computer check on investigation, the improved technological support and assistance would produce a higher homicide clearance rate. For example, they could conduct computer analysis to

compare the fingerprints of suspects with the system's records of the community's known offenders, or they could conduct a computer check on identifying the decedent. The analytical result displays a marginally significant and positive relationship (p-value = 0.057), as expected. It suggests that conducting a computer check on criminal investigation yields 0.0608 percentage point more in homicide clearance.

The first control variable, the city population, is expected to be negative. A larger city population would reduce police efficiency when searching for offenders. However, the result shows a negative, insignificant coefficient: -0.0002 (p-value = 0.0635), implying that the city population does not affect its homicide clearance rate.

The coefficient of the second control variable, the homicide rate, is also insignificant: 0.0257 (p-value = 0.4425). Since having more homicides in the area will stretch the police workload and lower its efficiency, the coefficient of the homicide rate is expected to be negative. However, as introduced in Chapter One, the homicide rates are changing upward and downward from 1970 to 2002 by nation and by the 100 city police departments. Therefore, an insignificant coefficient of this variable from the full sample is expected.

Moreover, 82 of the department fixed effects and 4 of the year fixed effects are significant. This suggests that there are other important determinants affecting the homicide clearance rates of the 100 police departments, but these determinants are omitted from the current model.

Analysis of Three Groups

High-Clearance Group

Table 10 shows the regression results from the high-clearance group (N = 140). As shown in Table 10, the R-square is 0.3694, and the adjusted R-square is 0.1184[20].

In the high-clearance group, none of the coefficients of interest is significant. However, two of the department fixed effects and one of the year fixed effect are significant. That suggests that there were other substantial determinants affecting the homicide clearance rates of those high-clearance departments, but these determinants were omitted from the current model.

Medium-Clearance Group

Table 11 shows the regression results from the medium-clearance group (N = 183). As shown in Table 11, the R-square is 0.4859, and the adjusted R-square is 0.3004[21].

Among those explanatory variables of interest, only the number of sworn officers yields a marginally significant coefficient, but it is negative (-0.0162, p-value = 0.06). The first hypothesis claims that an increase in the number of total sworn officers improves or worsens homicide clearance, and the result indicates that if a medium-clearance police department were to acquire 100 additional sworn officers, the

[20] The R-square is only 0.0240 and the adjusted R-square is -0.0208 if the model is run without those department- and year-fixed effects (see Table 10).

[21] The R-square is only 0.0455 and the adjusted R-square is 0.0128 if the model is run without those department- and year-fixed effects (see Table 11).

Table 10. Results of the High-Clearance Group

Variables	With Fixed Effects (N = 140)		Without Fixed Effects (N = 138)	
	β	Robust Std. Err.	β	Robust Std. Err.
Sworn Officer	-.0156849	.0276952	.0028219	.0081066
Proportion of Police in Investigation	1.272135	.9553878	.4553475	.5696148
Budget	-.0007899	.0010634	-.0006803	.0008518
Computer Used	.1918229	.1324628	.0995091	.1176722
City Population	-.0002439	.0006347	-.0000688	.0002213
Homicide Rate	-.6677604	.650557	-.2564726	.2477503
R^2	.3694		.0240	
Adjusted R^2	.1184		-.0208	

* indicates p-value < 0.05 level (1-tailed test)
** indicates p-value < 0.01 level (1-tailed test)
*** indicates p-value < 0.001 level (1-tailed test)

Table 11. Results of the Medium-Clearance Group

Variables	With Fixed Effects (N = 183)		Without Fixed Effects (N = 182)	
	β	Robust Std. Err.	β	Robust Std. Err.
Sworn Officer	-.016232*	.0103715	.0059937**	.002301
Proportion of Police in Investigation	.2273574	.6071656	.484073	.5574108
Budget	.0007519	.0010312	.0008326	.000802
Computer Used	.0190457	.0610797	-.0513355	.0645124
City Population	.0001035	.0003336	-.00011	.0000785
Homicide Rate	-.2530964	.2908127	-.3220458*	.1696714
R^2	.4859		.0455	
Adjusted R^2	.3004		.0128	

* indicates p-value < 0.05 level (1-tailed test)
** indicates p-value < 0.01 level (1-tailed test)
*** indicates p-value < 0.001 level (1-tailed test)

department's homicide clearance rate would decrease by 0.0162 percentage point. The police officers in a larger department might be lack of communication when investigating cases, and therefore work less efficiently. However, because most of those medium-clearance departments had varying clearance rates, the results are tentative.

Moreover, 24 of the department fixed effects and one of the year fixed effect are found significant. This suggests that there are other important determinants affecting the homicide clearance rates of the medium-clearance departments, but these determinants are omitted from the current model.

Low-Clearance Group

Table 12 shows the regression results from the low-clearance group (N = 143). As shown in Table 12, the R-square is 0.5030, and the adjusted R-square is 0.3080[22].

Among the explanatory variables of interest, only the number of sworn officers yields a significant coefficient. The first hypothesis states that an increase in the number of total sworn officers could either improve or worsen the homicide clearance rate, and the coefficient, 0.0031, is significantly positive (p-value = 0.000), suggesting that a low-clearance department's homicide clearance rate would increase by 0.0031 percentage point by adding 100 additional sworn officers. Moreover, one of the department fixed effect and four of the year fixed effects are significant. It suggests that there are other important determinants affecting the homicide clearance rates of the low-clearance departments, but these determinants are omitted from the current model.

Both control variables, the city population and homicide rate, were found

[22] The R-square is only 0.0648 and the adjusted R-square is 0.0236 if the model is run without those department- and year-fixed effects (see Table 12).

Table 12. Results of the Low-Clearance Group

Variables	With Fixed Effects (N = 143)		Without Fixed Effects (N = 143)	
	β	Robust Std. Err.	β	Robust Std. Err.
Sworn Officer	.0031483***	.0007301	.0002786	.0009685
Proportion of Police in Investigation	.3877921	.6222059	.9691714*	.4499562
Budget	.0019188	.0016103	.0004071	.0006473
Computer Used	.0473521	.0405028	.0356485	.0565213
City Population	-.0003711*	.0002341	-7.94e-06	.0000368
Homicide Rate	.4165389*	.2566415	-.1831308*	.1077208
R^2	.5030		.0648	
Adjusted R^2	.3080		.0236	

* indicates p-value < 0.05 level (1-tailed test)
** indicates p-value < 0.01 level (1-tailed test)
*** indicates p-value < 0.001 level (1-tailed test)

significant in the low-clearance group. The coefficient of the city population, -0.0004, is marginally significant and negative (p-value = 0.058). It has been suggested that a larger city population might complicate or preclude police searches for offenders and thereby reduce the efficiency. Homicide rate is also marginally significant (p-value = 0.054). The positive coefficient suggests that a police department would have a higher homicide clearance rate if it had a higher homicide rate. Table 7 shows that the homicide rate ranges from 0 to 0.8055 with a mean of 0.1998 in the low-clearance group; it is the highest among the three group. This positive relationship indicates that the homicide clearance rates of these police departments are higher when their homicide rates increase.

CHAPTER FIVE: DISCUSSION AND CONCLUSION

Discussion

The objective of this study was to demonstrate the impact of police resource characteristics on homicide clearance. It has been found that while there were increases and decreases in the homicide trend over the past few decades, the clearance trend of homicides has been consistently decreasing. The variations in the homicide trend did not seem to be the cause of the decline in homicide clearance.

Among the existing studies that have tried to explain the decline in homicide clearance, more attention has been paid to factors that significantly affect the likelihood of clearing a homicide, such as the nature of homicide, e.g., the victims' race (Lee, 2005; Liwin, 2004; Wellford and Cronin, 1999), handgun use, or the location of the case (Addington, 2006; Regoeczi, 2000; Wellford and Cronin, 1999). Moreover, growing attention has been paid to witnesses' behaviors and cooperation (Greenwood et al., 1977; Litwin, 2004; Riedel, 1995; Riedel & Jarvis, 1999; Wellford & Cronin, 1999). Rather less attention has been paid to the change in the police resources, e.g. officer's skill, department operating budgets (Greenwood et al., 1977), or technology use (Wellford and Cronin, 1999). From the perspective of policy implication, it is more practical to strengthen police resources than to change the nature of homicides or the behavior of witnesses. However, researchers have ignored to consider the importance of the police resources characteristics on homicide clearance rates..

To demonstrate the effects of police department characteristics, this study used a sample drawn from the Law Enforcement and Management Administrative Statistics

(LEMAS). The LEMAS provides detailed organizational and administrative variables of state and local police departments. Due to the data availability, four police resource variables were selected: the number of officers, the proportion of police on investigation, budget, and computer use. Specifically, four hypotheses were tested, and are discussed as follows.

H1: Homicide clearance rate is either positively or negatively associated with the change in the number of officers. Cordner (1989) ascertained that department size had a positive, yet minor, effect on clearance. Wellford and Cronin (1999) found only a modestly positive relationship between the number of homicide detectives and homicide clearance. The study by Greenwood et al. (1977) yielded mixed findings. Willmer (1970) and Sanders (1977) demonstrated that department size has a negative effect on clearance, although the environment (location) of the department plays a substantial role. Apparently, previous researches had mixed findings. The current analyses showed mixed results as well. From analyzing the full sample, the result showed that the availability of more sworn officers could significantly improve the homicide clearance rates. From analyzing the three groups, however, the results were mixed. Having more sworn officers did not change the homicide clearance rates of high-clearance police departments. Having more sworn officers may interfere with police efficiency, as it significantly decreased the homicide clearance rates of medium-clearance police departments. In the end, having more sworn officers significantly changed (increased) the homicide clearance rates of low-clearance departments.

Findings of this study generally supported this hypothesis. In the police departments of the 100 largest U.S. cities, the hiring of more sworn officers had a

significant, and positive, effect on homicide clearance. However, in the high-clearance departments, the hiring of more sworn officers did not change the homicide clearance rate. Table 5 shows that the average city population is 345,790, and the average homicide rate is 0.102 per 1,000 residents; both are relatively lower than the data for medium- and low-clearance departments. It was possible that the relatively lower city populations and homicide rates made homicides easier to solve. As a result, the hiring of more sworn officers did not matter in the high-clearance police departments. Consequently, these departments hired relatively fewer sworn officers. The average number of sworn officers is 607 (see Table 5); compared to the numbers in medium- and low-clearance police departments (see Tables 6 and 7). In the medium-clearance departments, the hiring of more sworn officers changed (decreased) the homicide clearance rate. The current results were tentative because the homicide clearance rates of medium-clearance departments varied considerably over the years. The continuous increases and decreases in homicide clearance rates may not be directly associated with the changes of the number of sworn officers. The results are subject to caution. In the low-clearance departments, the hiring of more sworn officers changed (increased) the homicide clearance rate. Table 7 shows that the average city population is 820,050, and the average homicide rate is 0.2 per 1,000 residents; both are relatively higher. Possibly, the relatively larger population and higher homicide rate made solving homicides more difficult. Those departments were in need of more sworn officers, and the hiring of more sworn officers had a positive effect on homicide clearance.

H2: Homicide clearance rate is either positively or negatively associated with the change in the percentage of police assigned to investigation. Greenwood et al.

(1977) claimed that the role of investigators was not significant and they made little contribution to clearing crimes. Greenwood et al. (1977) also observed that having a higher percentage of police assigned to investigation produced more clearances *per officer,* and produced a higher clearance rate for burglary only. Previous researches found insignificant effect of investigative function. The current analyses showed mixed results. From analyzing the full sample, the result showed that a higher proportion of full-time sworn officers assigned to investigation was significantly associated with a higher homicide clearance rate. However, from analyzing the three groups separately, all showed that having a higher percentage of full-time sworn officers assigned to investigation did not change the homicide clearance rate.

Findings of this study were inconsistent. In the police departments of the 100 largest cities, having a higher percentage of full-time sworn officers assigned to investigation increased the efficiency and yielded a higher homicide clearance rate. It is promising that the police investigative function can contribute to clearance, besides patrol functions. However, for the three groups, having a higher percentage of full-time sworn officers assigned to investigation did not significantly help improving the homicide clearance rate. Table 5, 6, and 7 show that the three groups differ slightly in the proportion of police assigned into investigation; the high-clearance group has an average of 21.1%, the medium-clearance group has an average of 21.4%, and the low-clearance group has an average of 20.3%. The results were also tentative because the LEMAS provided this variable in 2000 only, and this variable was mixed in the “proportion of police assigned to field operation.” variable in 1987, 1990, 1993, and 1997. I estimated the variable in these four years by roughly multiplying 20% to the “proportion of police

assigned to field operation." variable, since the BJS observed that usually 20% of the field officers were assigned into investigation (BJS, 2005).

H3: Homicide clearance rate is either positively or negatively associated with the budget per sworn officer. Wellford (1974) observed that the per capita police budget did not explain the variation in the clearance rate. Greenwood et al. (1977) found that the department budget did not have a consistent effect on the clearance rate; however, they found that salary per officer was negatively related to the clearance rate. Cloninger and Sartorius (1979) concluded that department expenditures had an insignificant effect on the clearance rate unless the amount was considerable. Wellford and Cronin (1999) found that the more time a detective takes to arrive at the crime scene, the lower the likelihood of clearance, which indirectly suggested the importance of police resource availability. Stevens et al. (1980) observed that a shorter response time did not improve the clearance rate, thus having more resources may not influence the clearance rate. Apparently, previous researches found insignificant effect of budgets on clearance. The current analyses also produced consistently insignificant results. In all analyses, the results showed that a higher budget per sworn officer did not influence the homicide clearance rate.

Findings of this study generally supported previous studies. The budget did not matter to homicide clearance. Table 5 shows that the average budget per sworn officer is $70827.43, Table 6 shows $ 77737.48, and Table 7 shows $86117.32. The average budget per sworn officer of the low-clearance group is the highest, and the high-clearance group has the lowest. All of the three tables show that the budget per sworn officer is positively correlated with both the city population and homicide rate. It was possible that the

volume of budgets was a result of the city population and homicide rate. As suggested by Sartorius (1979), department expenditures had an insignificant effect on the clearance rate unless the amount was considerable. If the budgets of these departments were considerable, some significant results might be produced. The budgets were not significant enough Moreover, according to Greenwood et al. (1977), salary per officer was found negatively related to the clearance rate. It was possible that department facilities were more substantial and desirable for the departments in their sample, rather than the salaries per officer. Any additional salary budgeted to officers was wasteful. Nevertheless, it was suggested that salary per officer could be a more direct variable with which to approach this hypothesis, rather than the department operating budget per sworn officer. Possibly, police officers may feel the increase in the department operating budgets and they could have more sufficient resources to use. However, more salaries budgeted to the officers can directly motivate them, and make them willing to put forth more effort and time.

H4: Homicide clearance rate increases when a police department uses computers in investigations. Wellford and Cronin (1999) observed four variables that could improve the homicide clearance rate: computer checks on the decedent, the suspect, a witness, and a gun. The current analyses showed mixed results. From analyzing the full sample, the result showed that using computers in investigation could significantly improve the homicide clearance rate. From analyzing the three groups, however, all showed that using computers in investigation did not improve the homicide clearance rate.

Findings of this study were inconsistent. In the analyzed 100 police departments, using computers in investigation was positively associated with homicide clearance. It

suggested the growing importance of computer use in investigation. However, from analyzing the three groups, using computers on investigation did not have a significant impact on the homicide clearance rate.

This study brought together previous findings of the police resource characteristics of interest, and applied them to the *homicide* clearance rate. In sum, the results from the full sample showed that the number of sworn officers, percentage of police assigned to investigative functions, and computer use were found to be positive determinants in solving homicide cases. The results from the medium-clearance group were tentative. As explained in Chapter Three, those departments were categorized into the medium-clearance group due to inconsistent levels in homicide clearance. The results from the high-clearance group were all insignificant, however, two department fixed effects and one year fixed effect were found significant. It indicated that there were other important factors that contributed to the high rates of the high-clearance departments, but these factors were omitted from the current model. Thus, no suggestions could be given to other police departments. The results from the low-clearance group showed that the number of sworn officers was positively related to homicide clearance rates. This suggested that larger police departments could produce higher homicide clearance rates. As for policy guidelines, this data suggest that hiring more officers, devoting more police officers to investigative functions and using computers in investigation can contribute to homicide clearance.

Limitations

Attentions should be paid to the measurement errors in this sample. As demonstrated in Chapter Two, the homicide clearance rate is calculated as the number of homicides cleared divided by the number of homicides reported. However, in the current sample, for example, zero homicides were reported in Plano (TX) in 1987, but the police department cleared eight homicides from previous year(s). In such case, the homicide clearance rate is not calculable.

Small sample size is another concern in this analysis, especially when the full sample is categorized into three groups. The numbers of observations of the high-, medium-, and low-clearance groups are 140, 183, and 143. A small sample size can mislead the results and weaken the power of hypothesis test, which is a possible reason for the situation that most of the results from the three groups were insignificant.

One critical issue of the sample utilized in the present study was that two variables, the number of sworn officers and city population, were highly correlated (see Tables A, B, C, and D). The multicollinearity resulted in the inability of determining the impact of one variable on the dependent variable, while holding the other variable constant, therefore it could result in inaccurate results. I have tried to either drop one of the variables or combine the sworn officer variable with other relevant variables. However, the model was not improved. Because city population was suggested by the previous studies to be an important factor, I decided to keep it in the model. Thus, an alternative way to improve the model would be to increase the number of observations.

The current findings should be considered only representative of the analyzed 100 city police departments. The model applied in the analyses was the fixed-effects LSDV

model, which controls the effects of omitted variables to be specific to each individual and each year, and treats those effects as intercept terms. When the effects are not controlled and are treated as random variables, an alternative model, random-effects model, is preferred. As demonstrated by Hsiao (1995, p.238), one basic consideration when deciding a better model is, “The fixed effects approach is viewed as one where investigators make inferences conditional on the effects that are in the sample. The random effects approach is viewed as one where investigators make unconditional inferences with respect to the population of all effects.” Accordingly, the results are only representative of the 100 police departments that were studied. In addition, the studied police departments are located in the 100 largest U.S. cities, having a population of 100,000 or more. Since population matters, the current findings should be applied to these 100 departments only. Other determinants might significantly influence the homicide clearance rates of smaller police departments.

Furthermore, an important assumption of the fixed-effects LSDV model is that the lagged dependent variable does not have an influence on the current dependent variable (Finkel, 1995). Often likely, that assumption is violated in a time-series or longitudinal data. When the assumption is violated, an alternative model, the dynamic model (including the lagged dependent variable), is preferred. In this sample, however, there are generally 3 years between each wave (1987, 1990, 1993, 1997, and 2000). It is not proper to assume that the current homicide clearance rate is directly affected by that of three years earlier. Hence, I did not use the dynamic model to analyze the current sample.

Conclusion and Implications

This study is designed to identify significant determinants of homicide clearance of the city police departments in the largest 100 U.S. cities. Out of four police resource characteristics—the department size, the police devoted to investigative functions, the budgets, and the computer use—three were found to be positively related to homicide clearance rates. It appears that the larger the police departments, the more police assigned to investigative functions, and the more a department uses computers for investigations, the more likely they are to close homicide cases.

Due to the data limitation, the dynamic model is not feasible. If a sample could be collected continuously and yearly on these variables, the dynamic model can be preformed. Then we will be able to know whether or not the homicide clearance rate in the previous year influenced the rate in the current year.

If a police department considers increasing its homicide clearance rate, the findings suggest that the department should devote more officers to criminal investigation functions, rather than only to patrol functions. It is not to suggest that police agencies transfer police officers from the patrol functions to investigative functions, rather police agencies should consider hiring more sworn officers and assigned these additional officers to investigative functions.

Police agencies should widely apply computers to investigations, and invest more resources into developing and training officers to adopt computers to better conduct investigations. For example, computers can be used to organize suspects' profiles, conduct suspects' portraits, etc. Wellford and Cronin (1999) have demonstrated the substantial effects of computer checks on the decedent, the suspect, a witness, and a gun,

future researchers may extend their finding and try to identify other types of useful technology for investigation, such as the use of video cameras in high crime areas. It is highly likely that technology has not yet been developed decades ago, and police agencies were unable to apply computer in criminal investigation. Therefore there was not sufficient data on computer usage, and the previous researchers were unable to conduct analyses. To date, computers have been found commonly used by police agencies. More studies are needed to identify how computers can be better applied, as well as the application of other types of technology on investigation.

Furthermore, even though the budget variable was found insignificant in all the analyses, police agencies should still take in account the costs when investing in more department resources. As for policy making, the costs would always be a concern. Future research is encouraged to further explore the impact of department expenditures on homicide clearance rates.

APPENDICES

Appendix A. Correlation Matrix of Explanatory and Control Variables: Full Sample

		1	2	3	4	5	6
1	**Sworn Officer**	1.0000					
2	**Proportion of Police in Investigation**	-0.0063	1.0000				
3	**Budget**	-0.0503	-0.0871	1.0000			
4	**Computer Used**	0.0469	0.0539	0.0194	1.0000		
5	**City Population**	0.9591	0.0053	-0.0201	0.0770	1.0000	
6	**Homicide Rate**	0.1781	-0.0098	-0.2138	-0.0733	0.1391	1.0000

Appendix B. Correlation Matrix of Explanatory and Control Variables: High-Clearance Group

		1	2	3	4	5	6
1	**Sworn Officer**	1.0000					
2	**Proportion of Police in Investigation**	-0.2308	1.0000				
3	**Budget**	0.0840	-0.1960	1.0000			
4	**Computer Used**	0.1522	-0.0567	0.0768	1.0000		
5	**City Population**	0.8477	-0.1356	0.2385	0.1477	1.0000	
6	**Homicide Rate**	0.5017	-0.0540	-0.2356	0.1350	0.2287	1.0000

Appendix C. Correlation Matrix of Explanatory and Control Variables: Medium-Clearance Group

		1	2	3	4	5	6
1	**Sworn Officer**	1.0000					
2	**Proportion of Police in Investigation**	0.0164	1.0000				
3	**Budget**	-0.1463	-0.1090	1.0000			
4	**Computer Used**	0.0300	0.1246	-0.1031	1.0000		
5	**City Population**	0.9002	0.0368	-0.0333	0.0604	1.0000	
6	**Homicide Rate**	0.3408	0.0107	-0.3532	0.0346	0.1702	1.0000

Appendix D. Correlation Matrix of Explanatory and Control Variables: Low-Clearance Group

		1	2	3	4	5	6
1	**Sworn Officer**	1.0000					
2	**Proportion of Police in Investigation**	0.0327	1.0000				
3	**Budget**	-0.1410	0.0353	1.0000			
4	**Computer Used**	0.1142	0.0417	0.1541	1.0000		
5	**City Population**	0.9644	0.0470	-0.1296	0.1508	1.0000	
6	**Homicide Rate**	0.0953	0.0200	-0.2726	-0.1544	0.0675	1.0000

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