# INFORMATION TECHNOLOGY AND CRIMINAL INVESTIGATIONS: DOES IT MATTER?

by

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# ABSTRACT

HAKAN HEKIM. Information Technology and Criminal Investigations: Does IT Matter? (Under the direction of DR.VIVIAN B. LORD)

As an important police activity, criminal investigation heavily relies on recovery, analysis and interpretation of information. Since information technologies facilitate creation, storage, retrieval, process and dissemination of information, police departments have extensively employed them in investigative activities. However, information technologies' impact on the outcome of criminal investigations is still unclear. This study examines whether use of information technologies makes an impact on the outcome of criminal investigations. The analysis results revealed that there is not a consistent relationship between police departments' use of information technologies and their clearance rates. In addition to this finding, this study made an important methodological contribution to the literature by showing that unbalanced data may be an important source of concern for observational studies of police departments, and it should be carefully investigated before conducting any inferential analysis.

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# CHAPTER 1: INTRODUCTION

## The Purpose and Significance of the Study

Investigative police work is mostly about the recovery, analysis and interpretation of information about criminal offenses (Osterburg and Ward, 2007). During the investigation of a crime, police take victim and witness statements, examine the crime scene, collect physical evidence, analyze collected material to identify the offender or offenders and then present the resulting information to the prosecutor. Since the success of criminal investigation depends on quality information, the production of quality information is the first objective of investigative work. As Luen & Al-Hawamdeh (2001) state timely and accurate information is critical to the success of policing. In order to increase the probability of generating quality information, the police employ information technologies. Information technologies appear as important instruments of criminal investigations because they facilitate creation, storage, retrieval, transfer, and application of investigation-related information (Gottschalk, 2007). Moreover, information technologies may help produce effective use of time devoted to criminal investigation by automating some routine investigative tasks (Eck, 1983; Folk, 1971). Nevertheless, the link between information technologies and the outcome of criminal investigation is not a clear one. Therefore, the purpose of this study is to examine whether information technologies really make any contribution to the outcome of criminal investigations.

Although criminal investigation is an important law enforcement activity, it is one of the least studied police functions. Early influential studies in the field were conducted in the 1970s (e.g., Chaiken, Greenwood, and Petersilia, 1976; Greenberg and Lang, 1973; Greenwood 1970). Those studies generally explored the criminal investigation process and analyzed its effectiveness in solving crimes. Perhaps as a result of consistent negative findings, researchers diverted their attention to the determinants of success of criminal investigation in the 1980s, and this trend continued through the 1990s (e.g., Burrows and Tarling, 1982; Marche, 1994; Welford and Cronin, 1999). Although Horvath, Meesig and Lee (2001) argue that criminal investigation is again becoming a focus of interest among criminal justice researchers and practitioners, the number of studies conducted in the field has not increased much yet. This study intends to contribute to the discussion about the effectiveness of criminal investigation by presenting an extensive review of the previous literature and providing new empirical evidence.

Police use of information technology (IT) is another issue that has not received much attention from scholars. One of the first systemic approaches to the topic was made in the 1960s when President's Commission decided to establish the Task Force on Science and Technology to explore possible contributions of science and technology to the fight against crime. Blumstein, who was the Director of the Task Force, stated that the Task Force began its work "with the then widely accepted cliché that 'if science and technology can get a man to the moon, then certainly it must have some important contributions to make in the realm of … controlling crime'" (Blumstein, 1994, p. 146) As a result, 13 out of 200 recommendations published in the President's Commission report, "The Challenge of Crime in a Free Society," were about use of science and technology

within the criminal justice system. Then, in 1968, President Lyndon Johnson had expressed his plan to bring the most advanced technology to the war on crime, and the Law Enforcement Administration Assistance (LEAA) was established to deliver on that promise. In the same year, President Johnson signed the Safe Streets Act, and until 1982 a huge amount of federal aid was sent to the state and local governments for their technology investments. Today, information technologies are critical to the police. Davis and Jackson (2004) reported that 100 percent of police departments serving cities with populations of 250,000 or more were using Computer Aided Dispatch (CAD) systems, and 92 percent of them were using in-field computers or terminals. Moreover, 71 percent of all local police departments reported to have enhanced 911 systems, and 40 percent of them were using in-field computers or terminals (Davis & Jackson, 2004). New information technologies have been developed by different vendors and implemented in law enforcement agencies, but their impact on police work is still a controversial issue, and available literature is very limited (Abt Associates, 2001). This study provides additional empirical evidence to the criminal justice community about information technologies' impact on police work.

In conclusion, this study intends to contribute to policing research by focusing on the intersection of two understudied topics: criminal investigations and police information technologies.

## Scope of the Study

This study analyzes the relationship between use of information technologies by U.S. police departments and the outcome of criminal investigations. Its unit of analysis is police departments, and the dependent variable is the clearance rates achieved by the

police departments. It must be noted that this study is not testing any causal relationship between use of information technologies and clearance rates. In order to be able to decide whether a causal relationship exists, three criteria must be considered: association, temporal order and nonspuriousness. In other words, there must be covariation between dependent and independent variables, variation in the dependent variable should occur after the variation in the independent variable and variation should not be due to variation in a third variable (Schutt, 2006). This study is an observational study and it only tests whether there is an association between use of information technologies and clearance rates; however, it cannot tell if there is a causal relationship between independent and dependent variables.

Crime and clearance data of this study is collected by the Unified Crime Reporting (UCR) Program. The UCR data and the use of clearance rate as a success measure for police departments have been criticized for several reasons. First of all, UCR data reports Part I crimes known to the police, and participation to the UCR program is voluntary. In addition, there is not a monitoring mechanism in place to ensure the accuracy of reported crimes. Therefore, it was argued that UCR data does not portray an accurate picture of crime problem in the U.S (Chambliss, 2001; Lott & Whitley, 2003; Martin & Legault, 2005). Despite of these critiques, UCR data is still used by researchers (e.g. Helms, 2008; Holmes, Smith, Freng & Munoz, 2008; Nolan, 2004; O'Brian, 2003). In addition, some researchers argued that UCR is a valid source of criminal statistics in the U.S. (Gove, Hughes & Geerken, 1985; Hindelang, 1974). Use of clearance rate as a measure of police performance is criticized mainly for two reasons. Firsty, in order to look better on the statistics, police departments can manipulate the crime and clearance

numbers (Chambliss, 2001). Secondly, clearance rates do not give any information about the difficulty of cases and the amount of effort police put in them (Pare, Felson, Quimet, 2007). However, clearance rates are also still used by researchers mainly because of lack of a better measure (e.g., Borg & Parker, 2001; Keel, Jarvis & Muirhead, 2009; Pare et al., 2007).

Although some criminal investigation studies differentiate the stages in which arrest or clearance occurs (e.g., Isaacs, 1967; Greenwood, 1970), this study takes criminal investigation as a whole and makes no distinction between different stages of the investigative process. Clearance is viewed as the final output of this process, and no attempt is made to determine in which stage it occurs. This approach is appropriate for this study for two reasons. First of all, the main concern of this study is information technologies' impact on the outcome of criminal investigation. Despite of the differences in information technology use across the stages of criminal investigation, information technologies can be utilized throughout the entire investigation process (Dunworth, 2004; Manning, 1992). Therefore, a holistic approach to the criminal investigation process is necessary to better assess information technologies' impact. This approach is also used by some other researchers in the field (e.g. Chan, 2001; Hauck and Chen, 1999; Manning, 2001) In addition to this, usually the rationale for analyzing preliminary and secondary investigation stages separately is to focus particularly on one of the stages and to assess the effectiveness of the patrol or detective work (e.g. Marshall, 1998; Nunn, 1994; Nunn & Quinet, 2002). Since that is not a goal of this study, taking criminal investigation as a whole is more appropriate.

The independent variable of this study is use of information technologies by police departments. The information technology concept has a very broad meaning, and there are several different ways to classify information technologies used by the police. Hogan and Radack (1997) defined information technology as the blend of hardware and software used for storage, processing, transfer, display, management, organization, and retrieval of information. The broadness of the definition depicts the variety of shapes and forms that information technologies can take. In fact, the literature review will show that police departments use information technologies for many administrative and operational purposes. While administrative use of information technologies consists of traditional support services such as personnel, budget, fleet management and inventory systems, the operational use of information technologies is related to law enforcement and investigative activities of the police. As will be discussed in the literature review, investigative use of police information technologies can be analyzed within four areas: records management, crime analysis, mobile computing and forensic analysis. In this respect, the independent variable of this study is an index variable measuring police departments' use of information technologies in those areas. The independent variable composes of 29 items collected by the "National Study of the Impact of Science and Technology on the Process of Criminal Investigation in Law Enforcement Agencies" project conducted by Eastern Kentucky University researchers.

DeLone and McLean's (1992; 2003) information system success model is used in this study. According to the model, information success can be measured at six levels: information quality, system quality, service quality, use and intention to use, user satisfaction and net benefits In addition, the model proposes a relationship between these

six levels of success. DeLone and McLean's information system success model is a highly complex model; for that reason, researchers have generally tested parts of it, and usually found supportive results (e.g. McGill, Hobbs & Klobas, 2004; Roldan & Millan, 2000; Seddon & Kiew, 1996). Similar to those studies, this study only looks at the information system success at system use level.

## Overview of the Chapters

This study consists of five chapters. The first chapter provides an introduction to the study and includes purpose and significance of the study, scope of the study, and overview of the chapters.

Chapter Two has two major parts. The first part provides a literature review of criminal investigation. The definition and the goals of criminal investigation, and empirical studies about the factors affecting the outcome of criminal investigation are discussed in this part. The second part of Chapter Two provides a literature review of police use of information technologies. This part includes development of police technologies in the U.S., types of information technologies used by the police, and empirical studies on the impact of information technologies in law enforcement organizations.

In Chapter Three, the research question, research methodology, and variables of the study are presented. Chapter Four provides data analysis and results. Finally, Chapter Five provides a discussion of findings, limitations, and the policy implications of this study.

# CHAPTER 2: LITERATURE REVIEW

The literature review chapter includes two major parts. In the first part, the literature examining criminal investigation and its goals and the factors affecting the outcome of criminal investigations are presented. In the second part, the literature concerning the development and use of police information systems and the impact of information technologies on police work is presented.

## Criminal Investigations

Criminal investigation is one of the central tasks of law enforcement agencies. In the public's view, criminal investigation may be the most important police task because most people only contact the police when they want to report a crime or become a victim of a crime and expect the police to find the perpetrator or recover their property (Cheurprakobkit, 2000). For that reason, it is not surprising to see that law enforcement agencies devote a huge portion of their resources to criminal investigations (Chaiken et al., 1976; Horvath, et al., 2001). Despite the importance of this factor, the number of studies conducted in this field is limited.

In July 1965, President Lyndon B. Johnson appointed the President's Commission on Law Enforcement and Administration of Justice to examine the crime problem and the use of the U.S. criminal justice system and new policies to curb crime. The Commission issued a 308-page report titled "The Challenge of Crime in a Free Society" and

encouraged Federal, State and local governments to fund criminal justice research[1]. Although it was argued that the Commission's recommendations related with criminal justice research did not come to fruition (DeZee, 1995), research on criminal investigation flourished in the 1970s after the publication of the President's Commission report. Early studies in this field attempted to describe and assess the effectiveness of the criminal investigation process. Although the number of studies on this topic had decreased by the 1980s, researchers continue to study various aspects of criminal investigation, and a body of literature has developed.

In this part of the literature review, major findings of criminal investigation research will be presented. The goal of this review is to better understand the criminal investigation activity and its usefulness for the crime control objective of police. In addition, the factors leading to success in criminal investigation will be laid out to assess how information technologies may contribute to the investigative process. This part is divided into two sections. First, the definition of criminal investigation will be provided, and the major goals attributed to the criminal investigation process will be discussed. Then, empirical studies about the factors affecting the outcome of criminal investigation will be presented.

### *Definition and the Goals of Criminal Investigation*

Generally, criminal investigation is viewed as a 'truth finding' process at the end of which the crime is solved, and offenders are caught (Maguire, 2003). This is evident in the most common definitions of criminal investigation. In the Department of Justice's "Managing Criminal Investigations Manual," criminal investigation is defined as "the

[1] The Commission stated that "Federal, State and local governments should make increased funds available for the benefits of individuals or groups with promising research program and the ability to execute them" (President's Commission on Law Enforcement and Administration of Justice, 1967: 277).

total police effort to: 1) collect facts leading to the identification, apprehension, and arrest of an offender, and 2) organize these facts to present the evidence of guilt in such a way that successful prosecution may occur" (Cawley et al., 1977, p. 1). Similarly, Osterburg and Ward (2007) defined it as "the collection of information and evidence for identifying, apprehending and convicting suspected offenders" (p. 5). Finally, Gilbert (2004) defined it in a rather general tone as "a logical, objective, legal inquiry involving a possible criminal activity" (p. 37).

These three definitions of criminal investigation point to a common process that begins with the determination of the offense, and is then followed by the collection of information, identification of the offender or offenders with the help of available information, and finally the presentation of the case for the prosecution. The truth-finding approach depicts a mechanistic view of criminal investigation. This depiction suggests that the truth about any crime can be uncovered by applying a set of well defined investigative activities through meticulous police work. However, the truth-finding view of criminal investigation is criticized for being unrealistic. Empirical studies of criminal investigation showed that instead of trying to uncover 'truth' by focusing on the crime scene of each offense, detectives usually pursue a suspect-centered approach in which they try to construct a case against the suspects known by the police. According to this view, criminal investigation is not a truth-finding process, but an interpretive activity in which police try to construct the truth by continuously collecting and analyzing available information (Maguire, 2003; Tong & Bowling, 2006).

The construction of truth approach claims that crimes are social constructs, and criminal investigation is an interpretive activity which translates a 'social reality' into a

'legal reality' (Maguire, 2003). Therefore, police interpretation of the facts is critical for criminal investigations (Ericson, 1993). Sanders (1977) argued that the decision to investigate an allegation depends on whether police interpretation of the facts constitutes a real crime. In order to discern real crime from the "phony cases," detectives develop a sense of "what really happened" about each case, which is called "establishing a case" (Sanders, 1977). Waegel (1981, 1982) called this process "case routinization" in which detectives categorize cases as routine versus non-routine based on the information about the victim, offense, and possible suspects. While routine cases were perceived as non-productive cases and receive only a superficial investigative effort, non-routine cases were seen as likely to produce arrest and are vigorously investigated. Therefore, the detective's construction of truth through interpretation of the facts, and the subsequent designation of a case as phony or real (routine or non-routine) were central elements of each criminal investigation

An important common point in the truth-finding and construction of truth approaches is the centrality and importance of information for the investigative work. If criminal activity is not detected by the police, usually some kind of information about a crime initiates the investigation (Eck, 1989; Maguire, 2003). After this occurs, the police collect additional information to understand what has happened, and to try to identify the offender by analyzing and interpreting that information. Finally, the police organize and prepare information for the prosecution in a way that will increase the suspect's chance of conviction. Due to the important role information plays in the investigative process, Innes (2003) defined criminal investigation as "the identification, interpretation and ordering of information with the objective of ascertaining whether a crime has occurred, and if so,

who was involved and how" (p, 113). Innes' 'information work' approach combines truth-finding and construction of truth approaches and provides a better definition of the police investigation. Moreover, the information work approach emphasizes the importance of information for the success of criminal investigation and implies that technologies helping police to better process information may be an important factor for solving crimes[2].

Innes (2007) identified three main stages of criminal investigation which emphasize the importance of the information for the investigative process. The first stage, 'identifying and acquiring,' involves separating relevant information from all other available information about a case. The second stage is 'interpreting and understanding,' which signifies translation of information into intelligence or knowledge. At this stage, bits of information from separate sources are fitted together to form inferences and hypotheses about the crime. Screening the cases is also done at this stage. The third stage, 'ordering and representing,' involves "configuring new knowledge with extant knowledge held by the investigator(s) in a format that enables a solution to the question that is the focus of the investigation to be established and communicated" (Innes, 2007, p. 255). This new knowledge enables investigators to identify and apprehend the offender or offenders, and forward the case for prosecution. Therefore, information is highly important to achieve the goals of criminal investigation.

While there are a variety of goals discussed in the literature (Kuykendall, 1982; McDevitt, 2005), clearance is found to be the most important goal of criminal investigation (Chaiken et al., 1976; Eck, 1989; Greenwood, 1970; Horvath et al., 2001;

[2] Actually, Innes (2003) argues that "increasingly sophisticated information management and communication systems" expand the organizational memory and, in turn, aid criminal investigations (p. 121).

McDevitt, 2005; Waegel, 1981). There are several arguments about the importance of clearance. First of all, clearance is important for the criminal justice system because criminal justice system generally deals with people who were arrested and charged (Maguire, 2003). Clearance is also important for crime prevention activities because clearing crimes can prevent future crime by deterring future offenders (Maguire, 2003). In addition, clearance is important for justice because justice is achieved when the police catch the right offender and provide the necessary information to the prosecution (Eck, 1989). Finally clearance is important for the citizens' trust in the police. By clearing crimes, police reassure people that they are fighting against crime and protecting the society.

## *Factors Affecting the Outcome of Criminal Investigation*

This part presents studies about the factors that are important for the outcome of criminal investigation. The reviewed studies are organized and presented according to the major findings in this literature.

### *Importance of Preliminary Investigation*

Studies on criminal investigation have consistently found that the quality of preliminary investigation[3] and information collected at this stage are crucial factors for the outcome of the investigation (Burrows, 1986; Chaiken et al., 1976; Eck, 1983; Eck, 2008; Greenberg, Elliott, Kraft, and Procter, 1977; Greenberg and Lang, 1973; Morris & Heal, 1981; Horvath & Meesig 1996; Isaacs, 1967; Skogan, & Antunes, 1979; Wilmer, 1970). Furthermore, some studies have stated that the single most important determinant

[3] Criminal investigation is generally divided into two parts: preliminary and secondary investigation. Preliminary investigation is generally consists of the search for the information that would help investigators to solve the case (Cawley et al., 1977). Secondary investigation, on the other hand, is police activity meant to identify and apprehend the offender or offenders and recover the losses (McDevitt, 2005).

of whether or not a case would be solved is the information the victim or witness supplied to the responding patrol officer (Chaiken et al., 1976, Isaacs, 1967; Reis, 1971). Although the importance of preliminary investigation and the information collected at this stage might be the most common and least challenged finding of criminal investigation research, it has not much altered the way that patrol services are conducted. Chaiken, et al. (1976) study that will be described further in the next section found that patrol officers in 58% of surveyed agencies had limited involvement in criminal investigation in the 1970s. In a more recent study, Horvath et al., (2001) analyzed investigative practices on a larger sample and compared their result with the Chaiken, et al. (1976) study results. They found that patrol officers still had limited involvement in criminal investigations in more than half of the surveyed agencies (Horvath et al., 2001).

Information about the suspect, availability of the witness statement and fingerprints collected during the preliminary investigation were identified as the most important determinants of success in Stanford Research Institute's (SRI) weighted screening model[4] for burglary cases (Greenberg and Lang, 1973). This model was tested by the Police Executive Research Forum on a sample of 1,200 cases from 26 police agencies and achieved 85 percent success in predicting the outcome of follow up investigations (Eck, 1983). SRI researchers had developed another case screening model for robbery cases (Greenberg, et al., 1977). Information about the suspect and forensic

[4] Case screening is "a mechanism that will facilitate making a decision concerning the continuation of an investigation based upon the existence of sufficient solvability factors obtained at the initial investigation" (Cawley et al., 1977, p. 37). In the weighted case screening approach, the investigative unit tries to ascertain the solvability of a crime by attaching statistically or non-statistically derived values to each solvability factor. In the unweighted case screening approach, the investigative unit tries to ascertain the solvability of a crime by answering critical questions for the case.

examination were again identified as the most influential factors determining the success of investigation.

The importance of information is also salient in the variation of arrest and clearance rates among different types of crime (Burrows & Tarling, 1982; Marche, 1994; Pucket & Lundman, 2003; Jiao, 2007; Pare, Felson & Quimet, 2007). Skogan and Antunes (1979) further argue that quality of information very much depends on the type of crime due to the "duration of personal contact between the parties." As the duration of contact increases, the victim's likelihood of giving useful information to the police also increases, and those crimes are more likely to get solved. This explains why burglaries are harder for police to solve, and personal crimes particularly ones involving greater duration of personal contact between the parties are more likely to get cleared than property crimes.

In sum, importance of preliminary investigation and the information collected in this stage was consistently found as the most important determinant of a successful criminal investigation.

*Organization of the Investigative Unit*

Organizational reforms are regularly implemented in law enforcement agencies especially in investigative units to increase effectiveness (Eck, 1989). The impact of generalist-specialist investigators and centralized-decentralized investigative units on the outcome of criminal investigation are among the topics discussed in the literature. In one of the earliest studies, Greenwood (1970) evaluated the effectiveness of apprehension programs and operating units of the New York Police Department (NYPD). He also analyzed the effectiveness of "detective patrols" in that study. NYPD's detective patrols

consisted of plain clothe investigators who were patrolling areas known as dangerous to detect and apprehend offenders. He reported that detective patrols were more successful in making primary arrests[5] than the traditional investigative units.

Greenwood's finding was challenged in Chaiken, et al.'s (1976) influential study, which was also known as the RAND study. The RAND study claimed that the organization of police investigators is not related to the variations in crime, arrest, and clearance rates; however, the RAND study and particularly its analysis of how crimes were solved was criticized by some researchers for its methodological weaknesses. For example, Gates & Knowles (1976) argued that the major findings of Chaiken et al.'s (1976) study were based on unreliable data collected from only one police agency (Kansas City Police Department, Missouri). They argued that, although authors had acknowledged this problem, they did not do anything to overcome or alleviate it[6]. RAND study authors responded to these and other critics at different venues;[7] however, their arguments did not eliminate that particular methodological concern about their study.

On the other hand, despite their conclusion on the organization of the investigative units, Chaiken et al. (1976) also stated that "investigative strike forces" had a potential to increase the arrest rates for hard-to-solve offenses if they were employed in their specialization fields. The difference of investigative strike forces from traditional investigative units was that they were organized to conduct both preliminary and

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[5]The author defined primary arrest as the arrest made for the following crimes: murder and non-negligent manslaughter, forcible rape, robbery, felonious assault, burglary, grand larceny, theft of a motor vehicle, possession of stolen property, dangerous weapons, or burglar tools, and petit larceny.

[6] See Chaiken et al. (1976) for validity problems of the Kansas City Detective Case Assignment File.

[7] In one article, they stated that "[o]ur conclusions and especially our policy recommendations should not be judged alone by whether they flow inevitably and exclusively from the data collected in our study. Instead they should be appraised in terms of whether they are within reason correct or incorrect as cast against a full backdrop of what is known about the criminal investigation process" (Greenwood, Chaiken & Petersilia, 1976, p. 62). They also argued that many of their findings had been previously reported and supported by other scholars.

secondary investigation, and they were organized to perform proactive instead of reactive investigation[8]. This argument conflicted with their previous finding stated above because investigative strike forces have a different organizational structure than the traditional investigative units.

Further evidence on the impact of the organization of investigative units was provided by Bloch and Bell (1976) and Elliot (1978). Bloch and Bell (1976) examined the effectiveness of Coordinated Team Patrols (CTP) of the Rochester Police Department, New York. CTP was an investigative unit, which was comprised of patrol officers and detectives working together at a specific geographical location with special emphasis on improving arrest and clearance rates. They found that CTP teams were more successful in terms of making arrest and clearing crimes than non-CTP teams. Similarly, Elliot (1978) examined the effectiveness of the Crime Control Teams (CCT) of Syracuse, New York. CCT was a special investigative unit responsible for all the stages of an incident occurring in its areas. Elliot (1978) found that the clearance rate was higher for the CCT areas than the non-CCT areas. When he compared the key factors that helped to clear more cases in CCT areas, he found that CCT detectives had achieved greater citizen involvement; they were better in intercepting ongoing crimes; and they conducted better investigative work than non-CCT detectives.

In conclusion, the majority of studies found that organizational structure was effective on the outcome of investigations. Alternative organizational structures were effectively increasing the time spent on investigations, detectives' motivation and citizens' involvement.

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[8] Reactive investigations are "investigations of crime events after they occur because a citizen initiates the investigation through a request;" on the other hand, "proactive investigations are police initiated, sometimes before any crime has been committed" (Eck, 1989, p 176)

*Agency Size and Workload of Investigators*

There are several studies that tested the impact of agency size or workload of detectives on the outcome of police investigations. Greenwood (1970) analyzed the impact of caseloads on the arrest rates and found inconclusive results. He divided NYPD precincts as low and high caseload precincts and found that low case load precincts had higher assault arrest rates than high caseload precincts, but the high caseload precincts had higher arrest rates for robbery and burglary cases. This finding suggested that the impact of caseload on the solution of crimes might differ according to the type of crime. Developing a computer simulation model, Folk (1971) reported that the time allocated to a case by detectives has a substantial effect on overall case processing in the system. On the other hand, Chaiken et al. (1976) claimed that differences in workload have no appreciable effect on crime, arrest or clearance rates because investigators spend more of their time doing clerical activities such as reviewing reports, documenting files, and interviewing suspects on cases that have less of a chance of being solved.

Ostrom, Parks and Whitaker's (1978) study took a different approach to the issue, and used citizen evaluations of police services and crime rates as their dependent variables and examined them to see whether they changed with patrol density. They found that larger departments were not performing more effectively than others. Conversely, small to medium sized departments were performing equally to or better than larger departments. The authors argued that the citizen-to-police ratio was the critical factor in this finding. Since small police departments were serving in smaller communities, they could achieve a higher citizen-to-police ratio than large police

departments, which were serving in larger communities. As a result, agency size was found to indirectly affect the level of citizen satisfaction in their study.

Later studies have tested this proposal on larger samples by employing improved models; however, they also arrived at conflicting conclusions. Burrows & Tarling (1982) explored the determinants of clearance with British data collected from 41 forces and found consistent and negative impact of workload on clearance rates after controlling for crime and socio-economic variables. On the contrary, using 76 cities' crime and arrest data, Liska and Chamlin (1984) found that the impact of agency size on arrest rates was usually insignificant and varied by type of crime and race, again, after controlling for crime and socio-economic variables[9].

After deeper analysis deeper, Cordner (1989) used the Unified Crime Report's (UCR) crime and clearance statistics and collected demographic data from municipal police departments and county police or sheriff departments in Maryland. With similar conclusions as Liska and Chamlin, he found that region and proportion of property crime variables were significantly related to the clearance, but agency size, and workload variables were insignificant. Cordner then divided his sample into metropolitan and non-metropolitan cities and ran two separate analyses. The agency size variable was again insignificant in both analyses. He concluded that the regional scale and community complexity may be more important, and environmental variables may be more influential than organization-level variables for clearance.

In sum, the majority of studies shows that there is not a clear relationship between agency size and investigative effectiveness. Although agency size appears as an

[9] Liska & Chamlin (1984) study investigated the impact of racial/economic composition of macrosocial units on arrest rates. Therefore, they selected 76 cities for which residential segregation rates had been calculated since 1940, and crime and clearance data was available.

important factor for citizens' evaluation of police services, larger agencies are not more successful than smaller agencies in solving crimes.

*Forensic Evidence*

Although physical evidence and forensic examination is generally expected to increase the effectiveness of criminal investigation, it is certain that it has been underutilized. Peterson, Mihajlovic, and Gilliland's (1984) study found that clearance rates were higher in cases for which physical evidence was collected and analyzed. Moreover, their analyses showed that physical evidence increased the odds for successful case outcome. On the other hand, Chaiken et al. (1976) reported that most police agencies collect more physical evidence than they could productively process. Moreover they argued that latent fingerprints rarely provide the only basis for identifying a suspect. Horvath and Meesig's (1996) study supported the conclusion drawn in Chaiken et al.'s (1976) study. They claimed that police investigate only a small percentage of crimes; physical evidence is collected in only a small percentage of cases investigated; only a small percentage of the collected evidence actually undergoes scientific analysis; and, in most cases physical evidence is not determinative of case outcomes.

More recently, Jones and Weatherburn's (2004) study also found that forensic evidence is underutilized. Similarly, Burrows, Tarling, Mackie, Poole and Hodgson (2005)[10] reported that forensic evidence contributed to only four percent of clearances in England and Wales in 2001. They attributed the little contribution of forensic evidence to

[10]Results were published before the release of the formal report: Burrows, J., & Tarling, R. (2004). Measuring the impact of forensic science in detecting burglary and auto crime offences. *Science & Justice, 44*(4), 217-222.

the difficulties of recovery of useful contact trace material from the crime scenes[11]. They argued that forensic evidence was a contributory factor, but not a critical factor in criminal investigations. Police training and culture were pointed as two possible causes for the underutilization of forensic evidence. Horvath & Meesig (1996) stated that since detectives have limited training and understanding of physical evidence and scientific analysis, they usually focus on the human aspects of the criminal investigations like victim statements and suspect interrogations. Bradbury and Feist (2005), on the other hand, stated that forensic analysis is still a contributory factor in criminal investigations, but by the introduction of automated searching of fingerprint, DNA and other forensic databases, forensic techniques began to help to identify unknown offenders as well. They also argued that forensic evidence made an important contribution to the identification of hard-to-solve cases especially when other forms of evidence were absent.

In sum, although it is underutilized, forensic evidence is effective when incorporated into criminal investigations. Currently, forensic evidence is used mainly as a support element in criminal investigations, and as a result, makes little contribution to the clearance of the cases. On the other hand, the extension of its role in criminal investigations requires changes in police training and culture.

*The Social Factors*

As argued by the construction of truth approach to the criminal investigation, social context and victim characteristics might have an impact on officers' interpretation of incidents and execution of criminal investigations. The society's impact on criminal investigation was generally discussed within two areas: 1) detectives' decision to initiate

[11] They calculated that examination of 100 burglary and vehicle crime scenes would yield only seven fingerprint, 2.6 SGM plus, and 1.4 LCN identifications (SGMplus and LCN are two different DNA analysis techniques).

an investigation, and 2) outcome of the investigations. For the first part of the discussion, Sanders (1977) and Ericson (1993) claimed that detectives' decision to investigate was a result of victim, case and agency related factors. Waegel's (1981, 1982) studies provided more insight into this debate. He revealed that detectives' decision to investigate depends on the information available about a case. Waegel stated that detectives were facing two kinds of pressure within the organization: paperwork and arrest production requirements. In order to satisfy these requirements, detectives group cases as routine and non-routine where routine cases are non-productive cases and receive only a superficial investigative effort, and non-routine cases are productive cases and are vigorously investigated. Waegel (1981, 1982) argued that social characteristics of the victim and the social context are important for detectives' interpretation of cases as routine and non-routine.

This issue was further tested by Bynum, Cordner and Greene (1982), and partial support was provided. Researchers analyzed the investigative activities of a Midwestern Police Department and found that the amount of existing evidence had significant impact on detectives' decision to investigate for property crimes. Furthermore, the victim's social class was significant for burglary crimes; a conclusion only partially supported later by Brandl (1993). Although Brandl's (1993) quantitative analysis results reported that victim's social structural characteristics did not have an impact on detectives' decision to investigate, qualitative observations suggested that they were influential. Based on observations, he argued that detectives' decisions were affected by the victim characteristics. Finally, Klinger (1997) argued that social characteristics of department's jurisdiction have an impact on officers' vigor with respect to investigating crimes. In

conclusion, available evidence indicates that social characteristics are influential on detectives' decision to investigate.

For the second part of the discussion, economic and demographic variables were tested as the predictors of the outcome of criminal investigation. For example, Swanson (1978) found that environmental variables (income inequality, percent nonwhite, males aged 15-19) have a greater impact on the arrest rates than the police organizational variables (centralization, specialization, professionalism, community relations orientation, task orientation). Later studies on this debate also generally found supportive evidence. Burrows & Tarling (1982) found that population and the proportion of the 15-24 age group with respect to the total population had a negative impact on clearance. Liska and Chamlin (1984) also found supportive evidence showing that the racial/economic composition of cities substantially, and economic inequality moderately affects arrest rates for violent crimes and property crimes. Pucket and Lundman (2003), on the other hand, found that socioeconomic composition was insignificant, but race composition was a significant predictor of homicide clearance. Pare et al. (2007) found that community size, poverty, and types of crimes were significant predictors of clearance. Therefore, the existing literature generally supports the argument that decision to investigate a crime and the outcome of a criminal investigation is affected by victim characteristics and the social context of department's jurisdiction.

In consequence, review of criminal investigation literature showed that preliminary investigation and the information collected in this stage were the most important determinants of outcome of criminal investigations. This finding emphasizes the importance of information for the criminal investigations. Social context of

department's jurisdiction, victim characteristics and the organization of investigative unit were also found influential on the outcome of investigations. There were not sufficient amount of studies about the impact of agency size and workload of investigators on criminal investigation; however, existing studies generally report that those variables were not influential on the outcome of investigations. Finally, forensic analysis was generally found influential on the outcome of investigations, but since it was underutilized, its impact was very small

## Police and Information Technologies

This part describes development, use and impact of IT in U.S. law enforcement agencies. It begins with the definitions of some important terms and the historical development of IT use by police agencies in the U.S. Then, the types of information technologies used by the police and IT implementation problems in law enforcement agencies are described. Finally, studies on the impact of information technologies on public domain, particularly on law enforcement agencies, are reviewed. Since the number of studies about the impact of information technologies on law enforcement organizations is low, a review of major studies conducted on other public agencies enriches our understanding of information technologies.

### *Definitions*

Definitions for information, information technology and information systems are given in this section. Information has been defined in many ways. These definitions include: facts organized to describe a situation or condition (Wiig, 1993); data with relevance and purpose (Davenport & Prusak, 1997); anything that reduces uncertainty about the next part of the message (Manning, 1992); the value attached or instantiated to

a characteristic or variable returned by a function or produced by a process (Losee, 1997). Within the police context, Innes defined information as the "meaningful data of potential relevance to the investigative activities of the police, either related to a specific crime being investigated, or some other matter in which the police may have an interest" (Innes, 2003, p. 113).

Since the information concept has a broad meaning, the domain of information technology extends to almost every corner of life. WordNet dictionary defines information technology as "the branch of engineering that deals with the use of computers and telecommunications to retrieve and store and transmit information" (WordNet). Similarly, Turk (2000) defined it as any technology that is used to deliver data, information, and knowledge. Finally, Hogan and Radack (1997) offered a more useful definition for this study. They defined it as the blend of hardware and software used for storage, processing, transfer, display, management, organization, and retrieval of information.

No single piece of information technology can satisfy the complex information needs of contemporary organizations by itself. Therefore, different types of information technologies interconnect and form information systems. O'Brian (2002, p. G-10) defines an information system as "a system that accepts data resources as inputs and processes them into information products as output." Although using any information technology is not a necessary condition for an information system to function, information technology and information systems are usually associated with each other. As a matter of fact, information technology has become a very important component of modern information systems, and it is highly critical for the success of an organization. Information

technology and information system concepts are so interconnected with each other that it is not possible to completely separate them. As a result, this study views information technology within the information system context as a part of an information system, not as a separate entity.

*Development of Law Enforcement Information Technologies in the U.S.*

Although extensive use of technology in the police organizations did not start until the 1970s (Brown, 2000), efforts for developing systematic information about the crime began as early as the 1800's (Seaskate, 1998). In 1834, Massachusetts became the first state to collect data on crimes, and in 1850, the Federal Government began to collect crime data in conjunction with the census. By the early 1900s, criminal statistical reports were prepared by compiling police reports (Dunworth, 2000). These initiatives were the initial steps in developing contemporary criminal justice information systems.

The early reformers of the American policing system tried to separate the police from the politics, and the professional or traditional policing era began by the 1920s and continued until the 1970s (Seaskate, 1998). August Vollmer, Bruce Smith, Harry Fosdick, and Orlando Wilson were among the influential figures, and the use of the polygraph machine and fingerprint and handwriting classification systems began in this period (Manning, 1992). Also in this era, police adoption of the automobile and two-way radios occurred, and the FBI established its own forensic laboratory in 1932 (Seaskate, 1998). In 1929, the International Association of Chiefs of Police (IACP) implemented the Uniform Crime Reporting (UCR) system, transferring the system to the FBI in 1930. President Hoover launched the National Commission on Law Observance and Enforcement, also known as the Wickersham Commission, in 1929. As the first national

initiative to evaluate the U.S. system of justice administration, the Commission recommended the collection of accurate nationwide statistics on crime and the criminal justice system (Dunworth, 2000; 2004).

In 1965, Lyndon B. Johnson appointed the President's Commission on Law Enforcement and Administration of Justice to examine the crime problem. The Commission offered more than 200 recommendations, and 13 of them were about the development of technologies related to police operations[12]. In order to be able to develop and use effective criminal justice technologies, huge amounts of federal subsidies were provided to local and state law enforcement agencies. The Law Enforcement Assistance Administration (LEAA) was established by the Omnibus Crime Control and Safe Streets Act of 1968 to manage the federal funds given to the criminal justice system (Dunworth, 2000; 2004). LEAA sought to spur the computerization of policing. This policy change had been coupled with advances in information technologies. Beginning from the 1960s through the 1990s, information technologies became more effective, efficient and affordable. Moreover, software manufacturers began to develop many useful programs for business and government use[13].

The professional model of policing has generally been characterized by its narrow focus on traditional law enforcement and crime control policies (Greene, 2000). In the 1970s, police agencies began to challenge this criticism by encouraging the community's involvement in crime prevention activities (Seaskate, 1998). Computerization of law enforcement continued in this era and during this period, the National Crime Information

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[12] The Commission stated that "scientific and technological revolution that has so radically changed most of the American society during the past few decades has had significantly little impact on the criminal justice system" (President's Commission on Law Enforcement and Administration of Justice, 1967, p. 245).
[13] See Brown (2000) for further discussion on the diffusion of technological innovations into the criminal justice system

Center (NCIC), 911 system and Automated Fingerprint Identification System (AFIS) were developed (Seaskate, 1998)[14]. Established in 1982 by the FBI, NCIC aimed to provide criminal justice information such as criminal record history information, and information about fugitives, stolen properties, and missing persons to the criminal justice agencies. This development further encouraged the adoption of computer technology (Davis & Jackson, 2004). In the same year, the FBI initiated the National Incident Based Reporting System (NIBRS) project to improve its crime reporting system (UCR) and began accepting NIBRS data in January 1989. NIBRS provides very detailed incident-based information about crimes; however, implementation of NIBRS has been a slow process mainly because of funding problems and lack of motivation of implementing agencies[15]. As of 2003, 5,271 agencies in 23 states were certified as NIBRS participating agencies (Bureau of Justice Statistics, 2004)

With the dissolution of LEAA, the National Institute of Justice (NIJ) became the research and development arm of the criminal justice system. NIJ pursues its technological research and development goal through the Office of Science and Technology (OST) and touts the development of lightweight body armor and DNA analysis among its important achievements (Dunworth, 2004).

Law enforcement agencies received funding from different federal and local agencies for their information technology needs, and those grant programs usually required them to focus on specific programmatic objectives. As a result, a "patchwork" of various computer systems that "are applicable only for very specific purposes, are unable to share information with other justice agencies, and serve only individual components of

[14] See Klug, Peterson, & Stoney (1992) for more information on development, implementation and impacts of AFIS.
[15] See Faggiani & Hirschel (2004) for an extended discussion of the issue

state and local governments" were implemented throughout the U.S. (Davis & Jackson, 2004, p. 29). For this reason, integration of criminal justice information systems became a priority for the criminal justice community. In 1998, the Crime Identification Technology Act (CITA) which provided funding for five years for integration of criminal justice information systems was enacted. However, integration problems were cited as major factors leading to the 9/11 terrorist attacks and even today continue to be critical problems (National Commission on Terrorist Attacks, 2004). The variety and complexity of police information systems are important factors impeding the research and integration of criminal justice information systems; therefore, it will be useful to explore the types of information systems used by law enforcement agencies.

### *Types of Law Enforcement Information Technologies*

There are numerous hardware and software systems developed for law enforcement agencies, and a concise overview of some important systems will be provided in this section. However, prior to this, it is useful to look at how researchers have grouped law enforcement information technologies in their studies. There are several law enforcement IT system classifications offered in the criminal justice literature[16]. For example, Colton (1972) grouped police information technologies around four main functional areas: Police patrol and daily operations, investigative analysis, administration management, and program/planning and evaluation. Ackroyd, Harper and Hughes (1992) grouped investigative information technologies under the management category, which consists of command and control, crime reporting, management of

[16] Similarly, police technologies are also discussed in the literature and several classifications are offered. See Nogala (1995), Nunn (2001), and Manning (2003).

information, and duty state systems[17]. Similarly, Stevens (1995) defined three kinds of law enforcement information systems: data retrieval systems, analytical systems, and process control systems. Manning (1992) offered a different categorization as primary, secondary and tertiary information technologies. Primary technologies mainly consist of communication systems and more related with the preliminary investigation stage; secondary information technologies are used to support ongoing cases and management functions and more related with the secondary information stage; and tertiary information technologies consist of analytic systems. Although tertiary information technologies are also related with the secondary investigation stage, they are mainly used for analysis, evaluation and strategic planning. Finally, Dunworth (2005) offered a more updated classification and presented law enforcement information technologies as crime analysis, records management systems, offender histories and offender identification, mobile data terminals, and forensic technology.

The examination of these different classifications revealed that investigative use of information technologies can be grouped according to following four areas: communications and remote data access, records management, crime analysis, and forensic analysis. Table 1 shows these areas and organizes other classifications according to these groups. For example Colton's police patrol and daily operations category involves communication and mobile computing and records management groups combined. The investigative analysis group, on the other hand, involves both crime analysis and forensic analysis groups. Table 1 shows that other classifications also generally fit to this new classification scheme.

[17] Duty state systems are generally used to keep records of status information of personnel such as work hours, location information, activities, etc.

Table 1

*Classification of Police Information Technologies*

| Areas | Colton (1972) | Ackroyd et al. (1992) | Stevens (1995) | Manning (1992) | Dunworth (2005) |
|---|---|---|---|---|---|
| Communication and Mobile Computing | Police patrol and daily operations (patrol activities, operations, traffic incidents, CAD, etc) | Command and control | Process control systems | Primary information technology | Mobile data terminals - |
| Records Management | | Crime reporting | Data retrieval systems | Secondary information technology | Records management, criminal histories and offender identification |
| Crime Analysis | Investigative analysis (Criminal histories, modus operandi system, fingerprint systems) | Management of information | Analytical systems | Tertiary information technology | Crime analysis, UCR, NIBRS |
| Forensic Analysis | | | | (Secondary information) technologies) | Forensic technology |

However, it must be noted that modern law enforcement information systems are usually integrated with each other to increase the information sharing capability and effectiveness of police operations[18]. For example, a 911 system can communicate with the CAD system which enables the call center officer to assign the appropriate patrol officer to the call. All the information produced by the 911 and the CAD systems can be transferred to the records management system for further analysis of investigators or for archiving purposes. Moreover, local, state or federal level records management systems can interact with crime analysis applications. Therefore, it should be taken into account that usually there are not solid borders between categories, and some technologies can be

[18] Weller et al. (2001) argues that the goals of current IS projects are 1) developing inter-agency collaboration as a way of doing business, 2) developing a capacity to create policy based on data and information, 3) creating system-wide approaches to solving problems, and 4) involving the community in the criminal justice policy (Weller et al., 2001).

recorded within more than one category[19]. A brief explanation of those four areas would be helpful in understanding the use of information technologies in law enforcement agencies

*Communication and Mobile Computing*

Communication and mobile computing technologies are used for wireless receipt and transmission of information to and from officers on foot or in patrol cars (Dunworth, 2004). Police departments generally use laptop computers and different handheld devices such as cell phone and personal digital assistant (PDA) for mobile access. Mobile computing is mainly employed to query databases, to communicate with the CAD system and peers, to prepare and file incident reports and to get information on job related topics. One of the important applications used with mobile computing is automated field reporting (AFR). The AFR application enables officers to prepare incident reports at the scene, to electronically submit these to a supervisor for approval and then to submit them to the RMS. AFR applications have useful features such as drop-down menus, spell-checking, prefilled fields, pre-population of multiple forms and error correction to maximize integrity of the information stored in the RMS (Harris & Romesburg, 2002). As new technologies are developed, mobile computing becomes more efficient, and more departments are benefiting from it (Dunworth, 2005).

*Records Management*

Records Management System (RMS) is probably the most important part of a law enforcement information system. RMS is mainly used for storage, retrieval and

[19] An insightful presentation of system integration in law enforcement information systems is provided by Dean and Gottschalk (2007). In their matrix of technological and policing functions, they visually show that some law enforcement IT systems are designed to perform more than one policing or technological functions together.

processing of information about every aspect of police business (Dunworth, 2005). A typical RMS stores and processes information regarding incidents, persons, vehicles, locations, arrests/bookings, traffic related incidents, property, evidence and many other things. Moreover, RMS provides access to a wide range of external RMS applications, which stores different kinds of information like offender histories and identifications. Major RMS applications that can be used as an extension to agency records are as follows:

1. National Crime Information Center (NCIC). The NCIC system houses a wide range of criminal justice information including criminal record history, fugitives, stolen properties and missing persons information. NCIC data are compiled by the FBI, federal, state, local and foreign criminal justice agencies, and authorized courts (FBI, 2009c).

2. Violent Criminal Apprehension Program (ViCAP). ViCAP keeps information related to the violent crimes; specifically homicides, sexual assaults, missing persons, and unidentified human remains (FBI, 2009b). All the information submitted to ViCAP system is compared with stored information, and similar cases are reported to the users.

3. Regional Information Sharing System (RISS). RISS is a federally funded program providing support to law enforcement agencies. Its main purpose is to combat illegal drug trafficking, identity theft, human trafficking, violent crime, terrorist activity, and to promote officer safety (BJA, 2007). RISS is comprised of six multi-state centers communicating on a secure network known as RISSNET.

4. National Incident Based Reporting System (NIBRS). As described above, NIBRS is developed as a complement to the Uniform Crime Reporting (UCR) system's

shortcomings. It is an incident-based reporting system for crimes known to the police and provides detailed information about offenses (FBI, 2009c).

In addition to these four systems, there are other RMS applications such as the Interstate Identification Index (III) and the National Instant Criminal Background Check System (NICS). "Modern RMS applications are focused on improving data accuracy and speedy retrieval of information" (Harris & Romesburg, 2002, p. 253). Therefore, they are integrated with other systems and allow them automatically to add new data to the system and to query databases for administrative and operational tasks.

*Crime Analysis*

Crime analysis is "the systematic study of crime and disorder problems as well as police related issues … to assist the police in criminal apprehension, crime and disorder reduction, crime prevention and evaluation" (Boba, 2005: p. 6). Crime analysis consists of the following three essential functions:

> 1) Assess the nature, extent, and distribution of crime in order to efficiently and effectively allocate and deploy resources. 2) Identify crime suspect correlations to assist investigations. 3) Identify conditions that facilitate crime and incivility so that policymakers may make informed decisions about prevention approaches (O'Shea and Nicholls, 2003, p. 8).

The crime analysis process consists of the collection, collation and analysis of data, dissemination of results and finally incorporation of feedback from the users into the analysis (Boba, 2005). Since information technologies have great potential to aid all of these steps, there are many different IT applications that are used for crime analysis

purposes. Two important IT systems that are closely related with crime analysis are as follows:

1. Geographic Information Systems (GIS) and Crime Mapping. GIS is "a system designed to store, manipulate, analyze and output map-based or spatial information" for many purposes (Steinberg, 2005, p.7). GIS store information about places in the forms of "layers". This structure enables a GIS system to present any kind of information about a location on a map. Therefore, GIS users can view either discrete levels of information for a specific analysis or many levels of information together to get a detailed picture of the location (Harris & Romesburg, 2002). In crime analysis, GIS is mainly used to produce crime maps by merging information from crime and geographical databases. Crime mapping applications synthesize crime related information from different sources and visualize them on a map in a way that is easier to understand the relationships and trends (Chu, 2001). Moreover, integrated with Global Positioning Systems (GPS) and the Automatic Vehicle Location system (AVL), GIS can be used in deploying units and analyzing patrol activities.

2. Computer-Aided Dispatch (CAD) System. The CAD System is generally the first point of data entry "designed to handle all information related to receiving and dispatching emergency calls for service" (Harris & Romesburg, 2002, p. 248). Although McEwen (2002) argued that CAD systems were designed mainly for improving operational efficiency and achieving crime control through arrest, modern CAD systems are an important part of crime analysis. Integrated with the E-911 (Enhanced 911) service, CAD systems can store incident location history and related information such as warrants, number and type of prior calls to the location. Moreover, combined with a

geographic database, CAD systems can pinpoint coordinates of a location on a map and store geospatial information suitable for further analysis (Harris & Romesburg, 2002). In addition, CAD Systems can be integrated with other systems. For example, with suitable message switch configurations, local, state and federal databases can be automatically queried both at the CAD center and from patrol cars. CAD systems can also be integrated with Internet so that users can get e-mails from the system and connect to the system from anywhere (Chu, 2001).

In addition to these systems, there are plenty of crime analysis software applications available to support criminal investigations. These applications usually help police to conduct link analysis, network analysis, event sequence analysis and transaction pattern analysis (Adderley & Musgrove, 2001)

*Forensic Analysis*

As discussed in the first part of the literature review, forensic analysis has a small impact on criminal investigations mainly because forensic evidence is not collected in majority of cases and most of the collected evidence is not even analyzed (Burrows et al., 2005; Chaiken et al., 1976; Weatherburn, 2004). Information technologies are mainly used for information sharing purposes in forensic analysis. There are several information sharing networks used by law enforcement agencies nationwide:

1. Integrated Automated Fingerprint Identification System (IAFIS). IAFIS is a national fingerprint and criminal history system. It provides automated fingerprint search capabilities, latent searching capability, electronic image storage, and electronic exchange of fingerprints to the law enforcement agencies (FBI, 2008b). With the developments in

imaging technologies and mobile computing systems, IAFIS inquiries can be made by patrol officers on the scene.

2. National Integrated Ballistic Information Network (NIBIN). NIBIN is a database of fired cartridge casing and bullet images. It allows partnering agencies to enter digital images into the system and to correlate them against earlier entries via electronic image comparison (ATF, 2009).

3. Combined DNA Index System (CODIS). CODIS stores DNA profiles of convicted felons and unidentified DNA found in crime scenes (FBI, 2009a). It allows forensic laboratories to add new records and compare them with the stored information.

In sum, there are many kinds of information technologies and different information systems available for law enforcement agencies. Although most of the law enforcement agencies are benefiting from those technologies (Davis & Jackson, 2004), it is not possible to say that all the benefits of information technologies are realized. Implementation problems still remain as the most important impediments, and they prevent law enforcement agencies from taking advantage of at least some of the opportunities provided by the information technologies. For that reason, it will be useful to outline implementation issues in the law enforcement context.

*Implementation Issues*

In 2005, the FBI's Virtual Case File project was cancelled with a loss of more than $100 million. The U.S. Department of Justice Report pointed to the following problems: "poorly defined and slowly evolving design requirements; overly ambitious schedules; and the lack of a plan to guide hardware purchases, network deployments, and software development for the bureau" (Goldstein, 2005, p. 1). The Virtual Case File

project is the most recent significant example of information technology implementation failures. Information technology implementation is difficult particularly for public organizations because IT projects are 1) big projects, 2) they often cross the line of authority, 3) they deal with technology and aligning technology to the agency's needs and 4) they are time-sensitive (Harris & Romesburg, 2002). For these reasons, there are several guides that are prepared and disseminated by different agencies to help law enforcement agencies in designing and implementing information systems (e.g. Harris & Romesburg, 2002; Institute of Policy Research, 2004; Weller, Martin, Price & Wagenknecht-Ivey, 2001)

Researchers have generally pointed to the organizational structure of police agencies as the root cause of implementation failures. In an early study, Colton (1979) stated that complexities concerning the implementation of technology and the context and nature of police work should have been considered while planning information technologies for police agencies. Similarly, Ackroyd et al., (1992) stated that IT has many potential benefits to police work; however, the internal and external characteristics of police organizations hinder the successful implementation of IT systems. The requirements of a successful IT implementation usually contradict work practices and the organizational context of the police force. Therefore, Ackroyd et al., (1992) argued that IT may make important contributions to police work, but IT innovation by itself is not a solution to the policing problems.

Along the same line, Manning (2001) argued that because of the different context of police organizations, technological solutions cannot be implemented as they are implemented in other organizations. The social context, organizational structure and

historical development of police organizations have an important impact on the success of IT systems. He claimed that law enforcement technology can be most useful only for crime analysis purposes. Manning argued that IT implementation in law enforcement agencies should be accompanied by organizational change in order to be successful. This point is reiterated in the Police Department Information Systems Technology Enhancement Project (ISTEP) report which argued that community and problem oriented policing require several fundamental changes in police agencies, and information systems should be designed to support the new framework (Abt Associates, 2001).

However, organizational change is not easy, and IT implementation studies reported that it is one of the biggest obstacles for law enforcement agencies. LeBeuf (2001) argued that the investigation community "accepts the required changes at a snail's pace" (p. 19). He stated that information technologies that were completely new to the police usually require an adjustment period, but this period has been seen as a loss of job efficiency by some managers. As a result, sometimes officers were forced to adopt new technologies without adequate training, which causes failure (LeBeuf, 2001). Similarly, studies by SEARCH (1997) and Brown, McCabe and Wellford (2007) showed stakeholder resistance to change, education and training as important challenges to the IT implementation in law enforcement agencies.

Consequently, IT implementation is problematic for organizations, and it is even more problematic for law enforcement organizations because of their formal structure and organizational culture.

## *Impact of Information Systems*

This section reviews the literature on the impact of information technology. It begins with a discussion of information system evaluation and DeLone and McLean's (2003) model. Subsequently, empirical studies about information technologies' impact on public and law enforcement organizations are presented. This section will end with a discussion of Compstat.

### *A Model for Evaluation of Information System Success*

Despite the huge amounts of money spent on IT each year[20], its contribution to organizational goals is not clear. As Nobel Laureate Robert Solow stated, computers are everywhere except in the productivity statistics (as cited in Brynjolfsson, 1993). This disappointing conclusion was called "productivity paradox." In the early days of information technologies, improving the efficiency of information processing was the primary target of IT investments, and evaluation of information technologies was relatively easy. Through the rapid development of information systems, information technologies became a "competitive advantage"[21] for particularly the private organizations, and the role of information technologies "has been changed from one of support to one of strategic importance" (Ballantine, Galliers & Straw, 1996). Meanwhile, the nature of the benefits accrued from IT investments changed and became more intangible. For this reason, Brynjolfsson, (1993) defined mismeasurement of inputs and

[20] For example, according to the 2009 Federal Budget plans, the Department of Homeland Security would get $400 million to protect the critical infrastructure and IT networks from hackers, $39 million in new spending to standardize IT acquisitions and "streamline maintenance and support contracts," and $71 million in new spending for Immigrations and Customs Enforcement IT, including detainee tracking, case management, data warehousing, and data center consolidation (Hoover, 2009).

[21] A competitive advantage exists when the firm is able to deliver the same benefits as competitors but at a lower cost (cost advantage), or deliver benefits that exceed those of competing products (differentiation advantage). Thus, a competitive advantage enables the firm to create a superior value for its customers and superior profits for itself (Porter, 1998).

outputs as the most important cause of the productivity paradox[22]. The measurement problem is particularly acute for the service sector and among white collar workers whose input and output is harder to measure.

As a result, many different evaluation models for information technologies were offered in the literature[23]. DeLone and McLean (1992) conducted an extensive review of IT evaluation literature and developed a new model. They argued that the variety of IT evaluation approaches can be seen as a result of the range of information system success measures. This variety is understandable when we think that information is the most basic output of an information system. DeLone and McLean (1992) argue that information can be measured at different levels including the technical level, the semantic level and the effectiveness level. Success at the technical level is measured by analyzing the accuracy and efficiency of the system that produces the information. Success at the semantic level is measured by investigating whether the information conveys the intended meaning. Finally, success at the effectiveness level is measured by analyzing the effect of the information on the receiver. Therefore, the variety of IT evaluation approaches and IS success measures is a manifestation of the characteristics of the information. By taking this into consideration, DeLone and McLean (1992) developed their causal model to measure IS success (Figure 1)[24]. Since the DeLone and McLean IS success model will be used in this study, an explanation of the model will be appropriate to better understand this study and also IT evaluation studies in general.

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[22] Other explanations for the productivity paradox offered by Brynjolfsson (1993) are lags due to learning and adjustment, redistribution and dissipation of benefits, and mismanagement of information and technology. Brynjolfsson (1998) also argued that organizational change is essential for information technology to be effective.

[23] See Rocheleau (2005), Garson (2006) and Gunasekaran, Ngai, & McGaughey (2008) for a detailed discussion of IT evaluation and major IT evaluation models.

[24] DeLone and McLean proposed their original model in their 1992 study and updated it in their 2003 study. Figure 1 presents the updated model.

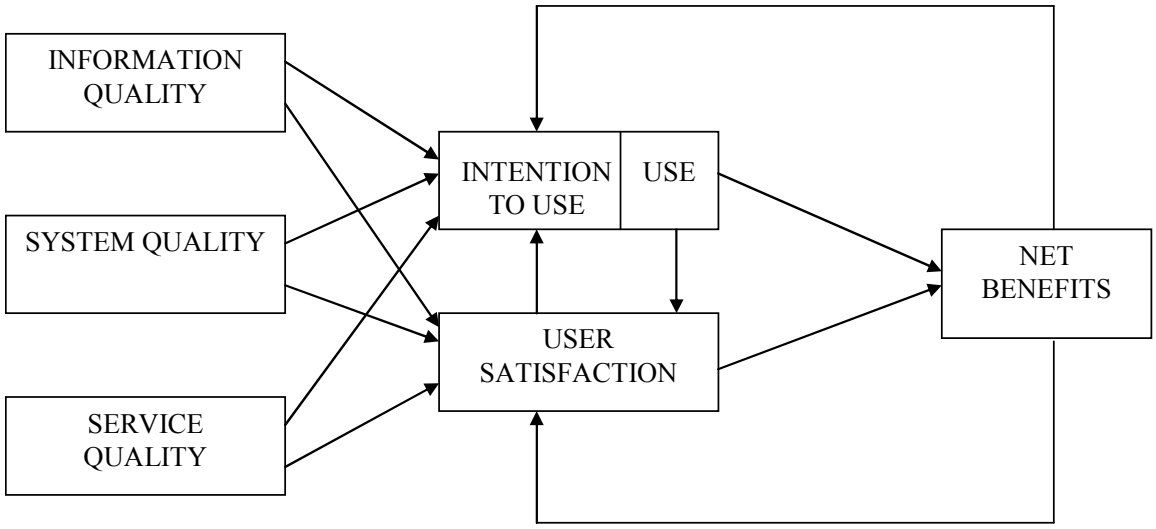


*Figure 1.* DeLone & McLean information system success model

As shown in Figure 1, there are six categories of IS success measures according to DeLone and McLean. The system quality and the service quality variables measure information system success at the technical level. System quality variables are engineering-oriented performance characteristics of the system. Adaptability, availability, usability, reliability and response time are commonly used system quality measures. The service quality, which was added to the model later, is measured by the assurance, empathy and responsiveness of the service unit. The information quality variables measure the information system success at the semantic level. Completeness, ease of understanding, personalization, relevance and security are used to measure information quality. These characteristics of the information system are usually measured from the perspective of the user; as a result, they are fairly subjective.

The remaining three groups of variables measure success at the effectiveness level. The use of information system is straightforward, and it measures the nature of use, navigation patterns, number of visits, and number of transactions executed. Intention to use was added to the model later because use of some systems might be mandatory. User

satisfaction is the most widely used measure for information system success. It is usually measured by user surveys. Numbers of repeat purchases or repeat visits were also used for measuring e-commerce systems' success. Finally, net benefits can be measured by many outcome variables such as cost savings, expanded markets, incremental additional sales, reduced search costs, and time savings. DeLone and McLean (2003: 19) argued that "[t]he choice of where the impacts should be measured will depend on the system or systems being evaluated and their purposes." Therefore, not to complicate their model with more success measures, they preferred to group all impact measures into a single category called net benefits. According to the model, information system success can be measured in all these six levels. Furthermore, there is a relationship between these six success levels. For example, information quality affects the use of the system and user satisfaction where use and user satisfaction affect the net benefit accrued from the information system.

Since DeLone and McLean's information system success model is a complex model, researchers have generally tested parts of the model. For example, Seddon and Kiew's (1996) and Roldan and Millan's (2000) studies tested the system quality and user satisfaction relationship and found supportive results. Almutairi & Subramanian (2005) tested system quality, information quality, system usage and user satisfaction and reported supportive results. Particularly, they found a significant relationship between system use and net benefit, which is measured as the effect of the information system on users' performance. Finally, Iivari (2005) was also tested system quality, information quality, system usage, user satisfaction and individual impact and reported partial support

for the model. Iivari (2005) also found significant relationship between system use and net benefit relationship.

*Information System Impact at the Technical and Semantic Level*

Technical and semantic measurement levels consist of measures related to system quality, service quality and information quality[25]. The PMIS studies generally report a positive contribution of information technologies to system and information quality (Danziger & Andersen, 2002). For example, Brown (1996) analyzed the hurdles to GIS success by conducting a survey study on a nonrandomized sample of local governments and found generally positive results at the technical level. Survey respondents were satisfied with the accuracy and timeliness, but somewhat dissatisfied about the availability of the data. To assess IS success at the semantic level, Kraemer, Danziger, Dunkle and King (1993) analyzed data gathered by conducting surveys and interviews at public agencies in 42 U.S. cities. They reported that generally users and managers found computer-based information useful and important for their tasks.

There are several studies investigating IS success at the technical and semantic level in law enforcement agencies. As presented below they report mixed findings about success at those levels.

*Technical Level.*

O'Shea (1996) and Brown (2001) analyzed law enforcement IS success at the technical level and arrived at contrasting conclusions. O'Shea (1996) conducted interviews and focus group sessions with Chicago Police Department officers to explore the information processing operations of the agency. His study generally depicted a

[25] No studies were found about IT service quality in public organizations including law enforcement agencies.

negative picture of IS success. Participants of focus group sessions complained that information was not accessible due to technical problems. Moreover, they contended that they could not get timely information because of red tape. Brown (2001) evaluated Charlotte-Mecklenburg Police Department's Knowledge-Based Community Oriented Problem Solving System by using survey and focus group methods before and after the implementation of the system. The pretest group stated that crime-related information was not readily available, and available information was not sufficient for the job. Posttest analysis, on the other hand, showed that the accessibility, accuracy and timeliness of the information increased after the implementation of the system.

Finally, Tien, Cahn, Neray, Einstein and Pei (2005) developed the Record Quality Index (RQI) to measure the performance of criminal history records systems. RQI was a function of 1) a set of outcome measures, 2) a timeliness measure, and 3) a completeness measure. They conducted an analysis on national data by using RQI and found that the state RQIs increased over time. In other words, data quality of criminal history records systems have increased over time (Tien et al., 2005).

*Semantic Level.*

O'Shea (1996) also reported negative findings about IS success at the semantic level. She argued that IS was potentially useful, but the collected information was underutilized because officers could get desired information easily by scanning the hard copies of case reports instead of querying the system. Therefore, according to O'Shea, problems at the technical level were shading the success at the semantic level. Similarly, LeBeuf (2001) argued that collected information was usually accurate, but quality of

information was in question. He argued that most of the information collected by the police was stored in databases without being used in any of the analysis.

In another study, Northrop, Kraemer & King (1995) investigated the use of computerized search capability by officers, its value to the police and factors that affect computer use by the police. They found that officers generally perceive computer generated information as important for their jobs. Finally, Paulsen (2004) investigated whether maps generated by a GIS system improve officers' perception and understanding of crime patterns and problem areas within a jurisdiction. Paulsen randomly assigned 40 officers into control and experiment groups and surveyed them before and after the treatment. Paulsen (2004) found no statistically significant difference between control and experimental groups' understanding of crime patterns within their jurisdictions. However, lack of training on the crime maps and the short time period of the experiment should be considered when interpreting the results.

In conclusion, available technical and semantic level IS impact studies have usually reported mixed results in terms of system and information quality.

*Information System Impact at the Effectiveness Level*

PMIS studies reported mixed findings about information systems' success at the effectiveness level. Several studies evaluated information system success by analyzing economic measures. Henman's (1996) analysis of computerization of Australia's Department of Social Security showed that efficiency did not increase with the increasing computerization; moreover, the client-to-staff ratio decreased and administrative costs increased. Lehr and Lichtenberg (1998) and Lee and Perry (2002), on the other hand, used the Cobb-Douglas production function and found that computers increased the

economic performance of the government. Heintze and Bretschneider (2000) found that IT adoption had a positive and significant effect on local government performance. Contrary to foregoing findings, Peled (2001) argued that information systems bring inefficiency by increasing red tape in the organization.

In the law enforcement context, effectiveness studies generally focused on the net benefit aspect of the question. There are only a few studies available about the use of law enforcement systems. Northrop, Kraemer & King (1995) conducted a longitudinal study of the use of computerized search capability by detectives and found that police use had increased since 1976. They also reported that both the characteristics of innovation (user friendliness of the systems and training) and characteristics of the user (computer literacy and prior computer experience) had associations with officers' use of computers. As presented above, O'Shea (1996) argued that Chicago Police Department officers prefer to use hard copies instead of querying the information system; however, DuBois, Skogan, Hartnett, Bump and Morris (2007) study's findings contradicted O'Shea's (1996) study. They conducted a survey study about the use of the Chicago Police Department's Citizen and Law Enforcement Analysis and Reporting (CLEAR) system. They stated that analyzing use patterns is not meaningful because use of most of the system modules is mandatory. In other words, officers must use the system to be able to do particular jobs. For that reason, they analyzed the use patterns of the data warehouse for which use is voluntary. They found that the data warehouse was used by 92% of the officers (DuBois et al., 2007).

The net benefit is usually measured in some form of system or officer performance such as usefulness of output of the system, arrest productivity, clearance

productivity, etc. A review of effectiveness studies showed that the majority of these are about communication and mobile computing technologies. There are only a few studies on crime analysis and forensic technologies. Although there is not any study that particularly tackles the records management systems, crime analysis studies can be extended to that area because they are generally integrated together. Therefore, these studies will be presented within two groups. In addition to them, there are several studies that analyzed information technologies' impact on the organizational structure of law enforcement agencies. Those studies will be presented as the third group.

*Crime analysis and forensic analysis.*

In an early study, Zavala and Mullen (1970) found that modus operandi systems can be effective in identifying offenders. Danziger and Kraemer (1985) examined the effects of computing on the performance of police detectives and found that more than 80% of detectives experienced information benefits from computing, and nearly two thirds of detectives indicated that computers assisted them in some of their arrests and clearances. Hauck and Chen (1999) evaluated the performance of the Coplink Concept Space application, which helps officers to uncover relationships between different types of information. They conducted a field experiment and reported that the Coplink Concept Space application is highly useful for investigative purposes. The Coplink project was evaluated also by the Chen et al. (2003) study, and supportive results were reported again. Wellford and Cronin (1999) examined factors affecting homicide clearance rates by using UCR statistics and a separate survey instrument. They analyzed the more than two hundred independent variables in their study. They found that officers' use of information systems in their daily job has relationship with homicide clearances.

In a recent study, Braga and Pierce (2004) analyzed the impact of the Integrated Ballistic Identification System (IBIS) in the Boston Police Department. Their analysis showed that the IBIS system significantly improved the productivity of the Boston Police Department's Ballistic Unit, and it was associated with a six fold increase in the monthly number of ballistic matches. In sum, available studies in this group generally reported the positive net benefits of information technologies on investigative activities.

*Communications and remote data access.*

Police command and control systems are generally found effective. In a series of studies, Colton (1972; 1980) reported that the rapid retrieval system increased the arrest rates of the Long Beach Police Department, and the CAD system increased the response time of both telephone operators and patrol officers in the San Diego Police Department. Colton, Brandeau, and Tien (1983) stated that the police command control and communication systems of a sample of cities were generally found successful in performing different patrol functions. Morckel (2002) and Mayer (2009) reported improvements in investigative operations after implementing GPS technology.

Similarly to command and control systems, mobile access systems are generally reported as effective in clearing crimes. Nunn (1994) examined the impact of mobile digital terminals (MDT) on the recovery rates of motor vehicle thefts. He argued that the MDT system would increase the number of vehicle checks conducted by patrol officers; and as the number of checks increased, the probability of identifying and recovering stolen vehicles should also increase. He found that the post-MDT recovery ratio was higher than the pre-MDT ratio in each of the MDT cities; the change in post-MDT ratios in the MDT cities exceeded that of non-MDT cities; and the presence of MDT technology

was significantly associated with higher percentages of motor vehicle thefts recovered, controlling for the total level of thefts. Meehan (1998) also examined MDT's impact on patrol and investigative services and found that MDT significantly improved effectiveness of the police. In another study about MDTs, Ioimo and Aronson (2003) analyzed whether the records, investigations and police administration bureaus derive measurable benefits from mobile computing. They used agency data and survey responses collected from a medium-sized police department located in Arizona and reported that computing improved the rate of recovery of stolen vehicles.

Marshall (1998) analyzed the impact of cellular digital packet data (CDPD) technology on officers' performance. Two cars from six local law enforcement agencies were equipped with CDPD technology and tested for 10 days. Researchers found that, although the test group worked less than the control group, they made 17.12% more inquiries, and 18.94% more arrests/citations than the control group. On the other hand, Nunn & Quinet (2002) also evaluated the impact of CDPD technology on problem oriented policing (POP) at a state police agency. The main responsibility of POP officers was forming partnerships with other law enforcement agencies and community groups to understand and address the underlying causes of problematic issues. Therefore, communications and information exchange were seen as crucial ingredients to a successful POP program. They compared performance of POP officers using CDPD with the performance of POP officers without CDPD, and found that CDPD use did not make any significant difference between the control and experiment group[26].

[26] Nunn & Quinet (2002) defined four measures of job performance: 1) officers' inquiry data, 2) data compiled from productivity reports, 3) actual job performance evaluations and 4) qualitative observations of the officers.

Finally, McRae and McDavid (1988) conducted a cost benefit analysis of mobile digital communications systems implemented at the Vancouver Police Department. Because of the difficulty of assigning monetary values to criminal cases, they analyzed arrests due to minor crimes. The equipment, installation, staff and maintenance costs were incorporated into the analysis. Arrest data and system usage patterns were collected with a survey administered to officers making warrant arrests. Researchers found that the system generated positive net benefits. In addition to the foregoing, the system has produced intangible benefits such as increased officer safety, inquiry speed and enhanced message security.

*IT's impact on organizational structure.*

Several studies discussed IT's impact on the structure of law enforcement organizations. Nunn (2001) studied the impact of IT on organizational resources by analyzing Law Enforcement Management and Administrative Statistics (LEMAS) survey data of the Department of Justice. He found that highly computerized agencies spend more per capita on IT and have more technical staff and deliver services with fewer officers per capita than agencies reporting lower levels of computerization. Over more than a decade, Peter Manning (1992; 1996; 2001; 2004; 2008) has made important contributions to this topic. He stated that there is a reciprocal impact between technology and organization. He argued that the "technology in the workplace is molded and shaped by the environment, the organizational structure, and the occupational culture of policing more than they are shaped by technology" (Manning, 1992, p. 388). Therefore, he argued that IT implementation in law enforcement agencies should be accompanied by organizational change in order to be successful.

Chan (2001) analyzed the extent to which information technology has modified the accountability structure, the occupational culture, and policing practices at the street supervisory and management levels of an Australian police department. She stated that, although information technology had not altered the dominant style of policing much within the department, it had altered the value of communicative and technical resources because increased information processing and dissemination capacity had increased the agency's ability to analyze criminogenic factors and to implement POP more effectively. Moreover, information technology had also altered the accountability structure and reporting procedures, and it had restructured daily routines of operational policing. On the other hand, similarly to the Manning, Chan acknowledged the dominance of the traditional police style and stated that IT's full benefit could only be realized after a massive change of agency culture.

In sum, majority of studies found that IT is contributing to the organizations' performance. However, as argued by DeLone and McLean, a variety of outcome measures were used to evaluate the success of information systems. Therefore, it is not possible to make a comparison between studies.

*Compstat*

Since Compstat has been acclaimed as an important police innovation involving information technologies (Silverman, 2006), it deserves special attention. Walsh & Vito (2004) considered Compstat innovation as the emergence of a new model of policing and defined it as "a goal-orientated strategic management process that uses information technology, operational strategy and managerial accountability to guide police operations" (p. 57). O'Connell (2002) described Compstat as a managerial strategy which

employs a "business-like" approach to crime fighting. Compstat has four core principles: 1) accurate and timely intelligence, 2) effective and appropriate crime prevention tactics, 3) rapid deployment of personnel and resources, and 4) relentless follow up and assessment.

Basically Compstat consists of directed patrol, geographic accountability of precinct commanders, and the use of information and mapping technology (Eck & Maguire, 2005). The Compstat process has three important components. The first step is the collection and compilation of detailed weekly crime statistics. The second step is the distribution of Compstat reports to the operational managers. The Compstat report contains a concise summary of current crime in each location and provides a comparison with previous crime rates to better see established and emerging crime trends. Finally, operational managers are empowered and held accountable (particularly through weekly Compstat meetings with managers) for addressing crime and disorder in their areas (Vito, Walsh & Kunselman, 2005)[27].

Compstat has been praised by some researchers and practitioners as a major factor in the decline of New York's crime rates. For example, Silverman (1999, 2006) claimed that Compstat is one of the three factors that contributed to New York's crime drop. He also maintained that a crime drop has been observed in other cities that implemented Compstat as well. In New Orleans, homicide rates dropped 55 percent within five years. In Minneapolis, homicides, aggravated assaults, robberies, burglaries and auto thefts decreased more than ten percent in each case. In Baltimore, overall crime rates dropped 25 percent (Silverman, 2006).

[27] See Shane's (2004) "Compstat Implementation" for further information.

However, there is a limited number of empirical studies on the impact of the Compstat program, and those studies are limited to its impact on crime rates. Rosenfeld, Fornango and Baurner (2005) discussed the crime prevention effects of Boston's Operation Ceasefire, New York's Compstat and Richmond Virginia's Project Exile. Their analysis yielded significant results only for Richmond Virginia's Project Exile. Eck & Maguire (2005) argued that in order to make an empirical claim about the effectiveness of Compstat (or any other similar innovation), there must be four types of evidence present. First, any explanation of Compstat's crime prevention effect should be theory-based. Then, there must be a statistical association and temporal order between Compstat and crime reduction. Finally, rival hypotheses about crime reduction must be eliminated. They stated that Compstat's crime prevention rationale and theoretical base can be likened to the hot spots approach. However, Weisburd, Mastrofski, Willis and Greenspan (2006) showed that statistical association and temporal order are problematic for New York crime data because the crime drop alone does not show any causation, and the crime drop in New York had begun before the Compstat implementation. Finally and most importantly, Compstat was implemented together with some other innovations, so it is not possible to differentiate the individual effects of each program on crime rates.

Weisburd , Mastrofski, McNally and Greenspan (2002) looked at Compstat's impact on the use of strategic problem solving by American police agencies. They examined the diffusion of Compstat programs and the nature of Compstat models throughout the United States. They found that strategic problem solving is not a result of Compstat because some elements of strategic problem solving had begun to be implemented before the Compstat programs. In addition, Weisburd et al. (2006) argued

that “Compstat as it has actually been implemented by American police agencies has focused more on reinforcing and legitimating the traditional bureaucratic military model of police organization than on innovation in the practices of policing” (p. 298). Similarly, Greene (2000) argued that Compstat is strengthening the traditional police outlook. In sum, Compstat is an important development in the use of information by policing, but evaluating its impacts is problematic, and available studies are not sufficient to make a conclusion about its impacts.

*Summary*

The literature review demonstrates that criminal investigation is a kind of information work, and recovery, analysis, and interpretation of information are crucial tasks for the success of criminal investigation. Several factors have been found to affect the outcome of criminal investigation. These are quality of preliminary investigation, availability of information about the suspect, specialized investigative units, and social characteristics of the community served. Forensic evidence is also found to be effective, but due to its underutilization, its contribution to the investigative process is small. Finally, there are mixed findings about the impact of agency size and workload of the investigators on the criminal investigations.

One of the most important findings of criminal investigation literature for this study was the importance of information in the investigative process. Numerous studies reported that the information gathered during the preliminary investigation is the most important determinant of the outcome of a criminal investigation. Moreover, some studies claimed that other factors affecting the success of criminal investigation are actually affecting police’s capacity of information processing first. For example, Burrows

& Tarling (1982) argued that some types of crimes are hard to solve because the lack of contact between victim and witness in those types of crimes decreases the likelihood of recovering useful information about the suspect. Therefore, availability of information and law enforcement agency's recovery, analysis and interpretation capability appear as crucial factors for the outcome of criminal investigations.

Since information is an important factor for the outcome of criminal investigations, information technologies have a great potential to help officers in their investigative duties. The literature review showed that information technologies have been used for both administrative and operational purposes in law enforcement agencies for almost four decades. While administrative use involves traditional services such as budgeting, personnel or fleet management, operational use involves mainly investigative activities. Within the criminal investigation sphere, information technologies are employed for records management, crime analysis, communication and mobile computing and forensic analysis. Although researchers argued that IT implementation was problematic for law enforcement agencies, most of the IT evaluation studies found that IT provides a positive contribution to various aspects of policing.

However, the number of available studies is not sufficient to make a safe conclusion about information technologies' impact on policing. Moreover, the diversity of measures used in those studies prevents us from making a comparison between them. For these reasons, this study will contribute to the field by providing new evidence about information technologies' impact on police work.

# CHAPTER 3: METHODOLOGY

## Research Question and Hypothesis

The review of the related literature showed that information technologies are used extensively in criminal investigations; however, their impact on the outcome of investigations is not well known. This study is an exploratory research which aims to shed more light onto the subject by employing an empirical model and testing it with the data gathered from U.S. police departments. This research examines the following question:

Does use of information technologies have an impact on the outcome of criminal investigations?

As discussed in the literature review chapter, DeLone and McLean's (1992; 2003) IS Success Model argued that there was a relationship between use of information technology and net benefits. The term Net Benefit was loosely defined by the authors, and it can mean any improvement depending on the context of the information systems. In the law enforcement context, clearance is one of the most important goals of investigative activities (Chaiken et al., 1976; Eck, 1989; Greenwood, 1970; Horvath et al., 2001; McDevitt, 2005; Waegel, 1981). Crime clearance in general is an important goal of traditional policing, which was also influential on the design and implementation of the majority of current police information systems (Greene, 2000). Therefore, this study expects that the investigative use of information technology increases crime control

abilities of law enforcement agencies. This research will test the following hypothesis:

$H_1$: As police departments' use of information technologies for investigative purposes increases, the number of crimes cleared by them also increases.

However, it must be said at this point that this study does not test any causal relationship between use of information technologies and clearance rates. In order to be able to investigate causal relationship, three things must be considered. First of all, there must be covariance between independent and dependent variables. Secondly, variation in the dependent variable must be occurred after the variation in the independent variable which is called temporal order. Finally, variation in the dependent variable should not be due to variation in a third variable which is called nonspuriousness (Schutt, 2006). Since this study is a one-group only post-test design, it lacks both the comparison group and the baseline measurement. Therefore, it is not possible to control for temporal order and the nonspuriousness. This study can show whether there is a relationship between use of information technologies and clearance rate, but it cannot show whether use of information technologies is the cause of variation in the clearance rates.

## Data

This study is a cross-sectional study. Its unit of analysis is the police departments. This study has three data sources: a self-administered survey, the Uniform Crime Report (UCR) Program data and U.S. Census data.

### *The impact of the science and technology survey.*

The biggest portion of the data is collected by the "National Study of the Impact of Science and Technology on the Process of Criminal Investigation in Law Enforcement Agencies" project (it will hereafter be referred to as the "Impact of Science and

Technology Survey") which was funded by National Institute of Justice (NIJ), and conducted by Eastern Kentucky University (EKU) researchers. The purpose of the Impact of Science and Technology Survey was to describe and assess the impact of science and technology on the process of criminal investigation in law enforcement agencies. The project began in 2005 and data collection ended in 2006. No publications have been written based on the project data yet. EKU has approved the use of data in this project, and EKU researchers delivered the survey dataset and other available documents via email.

The self-administered survey, which can be found in Appendix A, consisted of eleven parts. It was developed using some of the questions posed in the Chaiken et al. study published in 1976. Questions consisted of demographic information of participating agencies, agency procedures related to criminal investigation, formal investigative training received by the officers, selection and use of investigators, use of crime laboratory services, and available technologies. Survey instruments were sent to 1) the top 200 largest law enforcement agencies, 2) all the state law enforcement agencies and 3) a random sample of municipal, county and campus agencies. 630 agencies received the survey, and 280 of them responded. Table-2 illustrates the overall response rates achieved for each group and overall. The response rate is higher among bigger police agencies and state police agencies than municipal agencies, campus police and sheriff departments. Forty-four percent of all agencies that were solicited to participate in the study responded to the survey.

Table 2
*Police Departments' Response Rates to the Impact of Science and Technology Survey*

| | Number Mailed | Number Returned | Number Received | Response Rate (%) |
|---|---|---|---|---|
| Sheriff | 62 | 2 | 18 | 29.03 |
| Municipal | 267 | 4 | 94 | 35.21 |
| Campus | 52 | 1 | 17 | 32.69 |
| Top 200 | 200 | 8 | 121 | 60.5 |
| State | 49 | 1 | 30 | 61.22 |
| Total | 630 | 16 | 280 | 44.44 |

Four waves of mailings were used to collect the data. One mailing with the survey, cover letter, and return self-addressed, stamped envelope was sent to respondents. This mailing was followed by a reminder postcard. Another two waves of surveys were sent to the agencies that had yet to respond. Totally 280 agencies responded to the survey. Responding agencies were composed of 18 Sheriff, 94 municipal, 17 campus, 30 state and 121 of the top 200 agencies.

As stated above, there were 17 campus agencies in the sample. Differently from the local law enforcement agencies, campus law enforcement agencies' jurisdictions comprise of campuses and their surrounding areas. Although Peak, Barthe and Garcia (2008) reported that jurisdiction of campus law enforcement agencies has increased since 1986, 42% of agencies reported having jurisdiction only on their campuses. In addition, campus law enforcement agencies differ from local law enforcement agencies by their responsibilities. Peak et al. (2008) stated that in 2006 the top reported activity of campus agencies was criminal investigation. However, in a BJS report Reaves (2008) showed that there were differences between large and small campus agencies in terms of criminal investigations. Reaves (2008) reported that 98% of large campus agencies conduct any

type of property crime investigation, but this figure drops to 74% for small campus agencies. Again 98% of large campus agencies conduct any type of violent crime investigations, but only 66% of small campus agencies do the same. The biggest reported difference between campus agencies was homicide cases. While 77% of large campus agencies were conducting homicide investigations, only 27% of small campus agencies were doing so. Since not all campus law enforcement agencies have equal investigative responsibilities, and a big portion of campus agencies do not have investigative responsibilities for some crimes, campus agencies were removed from the sample.

On the other hand, state police departments were not suitable for the objectives of this study, either. The first state police agency was established in Pennsylvania as a military-style police force to deal with labor and ethnic violence (Steverson, 2007). Other states followed Pennsylvania, but the responsibilities of state police departments have changed over time. Today state police are mainly responsible for 1) motor vehicle law enforcement on state highways, 2) security for government personnel and property, 3) criminal investigation as a supplement to local agencies, 4) criminal records collection and distribution, 5) forensic services, 6) law enforcement training, 7) communication system coordination, and 8) some special services such as emergency response (Purpura, 1996). Since, criminal investigation is not a major function of state agencies, they were removed from the sample as well.

As a result, after removing 47 campus and state law enforcement agencies, 233 cases remained in the sample.

*UCR.*

The second data source of this study is the Uniform Crime Reporting (UCR) Program. The UCR Program is "a voluntary city, county, state, tribal, and federal law enforcement program that provides a nationwide view of crime based on the submission of statistics by law enforcement agencies throughout the country" (FBI, 2004a, ¶ 3). As stated in the literature review, the UCR Program was first implemented in 1929 by the International Association of Chiefs of Police, and transferred to the FBI in 1930. FBI's primary objective in collecting crime data is "to generate a reliable set of crime statistics for use in law enforcement administration, operation, and management" (FBI, 2004c, ¶ 1). Although the UCR Program is a good source of crime and clearance information for practitioners and researchers, UCR data has important limitations that must be well understood prior to any decision.

The UCR Program collects data by a series of administrative forms that is known as the Summary Reporting System (SRS). There are eight data reporting forms currently in use: 1) Return A: Report of Offenses known to the Police, 2) Supplement to Return A (capture information on the value and type of the property stolen and recovered and the nature of the offenses reported in Return A), 3) Age, Sex and Race of Persons Arrested, 4) Supplementary Homicide Reports (provides additional details about homicide cases), 5) the Law Enforcement Officers Killed and Assaulted forms, 6) the Hate Crime Data Collection forms, 7) the Monthly Return of Arson Offenses Known to Law Enforcement, and 8) Law Enforcement Employee Report (Barnett-Ryan, 2007).

This study will use the data collected by Return A which captures monthly information about Part I offenses reported to the law enforcement agencies and any

associated clearances. Offenses reported by this form include murder and non-negligent manslaughter, manslaughter by negligence, forcible rape[28], attempts to commit forcible rape, robbery by weapon type, aggravated assault by weapon type, other assaults, burglary –forcible entry, burglary – and unlawful entry (no force), attempted forcible entry, larceny-theft and motor vehicle theft by type of vehicle. Agencies report how many reports of offenses they received, and how many of them were found to be baseless or unfounded after initial investigation. Then agencies calculate the number of actual offenses by subtracting unfounded offenses from the total number of reported offenses (FBI, 2004b).

In addition to the number of crimes reported to law enforcement, Return A captures information about the clearances. First of all, it is important to note that the clearances reported in the Return A on any given month may not have any relationship with the offenses reported for that month. Therefore, clearance figures are not an adequate measure of how many of the crimes that were committed in that month were cleared. According to the UCR data, a case is cleared by two ways: arrest or exceptional means. To be able to clear an offense by arrest, at least one person should be 1) arrested, 2) charged with the commission of the offense, and 3) turned over to the court for the prosecution. In some situations, it becomes impossible to arrest and formally charge the offender. For example, if the offender is dead (e.g., suicide or justifiably killed by law enforcement or citizen) or if the victim or witness refuses to cooperate after the offender has been identified, arresting and formally charging becomes impossible. According to the UCR classifications, those cases are called exceptional clearance (FBI, 2004b). FBI

[28] Forcible rape is defined as "the carnal knowledge of a female forcibly and against her will," and statutory rape, incest or other sex offenses are not included in this category (FBI, 2004b, p. 19).

disseminates crime and clearance data in its annual publication called Crime in the United States.

In order to overcome conceptual problems, the UCR Program has developed uniform definitions for each offense type and devised a set of rules governing the classification and scoring of offenses. To ensure data quality, the FBI provides a handbook (UCR Handbook) to the participating agencies which explains those rules. According to the UCR Program's Hierarchy Rule, if more than one offense is committed in an incident, only the most serious one is reported and related offenses are not reported. Therefore, "when more than one Part I offense is classified, the law enforcement agency must locate the offense that is highest on the hierarchy list and score that offense involved and not the other offense(s) in the multiple-offense situation" (FBI, 2004b, p. 10). For example, if an individual breaks into a home to commit a theft and assaults the owner of the house, law enforcement will report the incident as aggravated assault. However, if there is a separation of time and place between multiple offenses then the agency reports them individually[29]. The hierarchy rule was adopted to prevent the multiple reporting of a criminal incident, but it obstructs the accurate depiction of the crime problem by not measuring related crimes. The UCR hierarchy of Part I offenses is presented in Table 3. Arson, motor vehicle theft and justifiable homicide are exceptions of hierarchy rule. Arson is reported independently of the other Part I crimes. If an incident contains both motor vehicle theft and theft of items located in the vehicle, only

[29] This is called the Separation of Time and Place Rule. Here is an example to that rule given in the UCR Handbook (FBI, 2004b): A man and a woman were parked at a secluded location. A gunman surprised them and shot and killed the man when he resisted. He abducted the woman and drove across town to a secluded area where he forcibly raped her. The police arrested the perpetrator at the scene. In this incident, the Hierarchy Rule does not apply, and two crimes are reported separately because there is a separation of time and place between two crimes.

motor vehicle theft is reported. Justifiable homicide is defined as "the killing of a felon by a peace officer in the line of duty or the killing of a felon, during the commission of a felony, by a private citizen" (FBI, 2004b, p. 17). An incident of justifiable homicide and the offender's felonious act are reported separately.

Table 3
*UCR Part I Offense Hierarchy*

| Offense Type | Description |
|---|---|
| 1. Criminal Homicide | a. Murder and Nonnegligent Manslaughter<br>b. Manslaughter by Negligence |
| 2. Forcible Rape | a. Rape by Force*<br>b. Attempts to Commit Forcible Rape |
| 3. Robbery | a. Firearm<br>b. Knife or Cutting Instrument<br>c. Other Dangerous Weapon<br>d. Strong-arm—Hands, Fists, Feet, etc. |
| 4. Aggravated Assault | a. Firearm<br>b. Knife or Cutting Instrument<br>c. Other Dangerous Weapon<br>d. Hands, Fists, Feet, etc.—Aggravated Injury |
| 5. Burglary | a. Forcible Entry<br>b. Unlawful Entry—No Force<br>c. Attempted Forcible Entry |
| 6. Larceny-theft | |
| 7. Motor Vehicle Theft | a. Autos<br>b. Trucks and Buses<br>c. Other Vehicles |
| 8. Arson | a. Structural<br>b. Mobile<br>c. Other |

After classifying the offenses, an agency should determine the count or the number of offenses committed. In order to correctly score the offenses, it is important to

distinguish crimes against the person from crimes against property. For scoring purposes, homicide, forcible rape and aggravated assault are grouped as crimes against the person, and robbery, burglary, larceny-theft, motor vehicle theft and arson are grouped as crimes against property[30]. In the case of crimes against the person, one offense is counted for each victim, and for crimes against property, one offense is counted for each distinct operation or attempt—except in the case of motor vehicle theft for which one offense is counted for each stolen vehicle and one offense for each attempt to steal a motor vehicle. An exception to these standards is called the Hotel Rule. According to this rule "if a number of dwelling units under a single manager are burglarized and the offenses are most likely to be reported to the police by the manager rather than the individual tenants, the burglary must be scored as one offense" (FBI, 2004b, p. 62).

Participation in the UCR Program is voluntary, and there are no rules that specify the mandatory amount of data to submit for participating agencies. Although the UCR Program has achieved participation of more than 90% of all police agencies, sometimes some agencies cannot provide data due to computer problems, changes in record management systems, personnel shortages, or a number of other reasons (FBI, 2004c). To provide a complete picture of crime in the United States, the FBI imputes values for the missing pieces of data caused by nonparticipation, incomplete participation and limited participation (Barnett-Ryan, 2007). This process is called estimation by the FBI[31].

There are two other issues about the UCR data that should be mentioned. First of all, it is well known that not all crime is reported to the police; hence, not all crime is

[30] This classification is used just for reporting purposes. The FBI uses a different classification in its crime reports. In that classification, crimes against the person consists of homicide, forcible rape, robbery and aggravated assault, and crimes against property consists of burglary, larceny-theft, motor vehicle theft and arson (FBI, 2004c).

[31] See Maltz (2007) for further information on the FBI's estimation procedures

known or recorded by the law enforcement agencies. Moreover, Part II crimes are not recorded by the UCR Program[32], and because of the Hierarchy Rule some Part I offenses are discarded in multiple offense incidents as stated above. Secondly, the accuracy of UCR data is dependent on the efforts of the reporting agency because the FBI does not have an adequate control mechanism to ensure that the reported data is flawless. In addition, it is also argued that UCR data is open to manipulation by participating agencies. In order to look better in the statistics and to abate the political pressure, some participating agencies may choose not to report all of the crimes occurring in their jurisdictions (Chambliss, 2001). Therefore, UCR data must be interpreted by taking these limitations into consideration.

For this study, 2005 and 2006 UCR datasets were downloaded from the Inter-University Consortium for Political and Social Research (ICPSR) web site. UCR data were incorporated into the analysis in three steps. First, 233 police agencies that had responded to the Criminal Investigation Survey were looked up in the UCR database. Crime and clearance data of 220 of the 233 agencies were located in the 2005 UCR dataset and 216 of the 233 agencies were located in the 2006 UCR dataset. Then, 2005 and 2006 crime and clearance data were added to the Criminal Investigation Survey dataset.

*U.S. Census.*

The third data source is the U.S Census Bureau's 2000 Census data. Depending on the jurisdiction of the responding police department, town, city and county level poverty, income and race variables were queried at the 2000 Census database via the U.S.

[32] Only arrest data involving the Part II crimes are reported to the UCR.

Census Bureau's American FactFinder website (U.S. Census Bureau, 2009). Census data was added to the Impact of Science and Technology Survey dataset.

## Variables

*Dependent variable.*

The dependent variable of this study is the clearance rates for Part I crimes which include murder and non-negligent manslaughter, forcible rape, robbery aggravated assault, burglary, larceny-theft, and motor vehicle theft[33]. Arson was not included in the analysis because it is reported separately in the UCR Program and a lesser number of agencies report arson statistics. In order to calculate the clearance rates, monthly crime and clearance figures were summed to get the annual crime and clearance numbers for each agency. Then, clearance rates were calculated by dividing number of clearances by the number of crimes known to the police.

Violent crime and property crime clearance rate variables were calculated by using the classification used by the FBI in its crime reports. According to that classification the violent crime category consisted of murder and nonnegligent manslaughter, forcible rape, robbery and aggravated assault. The property crime variable consisted of burglary, larceny-theft, and motor vehicle theft. In addition to the violent and property crime variables, an all crime clearance rate variable was also calculated. For these three variables, crime and clearance numbers were calculated by adding respective crime types and then calculating the clearance rate by dividing number of clearances by number of crimes known to the police.

[33] Information technologies may contribute to the solution of Part II crimes as well. However, Part II crimes are not reported by the UCR Program, and they were not collected by the Impact of Science and Technology Survey either.

Clearance rates vary depending on the type of crime. Literature review showed that Part I crimes are generally perceived as more serious, and more organizational resources are devoted to their investigations. The percentage of crimes cleared by arrest for 2005 and 2006 are given in Table 4 below. It shows that crimes against the person are more likely to get solved than crimes against property. Although property crimes were harder to solve due to lack of information about the suspect (Skogan & Antunes, 1979), different amount of resources devoted to crimes against the person and crime against property may also be influential on the difference between clearance rates.

Table 4
*Percentage of Crimes Cleared by Arrest or Exceptional Means in 2005 and 2006*

| Year | Murder | Forcible Rape | Robbery | Aggravated Assault | Burglary | Larceny -theft | Motor Vehicle Theft |
|---|---|---|---|---|---|---|---|
| 2005 | 62.1% | 41.3% | 25.4% | 55.2% | 12.7% | 18.0% | 13.0% |
| 2006 | 60.7% | 40.9% | 25.2% | 54% | 12.6% | 17.4% | 12.6 |

*Note.* Published in Crime in the United States (FBI 2005a; 2006a)

Use of clearance rates as a measure of police performance has been criticized for several reasons. First of all, the UCR does not differentiate among cases and accepts every cleared case as equal; however, as discussed in the literature review chapter investigation of some cases can be more difficult than others and may require more skill and resources. An agency might score low on clearance rates just because it handles more difficult cases than others. Unfortunately, UCR data do not provide any measure for the difficulty of the case or the effort that is put on a case by the investigators. Furthermore, as stated above, law enforcement agencies may distort the crime and clearance figures for political reasons. Despite these problems, clearance rates are still one of the best available

police performance indicators and used by researchers (e.g. Helms, 2008; Holmes et al., 2008; Nolan, 2004; O'Brian, 2003).

*Independent Variable.*

As presented in the literature review chapter, the DeLone and McLean model proposes a relationship between information technology use and net benefit. Intention to use was also added to the model later because use of some systems might be mandatory. The literature review showed that use of most of the law enforcement IT systems is mandatory. In other words, in most of the departments, officers are forced to use the IT system in order to accomplish the job. DeLone and McLean argued that the mandatory nature of system use does not cause rejection of the system use measure as a success variable. They stated that:

> Even when the use is required, variability in the quality and intensity of this use is likely to have a significant impact on the realization of the system benefits. Furthermore, no system use is totally mandatory. …. Thus, whereas usage of system may be mandatory at one level, the continued adoption and use of the system itself maybe wholly voluntary, based upon management judgment at a higher level. Management always has the option of discontinuing a system that is not providing the desired results and benefits. (DeLone and McLean, 2003: p.16-17).

The independent variable of this study measures IT use by police departments. As argued by DeLone and McLean (2003), different levels of IT use are expected to impact the outcome variable differently. In order to measure the extent of use of information systems in the surveyed agencies, "use of IT scale" was constructed. The use of IT scale

was composed of 29 items asking the availability of following information technologies in responding police departments:

1. Cellular or mobile phones
2. Global Positioning System (GPS)
3. Personal Digital Assistant (PDA) or handheld computer
4. Blackberry
5. Mobile Data Computer/Mobile Data Terminal (MDC/MDT)
6. Intranet
7. Web pages or web-based applications
8. Computer Based Training (CBT)
9. Laptop computer
10. National Integrated Ballistics Information Network (NIBIN)
11. Integrated Ballistics Identification System (IBIS)
12. Violent Criminal Apprehension Program (ViCap)
13. Regional Information Sharing Systems (RISS)
14. National Crime Information Center (NCIC)
15. Crime reports on computer form
16. Arrest reports on computer form
17. Case disposition information on computer form
18. Prosecution disposition information on computer form
19. Court dispositions information on computer form
20. Summary crime statistics on computer form
21. Fingerprints on computer form

22. Known offender on computer form

23. M.O. file on computer form

24. Mug shot on computer form

25. Organized crime intelligence on computer form

26. Narcotics intelligence on computer form

27. Sex offender information on computer form

28. Stolen property information on computer form

29. Stolen vehicles information on computer form

In order to determine whether those variables could be used to construct an index variable, their correlations were examined. 29 variables were incorporated into the analysis. Descriptive analysis results showed that there were some missing values in those variables, so observations with missing value were dismissed from the analysis to get more reliable results. Then, a correlation analysis was conducted. The correlation coefficients are presented in Appendix B. The correlation matrix revealed that information technology variables have generally moderate correlations with each other. The standardized alpha coefficient (or Cronbach's alpha) was 0.87 for all the variables. Although Kuder-Richardson Formula 20 was designed for reliability analysis of dichotomous variables, Cronbach's alpha gives same results with dichotomous variables (Traub, 1994). In this analysis, Cronbach's alpha measures how well the 29 variables measure a single unidimensional latent construct. If data would have a multidimensional structure, this value would usually be low. Since 0.7 or higher is generally considered acceptable (Traub, 1994), we can say that the 29 information technology variables have a unidimensional structure and can form an index variable.

To further investigate this proposition, and to see if there is any structure in the relationships between variables, a factor analysis was conducted. Factor analysis is an exploratory method. It is mainly used to reduce the number of variables in a dataset and to uncover the structure in the relationship between the variables. Basically, factor analysis condenses intercorrelated variables into fewer dimensions, which are called factors. There are different extraction methods used to do this. In this analysis, the principal axis factoring method was utilized as the extraction method because principal axis factoring seeks the least number of factors which can account for the correlation of a set of variables. In addition, the varimax method, which is an orthogonal method, was used as the rotation method. Since the varimax method (or orthogonal rotation methods) increases each variable's likelihood of loading on a single factor, it is more suitable for the purpose of this analysis (Kim & Mueller, 1978).

There are two common methods in factor analysis that can be used to determine the number of factors. The first method is to use eigenvalues as the cut-off value. Eigenvalue measures the amount of variation in the total sample that is accounted for by each factor, and eigenvalue greater than one is usually taken as the cut-off value. The second method is to look at the scree plot of eigenvalues against the number of factors. The point where the eigenvalues line begins to level off can be used as a cut-off point. Both methods can be used to determine the number of factors, but the best method is to use eigenvalues and scree plot together as a guide and to look at the interpretability of the factors given by the analysis. If a factor does not have any meaning, in other words, if it does not indicate any structure in the relationships between variables, then the solution may be discarded. Another important output of factor analysis is factor loading which is

the correlation coefficient between a variable and a factor. A factor loading greater than 0.3 is usually considered significant, and that variable is said to be loaded on that factor (Kim & Mueller, 1978).

In this analysis, factors with eigenvalues greater than 1 were chosen in the first run of the factor analysis. Eight factors were identified. 46.81 % of the total variance was explained by these eight factors, and 53.19% of variance remained unexplained. Only one variable did not load on any factor. Nine variables loaded onto the first factor, and they were mainly communication or IT infrastructure related variables; however the interpretation of the resulting distribution was difficult. The scree plot showed that three factors accounted for most of the variance. Therefore, factor numbers were constrained to three in the second run. Explained variance decreased to 32.93%. 15 variables loaded on the first factor, 8 variables loaded on the second factor and 4 variables loaded on the third one. 2 variables did not load on any factor.

In the third run, two variables that did not load on any factors were dismissed from the analysis for better results. The variables that were dismissed from the analysis were use of cellular/mobile phones and use of the National Crime Information Center. The table of factor loadings of the third factor analysis can be found in Appendix C. The explained variance slightly improved to 34.98%. Generally, variables that were related with the IT infrastructure and availability of external databases loaded on the first factor. Fingerprints, M.O. File, organized crime intelligence and narcotics intelligence items also loaded on the first factor. However, the M.O. file, organized intelligence and narcotic intelligence variables did not seem matched with this group. Moreover, the narcotic intelligence variable loaded on the third factor at the same time. The second factor

consisted of variables that were more related with record management systems and information processing capabilities of the agencies. And the third factor consisted of variables that were related with prosecution and court procedures. In sum, factor analysis did not reveal any meaningful structure among the items. Because of this, the decision was made to use all items on a single scale.

*Control Variables.*

Based on the review of literature, seven control variables were identified:

1. Department size: The department size variable is measured as the total number of full-time sworn officers by the Impact of Science and Technology Survey. As presented in the literature review, research on the impact of department size on clearance rate is mixed. Larger agencies generally have more resources which may be helpful in clearing crimes. In addition, larger agency personnel can build expertise on specific crimes which may help solution of crimes. Therefore, larger agencies are expected to have more clearances.

2. Proportion of sworn officers working at investigative functions: Department size may not be an adequate measure to capture a law enforcement agency's investigative capabilities because not all of the officers are working at investigative units in a police department. The proportion of officers working at investigative functions variable is calculated by dividing the number of sworn officers working at investigative functions by the total number of full-time sworn officers in the department. Both variables were measured by the Impact of Science and Technology Survey.

3. Population Served**:** Community size is the population that is served by the agency. It is measured by the Impact of Science and Technology Survey. Researchers

have argued that urban areas provide more anonymity to offenders because in urban areas it becomes more difficult for police to find witnesses and to know offenders and criminal networks (Pare et al., 2007; Wilmer, 1970).

4. Poverty: Poverty variable measures the economic status of the community. It is measured as the percentage of people below the poverty threshold as provided in the U.S. Census data.

5. Median Income: The median income variable is included as another indicator of economic status of the community. Moreover, median income variable is also used as a proxy to the resources available to the police departments. Median income variable was used as a proxy to the resources available to organizations in some other studies as well (Kennedy, 2009; Zaid, 1967). Median income variable is taken from the U.S. Census dataset.

6. Percent White: Percent white is another variable measuring societal characteristics of police department's jurisdiction. It is taken from U.S. Census data.

7. Crime rates: As discussed above, crime rates for Part I crimes reported in the UCR statistics are used. Since the number of crimes increases the workload of the police, detectives may not give adequate time to the cases and clearance rates may decrease. Crime rate variable is calculated by dividing number of crimes known to the police to the size of the population and scaling it up by a multiplier. In this study, 1,000 is preferred as the multiplier as commonly used by law enforcement agencies such as FBI.

# CHAPTER 4: RESULTS

This chapter presents data analysis results in three parts. In the first part, descriptive statistics of all variables are provided. Then, bivariate relationships are examined in the second part. The third part presents multivariate analysis results. A supplementary analysis of use of IT scale items is presented also within the third part.

## Univariate Analysis

The unit of analysis of this study is law enforcement organizations. As presented in the methodology chapter, 280 police departments responded to the Impact of Science and Technology Survey. Responding departments were composed of 18 Sheriff, 94 municipal, 17 campus, 30 state and 121 top 200 departments. Since campus and state law enforcement departments are different from local police departments in terms of investigative activities (Reaves, 2008; Purpura, 1996), they were removed from the dataset. As a result, 233 departments remained in the sample. The final dataset was composed of 18 Sheriff, 94 municipal, and 121 top 200 departments.

The basic descriptive statistics are given in Appendix D. Descriptive statistic tables show the number of missing values, valid N, minimum, maximum, standard error of the mean, median and standard deviation for each variable. As discussed in the methodology chapter, the clearance rate variable was calculated by dividing the number of clearances achieved by the departments by the number of crimes known to the police.

The examination of the descriptive statistics tables revealed that some agencies reported zero clearances. Table 5 shows the frequency of zero clearances for each offense type. For example, 107 departments reported that they did not clear any murder case in 2005 and 102 departments reported that they did not clear any murder case in 2006. Totally, there are 514 zero clearances reported in 2005 and 511 zero clearances reported in 2006. This means that 22.06% of reported clearances in 2005 and 21.93% of reported clearances in 2006 are zero.

Table 5
*Number of Zero Clearances*

| | 2005 Clearances | 2006 Clearances |
|---|---|---|
| Murder | 107 | 102 |
| Rape | 89 | 90 |
| Robbery | 71 | 76 |
| Assault | 32 | 33 |
| Burglary | 40 | 43 |
| Larceny | 35 | 37 |
| Vehicle Theft | 47 | 54 |
| Violent Crimes | 32 | 23 |
| Property Crimes | 31 | 23 |
| All Crimes | 30 | 30 |

There are two explanations for zero clearances. If a department reported zero clearances but at least one crime for any offense category, then that means the department did not clear any of the reported crimes. On the other hand, if a department reported zero crime, and zero clearance, then that means the department does not have any crime to clear for that year. Since division by zero is undefined, calculation of clearance rates would yield missing values for both groups of cases. However, reporting missing values

for the former group would bias the clearance rate variable by concealing some of the agencies with low clearance rates. For that reason, if an agency reported a number of crimes, but zero clearance for an offense category, its clearance rate value was defined as zero. However, if an agency reported zero crime and zero clearance in an offense category, its clearance rate value was defined as missing. For example, 93 departments did not report any homicide clearance in 2005 and 94 departments did not report any homicide clearance in 2006 because they did not have any homicide cases to report. Therefore, murder clearance rates of 93 departments in 2005 and 94 departments in 2006 are defined as missing. Murder, rape and robbery clearance rate variables have been affected more than others by these kinds of missing values. It is also important to keep in mind that clearances reported in any given month or year may not have any relationship with the offenses reported for that month or year as discussed in the methodology chapter. In other words, it is highly possible that an offense can be reported as occurring in one year and it can be reported as cleared in another year. As a result of this, sometimes departments may report more clearances than the number of crimes they reported for any offense type.

In order to learn more about the investigative performance of sampled departments, crime and clearance rates are discussed herein. As presented in the methodology chapter, crime rates are calculated for each department by dividing the number of crimes known to the police by the size of the population and scaling it up by a multiplier. In this study, 1,000 is preferred as the multiplier. The means of crime rates are calculated by dividing the sum of the crime rates involving the departments in this study by the number of reporting departments. Similarly, the mean of clearance rates is

calculated by dividing the sum of the clearance rates over the departments in this study by the number of reporting departments. Figure 2 presents graphs illustrating the mean values of 2005 and 2006 crime rates.

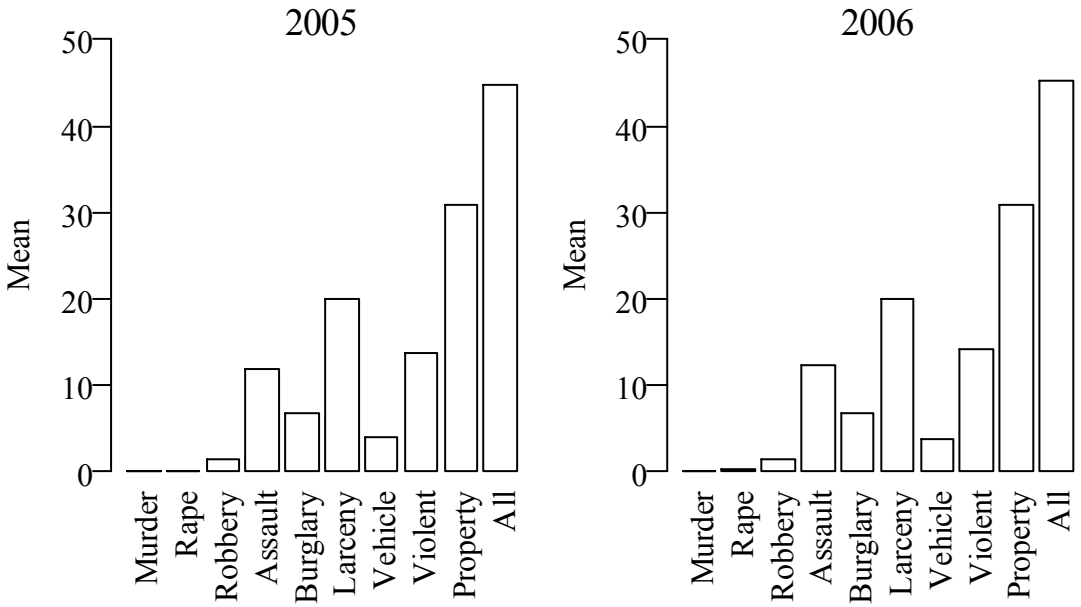


*Figure 2*. Mean values of 2005 and 2006 crime rates

Figure 2 shows that mean of property crime rates is higher than violent crime rates in both years. Assault and larceny crimes are the most prevalent crime types in violent and property crime groups, respectively. The mean of assault is 12.023 in 2005 and 12.307 in 2006. The mean of larceny is 20.094 in 2005 and 20.117 in 2006. Murder and rape offenses are the least prevalent crimes in the sample. The mean of murder crimes is 0.054 in 2005 and 0.057 in 2006. The mean of rape crimes is 0.227 in 2005 and 0.24 in 2006. Vehicle theft is the least prevalent crime type in property crimes. Its mean is 3.999 in 2005 and 3.882 in 2006.

Figure 3 presents graphs illustrating the means of 2005 and 2006 clearance rates. Similarly to 2005 and 2006 crime rates, the mean values of 2005 and 2006 clearance rates are also very close to each other. The graphs also shows that murder, assault and rape had

the highest clearance rates both in 2005 and 2006. In other words, the violent crimes category has a higher clearance rate than the property crimes category in the sample. The mean of the murder clearance rate is 0.6 in 2005 and 0.619 in 2005. The mean of the assault clearance rate is 0.538 in 2005 and 0.54 in 2006. The mean of the rape clearance rate is 0.375 in 2005 and 0.365 in 2006. On the other hand, burglary, larceny and motor vehicle theft had the lowest clearance rates in the sample. The means of burglary clearance rates are 0.14 and 0.122, larceny clearance rates are 0.79 and 0.549, and motor vehicle clearance rates are 0.196 and 0.177 in 2005 and 2006. 26% of all crimes were cleared in 2005 and 25% percent of all crimes were cleared in 2006.

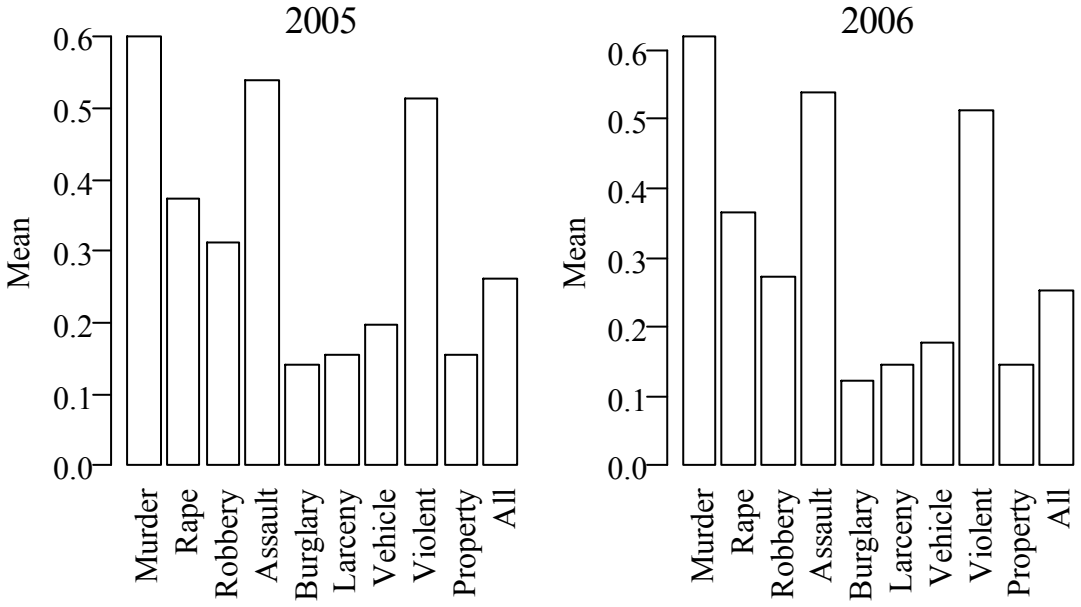


*Figure 3.* Mean values of 2005 and 2006 clearance rates

Figure 4 illustrates standard deviations of clearance rates for nine crime categories and all crimes. Standard deviations are calculated by taking square root of the variance. Standard deviations of 2005 and 2006 clearance rates are very close to each other, but 2005 figures are a little higher than 2006 figures indicating a little more variation in clearing crimes in 2005. The standard deviations of violent crimes such as murder, rape,

robbery and assault are larger than other crimes. Their standard deviations are 0.358, 0.314, 0.246, 0.246 in 2005 and 0.29, 0.281, 0.247, 0.251 in 2006. This indicates that there is more variation in the sample in clearances of violent crimes. On the other hand, standard deviations of property crimes such as burglary, larceny and motor vehicle theft are smaller. Their standard deviations are 0.149, 0.112 and 0.209 in 2005 and 0.086, 0.091 and 0.177 in 2006. The low standard deviation values of property crime clearance rates indicate that there is less difference among agencies in clearing property crimes.

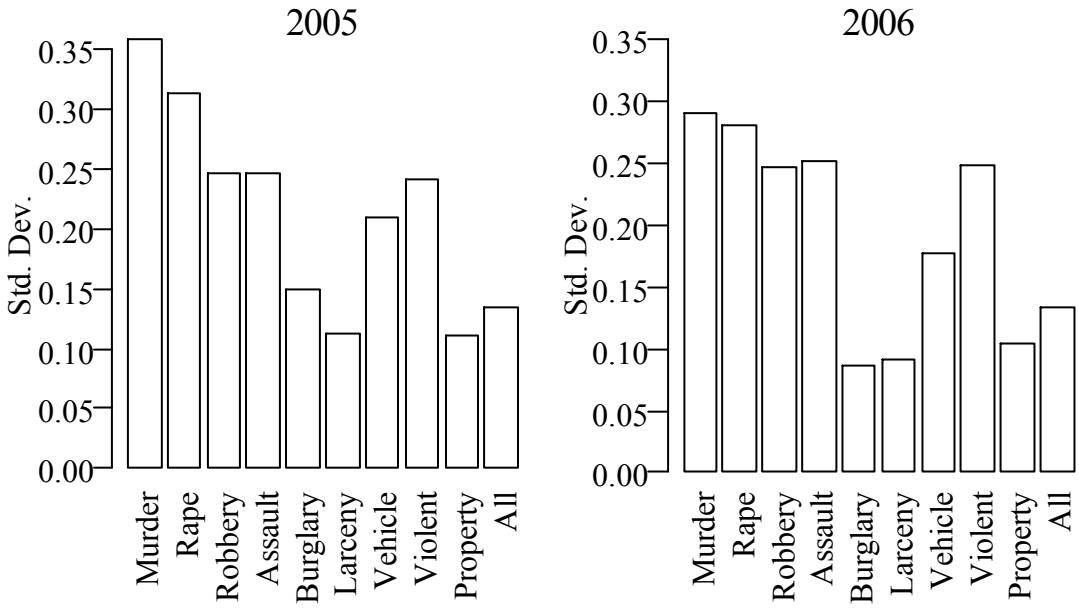


*Figure 4.* Standard deviations of 2005 and 2006 clearance rates

Histograms of frequency distributions of all variables are given in Appendix E. As presented in the literature review chapter, some studies found that use of information technologies has an impact on murder and motor vehicle theft clearance rates (Meehan, 1998; Nunn, 1994; Wellford & Cronin, 1999). For that reason, murder and motor vehicle crimes will be presented in more detail herein. Figure 5 and Figure 6 present the histograms and box plots of frequency distributions of 2005 and 2006 murder and motor vehicle theft clearance rates, respectively. The mean of 2005 murder clearance rates is 0.6

and the mean of vehicle theft clearance rates is 0.196. Their standard deviations are 0.358 and 0.209, respectively. Figure 5 shows that the 2005 murder clearance rate variable has a kurtosis problem. Five departments have a murder clearance rate bigger than 1 which indicates that those departments cleared murder cases that were reported in previous years. The motor vehicle theft variable is positively skewed. The clearance rate value of five departments is 1.

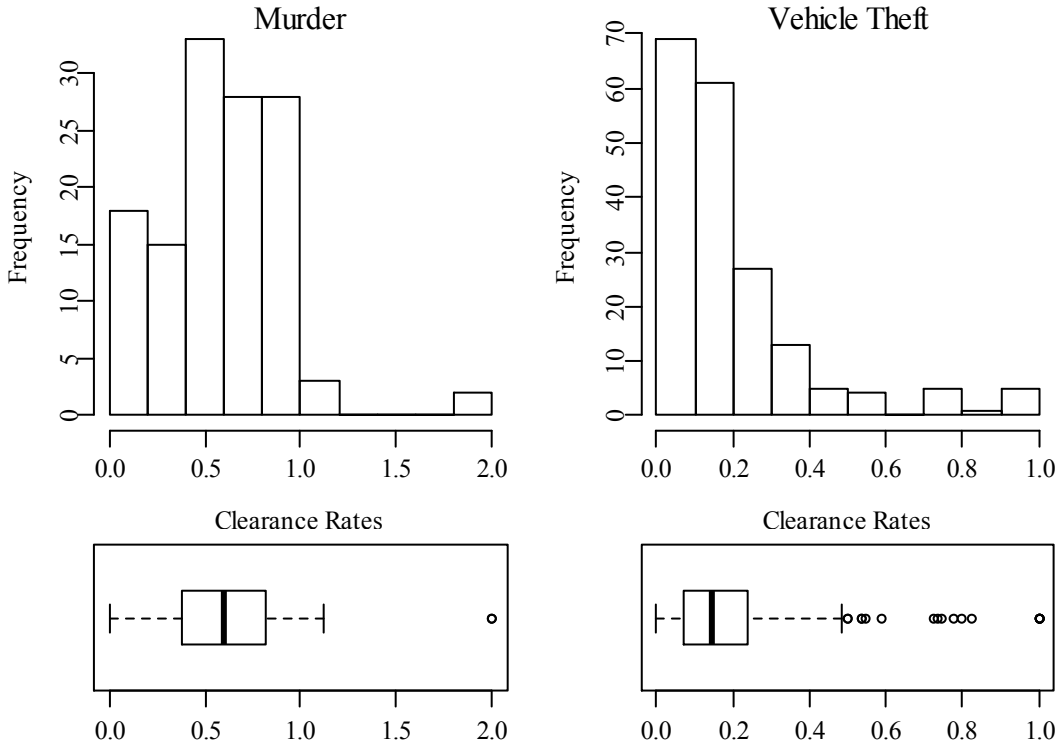


*Figure 5.* Histograms and box plots of 2005 murder and motor vehicle theft clearance rates

Histogram and box plots of 2006 murder and vehicle theft clearance rates are presented in Figure 6. The mean of 2006 murder clearance rates is 0.619 and that of vehicle theft clearance rates is 0.177. Their standard deviations are 0.29 and 0.177,

respectively. The histogram of the murder clearance rate shows that its distribution is not normal. There are 3 departments with a murder clearance rate of over 1, indicating that those agencies cleared homicides committed in previous years. The motor vehicle theft variable is again positively skewed. The clearance rate value of two departments is 1.

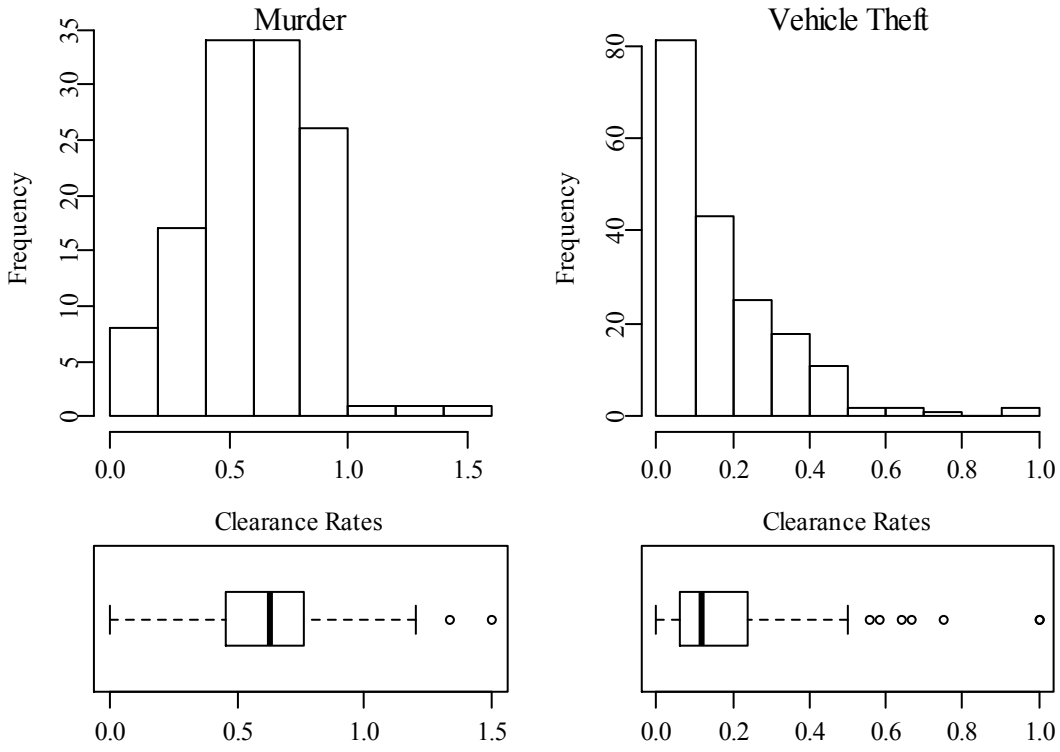


*Figure 6.* Histograms and box plots of 2006 murder and motor vehicle theft clearance rates

The examination of other clearance rate variables showed that they are not normally distributed. There are many transformation methods used to correct non-normally distributed data. Natural log transformation and square root transformation are frequently applied transformation methods. Log transformation is not suitable for clearance rate variables because they have too many zero values. Since the log of zero is undefined, log transformation would increase the number of missing values in clearance rate variables. For this reason, square root transformation is preferred. Figures 7 and 8

present square rooted 2005 murder and motor vehicle clearance rates. They show that square root transformation did not completely solve the non-normality problem, but brought variable distributions closer to the normal distribution. The histograms of square rooted clearance rate variables are also presented in Appendix E.

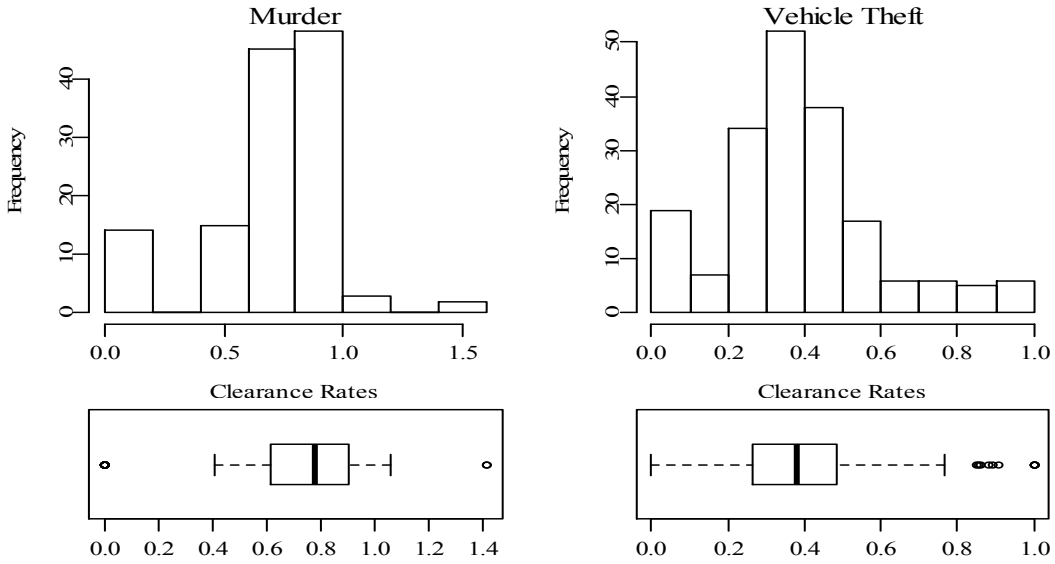


*Figure 7.* Histograms and box plots of 2005 murder and motor vehicle theft clearance rates after square root transformation

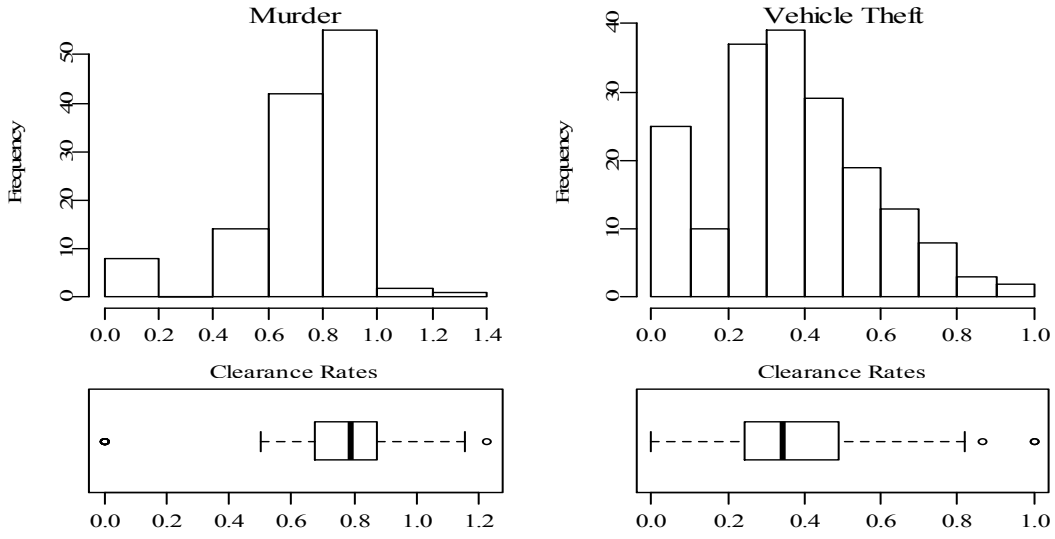


*Figure 8.* Histograms and box plots of 2006 murder and motor vehicle theft clearance rates after square root transformation

Figure 9 presents the frequency distribution of the Use of Information Technology scale. As presented in the methodology chapter, there are 29 items in the Use of Information Technology scale. They were collected by the Impact of Science and Technology Survey. All the items are binary response variables where zero indicates that the agency does not have that particular information technology and one indicates that the agency has that technology. The Use of IT score is calculated by summing 29 responses for each agency. The mean and median of the Use of Information Technology scale is 20.186 and 21. The histogram and box plot graphs show that the majority of cases are clustered between 10 and 29, and there are only a few agencies' scores below ten.

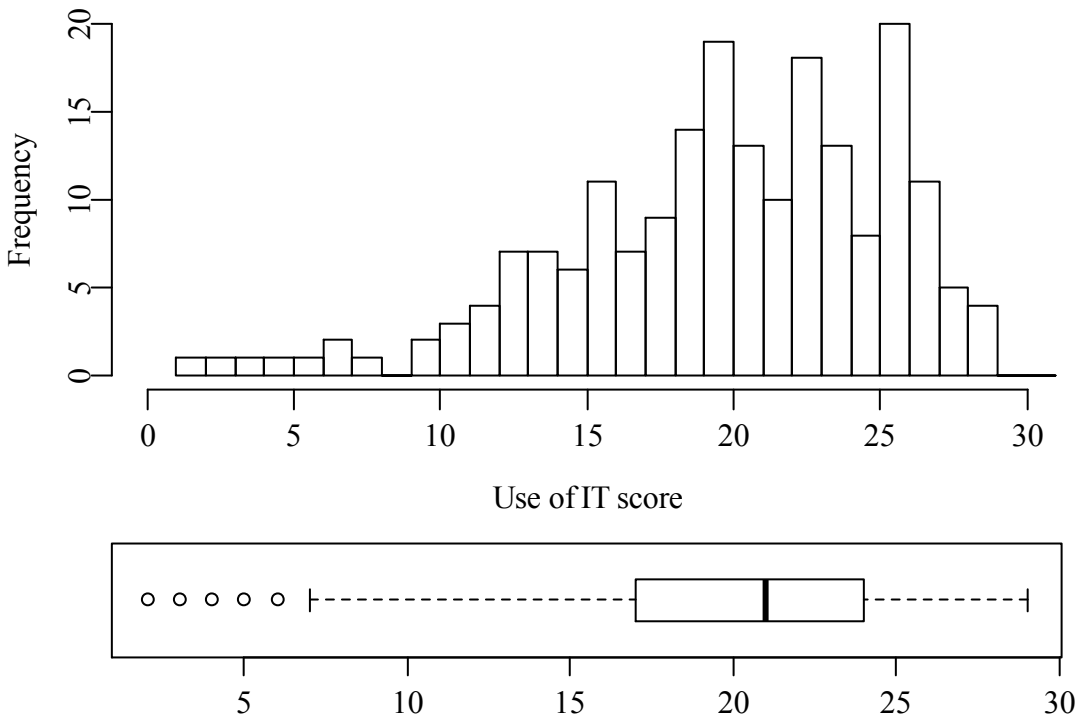


*Figure 9.* Histogram of Use of Information Technology scale

There are seven control variables used in this study. The number of officers variable is the number of sworn officers the department has. The population variable is the number of people living within the jurisdiction of the police department. The number of officers and population variables were measured by the Impact of Science and Technology Survey. The percent below poverty variable is the percentage of population living under the poverty line. The median income variable is the median income of people living within the jurisdiction of the police department. The percent white variable is the percentage of white people living within the jurisdiction of the police department. The population, poverty, median income, and race variables were measured by the U.S. Census. The proportion of sworn officers working at investigative functions is calculated by dividing the number of sworn officers working at investigative functions by the total number of officers. Finally, as presented above, the crime rate variable is calculated by dividing the number of crimes known to the police by the size of the population and scaling it up by a multiplier. Crime variables are collected by the UCR program.

Figure 10 presents the box plots of standardized values of the number of sworn officers, population, poverty, median income, race and proportion of investigators variables. Standardization converts variables to standard scores, but it does not change their frequency distributions. Data analysis, on the other hand, was conducted with the original data, not the standardized data. Standardization was applied just to be able to view those variables on the same scale. Box plots of median income, percent below poverty, percent white and proportion of investigators variables show that their distributions can be considered as normal. Median income and proportion of investigators variables have a lesser amount of variation than other variables. The mean and median of

the median income variable are 41,949.232 and 37,954. The mean and median of the proportion of investigators variable are 0.252 and 0.154. The mean and median of the percent below poverty variable are 13.786 and 12.7, and the mean and median of the percent white variable are 72.995 and 75.1. Their distributions are closer to normal distribution than in the case of other variables.

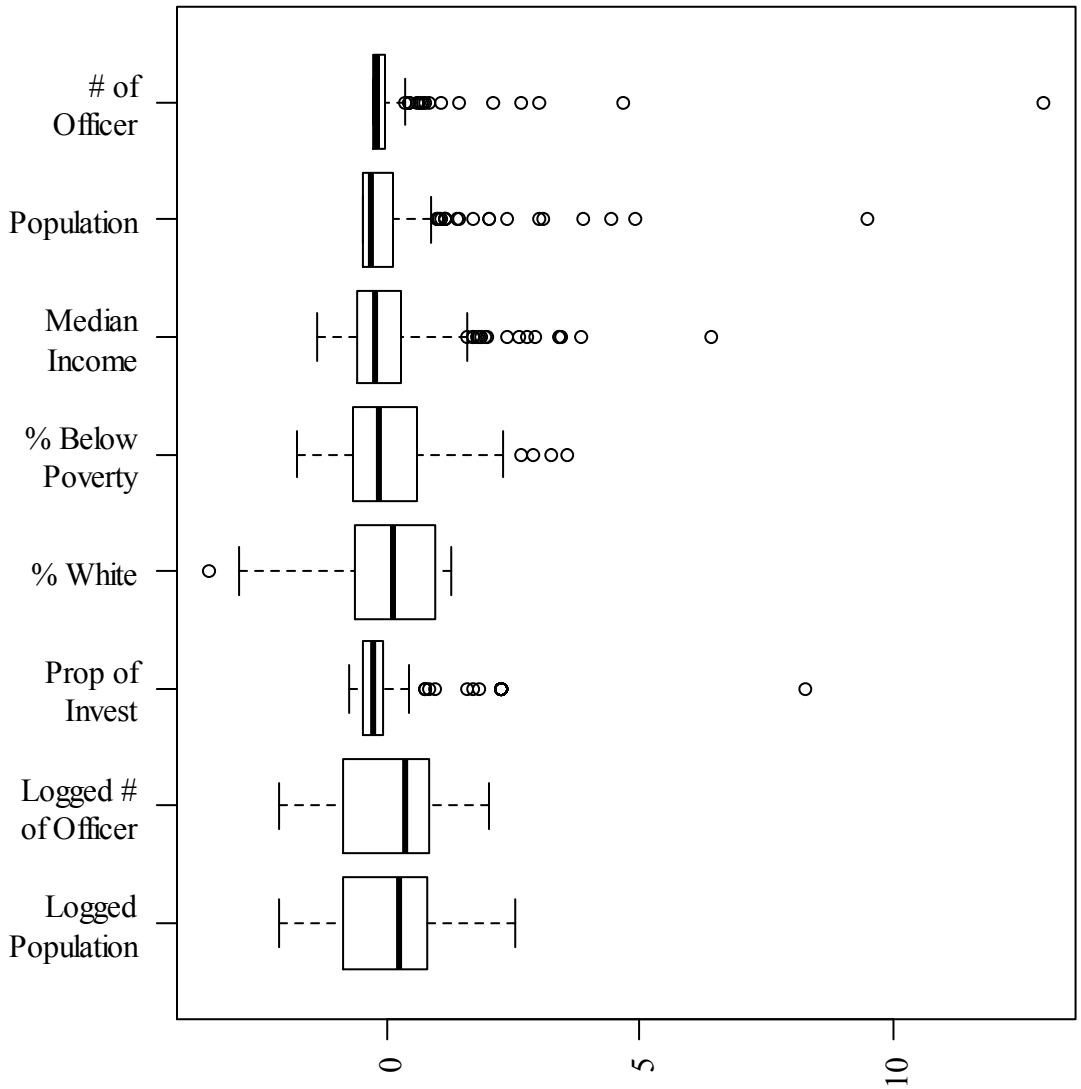


*Figure 10.* Box plots of standardized values of six control variables

However, the distributions of number of officers and population variables are problematic. Their median values are very close to their first and third quartiles indicating

that there is less variation in the sample in terms of number of officers and population variables. The examination of their frequencies showed that 93 departments have less than 100 officers, and 197 departments have less than 1000 officers in the sample. 42 departments have more than 999 officers and two of them have more than 10,000 officers. The population variable also has a similar distribution. 110 departments were serving jurisdictions with a population of less than 10,000. 210 departments were serving jurisdictions with a population of less than 1,000,000. 24 departments were serving jurisdictions with a population of more than 999,999 and one of these is serving a jurisdiction with a population of 8,000,000. The mean and median of the number of officers variable are 814.681 and 210, and the mean and median of the population variable are 398,987.399 and 152,000. Both variables' means are larger than twice of their medians because of several big city police departments. In order to normalize these variables, log transformation is applied to them. The box plots of standardized values of logged number of officers and logged population variables are presented at the bottom of Figure 10. Box plots show that log transformation approximately normalized their distributions. Bar charts showing the frequency distributions of the logged variables can be found in Appendix E.

## Bivariate Analysis

Pearson product-moment correlation coefficients were calculated for all variables and presented in Appendix F. The largest positive correlation coefficient between clearance rate variables and use of IT scale is 0.193, and the largest negative correlation coefficient is -0.169. In addition, there are eight negative correlation coefficients (assault, vehicle theft, violent crimes and all crimes in both 2005 and 2006 data). The use of IT

variable is significantly correlated only with rape clearance rates in both 2005 and 2006 data ($r=0.176$, $p<0.05$ and $r=0.252$, $p<0.05$). Other than rape clearances, the use of IT variable is significantly correlated with 2006 robbery clearance rates; however, this relationship is not significant in 2005 data. The direction of significant relationships is positive indicating that agencies that score higher on the use of IT scale achieve significantly more clearances in those crime categories than the agencies that score low on the use of IT scale. On the other hand, the direction of the relationship is negative for some of the clearance rates.

Correlation analysis of clearance rate and control variables also gave some statistically significant results. The percent white population variable has the highest number of significant correlation coefficients. Except rape and burglary offenses, it is significantly correlated with 2005 and 2006 clearance rate variables, and the direction of relationship is always positive. This indicates that agencies serving in jurisdictions that have a higher percentage of white population are more likely to achieve clearances than the agencies serving in jurisdictions that have a lower percentage of white population. The magnitude of the correlation coefficient varies between 0.153 and 0.338. The logged number of officers variable is significantly correlated with the rape, vehicle theft and violent crimes categories in both 2005 and 2006 data. Interestingly, while the direction of relationship is positive for rape clearances, it is negative for vehicle theft and violent crime categories. This indicates that large agencies are more likely to clear rape offenses than the small agencies, but they are less likely to clear vehicle theft crimes. Moreover, they are less likely to clear violent crimes than the small agencies. The median income and percent below poverty line variables have significant correlation coefficients for

assault and violent crimes categories. The direction of relationship is positive for the median income variable and negative for the percent below poverty line variable. This indicates that as the median income variable increases and the percent below poverty line variable decreases, clearance rates are likely to increase for assault and violent crime offenses. Finally, the population variable has a significant relationship with only vehicle theft clearances. The direction of the relationship is negative, which indicates that as the population increases, vehicle theft clearances are likely to decrease. The proportion of investigators variable has a significant relationship with burglary, vehicle theft and property crimes categories for only 2005 data, but it does not have a significant relationship with any variables from the 2006 data.

The use of IT variable has a strong correlation with the logged number of officers and population variables. The correlation coefficients are above 0.6 and the directions of relationships are positive indicating that larger agencies serving large populations are more likely to score higher on the use of IT scale. In other words, larger agencies serving large populations are more likely to use more information technologies than the small agencies. Although relationships are weaker, the use of IT scale is significantly correlated with other control variables with the exception of the proportion of investigators variable. The direction of relationship with the percentage of white variable is negative indicating that agencies whose jurisdictions have a large percentage of white population are less likely to use information technologies. The correlation coefficients of the median income and percent poverty variables suggest that agencies serving in more affluent communities are more likely to score higher on the use of IT scale. The use of IT scale has an

insignificant, weak and negative relationship with the proportion of investigators variable (r=-0.08).

The strong correlation between the use of IT scale and the logged number of officers deserves further attention. Correlation results show that large agencies are more likely to use information technologies. Because of this relationship it may be difficult to distinguish the impact of the use of information technology on clearance rates from the impact of the agency size on clearance rates. Since there is a very strong correlation between the logged number of officers and population variables (r=0.943) and both variables have a strong relationship with the use of IT scale, it is sufficient to examine just one of the two variables. Here we will look at the relationship between the use of IT scale and the logged number of officers variable. Figure 11 presents the scatter plot of the relationship between the logged number of officers and the use of IT variables.

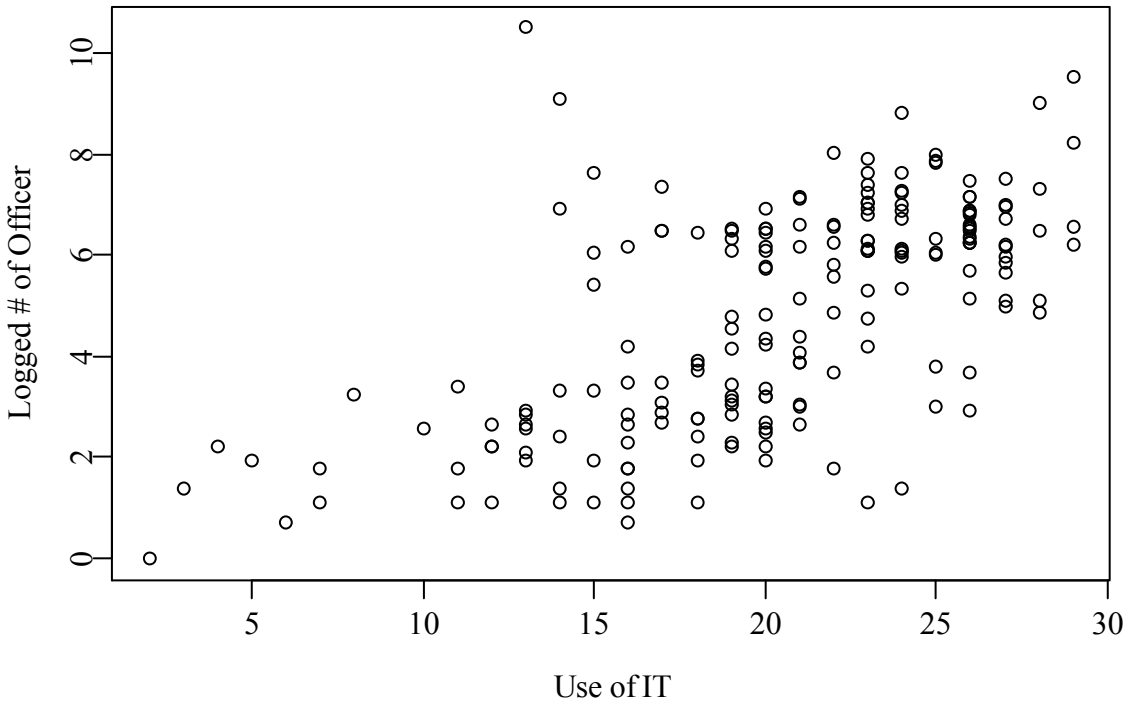


*Figure 11.* Scatter plot of logged number of officers and use of IT scale variables

Figure 11 verifies the positive correlation between the logged number of officers and use of IT scale variables. Figure 11 also shows that there is not sufficient number of observations in some regions of scatter plot. There is a large empty region at the top left portion of the scatter plot. It indicates that the sample does not have any large department which scored low on the use of IT scale. Similarly, there is another empty region at the bottom right portion of the scatter plot. It shows that the sample does not have any small department which scored high on use of IT scale.

This finding shows that the data is unbalanced. Unbalanced data means that there are unequal numbers of observations in the cells of a design (Sahai & Ojeda, 2005). In this case, if we make a two-way table of deciles of use of IT and logged number of officers variables, we would see that there were not equal numbers of observations in the cells. Moreover, some cells would have zero observations. This constitutes a problem for the multivariate analysis. Since there is not a sufficient number of small agencies that score high and big agencies that score low on the use of IT scale, it is not possible to control for the logged number of officers variable by just adding it into the analysis as a control variable. In a multivariate analysis, the derived regression line would be the product of just small agencies on one side, and it would be the product of just big agencies on the other side. Since we will not be able to adequately control for the logged number of officers variable, the regression coefficient of the use of IT variable is likely to be overestimated (Gelman & Hill, 2006).

To further examine the imbalance problem and to find the corresponding areas of number of officers and use of IT variables that drive the correlation high, the sample is divided into deciles of the use of IT scale, and correlation coefficients are calculated. The

scatter plots are presented in Appendix H. Scatter plots show that, except for the first decile, the range of the use of IT variable is very small in the remaining nine deciles. For example, in the second decile the minimum value of the use of IT scale is 13 and the maximum value is 16, so its range is 3. The range of use of IT variable is smaller in other deciles and it is 0 in the seventh and ninth deciles. For this reason, it is not very informative to calculate the correlation coefficient for those deciles. The range of use of IT scale in the first decile is 11. There are 18 cases in the first decile and the correlation coefficient is 0.43. On the other hand, the imbalance problem can be seen clearly by looking at the first and the tenth deciles. The first decile is populated by the small departments and the tenth decile is populated by the larger ones.

Since deciles of use of IT variables did not give much information, the sample is again divided into ten groups according to the logged number of officers variable. The logged number of officer variable ranged between 0 and 10.52 (if an agency has only 1 officer, the logged number of officers variable becomes 0). Therefore, the boundaries of ten groups are defined as follows: 0-09, 1-1.9, 2-2.9, 3-3.9, 4-4.9, 5-5.9, 6-6.9, 7-7.9, 8-8.9 and 9-10.52. Scatter plots and correlation coefficients are presented in Appendix I. Figure 12 presents the scatter plot of the logged number of officers and use of IT scale variables, again. The logged number of officers variable is divided into ten groups and the correlation coefficient and group sizes are provided on the graph. Figure 12 also presents a box plot comparison of the use of IT variable in ten groups of the logged number of officers variable.

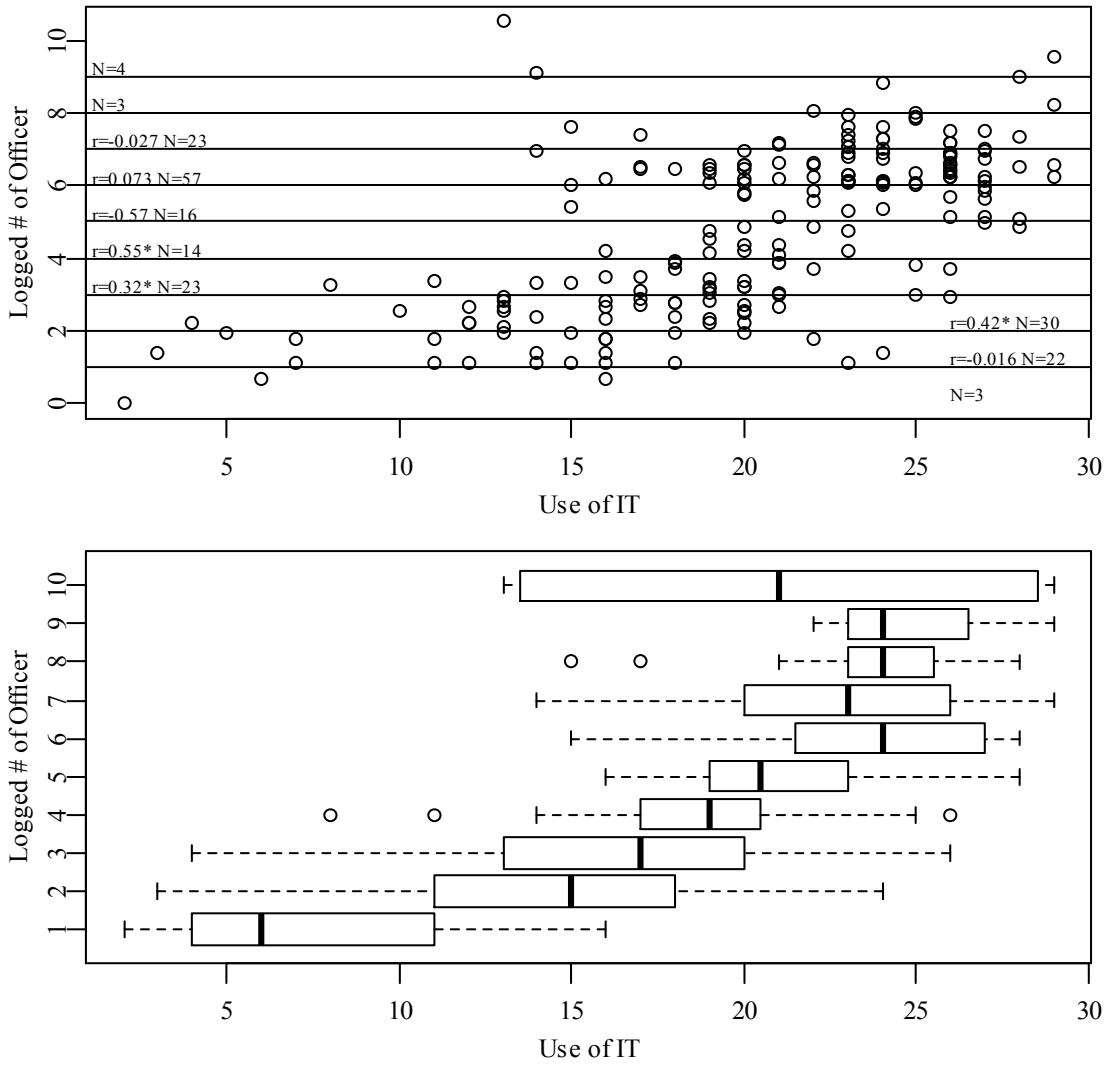


*Figure 12.* Scatter plot of logged number of officers and use of IT scale variables, and box plot comparison of use of IT scale across ten groups.

As shown on the first graph, the correlation coefficients are stronger in the third, fourth, fifth and sixth groups (it is significant for the third, fourth and fifth groups). The direction of relationship of the correlation coefficient is generally positive, but it is negative in the second, sixth and eighth groups. The scatter plot shows that correlation is mainly driven by the third, fourth and fifth groups. The second graph clearly shows that the distribution of the use of IT variable differs across the ten groups of the number of officers variable. Positive correlation is also visible in the second graph. This graph also

shows that distribution of the use of IT variable is overlapping in the $6^{th}$, $7^{th}$, $8^{th}$ and $9^{th}$ groups. The first group, on the other hand, is clearly different than other groups.

For the final analysis of the relationship between the number of officers and use of IT scale variables, a regression model was fitted in which use of IT scale is the dependent variable and the logged number of officers variable is the independent variable. The goal of regression analysis is to see the association between two variables. Regression analysis was conducted for the groups of logged number of officer variable that have at least 20 observations and for the entire sample The regression formula was expressed as follows:

$$Use\ of\ \ IT\ \ Scale = a + \beta_1(Logged\ \ Number\ of\ \ Officer) + e$$

Regression coefficients with brief model information are provided in Table 6. The direction of relationship in all cases is consistent with the correlation coefficients. The regression coefficient is large for the third and fourth groups and for the entire sample, but it is smaller than one for the remaining groups. The regression model and coefficients are significant for the third group and the overall model. Since the independent variable was a logged variable, its interpretation is made in terms of percent change (Gelman & Hill, 2006). Therefore, the third model suggests that a one percent increase in the number of officers increases the use of technology scale by 0.068 units. Similarly, the entire sample model suggests that a one percent increase in the number of officers increases use of technology scale by 0.015 units. Although the impact is fairly small, it reveals the existence of a relationship between the two variables which is important for the next part of this study.

Table 6

*Regression Coefficients of Logged Number of Officers Variable Predicting Use of IT Scale*

| | 2 | 3 | 4 | 7 | 8 | All |
|---|---|---|---|---|---|---|
| Intercept | 14.743 | -1.175 | 3.380 | 17.108 | 25.543 | 12.708 |
| # of Officer | -0.253 | 6.848* | 4.359 | 0.919 | -0.262 | 1.56*** |
| F | 0.005 | 5.857* | 2.334 | 0.293 | 0.015 | 125.1*** |
| $R^2$ | -0.050 | 0.143 | 0.057 | -0.013 | -0.047 | 0.39 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

In sum, the bivariate analysis revealed two problems. The first problem is the lack of balance in the sample. As shown above, there are not enough departments which are small but scored high on use of IT scale and vice versa. The second problem is the strong correlation between the use of IT scale and the logged number of officers variables.

## Multivariate Analysis

In this part, multiple regression analysis is employed with the ordinary least squares (OLS) estimation method to investigate functional relationships among variables. Multiple regression permits the estimation of the effect on the dependent variable of changing one variable while holding the other regressors constant. Linear functional form is preferred because examination of scatter plots of 2005 and 2006 clearance rate variables and the use of IT variable did not reveal any nonlinear pattern in the relationships between response and predictor variables. Two linear models are specified. The first model is the reduced model with the square rooted clearance rate variable as the response variable and the use of IT scale and number of officers variables as the predictor variables. The regression equation of the reduced model is expressed as follows:

$$\sqrt{Clearance\ Rate} = a + \beta_1(Use\ of\ IT\ Scale) + \beta_2(Logged\ \ Number\ of\ Officer) + e$$

The second model is the complex model with the use of IT scale as the independent variable controlling for the six variables discussed above, except for the population variable. The regression equation of the complex model is expressed as follows:

$$\begin{aligned}\sqrt{Clearance\ Rate} = a &+ \beta_1(Use\,of\ IT\ Scale) + \beta_2(Logged\ Number\,of\ Officers) + \\ &\beta_3(Median\ Income) + \beta_4(Poverty) + \beta_5(P.of\ Invest.) + \\ &\beta_6(Race) + \beta_7(Crime\ Rate) + e\end{aligned}$$

The population variable was excluded from the model because of its strong correlation with the number of officers variable (r=0.943); therefore, controlling for either one would be sufficient for the analysis. The median income and percent below poverty line variables have also a strong correlation with each other (r=-0.719). However, both variables were kept in the model because besides measuring the socio-economic condition of the population, the median income variable is also used as a proxy to the resources available to the police departments. Therefore, both variables are important for correctly measuring the environmental impact on clearance rates.

Three groups of regression analysis were conducted. First, regression parameters were estimated by including all the departments into the analyses after dropping eight departments scored below 10 on use of IT scale. As presented in the bivariate analysis, those eight cases are small departments. Their median of the logged number of officers variable is 1.59, and the largest logged number of officers variable in that group is 3.25. This shows that this portion of the dataset is very much unbalanced. Since they cannot contribute much to the analysis, those eight departments were dropped from the sample. Each of the twenty clearance rate variables (ten variables from each year) were plugged into reduced and complex models as dependent variables, so forty models were

estimated. In the second step, police departments were divided into two groups as moderate IT and high IT departments, and reduced and complex models were fitted to both moderate IT and high IT departments. Therefore, eighty models were estimated in this step. In the third step, the sample was divided into ten groups by the number of officers variable as described above, and regression parameters were estimated for the groups with enough sample size separately.

The results of regression analysis involving the whole sample are presented in Appendix J. F tests were significant for 12 models of 2005 and 12 models of 2006 crime data. Therefore, significant F test results reject the null hypothesis that all the regression coefficients in the regression equation are zero. Adjusted $R^2$ values are generally smaller than 0.1 indicating that models can generally explain less than 10 percent of variance in the dependent variable. Except for the rape models in both years' data, complex models' adjusted $R^2$ values have improved compared to the reduced models' adjusted $R^2$ values.

Figure 13 shows the regression coefficients of the use of IT scale (R and C letters at the end of offense types represent reduced and complex models). The bar graph shows that the magnitude of regression coefficients ranges between 0.001 and 0.014. It is generally higher in violent crime models than the property crime models, and it is higher in 2006 data than the 2005 data. The use of IT scale variable is significant in only four models. The direction of relationship is always positive indicating that high scores in the use of IT scale are associated with higher clearance rates, but the impact is fairly small. For example, the complex model of robbery fitted to the 2006 data has the highest regression coefficient of the use of IT scale which is 0.014. Since the dependent variable is square rooted, and its interpretation is difficult in this form, the regression coefficient is

transformed back by taking its square (Cohen, 2003). As a result; one unit change in the use of IT scale corresponds to 0.000196 or % 0.02 change in clearance rates.

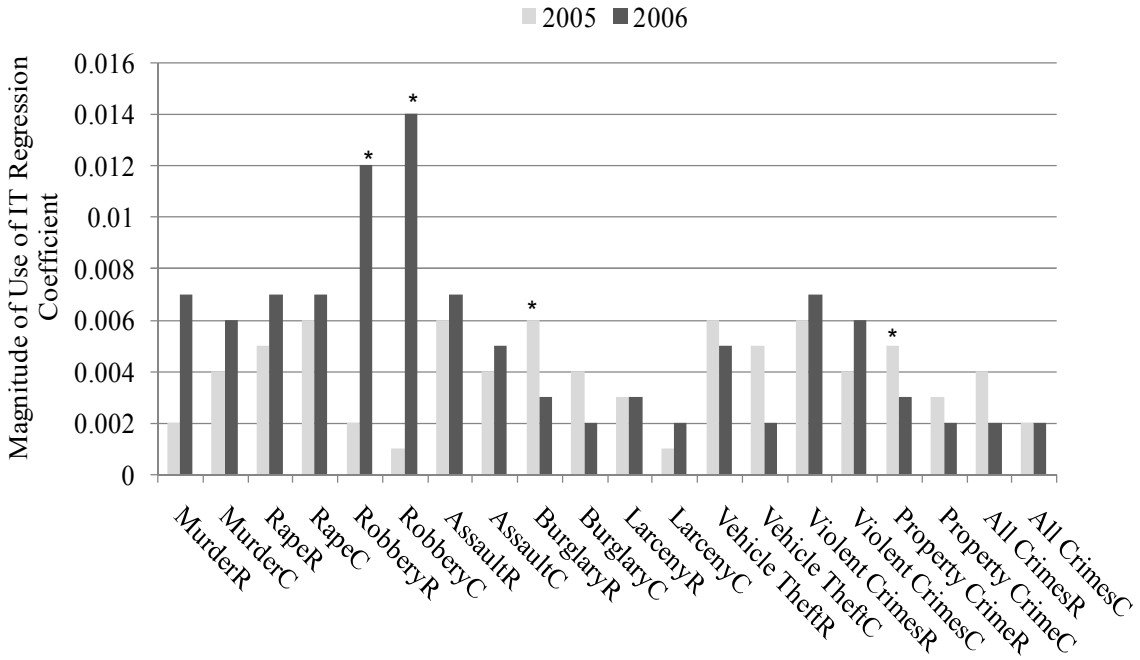


*Figure 13.* Regression coefficients of Use of IT scale estimated from 2005 and 2006 data (***p< 0.001, **p< 0.01, *p< 0.05)

The agency size variable was significant in 12 out of 40 models, and surprisingly its direction of relationship is generally negative. The percent white variable is significant in 13 out of 20 models. The direction of relationship is positive indicating that clearance rates are increasing as the percentage of white population increases. The proportion of investigators variable is significant in only five out of 20 models, and its direction of relationship is not consistent. The crime rate variable is significant in 6 out of 20 models and its direction is generally positive indicating that clearance rates increase as crime rates increase. Finally, it would be informative to look at details of several models. Table 7 presents murder and vehicle theft models of the 2005 and 2006 years.

Table 7

*2005 and 2006 Murder and Vehicle Theft Models*

| | Murder 05 | | Murder 06 | | Vehicle 05 | | Vehicle 06 | |
|---|---|---|---|---|---|---|---|---|
| | R | C | R | C | R | C | R | C |
| Intercept | 0.769 (0.202) | 0.008 (0.582) | 0.962 (0.16) | 0.603 (0.482) | 0.442 (0.075) | 0.087 (0.22) | 0.471 (0.075) | 0.395 (0.217) |
| Use of IT | 0.002 (0.007) | 0.004 (0.008) | 0.007 (0.006) | 0.006 (0.007) | 0.006 (0.004) | 0.005 (0.004) | 0.005 (0.004) | 0.002 (0.004) |
| # of Officer | -0.015 (0.022) | 0.011 (0.024) | -0.06** (0.017) | -0.032 (0.021) | -0.035*** (0.009) | -0.014 (0.011) | -0.037*** (0.01) | -0.012 (0.012) |
| Median Income | | 0.000 (0.000) | | 0.000 (0.000) | | 0.000 (0.000) | | 0.000 (0.000) |
| % Below Poverty | | 0.007 (0.011) | | 0.000 (0.009) | | 0.003 (0.005) | | -0.003 (0.005) |
| % White | | 0.007* (0.002) | | 0.004 (0.002) | | 0.002 (0.001) | | 0.002 (0.001) |
| Prop. Of Inves. | | 0.076 (0.177) | | -0.023 (0.145) | | 0.092 (0.056) | | 0.119 (0.054) |
| Crime rate | | 0.126 (0.363) | | -0.045 0.257 | | -0.007 (0.004) | | -0.006 (0.004) |
| F | 0.252 | 1.429 | 5.641* | 2.726* | 7.114** | 4.2*** | 8.27*** | 4.559*** |
| DF Reg | 2 | 7 | 2 | 7 | 2 | 7 | 2 | 7 |
| DF Res | 107 | 101 | 105 | 99 | 158 | 152 | 154 | 148 |
| Adj. $R^2$ | -0.013 | 0.027 | 0.08 | 0.102 | 0.071 | 0.124 | 0.085 | 0.139 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Except for 2005 murder models, the F test is significant in all the models. Complex models have higher adjusted $R^2$ values. The use of IT variable is not significant in any of the models. Except for the 2005 complex murder model, the number of officers variable is negative and it is significant in three reduced models. The regression coefficients of median income, percent below poverty line and percent white variables are very small, their direction of relationship is not consistent and only the percent white

variable is significant in one model. Finally, the crime rate variable also has a small regression coefficient with generally negative relationship with clearance rates.

In sum, multivariate analysis of 2005 and 2006 crime and clearance data showed that regression coefficient of use of IT variable was significant in only 4 out of 40 models. Although complex models generally improved the adjusted $R^2$ values, explanatory power is generally low in all models. Because of the imbalance problem presented in the previous part, the interpretation of regression coefficients is problematic. Since multivariate model cannot adequately control for the impact of logged number of officers variable, regression coefficient of use of IT variable might be overestimated.

In the second stage of multivariate analysis, the sample was divided into two, groups (after dropping 8 departments that scored below 10 on the use of IT scale) from the midpoint of the use of IT scale. The first group consisted of the departments that scored between 10 and 19, and the second group consisted of the departments that scored between 20 and 29. Since the departments scored low on use of IT scale was dropped, these groups are called as moderate and high IT groups. Two groups were compared to each other before conducting any multivariate analysis. Box plot comparisons of moderate and high IT departments (Appendix G) revealed that there is not much difference between moderate and high IT departments in terms of crime and clearance rates.

Figure 14 presents the box plot comparison of 2005-2006 all crime and clearance variables and the six control variables. Box plot comparison shows that moderate and high IT departments are very similar in terms of crime and clearance rates. There is an important difference between the logged number of officers variables of moderate and

high IT departments. High IT departments are generally the larger ones, and moderate IT departments are generally the smaller ones. Although they have some overlap, the population, median income and percent white variables also look different. High IT departments are generally serving larger populations whose median income is somewhat bigger than the jurisdictions that moderate IT departments are serving. On the other hand, the percentage of white people is bigger in moderate IT departments than in the high IT departments. High and moderate IT departments look similar in terms of the proportion of investigators and poverty variables,

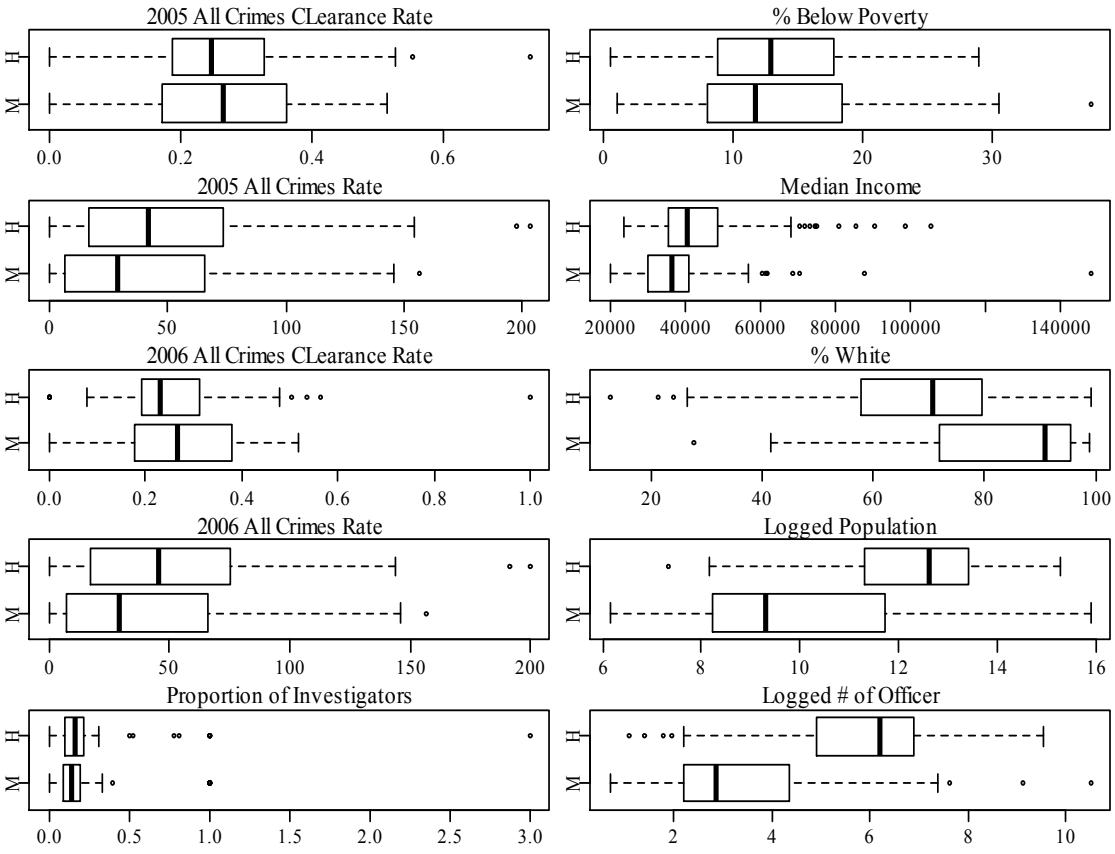


*Figure 14.* Box plot comparisons of variables between moderate and high IT departments

Multiple regression analysis was conducted in moderate and high IT departments, and regression coefficients were estimated for reduced and simple models for both 2005

and 2006 data. Eighty models were estimated. Regression coefficients, F values and $R^2$ values are given in Appendix K. F test results showed that none of the models were significant in 2005 moderate IT data, and 4 models (all reduced) were significant in 2006 moderate IT data. On the other hand, 12 models (4 reduced, 8 complex) were significant in 2005 high IT data and 10 models (4 reduced and 6 complex) were significant in 2006 high IT data. Adjusted $R^2$ values showed that the complex model did not increase explanatory power for moderate IT departments' data. In general, adjusted $R^2$ values of complex models are smaller than adjusted $R^2$ values of reduced models. On the other hand, adjusted $R^2$ values of complex models increased in high IT department data. Figure 15 presents the regression coefficients of use of IT variable.

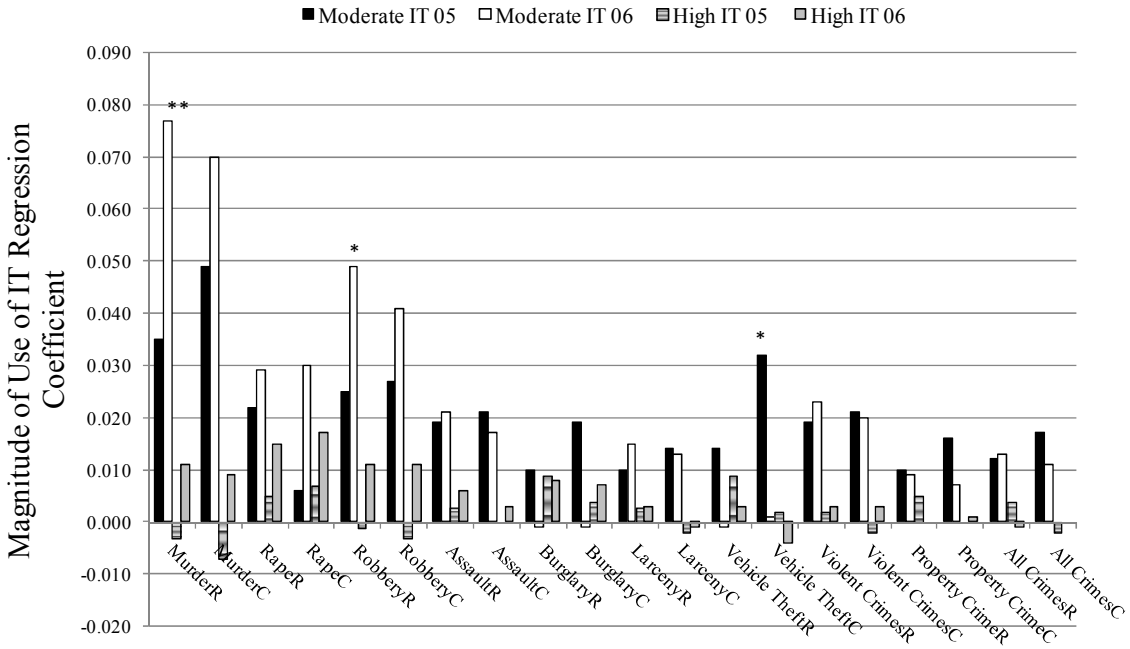


*Figure 15.* Regression coefficients of Use of IT scale of moderate and high IT departments estimated from 2005 and 2006 data (***p< 0.001, **p< 0.01, *p< 0.05)

As marked in the graph, the use of IT variable is significant only in three models. Moreover, it is interesting that the direction of relationship becomes negative in some models, particularly in 2006 reduced burglary, complex burglary and reduced vehicle

theft models. On the other hand, there are more negative coefficients in high IT department models. The coefficients of the number of officer variable are also weak. It is significant in 11 out of 80 models. The direction of relationship is again negative in 67 of 80 models. Other variables' coefficients are very small again, and generally do not have a constant direction of relationship.

Detailed model information of the complex models of murder and vehicle theft clearance rates are presented in Table 8. F tests are significant for only two models, and moderate IT departments have higher adjusted $R^2$ values in murder models, but high IT departments have higher adjusted $R^2$ values in vehicle theft models. As presented in Table 8, all the coefficients are small again, and generally inconsistent in terms of the direction of relationship. The use of IT variable has a positive impact on moderate IT departments, but it sometimes has a negative relationship in high IT departments. The same condition is visible for the number of officers variable. The percent white variable always has a positive coefficient and except for one case, the crime rate variable always has a negative coefficient.

Table 8

*Complex Models of Murder and Vehicle Theft Clearance Rates Fitted to 2005-2006 Moderate and High IT Departments*

| | Murder 05 | | Murder 06 | | Vehicle 05 | | Vehicle 06 | |
|---|---|---|---|---|---|---|---|---|
| | Mod. | High | Mod. | High | Mod. | High | Mod. | High |
| Intercept | -1.911 | -0.023 | -0.712 | 0.264 | -1.008 | 0.611 | 0.284 | 0.573 |
| | (3.172) | (0.627) | (1.857) | (0.538) | (0.571) | (0.244) | (0.583) | (0.252) |
| Use of IT | 0.049 | -0.007 | 0.07 | 0.009 | 0.032* | 0.002 | 0.001 | -0.004 |
| | (0.051) | (0.012) | (0.035) | (0.011) | (0.014) | (0.007) | (0.016) | (0.007) |
| # of Officer | 0.047 | 0.024 | 0.016 | -0.041 | -0.007 | -0.021 | -0.011 | -0.017 |
| | (0.083) | (0.023) | (0.044) | (0.028) | (0.026) | (0.012) | (0.028) | (0.012) |
| Median Income | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |

Table 8 (Continued)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| % Below Poverty | 0.009 (0.043) | 0.015 (0.013) | -0.003 (0.028) | 0.009 (0.01) | 0.031** (0.01) | -0.012* (0.005) | 0.006 (0.01) | -0.006 (0.005) |
| % White | 0.014 (0.017) | 0.008** (0.002) | 0.008 (0.008) | 0.005* (0.002) | 0.004 (0.003) | 0.001 (0.001) | 0.003 (0.004) | 0.002 (0.001) |
| Prop. Of Inves. | 0.438 (1.538) | 0.057 (0.174) | 0.373 (0.763) | -0.06 (0.144) | 0.017 (0.162) | 0.122* (0.052) | -0.043 (0.165) | 0.115* (0.053) |
| Crime rate | 1.994 (2.044) | -0.026 (0.368) | -0.012 (0.92) | -0.013 (0.266) | -0.036* (0.014) | -0.003 (0.003) | -0.014 (0.016) | -0.005 (0.003) |
| | | | | | | | | |
| F | 0.453 | 1.477 | 2.226 | 1.643 | 2.162 | 6.873*** | 1.01 | 6.369*** |
| DF Reg | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| DF Res | 10 | 83 | 13 | 78 | 42 | 102 | 43 | 97 |
| Adj. $R^2$ | -0.29 | 0.035 | 0.3 | 0.05 | 0.142 | 0.274 | 0.001 | 0.27 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Analysis of moderate and high IT groups did not provide much support for the relationship between use of IT and clearance rate variables either. However, as presented above, imbalance is still a problem for moderate and high IT groups. For that reason, the sample is again divided into ten groups by the number of officers variable as done in the bivariate analyses part. Regression coefficients were estimated for the groups that have at least 20 observations in dependent variable. As a result, regression coefficients were estimated for 35 reduced and complex models in 2005 data and 33 reduced and complex models in 2006 data. Figure 16 and Figure 17 present the use of IT coefficients. A table of regression coefficients with brief model information is presented in Appendix L

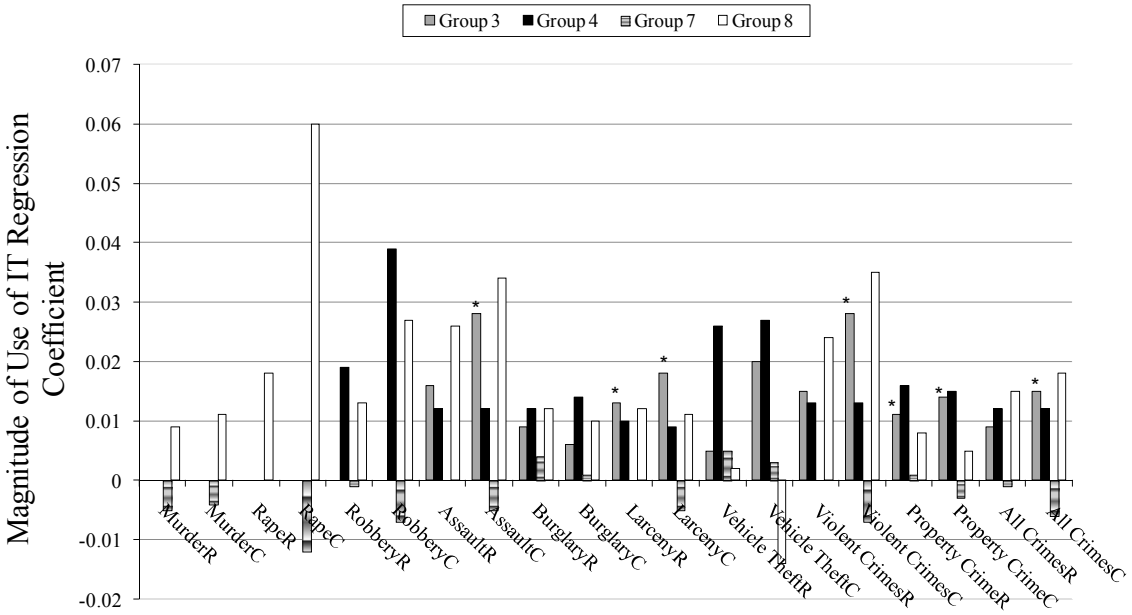


*Figure 16.* 2005 - Regression coefficients of Use of IT scale after dividing sample into ten groups (***p< 0.001, **p< 0.01, *p< 0.05)

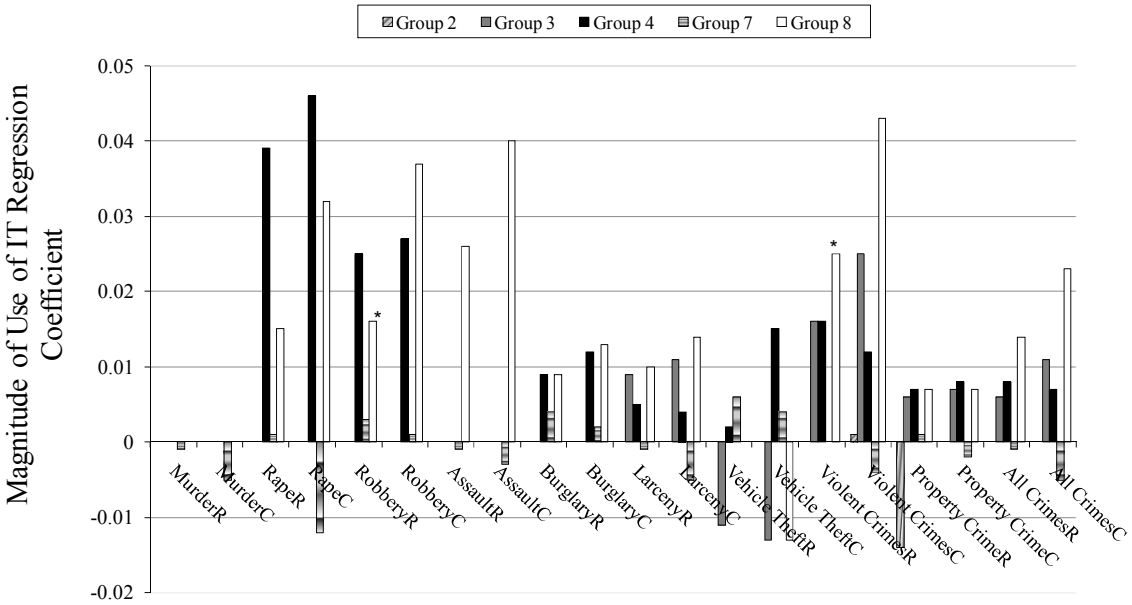


*Figure 17.* 2006 - Regression coefficients of Use of IT scale after dividing sample into ten groups (***p< 0.001, **p< 0.01, *p< 0.05)

There are 7 models fitted to the third group of 2005 data and 5 models fitted to the third group of 2006 data. As presented above, the use of IT scale and number of officers variables have strong and positively significant relationships in this group. Regression

coefficients are consistently positive in the 2005 data and six of them are significant. In fact, they are the only significant coefficients in the 2005 data. However, the regression coefficients are not consistent in the 2006 data, and they become negative for vehicle theft models. There are 8 models fitted to the fourth groups of 2005 and 2006 data. As presented above, the use of IT scale and number of officers variables have a significant relationship in the fourth group as well. The fourth group is consistent in terms of the direction of regression coefficients in that they are positive in both 2005 and 2006 data; however, none of them is significant. The seventh group also gives consistent results in terms of direction of regression coefficients, but most of the coefficients are negative in this group. Ten models were fitted to the seventh groups of 2005 and 2006 data. Except for robbery and vehicle theft models, all the regression coefficients are negative. Finally the eighth model is also consistent. Except for the vehicle theft model, all the coefficients are positive in 2005 and 2006 data. The regression coefficients of robbery and violent crime are significant in 2006 data. In sum, the examination of regression models did not reveal any consistent pattern in terms of the relationship between use of IT variable and clearance rates. Regression coefficients are small and the impact of the use of IT scale variable changes within and among groups.

In conclusion, in this chapter we tested the relationship between use of IT and the clearance rate variables. Because of the imbalance problem, dataset is divided into groups and the relationship between use of IT and the clearance rate variables was investigated in those groups as well. However, multivariate analyses did not reveal any significant relationship between use of IT variable and the clearance rate variables. The use of IT

variable was significant in only 16 out of 188 models. Moreover, the direction of relationship is not consistent across the models.

*Use of IT items.*

As a final analysis, each individual item of the use of IT scale is analyzed. As presented in the methodology chapter, there are 29 items in the use of IT scale. All of the items are binary variables where zero means that the department does not have that technology and one means that the department has it. To make the following discussion more understandable the group that does not have the technology is called non-technology group and the group that has the technology is called technology group.

Since previous analysis results showed that the use of IT scale is positively correlated with the agency size variable, it was highly possible that only certain types of agencies might use those individual technologies. To investigate this claim, departments are divided into two groups as technology and non technology groups for each item. Then, the technology and non-technology groups of each of the use of IT items were compared with each other. Box plots and t-test analysis were used for comparison purposes.

The examination of box plots revealed that, in general, the technology group is not very much different from the non-technology group for each of the use of IT items in terms of clearance rates. This finding is consistent for raw and square rooted clearance rate variables of both 2005 and 2006 data. On the other hand, crime rate variables showed a different pattern. For some use of IT items, departments that have the technology usually have higher crime rates than the departments that do not have that technology.

Box plot comparison of control variables revealed that departments are generally different from each other in terms of the logged number of officers variable. In 26 of 29 items, the technology group's median of the logged number of officers variable is larger than that of the non-technology group. Box plot comparisons showed that there is more overlap between departments in only three items (Appendix M), and t-test scores were not significant for these groups showing that the logged number of officers variable is not different with respect to these items. These items are availability of cellular/mobile phones, availability of RISS, and availability of NCIC system. This finding shows that sampled departments are not different from each other in using those three information technologies.

On the other hand, the box plot comparison revealed that the logged number of officers variable of technology and non-technology groups almost does not have any overlap for five use of IT items (Appendix N). In addition, t-test statistics were significant for them. Those items are availability of blackberry technology, availability MDC/MDT (mobile computing) technology, availability of fingerprints on computer, availability of mug shots on computer and availability of stolen vehicles on computer. The median of the logged number of officers variable is larger in the technology group for those five items indicating that generally larger agencies have those technologies. Box plot comparisons of the use of IT items that have good overlap and very poor or no overlap are presented in Figure 18.

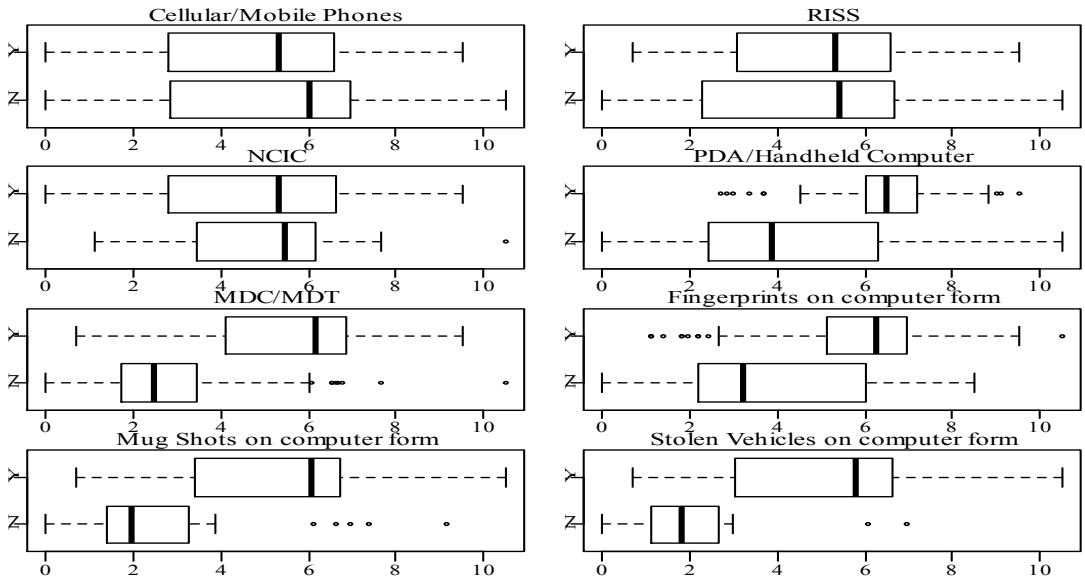


*Figure 18.* Use of IT items that have good overlap and very poor or no overlap

The remaining 21 items are in between these two groups. Box plot comparisons show that there is some overlap between technology and non-technology groups for those items. However, they still look different from each other. In addition, the t-test statistic is significant for 20 of them. Again, the median of the logged number of officers variable is larger in the technology group than in the non-technology group indicating that, generally, larger agencies have that technology.

Regression analysis was conducted to examine the relationship between use of IT items and clearance rates. The regression equation is expressed as follows:

$$\sqrt{Clearance\ Rate} = a + \beta_1 (Use\,of\ IT\ Items) + \beta_2 (Logged\ Number\,of\ Officers) + \beta_3 (Median\,Income) + \beta_4 (Poverty) + \beta_5 (P.of\ Invest.) + \beta_6 (Race) + \beta_7 (Crime\,Rate) + e$$

Each of the 20 dependent variables was regressed on each of the 29 use of IT item variables. As a result, 580 regression models were fitted to 2005 and 2006 data. Bar graphs of item coefficients were presented in Appendix O. Items in which there is an overlap between departments for the number of officers variable (the first group), items

in which there is poor or no overlap (the second group), and items in between these two groups (the third group) are separated with a dotted line on the graphs. Bar graphs of murder and vehicle theft models are also presented in Figure 19 below.

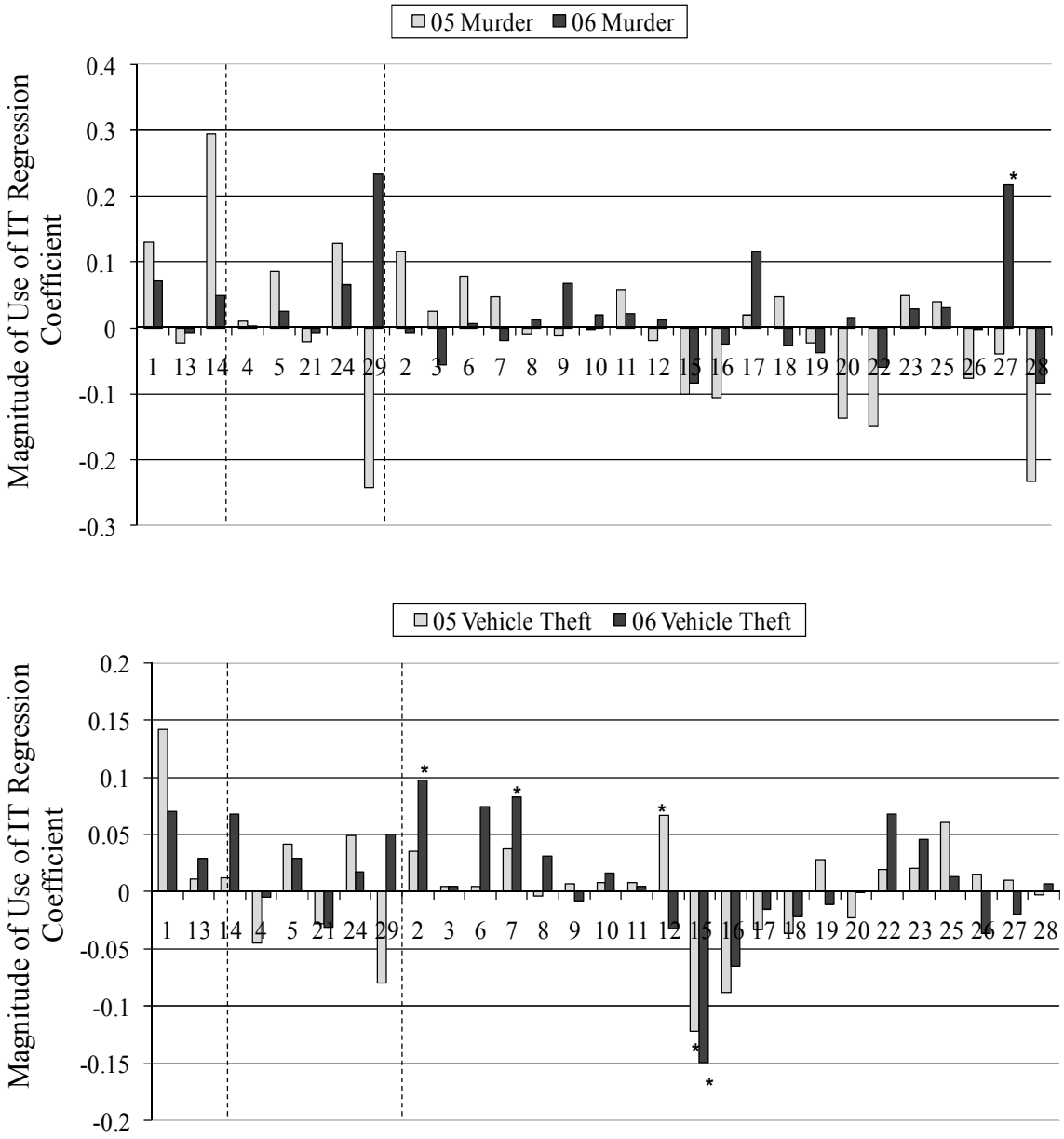


*Figure 19.* Bar graphs of use of information technology items' regression coefficients for murder and vehicle theft offenses (***p< 0.001, **p< 0.01, *p< 0.05)

The first bar graph shows the murder model. Only the 27th item (availability of sex offender data on computer form) coefficient is significant; however, its direction of

relationship is not consistent between 2005 and 2006 data. The existence of negative coefficients indicates that the availability of some information technologies may be associated with the decrease in clearance rates. The largest positive coefficient is 0.29 and the largest negative coefficient is -0.24. The direction of relationship is consistent between 2005 and 2006 coefficients in the first group which is the balanced group. Except for one item (29th item), this pattern is the same for the second group which is the unbalanced group. However, the direction of relationship is inconsistent for 9 items of the third group.

The second graph shows the vehicle theft model. Coefficients are smaller than -0.15 and +0.15. Five of 58 regression coefficients are significant. Those items are availability of GPS (2), Web Pages / Web-based technology (7), ViCAP (12), and crime reports (15). The crime report item is significant for both 2005 and 2006 data; however, its direction of relationship is negative indicating that the existence of crime reports in computer format reduces clearance rates. The direction of relationship of ViCAP coefficients is inconsistent between 2005 and 2006 data. The pattern of direction of relationship is similar to the murder model for the first, second and third groups. As presented in the literature review chapter, mobile computing systems were found (5th item) to be effective in clearing vehicle theft crimes in two studies (Meehan, 1998; Nunn, 1994). However, the regression coefficients of MDC/MDT systems are not statistically significant in this study.

In sum, the relationship between each use of IT items and clearance rates is tested in this supplementary section. 580 regression analyses were conducted and use of IT

items were significant in 47 or 8.1% of them. Moreover, none of the items had a consistent pattern of relationship.

# CHAPTER 5: CONCLUSION, LIMITATIONS AND POLICY IMPLICATIONS

Criminal investigation is one of the most important tasks of law enforcement agencies. Despite of this importance it is one of the least studied topics of criminal justice (Horvath, et al., 2001). Researchers' interest in this field intensified during the early 1970s, after the release of the President's Commission on Law Enforcement and Administration of Justice Report. Early studies generally found that criminal investigations are not effective in arresting criminals or clearing the crimes (e.g., Chaiken et al., 1976; Greenwood 1970). Particularly, the Chaiken et al. (1976) study found that organizational and procedural differences in criminal investigations among police departments did not have an impact on arrest or clearance rates. Although later studies have challenged some of its findings, the Chaiken et al. (1976) study has remained as one of the most cited studies in this field, and its critiques of criminal investigation have been influential in the field for a long time.

Criminal investigation studies have explored the criminal investigation process and analyzed the impact of internal or external factors on the success of criminal investigations. Researchers have pointed out several factors as the determinants of successful criminal investigation. For example, the quality of preliminary investigations, organizational structure of the investigative unit, agency size and workload of investigators were some of the major factors analyzed in that literature. Studies have generally reported mixed findings about most of the determinants of criminal

investigation. However, the quality of preliminary investigation and the information collected in this stage were consistently found as the most important factors of a successful criminal investigation. For that reason, it was argued that the single most important determinant of whether or not a case would be solved was the information the victim or witness supplied to the responding patrol officer (e.g. Burrows, 1986; Chaiken et al., 1976; Wilmer, 1970).

The importance of information for criminal investigations has led some researchers to redefine criminal investigation as a kind of "information work" in which investigators are continuously trying to reach to new information either by uncovering new facts about the case, or by analyzing, interpreting, and ordering the existing knowledge (Innes, 2007; Maguire, 2003). Since criminal investigation is a kind of information work, it has a natural fit with information technologies. As Hogan and Radack (1997) defined them, information technologies are blend of hardware and software used for storage, processing, transfer, display, management, organization, and retrieval of information. Therefore, information technologies may help investigators to collect and store more information about a case, to analyze and interpret a large amount of information more rapidly and to organize and present resulting information for various purposes. To that end, information technologies may provide criminal investigators with new tools to increase their capabilities of scanning, analysis and ordering of information.

In fact, information technologies are widely employed by the criminal justice community especially in law enforcement services (Dunworth, 2004). An exploration of law enforcement information technologies revealed that they are used in criminal investigations mainly for four purposes: records management, crime analysis,

communication and mobile computing and forensic analysis. In modern law enforcement information systems, however, these four functions are integrated to increase their effectiveness. For example, crime analysis systems generally work together with records management systems. Similarly, communication and mobile computing technologies are used mainly to access record management systems and to extend crime analysis activities to the patrol.

On the other hand, despite their popularity among practitioners and policymakers, law enforcement information systems, their nature, use and user characteristics and impacts on police work constitute another understudied topic in criminal justice literature. Moreover, researchers have used many different outcome variables to measure the success of law enforcement information systems. For example, some studies measured the effectiveness of a mobile computing system by the number of stolen vehicles recovered (Braga and Pierce, 2004; Nunn, 1994), but in another study effectiveness is measured by the number of inquiries made by officers by using the system (Marshall, 1998), and in another it is measured by information technologies' contribution to the objectives of problem-oriented policing perspective (Nunn & Quinet, 2002). As a result, it is difficult to compare different studies conducted in this field and to arrive at a conclusion about the impact of information technologies in the law enforcement world.

This study contributes to both criminal investigation and law enforcement information technologies literature. Within the criminal investigation area, this study investigated whether there is a relationship between modern law enforcement information technologies and outcome of criminal investigations, namely clearance rates. Within the law enforcement information technologies area, this study investigated the

appropriateness of the clearance rate variable as an outcome measure. Besides these two empirical contributions, this study also reviewed and presented the current status of research in these fields. This study used the data collected from a national sample of police departments by the Impact of Science and Technology Survey, the UCR program data and U.S. Census data.

The first conclusion of this study is about the impact of information technologies on police work. The relationship between clearance rates and the use of the information technology variable was investigated both on the whole dataset and subgroups of dataset that were suitable for multivariate analysis. As a result, 188 regression models were estimated with 2005 and 2006 data. Analysis results showed that the use of information technology scale was statistically significant in only 8.5% of the models. In addition to this, each of the use of information technology scale item was used as independent variable in multivariate analysis, and 580 models were estimated. The regression coefficient of use of information technology items was statistically significant in only 8.1% of the models. This finding supported the argument that there may not be a relationship between clearance rates and the use of information technology variables.

However, it must be noted again that this study is a one-group post-test only design. Since this design lacks any pretest baseline or a comparison group, this study does not control for temporal order and nonspuriousness; therefore, it cannot provide much information about causal relationship between independent and dependent variables. All one can say with the one-group post-test only design is that there is or there is not a correlational relationship between variables, and a correlational relationship only says that two things perform in a synchronized manner. As a result, for the majority of

the analyses, this study did not find a significant correlational relationship between use of information technologies and the clearance rates.

Despite of the design considerations, this finding argues that there may not be really a relationship between use of information technologies and clearance rates. Moreover, this study also controlled for a set of other variables that might be influential on the outcome of criminal investigations. Those variables were specified after a careful review of available literature and they were department size, proportion of officers working at investigative functions, percent of people living under poverty threshold, median income, percent white and crime rates. Analysis results showed that clearance rates do not have a consistent relationship with any of the control variables either.

Another important conclusion of this study is a methodological contribution to the criminal justice research. Data analysis results revealed that there was a strong correlation between use of information technology, which was an index variable constructed from 29 information technology items, and the agency size variable, which was measured by the number of sworn officers working in the department. On the other hand, further examination of this relationship by looking at the scatter plot of two variables yielded more concerning results. Besides the strong correlation between the two variables, the scatter plot showed that there is a great difference between small and large agencies in terms of information technology use. There were no large departments that scored low on the use of information technology scale and there were almost no small departments that scored high on the use of information technology scale. In other words, the data was unbalanced.

The imbalance problem became more visible as the sample was divided into the deciles of the use of information technology scale. There were only small departments in the first decile of the use of information technology scale, and there were only large departments in the tenth decile. This meant that the regression coefficients would be the product of only small departments on one end, and the product of only the large departments on the other end. As a result, it would be impossible to distinguish the impact of use of information technology from the impact of agency size. Because of the differences between large and small law enforcement agencies, this problem can arise in most of the datasets of cross-sectional studies about police departments, and it cannot be remedied by just plugging the agency size variable into the equation as a control variable. If the data is unbalanced, it is quite possible that the regression coefficient of the independent variable would be overestimated. For this reason, researchers conducting observational studies on police departments should further investigate the correlation between the independent variable and the agency size variable before conducting any multivariate analysis and arriving at some conclusions based on that analysis.

A final conclusion of this study is related to the DeLone and McLean Information System Success model's implementation to law enforcement agencies (1992; 2003). As presented in the literature review chapter, the DeLone and McLean model identifies six levels where information technology success can be measured and proposes a relationship among them. Those success levels are information quality, system quality, service quality, use-intention to use, user satisfaction and net benefits. Because of the complexity of the model, previous studies have tested some parts of it and generally reported supportive findings. This study tested the relationship between use-intention to

use and net benefits and did not find a relationship between them. This study measured the system use by looking at the availability of particular information technologies at responding agencies because as DeLone and McLean argued managerial decision to invest in information technologies shows intention to use the system. However, this measure lacks the variability in the quality and intensity of use. Therefore, before arriving at a conclusion about the relationship between use-intention to use and net benefits, it must be tested with other measures of use-intention to use that have greater variability in the quality and intensity of use.

In addition to this, Net Benefits level should also be reconsidered. DeLone and McLean defined the Net Benefits success level broadly, and argued that any kind of improvement, depending on the context of the information system, can be counted as a benefit (DeLone & McLean, 2003). Therefore, this study assessed the adequacy of clearance rates as a Net Benefit accrued from the use of information technologies by law enforcement agencies particularly for investigative activities. However, as explained above, this study found no relationship between use of information technologies and clearance rates. Therefore, it may be argued that the clearance rate variable may not be the correct outcome variable for measuring Net Benefit in the law enforcement context. Nevertheless, information technologies may still be influential on some other aspects of police departments. For example, information technologies may have an impact on the management of organizational resources. As Nunn (2001) argued, information technologies can make an impact on efficacy and efficiency of use of organizational resources in police departments if they are used correctly. Therefore, information

technologies' impact on the management of organizational resources may be analyzed as a potential net benefits variable.

In order to have a complete view of police information technology systems, other success levels should also be analyzed. As discussed in the literature review chapter, system quality variables measure the adoptability, availability, usability, reliability and the response time of the systems. These and other engineering-oriented variables can be used to test the system quality of police information technology systems. Information quality variables measure the completeness, ease of understanding, personalization, relevance and security of information. In addition to these variables, accuracy and privacy of information should also be considered for the information quality of police information technology systems. The service quality and user satisfaction can also be measured with the variables offered by DeLone and McLean.

*Limitations.*

This study has several important limitations that must be acknowledged. The first limitation of this study is about its independent variable. The use of information technology variable measures whether the responding police departments have or do not have particular kind of information technologies. It does not measure the variability in the quality and intensity of use; in other words, it does not measure how well those technologies are used by the police departments. Effective implementation and use of information systems often require organizational change; however, police departments are generally resistant to change, and resistance to change prevents the realization of information technologies' benefits (LeBeuf, 2001; Manning, 2001). In addition to this, the performance of information technologies depends much on the performance of its

user. If users were not adequately trained to use the system, then it may not be possible to get benefit from the system (LeBeuf, 2001). In sum, there may be differences between this study's departments in terms of implementation and use of information technologies. Departments that are effectively implementing and using IT may get more from their IT systems than the departments with poorly implemented and used IT systems.

Another important limitation of this study is the imbalance problem. As presented in the results chapter, the Impact of Science and Technology Survey dataset is unbalanced. There are no large agencies scoring low on use of information technology scale, and there are almost no small agencies scoring high on information technology scale. Because of the imbalance problem, it is not possible to distinguish the impact of agency size from the impact of use of information technology in multivariate analysis. Overestimation of the regression coefficient of independent variable is a possible outcome of this problem.

Finally, as presented in the methodology chapter, UCR data introduces some important problems that should be noted also here. First of all, the UCR reports Part I crimes that are known to the police. It does not report Part II crimes, and it is well known that some criminal activities are not even reported to the police. Related to these problems, participation to the UCR program is voluntary. Although the UCR program has achieved the participation of more than 90% of all police departments, sometimes some agencies cannot provide data due to various organizational problems. In order to eliminate the missing data problem, the FBI imputes values for the missing pieces of data. In addition, there is no monitoring in place to ensure accurate reporting. For that reason, UCR data is open to manipulation by participating agencies. It is argued that in

order to look better in the statistics, some participating agencies may choose not to report all of the crimes occurring in their jurisdictions (Chambliss, 2001). The UCR's hierarchy rule is another problem affecting reported crime. According to the UCR Program's Hierarchy Rule, if more than one offense is committed in an incident, only the most serious one is reported, and related offenses are not reported. The hierarchy rule was implemented to prevent multiple reports of the same offense, but it also conceals related offenses. As a result, it can be argued that the UCR does not provide a complete picture of the crime problem in the U.S.

In addition to crime-reporting issues, the UCR's clearance data also have some problems. As presented in the literature review chapter, a law enforcement agency reports that an offense is cleared by arrest, or solved for crime reporting purposes of the UCR, when all of the following conditions have been met for at least one person: 1) arrested, 2) charged with the commission of the offence, and 3) turned over to the court for prosecution. However, arrest data do not provide the real number of perpetrators who are apprehended by the police because arrested individuals might be found innocent after the trial and are released by the court. Related with this problem, an offense that is committed in one year can be reported as cleared in later years. Therefore, clearance rates do not reflect how much of a crime that is committed in a particular year is cleared by the police. It only shows the clearance achieved in a year proportional to the crimes committed in that year. Despite all of these problems, some researchers argue that the UCR is a valid source of criminal statistics in the U.S., and it continues to be an important source for criminal justice research (Gove et al., 1985;Hindelang, 1974; Pare et al., 2007)

*Policy implications.*

This study showed that issues related to the implementation and use of information technologies in law enforcement agencies require more attention. As outlined above, the lack of relationship between use of information technologies and the clearance rates may be caused by poor implementation and use of information technologies by police departments. In order to investigate this claim and to ensure proper implementation and use of information technologies by police departments, more process evaluation studies should be accompanied by information technology projects. These evaluations would also be critical for future investments in this field because they would help to separate promising information technologies from the problematic ones and to guide policymakers in their choices.

Another policy implication related with the first one is the need for more attention to human factors in planning and designing information technologies. A review of related literature showed that law enforcement information systems can be considered successful at the technical and semantic level. This supports the argument that the problem with most of the law enforcement information systems is related with the use of the system. In other words, the collection of information is one thing and the use of that information is another thing. Therefore, policymakers should ensure the acceptance of the systems by the user community to get the most from the information technology projects. One way to accomplish this acceptance is the provision for proper training of users on the information technologies and related issues.

The final policy implication of this study is related with the use of information technologies by police departments in their investigative activities. This study's findings

showed that there is not a consistent relationship with use of information technologies and clearance rates. As a matter of fact, despite of the large investments on the information technologies by police departments, use of information technologies may not have a direct impact on clearance rates. The review of criminal investigation literature showed that there are some other factors that may have an impact on the outcome of criminal investigations. Although there are mixed evidence about the impact of most of those factors, the preliminary investigation and the availability of information about the suspect were consistently found as the most important determinant of criminal investigations. Therefore, in order to be able to explain the fluctuations in the clearance rates of police departments, preliminary investigation process should be examined in more detail. An analysis of use of information technologies at preliminary investigation stage may also provide better evidence about the impact of information technologies on criminal investigations. Moreover, this kind of analysis can inform policy on how to use information technologies more effectively in police departments.

# REFERENCES


Abt Associates. (2001). *Police Department Information Systems Technology Enhancement Project (ISTEP)*. Washington, D.C: Department of Justice, Office of Community Oriented Policing Services.

Ackroyd, S., Harper, R., & Hughes, J. A. (1992). *New technology and practical police work: The social context of technical innovation*. Open Univ Pr.

Adderley, R. W., & Musgrove, P. (2001). Police crime recording and investigation systems-a user's view. *Policing: An International Journal of Police Strategies & Management*, *24*(1), 100–114.

Alison, L., Snook, B., & Stein, K. L. (2001). Unobtrusive measurement: using police information for forensic research. *Qualitative Research*, *1*(2), 241.

Almutairi, H., & Subramanian, G. H. (2005). An empirical application of the DeLone and McLean model in the Kuwaiti private sector. *Journal of Computer Information Systems*, *45*(3), 113–122.

ATF. (2009). Bureau of Alcohol, Tobacco, Firearms and Explosives - Fact Sheet. Bureau of Alcohol, Tobacco, Firearms and Explosives. Retrieved from http://www.nibin.gov/press/factsheets/0409-factsheet-nibin.pdf.

Ballantine, J. A., Galliers, R. D., & Straw, S. (1996). Information systems/technology evaluation practices: Evidence from uk organizations. *Journal of Information Technology*, *11*(2), 129 - 141.

Barnett-Ryan, C. (2007). Introduction to the uniform crime reporting program. In J. P. Lynch & L. Addington (Eds.), *Understanding Crime Statistics: Revisiting the Divergence of the NCVS and UCR*, Cambridge studies in criminology. Cambridge: Cambridge University Press.

BJA. (2007). Regional Information Sharing Systems. *RISS Overview*. Retrieved April 13, 2009, from http://www.riss.net/overview.aspx.

Bloch, P. B., & Bell, J. (1976). *Managing investigations: The Rochester system*. Washington: Police Foundation.

Blumstein, A. (1994). The task force on science and technology. In J. A. Conley (Ed.), *The 1967 President's crime commission report: Its impact 25 yearslater*, ACJS/Anderson monograph series. Highland Heights, KY: Academy of Criminal Justice Sciences, Northern Kentucky University.

Boba, R. (2005). *Crime Analysis and Crime Mapping*. Thousand Oaks, Calif: Sage Publications.

Borg, M. J., & Parker, K. F. (2001). Mobilizing law in urban areas: The social structure of homicide clearance rates. *Law & Society Review*, *35*, 435.

Bozeman, B., & Bretschneider, S. (1986). Public management information systems: Theory and prescription. *Public Administration Review*, 475-487.

Bradbury, S., & Feist, A. (2005). *The use of forensic science in volume crime investigations: a review of the research literature* . Home Office Online Report , Great Britain Home Office.

Braga, A. A., & Pierce, G. (2004). Linking Crime Guns: The Impact of Ballistics Imaging Technology on the Productivity of the Boston Police Department's Ballistics Unit. *Journal of Forensic Sciences*, *49*(4).

Brandl, S. (1993). The impact of case characteristics on detectives' decision making*. *Justice Quarterly*, *10*(3), 395-415.

Brown, M. M. (1996). An empirical assessment of the hurdles to geographic information system success in local government. *State & Local Government Review*, 193-204.

Brown, M. M. (2000). Criminal justice discovers information technology. In National Institute of Justice (U.S.) (Ed.), *Criminal justice 2000 - V.1 - The nature of crime: Continuity and change*. Washington, D.C.: U.S. Dept. of Justice, Office of Justice Programs, National Institute of Justice.

Brown, T. M. L., McCabe, S. A., & Wellford, C. (2007). *Global Positioning System (GPS) Technology for Community Supervision: Lessons Learned*. NOBLIS.

Brynjolfsson, E. (1993). The productivity paradox of information technology: Review and assessment. *Communications of the ACM*, *36*(12), 67-77.

Brynjolfsson, E., & Hitt, L. M. (1998). Beyond the productivity paradox. *Communications of the ACM*, *41*(8), 49-55.

Bureau of Justice Statistics. (2004). UCR and NIBRS participation. *Bureau of Justice Statistics UCR and NIBRS Participation*. Government, . Retrieved February 11, 2009, from http://www.ojp.usdoj.gov/bjs/nibrsstatus.htm.

Burrows, J. (1986). *Investigating burglary: The measurement of police performance*. Home Office Research Study, Great Britain Home Office.

Burrows, J., & Tarling, R. (1982). *Clearing up crime*. Great Britain Home Office.

Burrows, J., & Tarling, R. (2004). Measuring the impact of forensic science in detecting burglary and autocrime offences. *Science & Justice*, *44*(4), 217-222.

Burrows, J., Tarling, R., Mackie, A., Poole, H., & Hodgson, B. (2005). *Forensic science pathfinder project Evaluating increased forensic activity in two English police forces*. Home Office Online Report, Great Britain Home Office.

Bynum, T., Cordner, G., & Greene, J. R. (1982). Victim and offense characteristics: Impact on police investigative decision-making. *Criminology*, *20*(3-4), 301-318.

Cawley, D. F., Miron, H. J., Araujo, W. J., Wasserman, R., Mannello, T. A., & Huffman, Y. (1977). *Managing criminal investigations manual*. US Dept. of Justice, Law Enforcement Administration, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice: For sale by Supt. of Docs., US Govt. Print. Off.

Chaiken, J. M., Greenwood, P. W., & Petersilia, J. (1976). *The criminal investigation process*. RAND Corporation.

Chan, J. B. L. (2001). The technological game:: How information technology is transforming police practice. *Criminology and Criminal Justice*, *1*(2), 139.

Chen, H., Schroeder, J., Hauck, R. V., Ridgeway, L., Atabakhsh, H., Gupta, H., et al. (2003). COPLINK Connect: Information and knowledge management for law enforcement. *Decision Support Systems*, *34*(3), 271-285.

Cheurprakobkit, S. (2000). Police-citizen contact and police performance Attitudinal differences between Hispanics and non-Hispanics. *Journal of Criminal Justice*, *28*(4), 325-336.

Chu, J. (2001). *Law enforcement information technology*. CRC Press.

Cohen, B., & Chaiken, J. M. (1987). *Investigators who perform well*. Issues and practices in criminal justice. Washington, D.C: U.S. Dept. of Justice, National Institute of Justice, Office of Communication and Research Utilization.

Cohen, J. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences*. Lawrence Erlbaum Associates.

Colton, K. W. (1972). *Use of computers by police: Patterns of success and failure*. International City Management Association.

Colton, K. W. (1980). Police and computer technology: The case of the San Diego computer-aided dispatch system. *Public Productivity Review*, A Symposium on Computers and Productivity, *4*(1), 21-42.

Colton, K. W., Brandeau, M. L., & Tien, J. M. (1983). *A national assessment of police command, control, and communications systems*. US Dept. of Justice, National Institute of Justice.

Cordner, G. (1989). Police agency size and investigative effectiveness. *Journal of Criminal Justice*, *17*(1), 145-155.

Danziger, J. N., & Andersen, K. V. (2002). The impacts of information technology on public administration: An analysis of empirical research from the "golden age" of transformation. *International Journal of Public Administration*, *25*(5), 591-627.

Danziger, J. N., & Kraemer, K. L. (1985). Computerized data-based systems and productivity among professional workers: The case of detectives. *Public Administration Review*, 196-209.

Davenport, T. H., & Prusak, L. (1997). *Information ecology: Mastering the information and knowledge environment*. New York: Oxford University Press.

Davis, L. M., & Jackson, B. A. (2004). Acquiring, implementing and evaluating information technology. In A. Pattavina (Ed.), *Information technology and the criminal justice system* (1st ed.). Sage Publications, Inc.

Dean, G., & Gottschalk, P. (2007). *Knowledge management in policing and law enforcement: Foundations, structures, applications*. Oxford: Oxford University Press.

DeLone, W. H., & McLean, E. R. (1992). Information systems success: the quest for the dependent variable. *Information systems research*, *3*(1), 60-95.

DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: a ten-year update. *Journal of Management Information Systems*, *19*(4), 9-30.

DeLone, W. H., & McLean, E. R. (2004). Measuring e-commerce success: applying the DeLone & McLean information systems success model. *International Journal of Electronic Commerce*, *9*(1), 31-47.

DeZee, M. (1995). Review of the book The 1967 President's Crime Commission Report: Its impact 25 years later. *Journal of Criminal Justice*, *23*(5), 489-492.

DuBois, J., Skogan, W. G., Hartnett, S. M., Bump, N., & Morris, D. (2007). *CLEAR and I-CLEAR: A Report on New Information Technology in Chicago and Illinois*. Chicago, IL: Illinois Criminal Justice Information Authority.

Dunworth, T. (2000). Criminal justice and the IT revolution. In National Institute of Justice (U.S.) (Ed.), *Criminal justice 2000 - V.3 - Policies, processes, and decisions of the criminal justice system*. Washington, D.C.: U.S. Dept. of Justice, Office of Justice Programs, National Institute of Justice.

Dunworth, T. (2004). Information technology and the criminal justice system: A historical perspective. In A. Pattavina (Ed.), *Information technology and the criminal justice system* (1st ed.). Sage Publications, Inc.

Eastern Kentucky University. (2005). National Study of the Impact of Science and Technology on the Process of Criminal Investigation in Law Enforcement Agencies [Data File].

Eck, J. E. (1989). Rethinking detective management: Why investigative reforms are seldom permanent or effective. In D. J. Kenney (Ed.), *Police and policing: Contemporary issues*. New York: Praeger.

Eck, J. E. (2008). Foreword: Investigators, information, and interpretation: A summary of criminal investigation research. In D. Rossmo (Ed.), *Criminal investigative failures*. CRC.

Eck, J. E., & Maguire, E. R. (2005a). Have changes in policing reduced violent crime? An assessment of the evidence. In A. Blumstein & J. Wallman (Eds.), *The crime drop in America*. Cambridge University Press.

Eck, J. E., & Maguire, E. R. (2005b). Have changes in policing reduced violent crime? An assessment of the evidence. In A. Blumstein & J. Wallman (Eds.), *The crime drop in America*. Cambridge University Press.

Eck, J. E. (1983). *Solving crimes: The investigation of burglary and robbery*. Washington, DC: Police Executive Research Forum.

Elliott, J. F. (1978). Crime control teams: An alternative to the conventional operational procedure of investigating crimes. *Journal of Criminal Justice*, *6*(1), 11-23.

Ericson, R. V. (1993). *Making crime: A study of detective work*. Toronto: University of Toronto Press.

Faggiani, D., & Hirschel, D. (2004). The impact of information technology on crime reporting: The NIBRS process. In A. Pattavina (Ed.), *Information technology and the criminal justice system* (1st ed.). Sage Publications, Inc.

FBI. (2004a). Uniform crime reports. *Uniform crime reports-Frequently asked questions*. Retrieved April 13, 2009, from http://www.fbi.gov/ucr/ucrquest.htm.

FBI. (2004b). *Uniform Crime Reporting Handbook*.

FBI. (2004c). A word about UCR data. *Federal Bureau of Investigation - Uniform Crime Reports*. Retrieved April 13, 2009, from http://www.fbi.gov/ucr/word.htm.

FBI. (2005a). Crime in the United States. *Crime in the United States, 2005*. Retrieved April 13, 2009, from http://www.fbi.gov/ucr/ucrquest.htm.

FBI. (2005b). Uniform Crime Reporting program data [United States]: Offenses known and clearances by arrest, 2005 [Data FIle]. Inter-university Consortium for Political and Social Research . Retrieved from http://www.icpsr.umich.edu/.

FBI. (2006a). Crime in the United States. *Crime in the United States, 2006*. Retrieved April 13, 2009, from http://www.fbi.gov/ucr/ucrquest.htm.

FBI. (2006b). Uniform Crime Reporting program data [United States]: Offenses known and clearances by arrest, 2006 [Data FIle]. Inter-university Consortium for Political and Social Research . Retrieved from http://www.icpsr.umich.edu/.

FBI. (2008a). National Crime Information Center (NCIC). *National Crime Information Center (NCIC) - FBI Information Systems*. Retrieved April 13, 2009, from http://www.fas.org/irp/agency/doj/fbi/is/ncic.htm.

FBI. (2008b). Integrated Automated Fingerprint Identification System or IAFIS. *FBI - CJIS Division - Integrated Automated Fingerprint Identification System*. Retrieved April 13, 2009, from http://www.fbi.gov/ucr/faqs.htm.

FBI. (2009a). CODIS Combined DNA Index System. *FBI - CODIS*. Retrieved April 13, 2009, from http://www.fbi.gov/hq/lab/html/codisbrochure_text.htm.

FBI. (2009b). Violent Criminal Apprehension Program (ViCAP). *Federal Bureau of Investigations - Investigative Programs - Critical Incidence Response Group*. Retrieved April 13, 2009, from http://www.fbi.gov/hq/isd/cirg/ncavc.htm#vicap.

FBI. (2009c). National Incident-Based Reporting System. *FBI National Incident-Based Reporting System - Frequently Asked Questions (FAQs)*. Retrieved April 13, 2009, from http://www.fbi.gov/ucr/faqs.htm.

Folk, J. (1971). *Municipal detective systems-A quantitative approach*. Technical Report, Cambridge, MA: Massachusetts Institute of Technology.

Garson, G. D. (2006). *Public information technology and e-governance: Managing the virtual state* (1st ed.). Jones & Bartlett Pub.

Gates, D., & Knowles, L. (1976). An evaluation of the RAND Corporation's analysis of the criminal investigation process. *Police Chief*, *43*(7), 20-24, 74-77.

Gelman, A., & Hill, J. (2006). *Data Analysis Using Regression and Multilevel/Hierarchical Models* (1st ed.). Cambridge University Press.

Gilbert, J. N. (2004). *Criminal investigation* (6th ed., p. 624). Upper Saddle River, N.J: Pearson, Prentice Hall.

Goldstein, H. (2005). Who Killed the Virtual Case File? *IEEE Spectrum Online*, (September). Retrieved July 15, 2008, from http://www.spectrum.ieee.org/sep05/1455.

Gottschalk, P. (2007). *Knowledge management systems in law enforcement: technologies and techniques*. Hershey, PA: Idea Group Pub.

Gove, W. R., Hughes, M., & Geerken, M. (1985). Are Uniform Crime Reports a Valid Indicator of the Index Crimes-An Affirmative Answer with Minor Qualifications. *Criminology*, *23*, 451.

Greenberg, B., Elliott, C. V., Kraft, L. P., & Procter, H. S. (1977). *Felony investigation decision model: An analysis of investigative elements of information.* Rockville, MD: Stanford Research Institute, US Dept of Justice Law Enforcement Assistance Administration.

Greenberg, B., & Lang, K. I. (1973). *Enhancement of the investigative function Vol. 4, burglary investigative checklist and handbook*. Springfield, VA: National Technical Information Service.

Greenberg, I., & Wasserman, R. (1979). *Managing criminal investigations*. Washington: Dept. of Justice, Law Enforcement AssistanceAdministration, National Institute of Law Enforcement and Criminal Justice, Office of Development, Testing and Dissemination : for sale by the Supt. of Docs., U.S. Govt.Print. Off.

Greene, J. R. (2000). Community policing in America: Changing the nature, structure, and function of the police. In National Institute of Justice (U.S.) (Ed.), *Criminal justice 2000 - V.3 - Policies, processes, and decisions of the criminal justice system*. Washington, D.C.: U.S. Dept. of Justice, Office of Justice Programs, National Institute of Justice.

Greenwood, P. W. (1970). *An analysis of the apprehension activities of the New York city police department*. RAND.

Greenwood, P., Chaiken, J. M., & Petersilia, J. (1976). Response to - An evaluation of the RAND Corporation's analysis of the criminal investigation process. *Police Chief*, *43*(12), 62-71.

Gunasekaran, A., Ngai, E., & McCaughey, R. (2008). Information technology and systems justification. In Z. Irani & P. Love (Eds.), *Evaluating information systems: Public and private sector*. Butterworth-Heinemann.

Harper, R. R. (1991). The computer game detectives, suspects, and technology. *British Journal of Criminology*, *31*(3), 292-307.

Harris, K., & Romesburg, W. (2002). Law Enforcement Tech Guide - How to plan, purchase and manage technology (successfully!). Office of Community Oriented Services. Retrieved July 15, 2009, from http://www.cops.usdoj.gov/files/RIC/Publications/lawenforcementtechguide.pdf.

Hauk, R. V., & Chen, H. (1999). COPLINK: A case of intelligent analysis and knowledge management (pp. 15-28). Association for Information Systems Atlanta, GA, USA.

Heintze, T., & Bretschneider, S. (2000). Information technology and restructuring in public organizations: does adoption of information technology affect organizational structures, communications, and decision making? *Journal of Public Administration Research and Theory*, *10*(4), 801-830.

Henman, P. (1996). Does computerization save government money? *Information Infrastructure & Policy*, *5*(4).

Hindelang, M. J. (1974). The uniform crime reports revisited. *Journal of Criminal Justice*, *2*(1), 1–17.

Hogan, M. D., & Radack, S. M. (1997). The quest for information technology standards for the global information infrastructure. *StandardView*, *5*(1), 30-35.

Holmes, M. D., Smith, B. W., Freng, A. B., & Munoz, E. A. (2008). Minority Threat, Crime Control, and Police Resource Allocation in the Southwestern United States. *Crime & Delinquency*, *54*(1), 128.

Hoover, J. (2009). Obama's Budget Calls For Shifts In IT Spending. *InformationWeek*. Retrieved from http://www.informationweek.com/news/government/federal/showArticle.jhtml;jsessionid=THC3XYCZUQG24QSNDLOSKH0CJUNN2JVN?articleID=217400028&pgno=1&queryText=&isPrev=.

Horvath, F., & Meesig, R. (1996). The Criminal Investigation Process And The Role Of Forensic Evidence: A Review Of Empirical Findings. *Journal of forensic sciences*, *41*(6), 963-969.

Horvath, F., Meesig, R., & Lee, Y. (2001). *A national survey of police policies and practices regarding the criminal investigation process: Twenty-five years after RAND*. U.S. Department of Justice.

Iivari, J. (2005). An empirical test of the DeLone-McLean model of information system success. *ACM SIGMIS Database*, *36*(2), 8-27.

Innes, M. (2003). *Investigating murder: detective work and the police response to criminal homicide*. Clarendon studies in criminology. Oxford: Oxford University Press.

Innes, M. (2007). Investigation order and major crime inquaries. In T. Newburn, T. Williamson, & A. Wright (Eds.), *Handbook of criminal investigation*. Cullompton, UK: Willan.

Institute of Policy Research. (2004). Policing Smarter Through IT: Lessons in Enterprise Implementation. COPS.

Ioimo, R. E., & Aronson, J. E. (2003). The benefits of police field mobile computing realized by non-patrol sections of a police department. *International Journal of Police Science & Management*, *5*(3), 195-206.

Isaacs, H. (1967). A study of communications, crimes, and arrests in a metropolitan police department. *Appendix to the Task Force Report: Science and Technology*.

Jiao, A. Y. (2007). Explaining homicide clearance: An analysis of Chicago homicide data 1965–1995. *Criminal Justice Studies*, *20*(1), 3-14.

Jones, C., & Weatherburn, D. (2004). *Evaluating police operations (1): A process and outcome evaluation of operation vendas*. New South Wales Bureau of Crime Statistics and Research, Australia.

Keel, T. G., Jarvis, J. P., & Muirhead, Y. E. (2009). An Exploratory Analysis of Factors Affecting Homicide Investigations: Examining the Dynamics of Murder Clearance Rates. *Homicide Studies*, *13*(1), 50.

Kennedy, W. (2009). *The Impact of Police Agency Size on Crime Clearance Rates*. UNC Charlotte.

Kim, J., & Mueller, C. W. (1978). *Introduction to Factor Analysis: What It Is and How To Do It*. Sage Publications, Inc.

Klinger, D. (1997). Negotiating order in patrol work: An ecological theory of police response to deviance. *Criminology*, *35*(2), 277-306.

Klug, D. J., Peterson, J. L., & Stoney, D. A. (1992). *Automated Fingerprint Identification Systems: Their Acquisition, Management, Performance, and Organizational Impact: a Report to the National Institute of Justice*. National Institute of Justice.

Kraemer, K. L., Danziger, J. N., Dunkle, D. E., & King, J. L. (1993). The usefulness of computer-based information to public managers. *MIS Quarterly*, 129-148.

Kuykendall, J. (1982). The criminal investigative process: Toward a conceptual framework. *Journal of Criminal Justice*, *10*(2), 131-145.

LeBeuf, M. E. (2001). *Organized Crime and Cybercrime Criminal Investigations and Intelligence on the Cutting Edge*. Information Technology Series. Ottawa: Police Sciences School Canadian Police College. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.90.1936&rep=rep1&type=pdf.

Lee, G., & Perry, J. L. (2002). Are computers boosting productivity? A test of the paradox in state governments. *Journal of Public Administration Research and Theory*, *12*(1), 77-102.

Lehr, W., & Lichtenberg, F. R. (1998). Computer use and productivity growth in US federal government agencies, 1987-92. *Journal of Industrial Economics*, 257-279.

Liska, A. E., & Chamlin, M. B. (1984). Social structure and crime control among macrosocial units. *American Journal of Sociology*, *90*(2), 383.

Losee, R. M. (1997). A discipline independent definition of information. *Journal Of The American Society For Information Science*, *48*(3), 254-269.

Lott, J. R., & Whitley, J. (2003). Measurement error in county-level UCR data. *Journal of Quantitative Criminology*, *19*(2), 185–198.

Luen, T. W., & Al-Hawamdeh, S. (2001). Knowledge management in the public sector: principles and practices in police work. *Journal of Information Science*, *27*(5), 311.

Maguire, M. (2003). Criminal investigation and crime control. In T. Newburn (Ed.), *Handbook of policing*. Cullompton: Willan.

Maltz, M. (2007). Missing UCR data and divergence of NCVS and UCR trends. In J. P. Lynch & L. Addington (Eds.), *Understanding Crime Statistics: Revisiting the Divergence of the NCVS and UCR*, Cambridge studies in criminology. Cambridge: Cambridge University Press.

Manning, P. K. (1992). Information technologies and the police. *Crime and Justice: A Review of Research*, *15*, 349.

Manning, P. K. (1996). Information technology in the police context: The. *Information Systems Research*, *7*(1), 52–62.

Manning, P. K. (2001). Technology's ways: Information technology, crime analysis and the rationalizing of policing. *Criminology and Criminal Justice*, *1*(1), 83.

Manning, P. K. (2004). Environment, technology and organizational change: Notes from the police world. In A. Pattavina (Ed.), *Information technology and the criminal justice system* (1st ed.). Sage Publications, Inc.

Manning, P. (2008). *The technology of policing: crime mapping, information technology, and the rationality of crime cControl* (illustrated edition.). NYU Press.

Manning, P. K. (2003). *Policing contingencies*. Chicago: University of Chicago Press.

Marche, G. E. (1994). The production of homicide solutions: An empirical analysis. *American Journal of Economics and Sociology*, *53*(4), 385-401.

Marshall, K. (1998). Mobile Data Access Increases Officer Efficiency. *FBI Law Enforcement Bulletin*, *6*.

Martin Jr, R. A., & Legault, R. L. (2005). Systematic Measurement Error with State-Level Crime Data: Evidence from the" More Guns, Less Crime" Debate. *Journal of Research in Crime and Delinquency*, *42*(2), 187.

Mayer, A. (2009). Geospatial Technology Helps East Orange Crack Down on Crime. *Geography & Public Safety*, *1*(4), 3.

McDevitt, D. S. (2005). *Managing the investigative unit*. Springfield, Ill: C.C. Thomas.

McEwen, T. (2002). *Computer Aided Dispatch in Support of Community Policing*. National Institute of Justice .

McGill, T., Hobbs, V., & Klobas, J. (2003). User developed applications and information systems success: A test of DeLone and McLean's model. *Information Resources Management Journal*, *16*(1), 24-45.

McRae, J. J., & McDavid, J. (1988). Computer-based Technology in Police Work: A Benefit-Cost Analysis of a Mobile Digital Communications System. *Journal of Criminal Justice*, *16*(1), 14.

Meehan, A. J. (1998). The impact of mobile data terminal (MDT) information technology on communication and recordkeeping in patrol work. *Qualitative Sociology*, *21*(3), 225-254.

Morckel, K. L. (2002). GPS Vehicle Tracking Improves Auto Theft Enforcement. *Police Chief*, *69*(12), 39–43.

Morris, P., & Heal, K. (1981). *Crime control and the police: A review of research*. Home Office Research Study, Her Majesty's Stationery Office.

National Commission on Terrorist Attacks. (2004). *The 9/11 commission report: Final report of the national commission on terrorist attacks upon the United States*. W. W. Norton & Company.

Nogala, D. (1995). The future role of technology in policing. In J. P. Brodeur (Ed.), *Comparisons in policing: An international perspective*. Aldershot, Hants, England: Avebury.

Nolan, J. J. (2004). Establishing the statistical relationship between population size and UCR crime rate: Its impact and implications. *Journal of Criminal Justice*, *32*(6), 547–555.

Northrop, A., Kraemer, K. L., & King, J. L. (1995). Police use of computers. *Journal of Criminal Justice*, *23*(3), 259-275.

Nunn, S. (1994). How capital technologies affect municipal service outcomes: The case of police mobile digital terminals and stolen vehicle recoveries, (13), 539- 559.

Nunn, S. (2001). Police information technology: Assessing the effects of computerization on urban police functions. *Public Administration Review*, *61*(2), 221-234.

Nunn, S., & Quinet, K. (2002). Evaluating the effects of information technology on problem-oriented policing: If it doesn't fit, must we quit? *Evaluation Review*, *26*(1), 81.

O'Brien, R. M. (2003). UCR violent crime rates, 1958–2000: recorded and offender-generated trends. *Social Science Research*, *32*(3), 499–518.

O'Brien, J. A. (2002). *Introduction to information systems: Essentials for the e-business enterprise*. McGraw-Hill.

O'Connell, P. E. (2002). *An intellectual history of the Compstat model of police management*. Ph.D. Dissertation, City University of New York.

O'Shea, T., & Nicholls, K. (2003). *Crime analysis In America: Findings and recommendations*. Office of Community Oriented Policing Services: Washington, DC.

O'Shea, T. (1998). Analyzing police department data: How and how well police officers and police departments manage the data they collect. In L. Moriarty & D. Carter (Eds.), *Criminal Justice Technology in the 21st Century*. Springfield, Ill: Charles C. Thomas.

Osterburg, J. W., & Ward, R. H. (2007). *Criminal investigation: A method for reconstructing the past* (5th ed.). Newark, NJ: LexisNexis.

Ostrom, E., Parks, R. B., & Whitaker, G. P. (1978). Police agency size: Some evidence on Its effects. *Police Studies*, *1*(1), 34-46.

Paré, P. P., Felson, R. B., & Ouimet, M. (2007). Community variation in crime clearance: A multilevel analysis with comments on assessing police performance. *Journal of Quantitative Criminology*, *23*(3), 243-258.

Paulsen, D. J. (2004). To map or not to map: Assessing the impact of crime maps on police officer perceptions of crime. *International Journal of Police Science & Management*, *6*(4), 234-246.

Peak, K. J., Barthe, E. P., & Garcia, A. (2008). Campus Policing in America: A Twenty-Year Perspective. *Police Quarterly*, *11*(2), 239.

Peled, A. (2001). Do computers cut red tape? *The American Review of Public Administration*, *31*(4), 414.

Peterson, J. L., Mihajlovic, S., & Gilliland, M. (1984). *Forensic evidence and the police: The effects of scientific evidence on criminal investigations*. US Dept. of Justice, National Institute of Justice.

Porter, M. E. (1998). *Competitive strategy: techniques for analyzing industries and competitors: with a new introduction*. Free Press.

President's Commission on Law Enforcement and Administration of Justice. (1967). *The challenge of crime in a free society; a report*. Washington: U.S. Govt. Print. Off.

Puckett, J. L., & Lundman, R. J. (2003). Factors affecting homicide clearances: Multivariate analysis of a more complete conceptual framework. *Journal of Research in Crime and Delinquency*, *40*(2), 171.

Purpura, P. P. (1996). *Criminal justice*. Elsevier.

R Development Core Team. (2009). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing. Retrieved from http://www.R-project.org.

Reaves, B. (2008). *Campus Law Enforcement, 2004–2005*. Washington, DC: US Department of Justice, Office of Justice Programs, Bureau of Justice Statistics.

Reiss, A. J. (1971). *The police and the public*. New Haven: Yale University Press.

Rocheleau, B. A. (2005). *Public management information systems* (illustrated edition.). Idea Group Publishing.

Rocheleau, B., & Wu, L. (2002). Public versus private information systems: Do they differ in important ways? A review and empirical test. *The American Review of Public Administration*, *32*(4), 379.

Roldan, J., & Millian, A. (2000). Analysis of the information system success dimensions interdependence: An adaptation of the DeLone and McLean's model in the Spanish EIS field. Presented at the BITWorld 2000.

Rosenfeld, R., Fornango, R., & Baumer, E. (2005). Did ceasefire, compstat, and exile reduce homicide. *Criminology & Public Policy*, *4*(3), 419-449.

Sahai, H., & Ojeda, M. M. (2005). *Analysis of Variance for Random Models: Unbalanced data*. Birkhäuser.

Sanders, W. B. (1977). *Detective work: A study of criminal investigations*. New York: Free Press.

Schutt, R. (2006). *Investigating the Social World - The Process and Practice of Research - 5th (Fifth) Edition*.

SEARCH. (1997). *Implementing the National Incident-Based Reporting System: A Project Status Report*. Washington, DC: Bureau of Justice Statistics. Retrieved from http://www.ojp.usdoj.gov/bjs/pub/pdf/inibrs.pdf.

Seaskate. (1998). *The evolution and development of police technology: A technical report*. Seaskate, Inc.

Seddon, P., & Kiew, M. (1996). A partial test and development of DeLone and McLean model of IS success. *Australian Journal of Information Systems*, *4*(1), 90-109.

Shane, J. (2004). Compstat implementation. *FBI Law Enforcement Bulletin* , *73*(6).

Silverman, E. B. (1999). *NYPD battles crime: Innovative strategies in policing*. Boston: Northeastern University Press.

Silverman, E. B. (2006). Compstat's innovation. In D. Weisburd & A. A. Braga (Eds.), *Police innovation: Contrasting perspectives*. Cambridge, UK: Cambridge University Press.

Skogan, W. G., & Antunes, G. E. (1979). Information, apprehension, and deterrence: Exploring the limits of police productivity. *Journal of Criminal Justice*, *7*(21), 217-241.

Sparrow, M. K. (1993). Information systems and the development of policing. *National Institute of Justice, Perspectives on Policing*, (16).

SPSS Inc. (2008). *SPSS for Windows*. Chicago, IL.

Steinberg, S. L. (2005). *GIS*. SAGE.

Stevens, J. W. (1995). Computer technology. In W. Bailey (Ed.), Garland reference library of the humanities (2nd ed.). New York: Garland Pub.

Steverson, L. A. (2007). *Policing in America*. ABC-CLIO.

Swanson, C. (1978). The influence of organization and environment on arrest policies in major US cities. *Policy Studies Journal*, *7*, 390-398.

Tien, J. M., Cahn, M. F., Neray, R. C., Einstein, D. M., & Pei, K. (2005). *Measuring the Performance of Criminal History Records Systems: The Records Quality Index*. Structured Decisions Corporations.

Tong, D. S., & Bowling, B. (2006). Art, Craft and Science of Detective Work. *The Police Journal*, *79*(4), 323–330.

Traub, R. E. (1994). *Reliability for the Social Sciences: Theory and Applications* (illustrated edition.). Sage Publications, Inc.

Turk, Z. (2000). What is construction information technology. Presented at the Informacni technologie ve stavebnictvi 2000, Prague.

U.S. Census Bureau. (2000). American fact finder. Retrieved March 8, 2009, from http://factfinder.census.gov/.

Vito, G. F., Walsh, W. F., & Kunselman, J. (2005). Compstat: the manager's perspective. *International Journal of Police Science & Management*, *7*(3).

Waegel, W. B. (1982). Patterns of police investigation of urban crimes. *Jounal of Police Science and Administration*, *10*(4), 452-465.

Waegel, W. (1981). Case routinization in investigative police work. *Social Problems*, *28*(3), 263-275.

Walsh, W. F., & Vito, G. F. (2004). The meaning of Compstat: Analysis and response. *Journal of Contemporary Criminal Justice*, *20*(1), 51.

Weisburd, D., Mastrofski, S. D., McNally, A. M., & Greenspan, R. (2002). Reforming to preserve: Compstat and strategic problem solving in American policing. *Criminology & Public Policy*, *2*, 421.

Weisburd, D., Mastrofski, S. D., Willis, J. J., & Greenspan, R. (2006). Changing everything so that everything can remain the same: Compstat and American policing. In D. Weisburd & A. A. Braga (Eds.), *Police innovation: Contrasting perspectives*. Cambridge, UK: Cambridge University Press.

Weller, S., Martin, J., Price, D., & Wagenknecht-Ivey, B. (2001). *Criminal justice system project final report of evaluation findings: Critical components for successful criminal justice system planning*. Washington, D.C.: National Institute of Justice.

Wellford, C., & Cronin, J. (1999). *Analysis of variables affecting the clearance of Homicides: a multisite study*. Washington, DC: Justice Research and Statistics Association.

Wiig, K. M. (1993). *Knowledge management foundations: Thinking about thinking: How people and organizations create, represent, and use knowledge*. Arlington, Tex: Schema Press.

Willman, M. T., & Snortum, J. R. (1984). Detective work: The criminal investigation process in a medium-size police department. *Criminal Justice Review*, *9*(1), 33-39.

Willmer, M. A. P. (1970). *Crime and information theory*. Edinburgh: University Press.

WordNet. (n.d.). information Technology. *WordNet*. Online Dictionary, . Retrieved July 25, 2008, from http://wordnet.princeton.edu/perl/webwn?s=information+technology&sub=Search+WordNet&o2=&o0=1&o7=&o5=&o1=1&o6=&o4=&o3=&h=.

Zaid, M. N. (1967). Urban differentiation, characteristics of boards of directors, and organizational effectiveness. *American Journal of Sociology*, 261–272.

Zavala, A., & Mullen, T. H. (1970). *Use Of computer-based modus operandi data systems*. US Dept of Justice Law Enforcement Assistance Admin.

# APPENDIX A: CRIMINAL INVESTIGATION SURVEY

## General

1. What is your title/rank? _____

   1a. How long have/did you serve as an investigator? (If not applicable, please write 0.) _____

2. Name of Department: _____

3. Population served: _____

4. Area of agency's jurisdiction (square miles): _____

5. Total number of full-time sworn officers: _____

6. Total number of personnel in the department assigned primarily to investigative duties
   Sworn: _____
   Civilian: _____

7. Does your department have a special title for officers assigned to investigative duties, whether or not they have a special official rank?
   0 = No 1 = Yes

   7a. If yes, what is this title? _____

8. How many officers in the department have this title? _____

## Investigative Training

9. How many hours of formal investigative training are provided to recruits in the basic academy? _____ Hours

10. How many hours of additional formal investigative training are provided to newly appointed investigators? _____ Hours

11. If routine refresher training is provided to investigators, please specify how often. _____ If not, go to Question 12.

    11a. Number of hours: _____

    11b. What type(s) of routine refresher training is provided? (Circle all that apply)

a. Crime type training (homicide, crimes against property, drugs, etc.)
b. Investigative techniques (interviews/interrogations, crime scene management, etc.)
c. Legal issues (arrest, search, court testimony, etc.)
d. Management/administration (report writing, case management, data systems, etc.)
e. Other – Specify: _____

11c. What portion of the required training is documented for liability purposes?
0 = None
1 = Some
2 = Most
3 = All

12. For classroom instruction on investigations provided for investigators and/or uniformed officers, who does the training? (Circle all that apply)
a. Educational institutions
b. Federal agencies
c. In-house personnel
d. Other local agencies
e. Private organizations
f. State agencies
g. Other – Specify: _____

13. To what degree has each of the factors listed below been a problem regarding training of investigators?

| **Factor** | **None** | **Slight** | **Moderate** | **Large** |
|---|---|---|---|---|
| a. Excessive length of training | | | | |
| b. Ineffectiveness of training | | | | |
| c. Lack of funding | | | | |
| d. Lack of management support | | | | |
| e. Lack of quality of training | | | | |
| f. Low individual motivation | | | | |
| g. Manpower shortage | | | | |
| h. Availability of desired training | | | | |
| i. Technology for training | | | | |

| | | | | |
|---|---|---|---|---|
| j. Other – Specify: _____ | | | | |

**Investigative Roles**

14. For each of the items listed below, place an X in the column that most closely describes the frequency for which investigators in your agency participate when investigating serious crimes. If your agency does not have an investigator(s), please skip to question 17.

| **a. Tasks** | **Never** | **Sometimes** | **Usually** | **Always** |
|---|---|---|---|---|
| (1) Conduct undercover investigations | | | | |
| (2) Perform community problem solving | | | | |
| (3) Process crime scenes for physical evidence | | | | |
| (4) Prioritize cases based on local area problems | | | | |
| (5) Self-assign cases based on local problems | | | | |
| (6) Work in pairs | | | | |
| **b. Work with Uniformed Officers** | | | | |
| (1) In teams | | | | |
| (2) On decoy units, stakeouts, etc. | | | | |
| (3) To analyze crime patterns | | | | |
| **c. Community-related Activities** | | | | |
| (1) Provide crime information to the public | | | | |
| (2) Receive at least 8 hours of community policing training | | | | |
| (3) Regularly participate in community | | | | |

| | | | | |
|---|---|---|---|---|
| meetings | | | | |
| (4) Use citizen volunteers to assist in investigations | | | | |
| (5) Work in teams with citizen groups | | | | |
| (6) Work with citizens on community outreach | | | | |

15. Listed below are a number of criteria and processes that can be used to select investigators. For each one, please indicate the frequency it is used in your agency.

| **a. Criteria:** | **Never** | **Sometimes** | **Usually** | **Always** |
|---|---|---|---|---|
| (1) Arrest productivity | | | | |
| (2) Education requirements specifically for investigators | | | | |
| (3) Investigation skills | | | | |
| (4) Minimum number of years of experience | | | | |
| (5) Personnel records (commendations, complaints, etc) | | | | |
| (6) Promotion to a certain grade level | | | | |
| (7) Supervisor/staff ratings or evaluations | | | | |
| (8) Competitive examination | | | | |
| (9) Other – Specify:_____ | | | | |
| | **Never** | **Sometimes** | **Usually** | **Always** |
| **b. Processes:** | | | | |
| (1) Civil service exam | | | | |

| | | | | |
|---|---|---|---|---|
| (2) Oral board interview | | | | |
| (3) Peer evaluation | | | | |
| (4) Personal interview | | | | |
| (5) Written tests | | | | |
| (6) Verbal tests | | | | |
| (7) Other –<br>Specify:_____ | | | | |

16. Is a probationary period required for newly selected investigators? If no, go to Question 17.
    0 = No  1 = Yes

    16a. If yes, number of weeks of probation? _____weeks

**Case Assignments**

17. Many agencies "screen out" burglaries with low solvability. Approximately what percentage of your agency's burglary cases are screened out, i.e., not given any investigation following completion of the initial crime report? _____

18. How does your agency "screen out" or "skim" cases? (Circle all that apply)
    a. Seriousness of offense
    b. Presence of physical or forensic evidence
    c. Witness testimony
    d. Victim characteristics
    e. Offender history
    f. Formal solvability factors
    g. Supervisor judgment
    h. Investigator judgment
    i. By type of crime (i.e. Cyber crime) – Specify: _____
    j. We don't screen out cases
    k. Others – Specify: _____

19. Many agencies use alternative methods of taking crime reports, such as telephone reporting. Does your agency utilize any alternative methods for Part 1 crimes? If no, go to Question 20.
    0 = No  1 = Yes

19a. If yes, please specify the alternative method(s) and for which crimes methods are used.

_____
_____
_____

20. Once a decision is made to investigate a case, how is it assigned to an investigator? If your agency does not have an investigator(s), please skip to question 21.

| | Never | Sometimes | Usually | Always |
|---|---|---|---|---|
| a. By rotation | | | | |
| b. By the size of investigator's caseload | | | | |
| c. By the experience of the investigator | | | | |
| d. By the personal characteristics of the investigator | | | | |
| e. By the specialty of the investigator | | | | |
| f. Other – Specify: _____ | | | | |

21. Which of the following investigative functions do uniformed officers perform in your agency?

| | Never | Sometimes | Usually | Always |
|---|---|---|---|---|
| a. Canvass areas for witnesses | | | | |
| b. Collect physical evidence from crime scene | | | | |
| c. Collect physical evidence from suspect | | | | |
| d. Conduct drug field tests | | | | |
| e. Conduct records checks | | | | |
| f. Conduct surveillance | | | | |

| | | | | |
|---|---|---|---|---|
| g. Conduct undercover activities | | | | |
| h. Coordinate investigations with prosecutors | | | | |
| i. Interrogate suspects | | | | |
| j. Interview suspects | | | | |
| k. Interview victims | | | | |
| l. Interview witnesses | | | | |
| m. Secure crime scene | | | | |
| n. Submit evidence for forensic analysis | | | | |
| o. Testify in court | | | | |

**Job Enhancement**

22. Within the past five years, has your agency attempted to enhance the role of uniformed officers in investigating crimes? If no, go to Question 23.
0 = No 1 = Yes

22a. If yes, in what ways? (Circle all that apply)
a. Investigators can refer cases back to officers for follow-up investigation
b. Officers conduct complete follow-up investigation as part of a team
c. Officers conduct more investigation at scene prior to handing case to investigator
d. Officers are temporarily assigned to an investigation unit as part of career development
e. Other – Specify: _____

22b. Why did your agency try to enhance the uniformed officer's role in investigating crime? (Circle all that apply)
a. To assist in evaluating the work performance of uniformed officers
b. To clear more crimes
c. To free investigators for major crime investigation
d. To improve the morale of uniformed officers
e. To improve the quality of reports passed to investigators
f. To improve the relationship between uniformed officers and investigators
g. To improve uniformed officer awareness of the investigative process

h. To meet budgetary constraints
i. To shorten case closure time
j. Other – Specify: _____

**Investigative Functions and Effectiveness**

23. Listed below are a number of different goals that may be associated with the criminal investigation function. For each goal, indicate how important your agency considers it to be with regard to criminal investigations.

| **Crime-related Goals** | **Not Important** | **Slightly Important** | **Moderately Important** | **Largely Important** |
|---|---|---|---|---|
| (1) Clear cases | | | | |
| (2) Collect intelligence about other crimes | | | | |
| (3) Convict suspects | | | | |
| (4) Investigate all serious crimes | | | | |
| (5) Prevent crime | | | | |
| (6) Prosecute suspects | | | | |
| (7) Protect victim and witnesses | | | | |
| (8) Reduce crime | | | | |
| (9) Solve problems | | | | |
| (10) Other – Specify: _____ | | | | |
| **Other Goals** | | | | |
| (1) Citizen satisfaction/support | | | | |
| | **Not** | **Slightly** | **Moderately** | **Largely** |

| | Important | Important | Important | Important |
|---|---|---|---|---|
| (2) Keep the community informed | | | | |
| (3) Plan/implement crime prevention strategies | | | | |
| (4) Protect the public | | | | |
| (5) Provide support/feedback to victims | | | | |
| (6) Recover/return property | | | | |
| (7) Insure justice in the community | | | | |
| (8) Other – Specify: _____ | | | | |

**Evidence and Crime Labs**

24. Does your department use evidence technicians who respond to the crime scene? If no, go to Question 26.
    0 = No  1 = Yes

    24a. If yes, are they sworn personnel?
    0 = No  1 = Yes

25. Are people who are designated as evidence technicians in your agency required to have any specialized experience or training? If no, go to Question 26.
    0 = No  1 = Yes

    25a. If yes, what type(s)? (Circle all that apply)
    a. A college degree
    b. Investigative experience
    c. Some college education
    d. Specialized in-house training
    e. Specialized training outside of your agency
    f. Sworn officer experience
    g. Other-Specify: _____

26. Please estimate how frequently the following physical evidence checks (i.e. systematic efforts to determine if such evidence is present) are made at the crime scene.

| **Enter 0 = Never, 1 = Rarely, 2 = Sometimes, 3 = Usually, 4 = Always** | | | | | | |
|---|---|---|---|---|---|---|
| **Physical Evidence Check** | | | | | | |
| **Crime Type** | **Finger Prints** | **Tool Marks** | **Chemical Analysis** | **Shoe Print or Tire Casing** | **Digital Evidence** | **Other: _____** |
| Homicide | | | | | | |
| Residential Burglaries | | | | | | |
| Commercial Burglaries | | | | | | |
| Robberies | | | | | | |

27. In your experience, what proportion/percentage of the following types of solved cases are solved today based primarily on fingerprint evidence? (i.e., 50% would indicate that half of the cases that are solved are solved primarily due to fingerprint evidence).
    a. Homicide _____
    b. Rape _____
    c. Burglary _____
    d. Auto theft _____
    e. Robbery _____

28. When your investigators make use of routine crime laboratory services, what type of laboratory is most often used? (Circle one)
    a. Your agency's own crime laboratory
    b. A crime laboratory that is part of another local/county police agency
    c. A crime laboratory that is part of another state/federal police agency
    d. A state laboratory that is not part of a police organization (e.g., public health)
    e. A laboratory that is privately owned

29. How would personnel in your agency describe their access to routine crime laboratory services?
    a. Readily available in all cases
    b. Readily available but only in serious cases
    c. Available but difficult to get timely access
    d. Access is limited, hindering some investigations

30. When personnel make use of routine crime laboratory services, how would they describe the average turn-around time for analysis other than for drug/alcohol cases?
    1 = Timely
    2 = Somewhat slow
    3 = Very slow
    4 = Completely inadequate

31. Does your agency own a mobile crime scene/laboratory vehicle? If no, go to Question 32.
    0 = No  1 = Yes

    31a. If yes, please describe the vehicle.
    _____
    _____
    _____

32. What is the approximate number of cases that your agency has cleared as a result of DNA analysis? _____

    32a. How many cases in the past year would not have been cleared otherwise?
    _____

33. In your experience, what proportion/percentage of the following types of solved cases are solved today based primarily on DNA evidence?
    a. Homicide _____
    b. Rape _____
    c. Burglary _____
    d. Robbery _____
    e. Auto theft _____

34. When your agency uses the Automated Fingerprint Identification System (AFIS), who provides the service? (Circle all that apply)
    a. Your agency's own AFIS
    b. A neighboring agency's AFIS
    c. A state administered AFIS
    d. A federally administered AFIS
    e. Other – Specify: _____

**Technology**

35. Does your agency have electronic crime investigation capability, i.e. the ability to analyze digital information located on a variety of storage mediums? If no, go to Question 36.
    0 = No  1 = Yes

35a. If yes, how many investigators are assigned to investigate electronic crimes?
Full-time: _____
Part-time: _____

36. Does your department use any of the following technologies? (Circle all that apply)
a. Cellular or mobile phones
b. Global Positioning System (GPS)
c. Personal Digital Assistant (PDA) or handheld computer
d. Blackberry
e. Mobile Data Computer/Mobile Data Terminal (MDC/MDT)
f. Intranet
g. Web pages or web-based
h. Computer Based Training (CBT)
i. Laptop computer

37. Does your department use any of the following services for investigative purposes? (Circle all that apply)
a. National Integrated Ballistics Information Network (NIBIN)
b. Integrated Ballistics Identification System (IBIS)
c. Violent Criminal Apprehension Program (ViCap)
d. Regional Information Sharing Systems (RISS)
e. National Crime Information Center (NCIC)

**Agency Policies**

38. In some jurisdictions recording of police-witness and/or victim interviewing is legally required. Is this true in your agency's jurisdiction? If no, go to Question 39.
0 = No 1 = Yes

38a. If yes, how are you required to record interrogations?
a. Only written recording (by stenographer, court reporter) is required
b. Only audio is required
c. Both audio and visual recording is required

38b. Have you had cases that were denied prosecution or which did not go to trial because the required interrogation recording was not available?
0 = No 1 = Yes

39. Even if not legally required, are interrogations of suspects routinely recorded by audio or audio/visual means?
0 = No 1 = Yes

**Agency Files and Records**

40. Do personnel conducting investigations complete any kind of formal activity log to account for how their time is spent?
    0 = No  1 = Yes

41. Are the types of records listed below available to personnel conducting investigation in your agency in manual or computer form?

| Records | Not Available | Available Manually | Available on Computer | Available Both Manually and on Computer |
|---|---|---|---|---|
| a. Crime reports | | | | |
| b. Arrest reports | | | | |
| c. Case disposition | | | | |
| d. Prosecution disposition | | | | |
| e. Court dispositions | | | | |
| f. Summary crime statistics | | | | |

42. Please identify the availability of the following files for criminal investigations purposes.

| Files | Not Available | Available Manually | Available on Computer | Available Both Manually and on Computer |
|---|---|---|---|---|
| a. Fingerprints | | | | |
| b. Known offender | | | | |
| c. M.O. file | | | | |
| d. Mug shot | | | | |
| e. Organized crime intelligence | | | | |

| | | | | |
|---|---|---|---|---|
| f. Narcotics intelligence | | | | |
| g. Sex offender | | | | |
| h. Stolen property | | | | |
| i. Stolen vehicles | | | | |
| j. Other – Specify: _____ | | | | |

43. Within the next year, does your agency plan to upgrade or enhance any of the following? (Circle all that apply)
    a. Computers in police vehicles
    b. Crime analysis capabilities
    c. Crime report forms
    d. Records Management Systems
    e. Case disposition files
    f. Investigative support files
    g. Personal communication devices
    h. Dispatch communication systems
    i. Other – Specify: _____

**Agency Needs**

44. What is the extent of your agency's need for additional funding in the areas listed below in order to improve investigative effectiveness?

| | None | Slight | Moderate | Large |
|---|---|---|---|---|
| a. Equipment (e.g., vehicles, surveillance) | | | | |
| b. Evidence collection issues | | | | |
| c. Evidence processing (e.g., crime labs, DNA analysis) | | | | |
| d. Funding for informants | | | | |
| e. Investigative operations (e.g., task forces, stings) | | | | |
| f. Personnel | | | | |

| | | | | |
|---|---|---|---|---|
| g. Communication technology | | | | |
| h. Information technology | | | | |
| i. Investigative technology | | | | |
| j. Training | | | | |
| k. Crime mapping | | | | |
| l. Other – Specify: _____ | | | | |

## Other

45. Please respond to each of the following statements as they apply to criminal investigation in your agency today.

| | Strongly Agree | Agree | Don't Know | Disagree | Strongly Disagree | N/A |
|---|---|---|---|---|---|---|
| a. A lot of fingerprint evidence at crime scenes is not collected. | | | | | | |
| b. A lot of latent fingerprints collected at crime scenes are never processed through AFIS. | | | | | | |
| c. Our department could solve a lot more cases with fingerprint evidence if we had more crime scene technicians. | | | | | | |
| d. Our department could solve a lot more cases with better crime scene technology. | | | | | | |
| e. Our department could solve a lot more cases with better access to AFIS. | | | | | | |
| f. A lot of DNA evidence at crime scenes is not collected. | | | | | | |
| g. A lot of DNA evidence collected at crime scenes is never | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| processed for analysis. | | | | | | |
| h. Our department could solve a lot more cases with DNA evidence if we had more crime scene technicians. | | | | | | |
| i. Our department could solve a lot more cases with better access to the crime lab. | | | | | | |
| j. Our department could solve a lot more cases if there were more convicted offenders in the DNA database. | | | | | | |
| k. We are currently maximizing the potential of fingerprints for solving crimes. | | | | | | |
| l. We are currently maximizing the potential for solving crimes using DNA. | | | | | | |

46. If additional research on the criminal investigation process were carried out, what priority would you give each of the following areas?

| **Research** | **None** | **Low** | **Moderate** | **High** |
|---|---|---|---|---|
| a. Case screening | | | | |
| b. Clearance rates | | | | |
| c. Crime intelligence | | | | |
| d. Crime mapping | | | | |
| e. Information systems | | | | |
| f. Decentralization/centralization of investigators | | | | |
| g. Generalization/specialization of investigator roles | | | | |

| | | | | |
|---|---|---|---|---|
| h. Integration of community policing and investigations | | | | |
| i. Interagency cooperation | | | | |
| j. Investigator relationship with communities | | | | |
| k. Investigative role of patrol officers | | | | |
| l. Investigator selection | | | | |
| m. Investigator training | | | | |
| n. Management of continuing investigations | | | | |
| o. Performance evaluation of investigators | | | | |
| p. Police/prosecutor relations | | | | |
| q. Prosecution and conviction rates | | | | |
| r. Role of technology in criminal investigations | | | | |
| s. Technological improvements in investigations management | | | | |
| t. Technological improvements in investigative techniques | | | | |
| u. Other – Specify: _____ | | | | |

## APPENDIX B: CORRELATION COEFFICIENTS OF USE OF IT ITEMS

Table 1
*Correlation Coefficients*

| | Cellular / Mobile Phones | GPS | PDA / Handheld Computer | Blackberry | MDC / MDT | Intranet | Web Pages / Web-based | CBT | Laptop Computer | NIBIN |
|---|---|---|---|---|---|---|---|---|---|---|
| Cellular / Mobile Phones | 1 | .193** | .112 | .072 | .118* | .231** | .197** | .128* | .139* | .073 |
| GPS | .193** | 1 | .353** | .315** | .253** | .270** | .269** | .228** | .384** | .253** |
| PDA / Handheld Computer | .112 | .353** | 1 | .429** | .311** | .210** | .357** | .325** | .366** | .268** |
| Blackberry | .072 | .315** | .429** | 1 | .336** | .271** | .293** | .286** | .266** | .224** |
| MDC / MDT | .118* | .253** | .311** | .336** | 1 | .355** | .330** | .229** | .451** | .347** |
| Intranet | .231** | .270** | .210** | .271** | .355** | 1 | .370** | .289** | .308** | .247** |
| Web Pages / Web-based | .197** | .269** | .357** | .293** | .330** | .370** | 1 | .342** | .391** | .209** |
| CBT | .128* | .228** | .325** | .286** | .229** | .289** | .342** | 1 | .245** | .214** |
| Laptop Computer | .139* | .384** | .366** | .266** | .451** | .308** | .391** | .245** | 1 | .242** |
| NIBIN | .073 | .253** | .268** | .224** | .347** | .247** | .209** | .214** | .242** | 1 |
| IBIS | .064 | .214** | .266** | .208** | .300** | .253** | .267** | .138* | .219** | .566** |
| ViCap | .176** | .353** | .425** | .310** | .305** | .236** | .352** | .252** | .374** | .402** |
| RISS | .045 | .175** | .288** | .173** | .147* | .159** | .177** | .213** | .195** | .207** |
| NCIC | .339** | .148* | .130* | .087 | .161** | .191** | .160** | .120* | .196** | .168** |
| Crime Reports | -.005 | .037 | .087 | .047 | .169** | .058 | .071 | .083 | -.019 | .067 |
| Arrest Reports | .004 | .054 | .030 | -.059 | .133* | .012 | .048 | .060 | -.055 | .081 |
| Case Disposition | -.029 | .138* | .065 | .079 | .181** | .143* | .076 | .064 | .034 | .065 |
| Prosecution Disposition | .059 | .164** | .117 | .016 | .148* | -.006 | .041 | -.003 | .010 | .129* |
| Court Dispositions | .019 | .122* | .163** | .042 | .202** | .085 | .057 | .026 | .030 | .099 |
| Summary Crime Statistics | .009 | .241** | .160** | .179** | .237** | .128* | .098 | .081 | .060 | .235** |

Table 1 (Continued)

| | IBIS | ViCap | RISS | NCIC | Crime Reports | Arrest Reports | Case Disposition | Prosecution Disposition | Court Dispositions | Summary Crime Statistics |
|---|---|---|---|---|---|---|---|---|---|---|
| Cellular / Mobile Phones | .064 | .176** | .045 | .339** | -.005 | .004 | -.029 | .059 | .019 | .009 |
| GPS | .214** | .353** | .175** | .148* | .037 | .054 | .138* | .164** | .122* | .241** |
| PDA / Handheld Computer | .266** | .425** | .288** | .130* | .087 | .030 | .065 | .117 | .163** | .160** |
| Blackberry | .208** | .310** | .173** | .087 | .047 | -.059 | .079 | .016 | .042 | .179** |
| MDC / MDT | .300** | .305** | .147* | .161** | .169** | .133* | .181** | .148* | .202** | .237** |
| Intranet | .253** | .236** | .159** | .191** | .058 | .012 | .143* | -.006 | .085 | .128* |
| Web Pages / Web-based | .267** | .352** | .177** | .160** | .071 | .048 | .076 | .041 | .057 | .098 |
| CBT | .138* | .252** | .213** | .120* | .083 | .060 | .064 | -.003 | .026 | .081 |
| Laptop Computer | .219** | .374** | .195** | .196** | -.019 | -.055 | .034 | .010 | .030 | .060 |
| NIBIN | .566** | .402** | .207** | .168** | .067 | .081 | .065 | .129* | .099 | .235** |
| IBIS | 1 | .405** | .219** | .086 | .094 | .089 | .042 | .146* | .190** | .215** |
| ViCap | .405** | 1 | .298** | .200** | .209** | .147* | .123* | .119 | .150* | .234** |
| RISS | .219** | .298** | 1 | .149* | .050 | .098 | .109 | .026 | .091 | .129* |
| NCIC | .086 | .200** | .149* | 1 | .039 | .111 | .055 | .086 | .117 | .036 |
| Crime Reports | .094 | .209** | .050 | .039 | 1 | .748** | .347** | .169** | .146* | .332** |
| Arrest Reports | .089 | .147* | .098 | .111 | .748** | 1 | .390** | .270** | .269** | .285** |
| Case Disposition | .042 | .123* | .109 | .055 | .347** | .390** | 1 | .542** | .472** | .278** |
| Prosecution Disposition | .146* | .119 | .026 | .086 | .169** | .270** | .542** | 1 | .713** | .338** |
| Court Dispositions | .190** | .150* | .091 | .117 | .146* | .269** | .472** | .713** | 1 | .251** |
| Summary Crime Statistics | .215** | .234** | .129* | .036 | .332** | .285** | .278** | .338** | .251** | 1 |

Table 1 (Continued)

| | Fingerprints | Known Offender | M.O. File | Mug Shot | Organized Crime Intelligence | Narcotics Intelligence | Sex Offender | Stolen Property | Stolen Vehicles |
|---|---|---|---|---|---|---|---|---|---|
| Cellular / Mobile Phones | -.004 | .028 | -.017 | .109 | .083 | .054 | .006 | .010 | .034 |
| GPS | .207** | .116 | .252** | .189** | .336** | .243** | .189** | .113 | .141* |
| PDA / Handheld Computer | .268** | .129* | .217** | .215** | .266** | .302** | .195** | .155* | .149* |
| Blackberry | .244** | .037 | .124* | .204** | .195** | .219** | .123* | .085 | .094 |
| MDC / MDT | .273** | .219** | .223** | .433** | .161** | .187** | .250** | .247** | .306** |
| Intranet | .219** | .088 | .100 | .226** | .150* | .062 | .100 | -.026 | .008 |
| Web Pages / Web-based | .203** | .185** | .200** | .216** | .239** | .143* | .249** | .192** | .160** |
| CBT | .206** | .144* | .105 | .189** | .243** | .205** | .125* | .078 | .111 |
| Laptop Computer | .208** | .103 | .194** | .242** | .187** | .229** | .162** | .149* | .051 |
| NIBIN | .214** | .106 | .154* | .200** | .110 | .169** | .098 | .004 | .123* |
| IBIS | .229** | .128* | .204** | .176** | .141* | .157* | .107 | .013 | .079 |
| ViCap | .329** | .252** | .282** | .222** | .294** | .292** | .186** | .113 | .181** |
| RISS | .054 | .106 | .205** | .115 | .229** | .240** | .139* | .066 | .101 |
| NCIC | .074 | -.037 | .024 | .080 | .079 | .055 | .115 | .061 | .096 |
| Crime Reports | .124* | .235** | .210** | .242** | .207** | .135* | .245** | .269** | .316** |
| Arrest Reports | .103 | .310** | .197** | .281** | .190** | .161** | .276** | .342** | .445** |
| Case Disposition | .259** | .217** | .204** | .272** | .274** | .293** | .348** | .314** | .426** |
| Prosecution Disposition | .251** | .202** | .212** | .222** | .222** | .351** | .211** | .220** | .261** |
| Court Dispositions | .272** | .209** | .192** | .318** | .213** | .324** | .250** | .218** | .254** |
| Summary Crime Statistics | .253** | .383** | .321** | .284** | .330** | .375** | .213** | .177** | .269** |

Table 1 (Continued)

| | Cellular / Mobile Phones | GPS | PDA / Handheld Computer | Blackberry | MDC / MDT | Intranet | Web Pages / Web-based | CBT | Laptop Computer | NIBIN |
|---|---|---|---|---|---|---|---|---|---|---|
| Fingerprints | -.004 | .207** | .268** | .244** | .273** | .219** | .203** | .206** | .208** | .214** |
| Known Offender | .028 | .116 | .129* | .037 | .219** | .088 | .185** | .144* | .103 | .106 |
| M.O. File | -.017 | .252** | .217** | .124* | .223** | .100 | .200** | .105 | .194** | .154* |
| Mug Shot | .109 | .189** | .215** | .204** | .433** | .226** | .216** | .189** | .242** | .200** |
| Organized Crime Intelligence | .083 | .336** | .266** | .195** | .161** | .150* | .239** | .243** | .187** | .110 |
| Narcotics Intelligence | .054 | .243** | .302** | .219** | .187** | .062 | .143* | .205** | .229** | .169** |
| Sex Offender | .006 | .189** | .195** | .123* | .250** | .100 | .249** | .125* | .162** | .098 |
| Stolen Property | .010 | .113 | .155* | .085 | .247** | -.026 | .192** | .078 | .149* | .004 |
| Stolen Vehicles | .034 | .141* | .149* | .094 | .306** | .008 | .160** | .111 | .051 | .123* |

Table 1 (Continued)

| | IBIS | ViCap | RISS | NCIC | Crime Reports | Arrest Reports | Case Disposition | Prosecution Disposition | Court Dispositions | Summary Crime Statistics |
|---|---|---|---|---|---|---|---|---|---|---|
| Fingerprints | .229** | .329** | .054 | .074 | .124* | .103 | .259** | .251** | .272** | .253** |
| Known Offender | .128* | .252** | .106 | -.037 | .235** | .310** | .217** | .202** | .209** | .383** |
| M.O. File | .204** | .282** | .205** | .024 | .210** | .197** | .204** | .212** | .192** | .321** |
| Mug Shot | .176** | .222** | .115 | .080 | .242** | .281** | .272** | .222** | .318** | .284** |
| Organized Crime Intelligence | .141* | .294** | .229** | .079 | .207** | .190** | .274** | .222** | .213** | .330** |
| Narcotics Intelligence | .157* | .292** | .240** | .055 | .135* | .161** | .293** | .351** | .324** | .375** |
| Sex Offender | .107 | .186** | .139* | .115 | .245** | .276** | .348** | .211** | .250** | .213** |
| Stolen Property | .013 | .113 | .066 | .061 | .269** | .342** | .314** | .220** | .218** | .177** |
| Stolen Vehicles | .079 | .181** | .101 | .096 | .316** | .445** | .426** | .261** | .254** | .269** |

Table 1 (Continued)

| | Fingerprints | Known Offender | M.O. File | Mug Shot | Organized Crime Intelligence | Narcotics Intelligence | Sex Offender | Stolen Property | Stolen Vehicles |
|---|---|---|---|---|---|---|---|---|---|
| Fingerprints | 1 | .288** | .369** | .310** | .287** | .318** | .215** | .092 | .162** |
| Known Offender | .288** | 1 | .432** | .327** | .242** | .250** | .202** | .267** | .356** |
| M.O. File | .369** | .432** | 1 | .251** | .248** | .328** | .194** | .246** | .240** |
| Mug Shot | .310** | .327** | .251** | 1 | .232** | .227** | .292** | .330** | .413** |
| Organized Crime Intelligence | .287** | .242** | .248** | .232** | 1 | .613** | .327** | .158* | .207** |
| Narcotics Intelligence | .318** | .250** | .328** | .227** | .613** | 1 | .358** | .229** | .235** |
| Sex Offender | .215** | .202** | .194** | .292** | .327** | .358** | 1 | .394** | .505** |
| Stolen Property | .092 | .267** | .246** | .330** | .158* | .229** | .394** | 1 | .769** |
| Stolen Vehicles | .162** | .356** | .240** | .413** | .207** | .235** | .505** | .769** | 1 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

# APPENDIX C. FACTOR ANALYSIS RESULT

Table 3
*The Third Factor Analysis*

| | Factors | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Cellular or mobile phones | .492 | .002 | .151 |
| Global Positioning System (GPS) | .577 | .084 | .101 |
| Personal Digital Assistant (PDA) or handheld computer | .525 | .024 | .021 |
| Blackberry | .504 | .270 | .104 |
| Mobile Data Computer/Mobile Data Terminal (MDC/MDT) | .503 | .009 | .005 |
| Intranet | .579 | .148 | -.053 |
| Web pages or web-based | .463 | .132 | -.063 |
| Computer Based Training (CBT) | .607 | .032 | -.028 |
| Laptop computer | .496 | .000 | .129 |
| National Integrated Ballistics Information Network (NIBIN) | .479 | .013 | .200 |
| Integrated Ballistics Identification System (IBIS) | .618 | .115 | .159 |
| Does your department use "ViCap" for investigative purposes? | .339 | .070 | .065 |
| Crime reports | .050 | .473 | .156 |
| Arrest reports | -.046 | .574 | .227 |
| Case disposition | .039 | .404 | .517 |
| Prosecution disposition | -.008 | .198 | .820 |
| Court dispositions | .045 | .182 | .724 |
| Summary crime statistics | .200 | .291 | .358 |
| Fingerprints | .402 | .136 | .312 |
| Known offender | .191 | .460 | .220 |
| M.O. file | .325 | .279 | .235 |
| Mug shot | .290 | .459 | .157 |
| Organized crime intelligence | .370 | .226 | .307 |
| Narcotics intelligence | .351 | .222 | .425 |
| Sex offender. | .209 | .410 | .160 |
| Stolen property | -.010 | .763 | .029 |
| Stolen vehicles | .030 | .856 | .074 |

# APPENDIX D: DESCRIPTIVE STATISTICS

Table 1
*2005 Clearance Rates*

| N=233 | Zero Crime | Missing | Valid N | Min | Max | Mean | SE of Mean | Median | Std Dev |
|---|---|---|---|---|---|---|---|---|---|
| **Murder** | 93 | 13 | 127 | 0 | 2 | 0.6 | 0.032 | 0.6 | 0.358 |
| **Rape** | 65 | 13 | 155 | 0 | 2 | 0.375 | 0.025 | 0.333 | 0.314 |
| **Robbery** | 53 | 13 | 167 | 0 | 1 | 0.311 | 0.019 | 0.276 | 0.246 |
| **Assault** | 23 | 13 | 197 | 0 | 1 | 0.538 | 0.018 | 0.525 | 0.246 |
| **Burglary** | 24 | 13 | 196 | 0 | 1.5 | 0.14 | 0.011 | 0.111 | 0.149 |
| **Larceny** | 21 | 13 | 199 | 0 | 0.79 | 0.156 | 0.008 | 0.146 | 0.112 |
| **Vehicle Theft** | 30 | 13 | 190 | 0 | 1 | 0.196 | 0.015 | 0.143 | 0.209 |
| **Violent Crimes** | 23 | 13 | 197 | 0 | 1 | 0.514 | 0.017 | 0.501 | 0.241 |
| **Property Crime** | 21 | 13 | 199 | 0 | 0.752 | 0.156 | 0.008 | 0.139 | 0.111 |
| **All Crimes** | 21 | 13 | 199 | 0 | 0.788 | 0.261 | 0.01 | 0.247 | 0.134 |

Table 2
*2006 Clearance Rates*

| N=233 | Zero Crime | Missing | Valid N | Min | Max | Mean | SE of Mean | Median | Std Dev |
|---|---|---|---|---|---|---|---|---|---|
| **Murder** | 94 | 17 | 122 | 0 | 1.5 | 0.619 | 0.026 | 0.626 | 0.29 |
| **Rape** | 64 | 17 | 152 | 0 | 1 | 0.365 | 0.023 | 0.34 | 0.281 |
| **Robbery** | 51 | 17 | 165 | 0 | 2 | 0.274 | 0.019 | 0.25 | 0.247 |
| **Assault** | 25 | 17 | 191 | 0 | 1.044 | 0.54 | 0.018 | 0.533 | 0.251 |
| **Burglary** | 25 | 17 | 191 | 0 | 0.5 | 0.122 | 0.006 | 0.104 | 0.086 |
| **Larceny** | 24 | 17 | 192 | 0 | 0.549 | 0.145 | 0.007 | 0.134 | 0.091 |
| **Vehicle Theft** | 31 | 17 | 185 | 0 | 1 | 0.177 | 0.013 | 0.117 | 0.177 |
| **Violent Crimes** | 23 | 17 | 193 | 0 | 1 | 0.513 | 0.018 | 0.498 | 0.249 |
| **Property Crime** | 23 | 17 | 193 | 0 | 1 | 0.145 | 0.008 | 0.128 | 0.104 |
| **All Crimes** | 22 | 17 | 194 | 0 | 1 | 0.253 | 0.01 | 0.232 | 0.134 |

Table 3
*2005 Crime Rates*

| N=233 | Missing | Valid N | Min | Max | Mean | SE of Mean | Median | Std Dev |
|---|---|---|---|---|---|---|---|---|
| **Murder** | 13 | 220 | 0 | 0.431 | 0.054 | 0.006 | 0.014 | 0.085 |
| **Rape** | 13 | 220 | 0 | 1.22 | 0.227 | 0.018 | 0.143 | 0.267 |
| **Robbery** | 13 | 220 | 0 | 9.354 | 1.429 | 0.131 | 0.47 | 1.946 |
| **Assault** | 13 | 220 | 0 | 62.182 | 12.023 | 0.832 | 9.006 | 12.346 |
| **Burglary** | 13 | 220 | 0 | 35.545 | 6.805 | 0.463 | 4.971 | 6.862 |
| **Larceny** | 13 | 220 | 0 | 85.636 | 20.094 | 1.206 | 16.584 | 17.885 |
| **Vehicle Theft** | 13 | 220 | 0 | 25.691 | 3.999 | 0.328 | 1.924 | 4.871 |
| **Violent Crimes** | 13 | 220 | 0 | 65.636 | 13.733 | 0.942 | 10.279 | 13.974 |
| **Property Crime** | 13 | 220 | 0 | 143.089 | 30.897 | 1.852 | 24.883 | 27.469 |
| **All Crimes** | 13 | 220 | 0 | 203.489 | 44.663 | 2.698 | 33.812 | 40.025 |

Table 4
*2006 Crime Rates*

| N=233 | Missing | Valid N | Min | Max | Mean | SE of Mean | Median | Std Dev |
|---|---|---|---|---|---|---|---|---|
| **Murder** | 17 | 216 | 0 | 0.545 | 0.057 | 0.006 | 0.016 | 0.091 |
| **Rape** | 17 | 216 | 0 | 1.409 | 0.24 | 0.019 | 0.153 | 0.279 |
| **Robbery** | 17 | 216 | 0 | 9.283 | 1.545 | 0.14 | 0.597 | 2.057 |
| **Assault** | 17 | 216 | 0 | 56.636 | 12.307 | 0.841 | 9.194 | 12.362 |
| **Burglary** | 17 | 216 | 0 | 34.273 | 6.923 | 0.452 | 5.762 | 6.642 |
| **Larceny** | 17 | 216 | 0 | 84.545 | 20.117 | 1.22 | 16.78 | 17.93 |
| **Vehicle Theft** | 17 | 216 | 0 | 25.531 | 3.882 | 0.326 | 1.79 | 4.794 |
| **Violent Crimes** | 17 | 216 | 0 | 60 | 14.15 | 0.955 | 10.349 | 14.031 |
| **Property Crime** | 17 | 216 | 0 | 141.711 | 30.922 | 1.852 | 26.701 | 27.213 |
| **All Crimes** | 17 | 216 | 0 | 199.8 | 45.104 | 2.719 | 39.385 | 39.965 |

Table 5
*Use of IT and Control Variables*

| N=233 | Missing | Valid N | Min | Max | Mean | SE of Mean | Median | Std Dev |
|---|---|---|---|---|---|---|---|---|
| **Use of IT** | 34 | 199 | 2 | 29 | 20.186 | 0.391 | 21 | 5.516 |
| **# of Officer** | 4 | 229 | 1 | 37038 | 814.681 | 184.634 | 210 | 2794.016 |
| **Log of # of Officer** | 4 | 229 | 0 | 10.52 | 4.804 | 0.149 | 5.347 | 2.255 |
| **Population** | 0 | 233 | 465 | 8e+06 | 398987.399 | 52438.69 | 152000 | 800441.869 |
| **Log of Population** | 0 | 233 | 6.142 | 15.895 | 11.145 | 0.153 | 11.932 | 2.339 |
| **Median Income** | 0 | 233 | 19063 | 148173 | 41949.232 | 1086.673 | 37954 | 16587.337 |
| **% Below Poverty** | 0 | 233 | 0.5 | 40 | 13.786 | 0.484 | 12.7 | 7.382 |
| **% White** | 0 | 233 | 1.1 | 99.2 | 72.995 | 1.338 | 75.1 | 20.427 |
| **Proportion of Investigators** | 7 | 226 | 0 | 3 | 0.252 | 0.022 | 0.154 | 0.332 |

APPENDIX E: HISTOGRAMS OF ALL VARIABLES

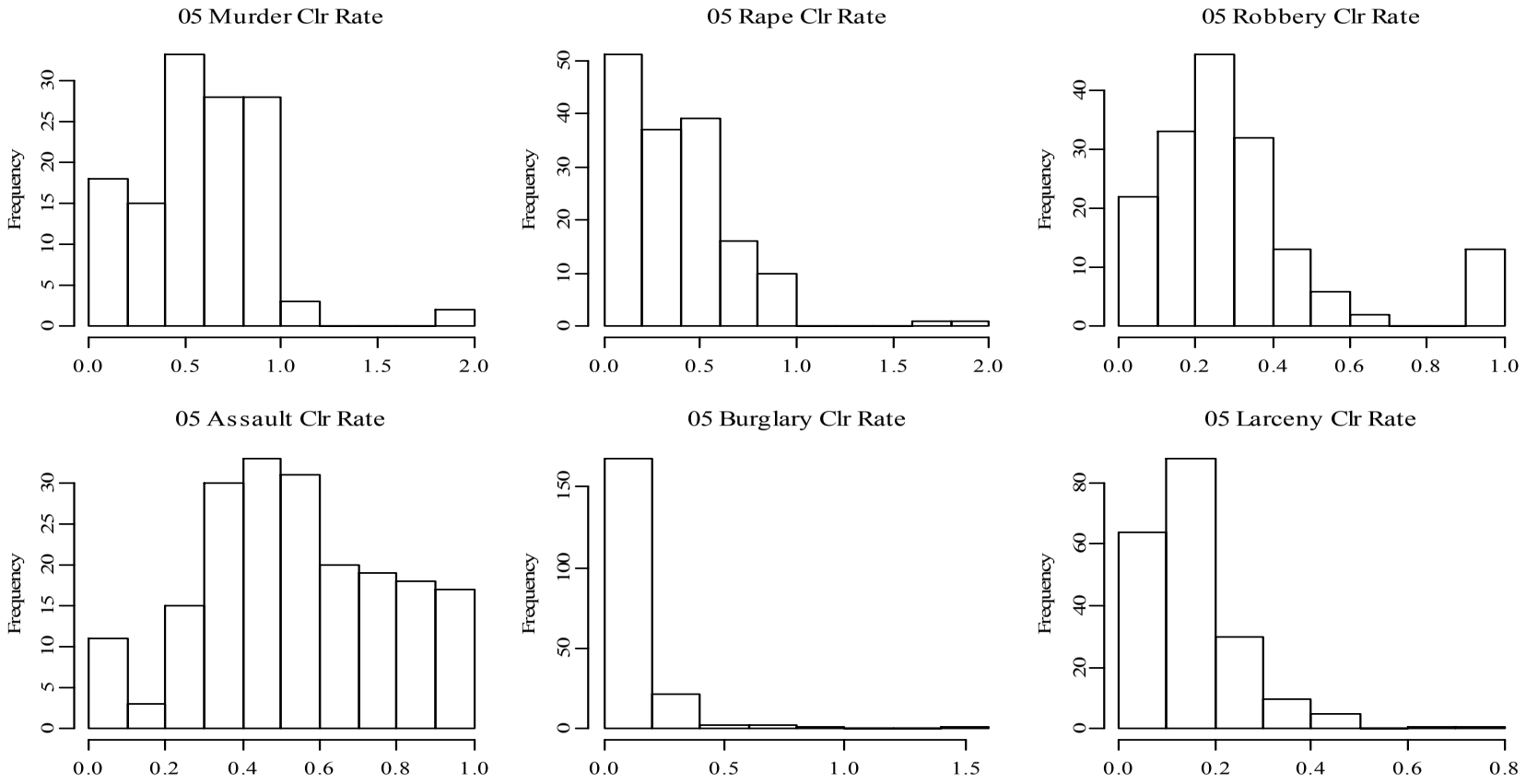


*Figure 1.* 2005 Clearance Rate Variables

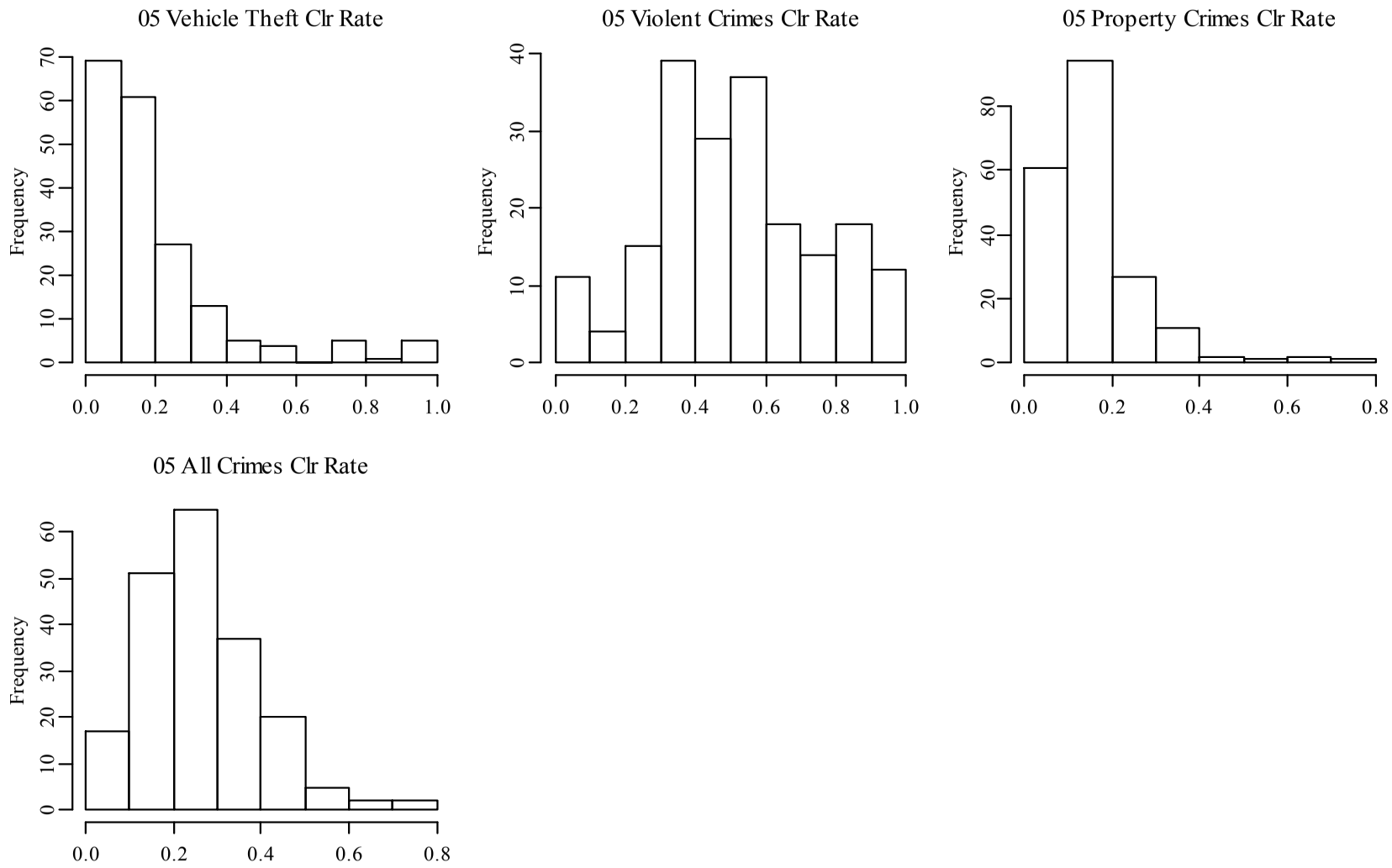


*Figure 2.*2005 Clearance Rate Variables

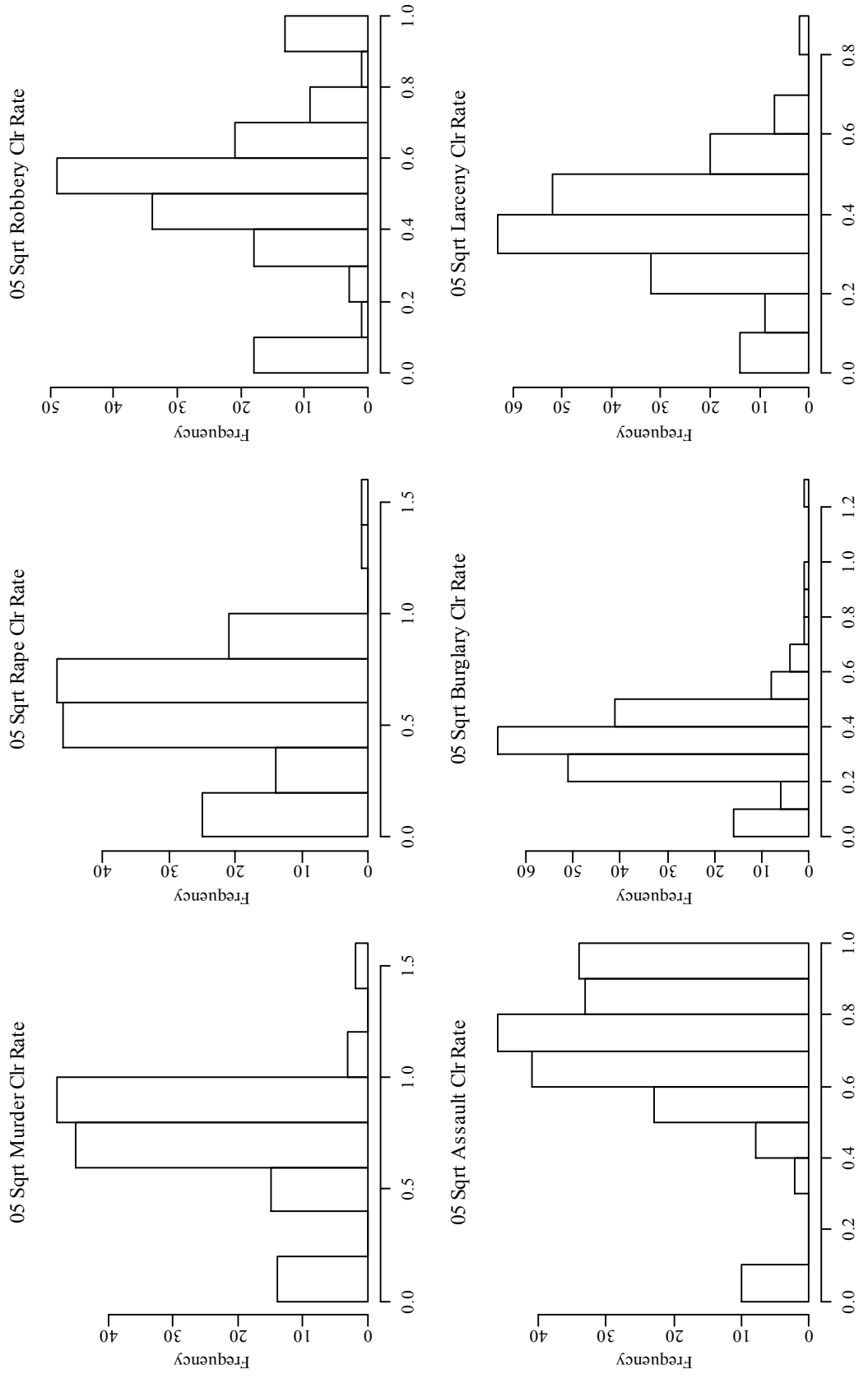


*Figure 3.* Square Rooted 2005 Clearance Rate Variables

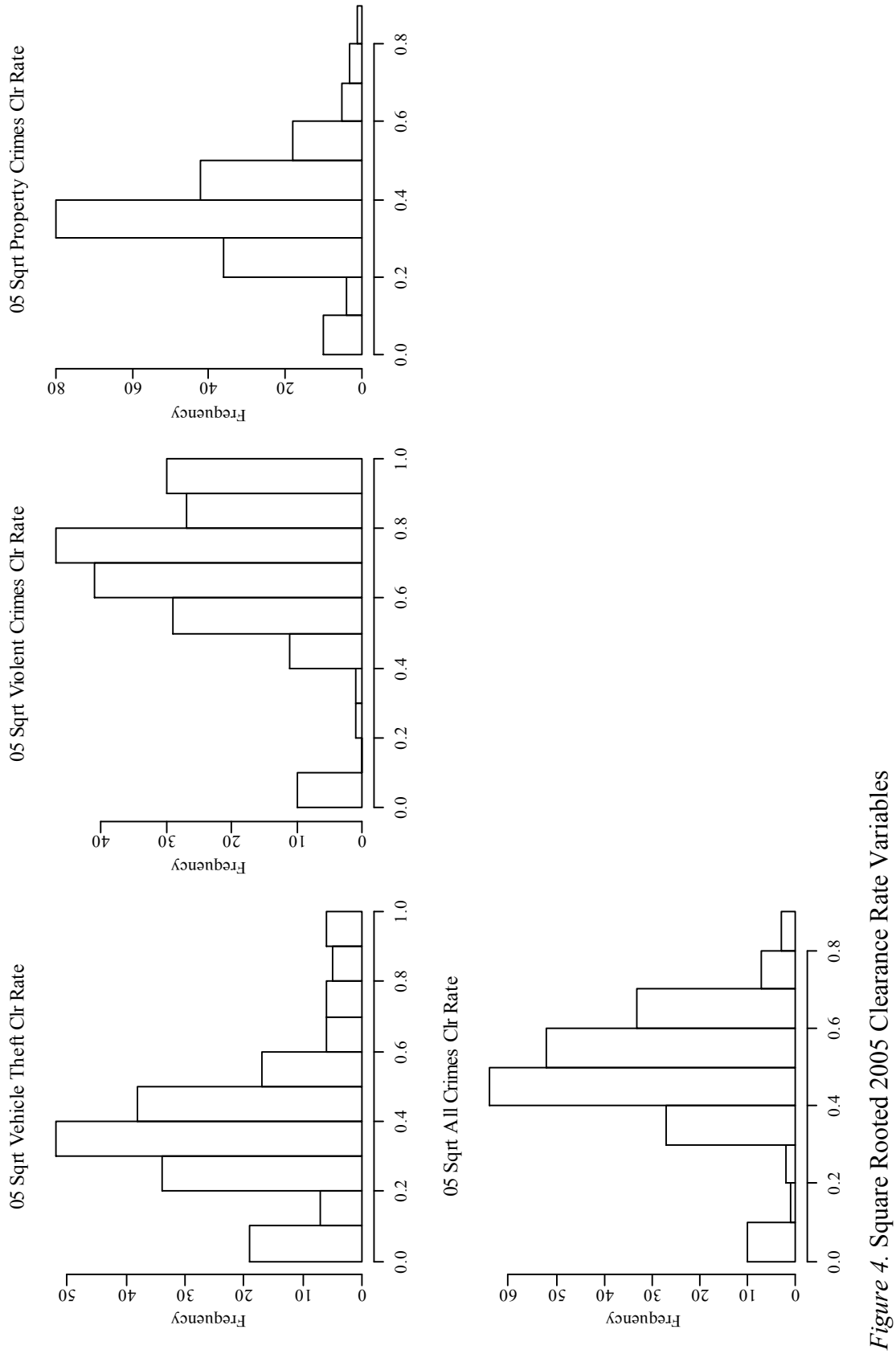


*Figure 4.* Square Rooted 2005 Clearance Rate Variables

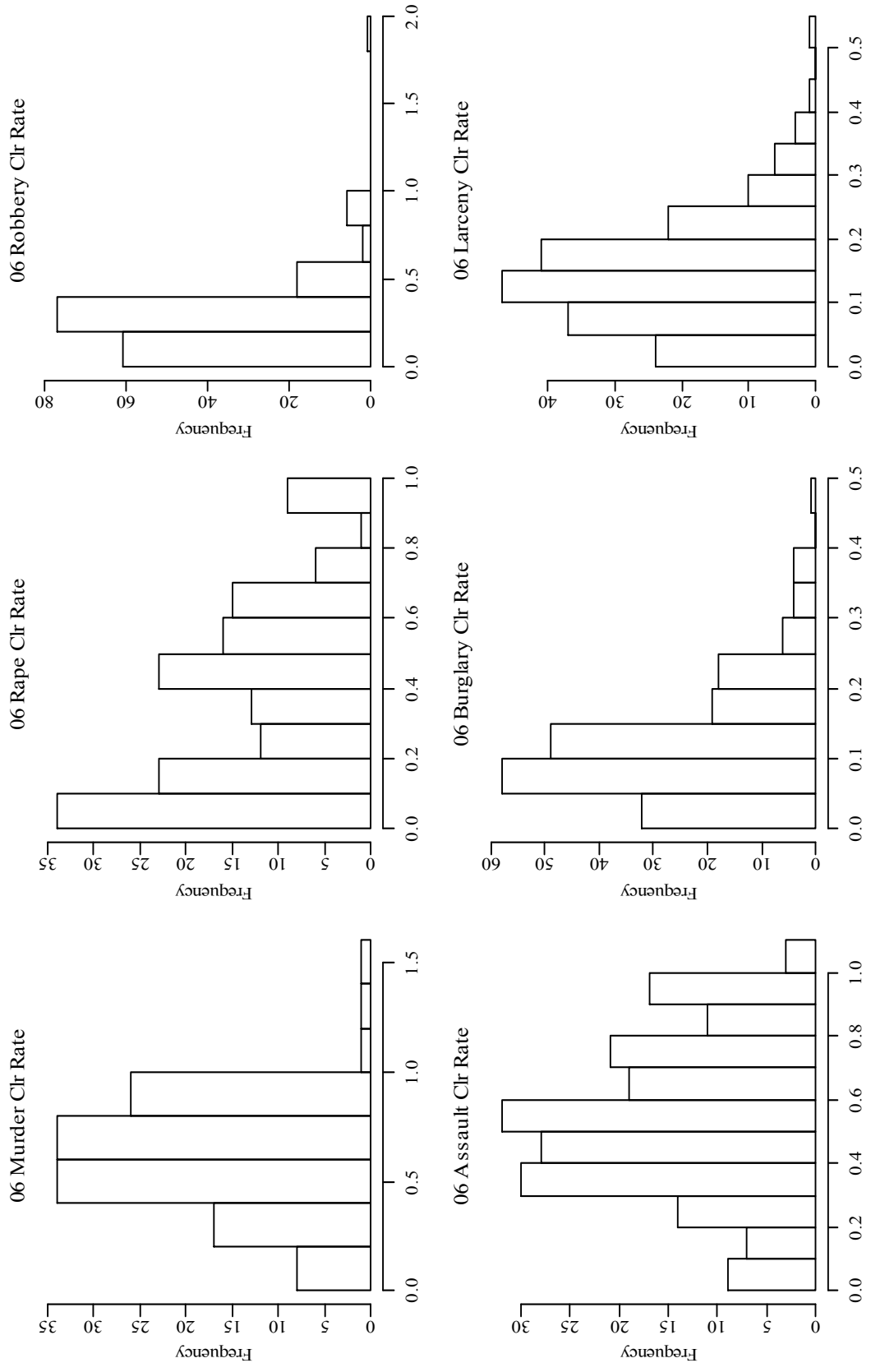


*Figure 5.* 2006 Clearance Rate Variables

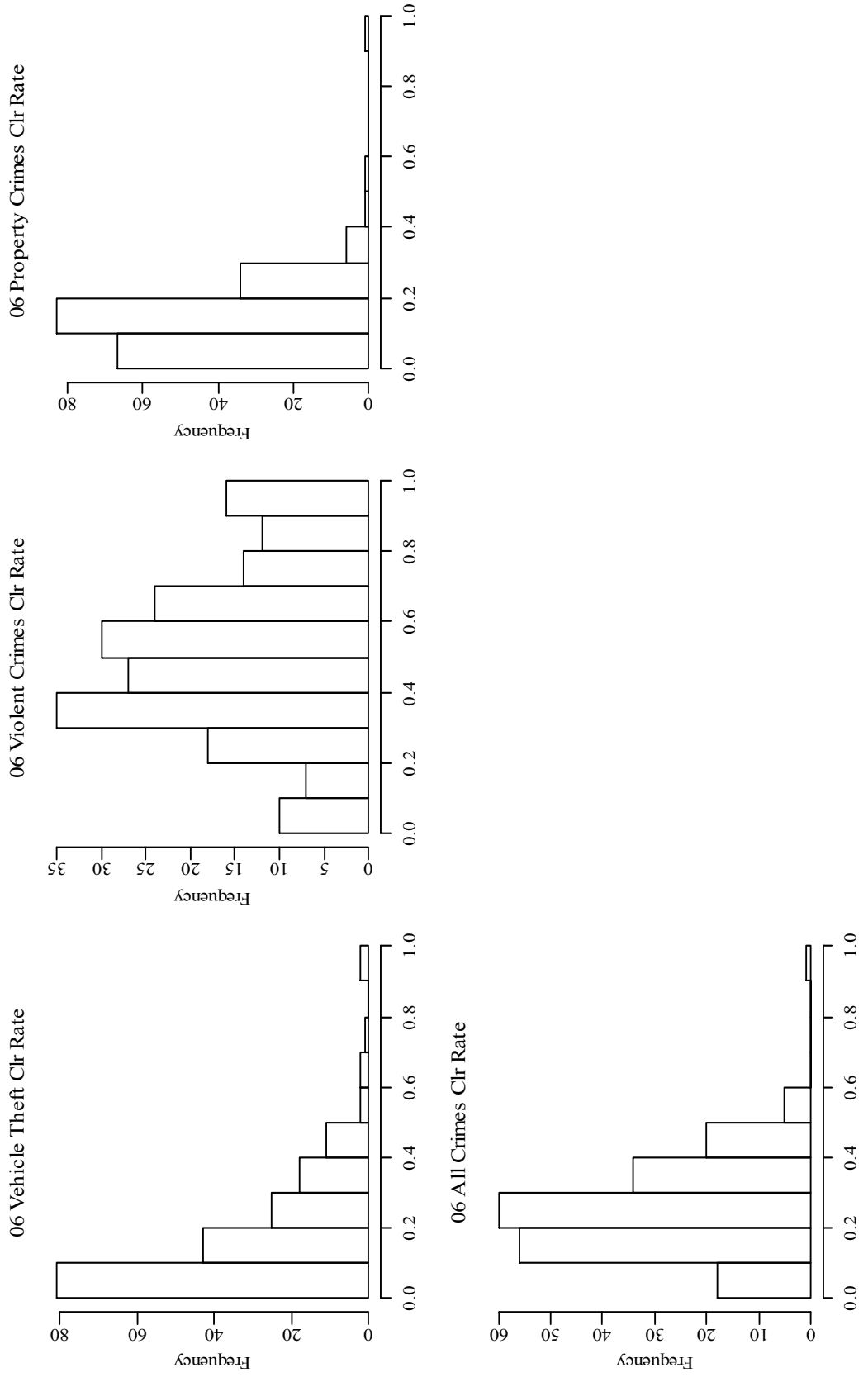


*Figure 6.* 2006 Clearance Rate Variables

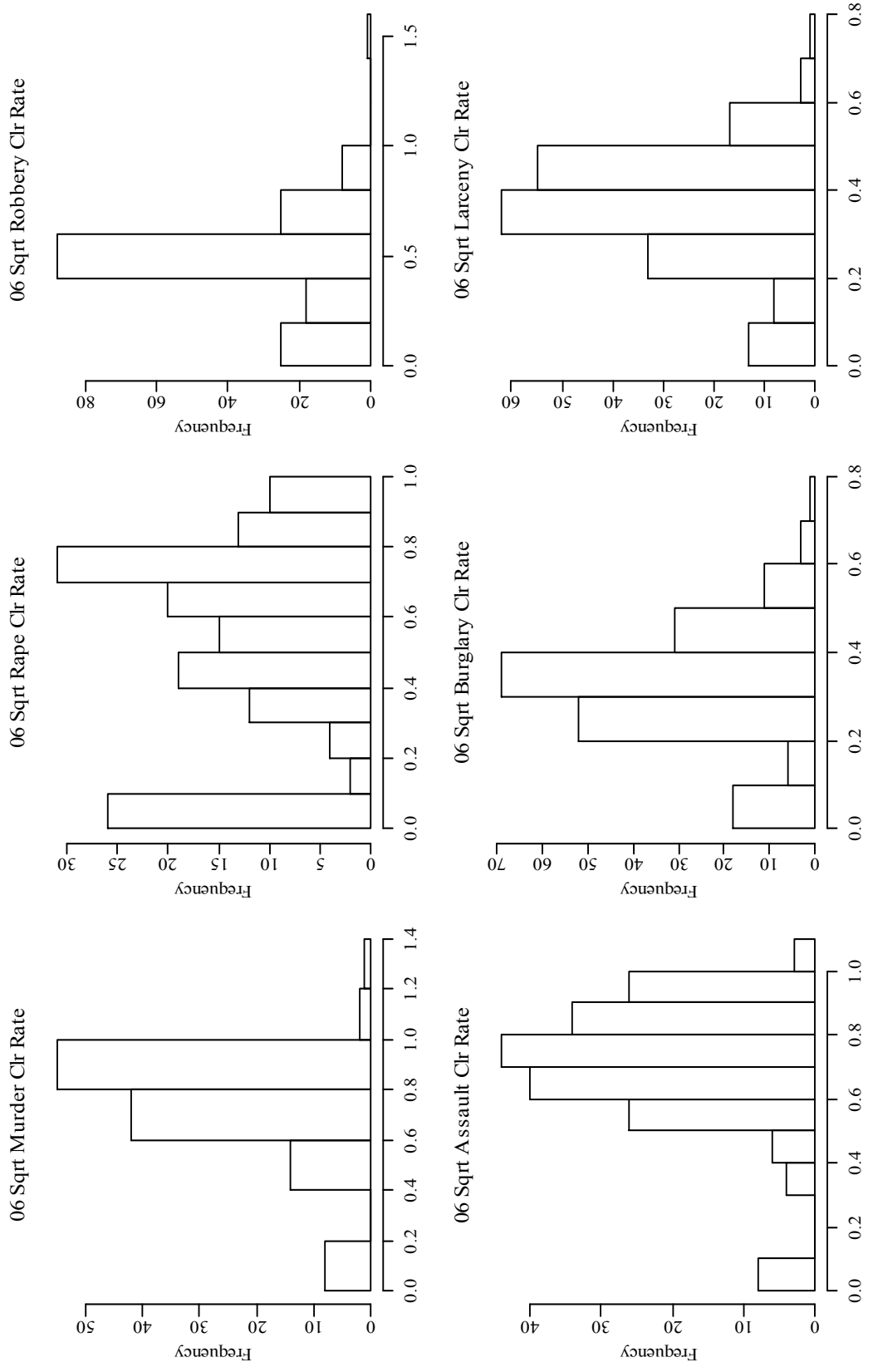


*Figure 7*. Square Rooted 2006 Clearance Rate Variables

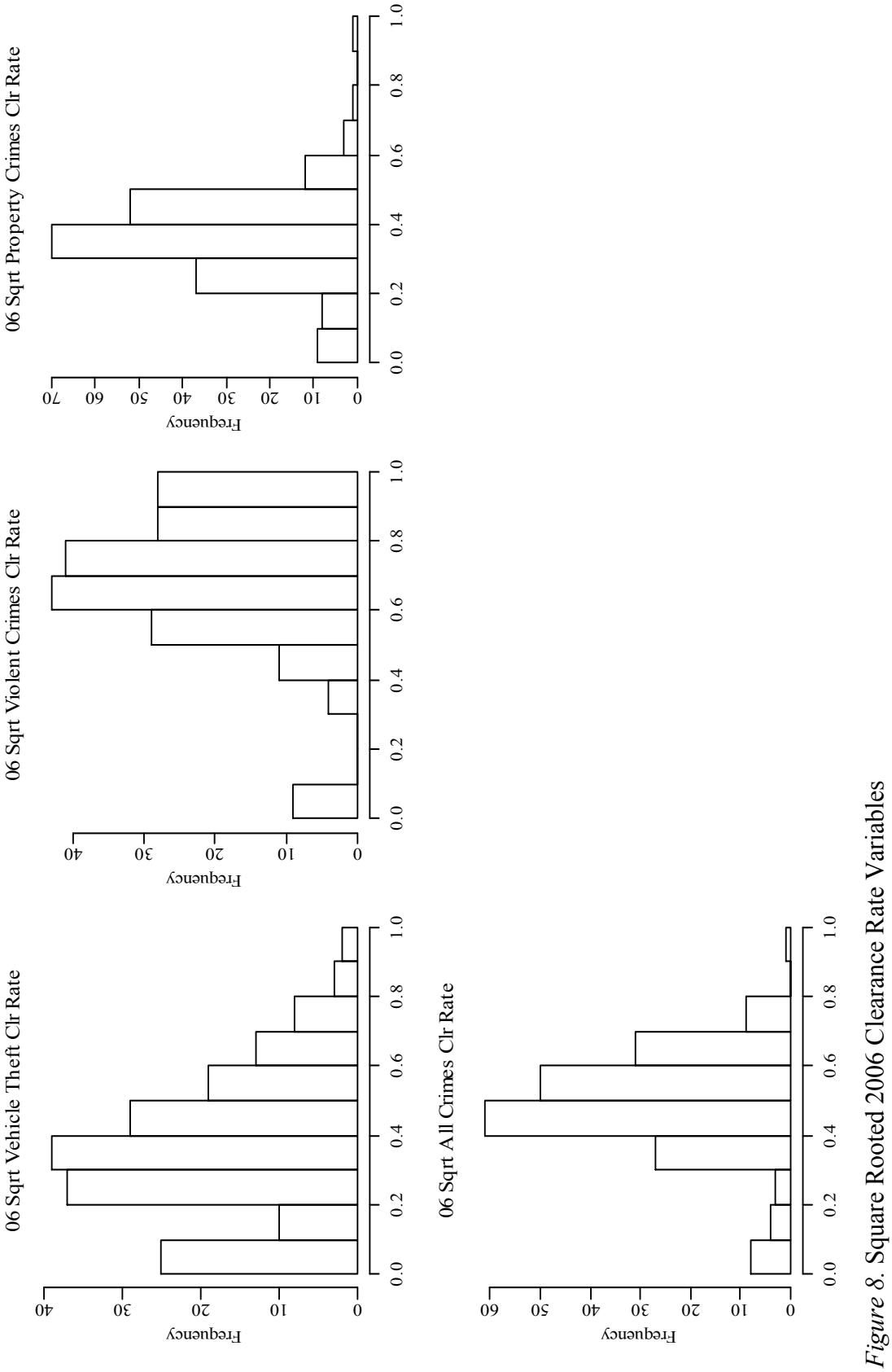


*Figure 8.* Square Rooted 2006 Clearance Rate Variables

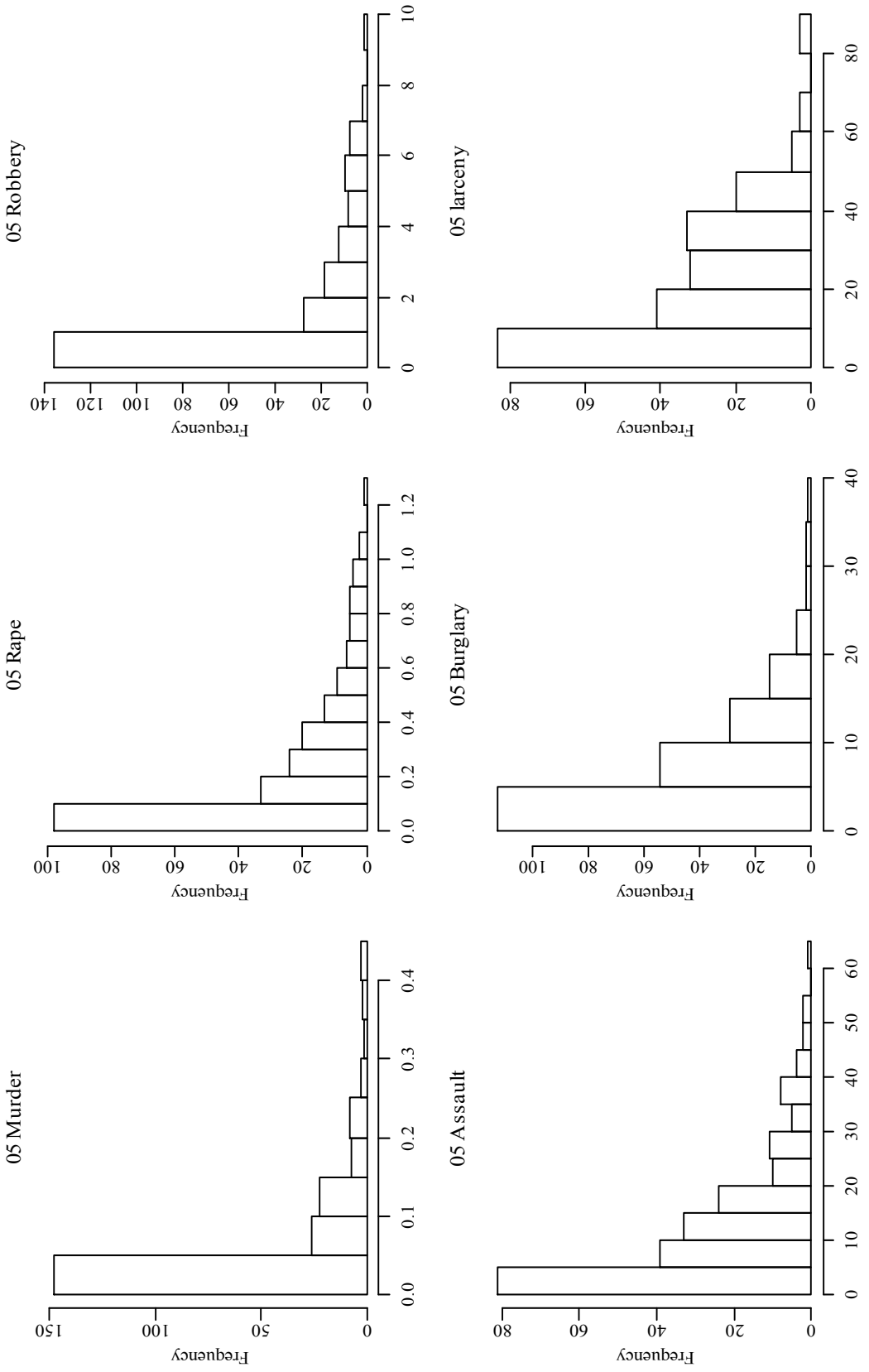


*Figure 9.* 2005 Crime Rate Variables

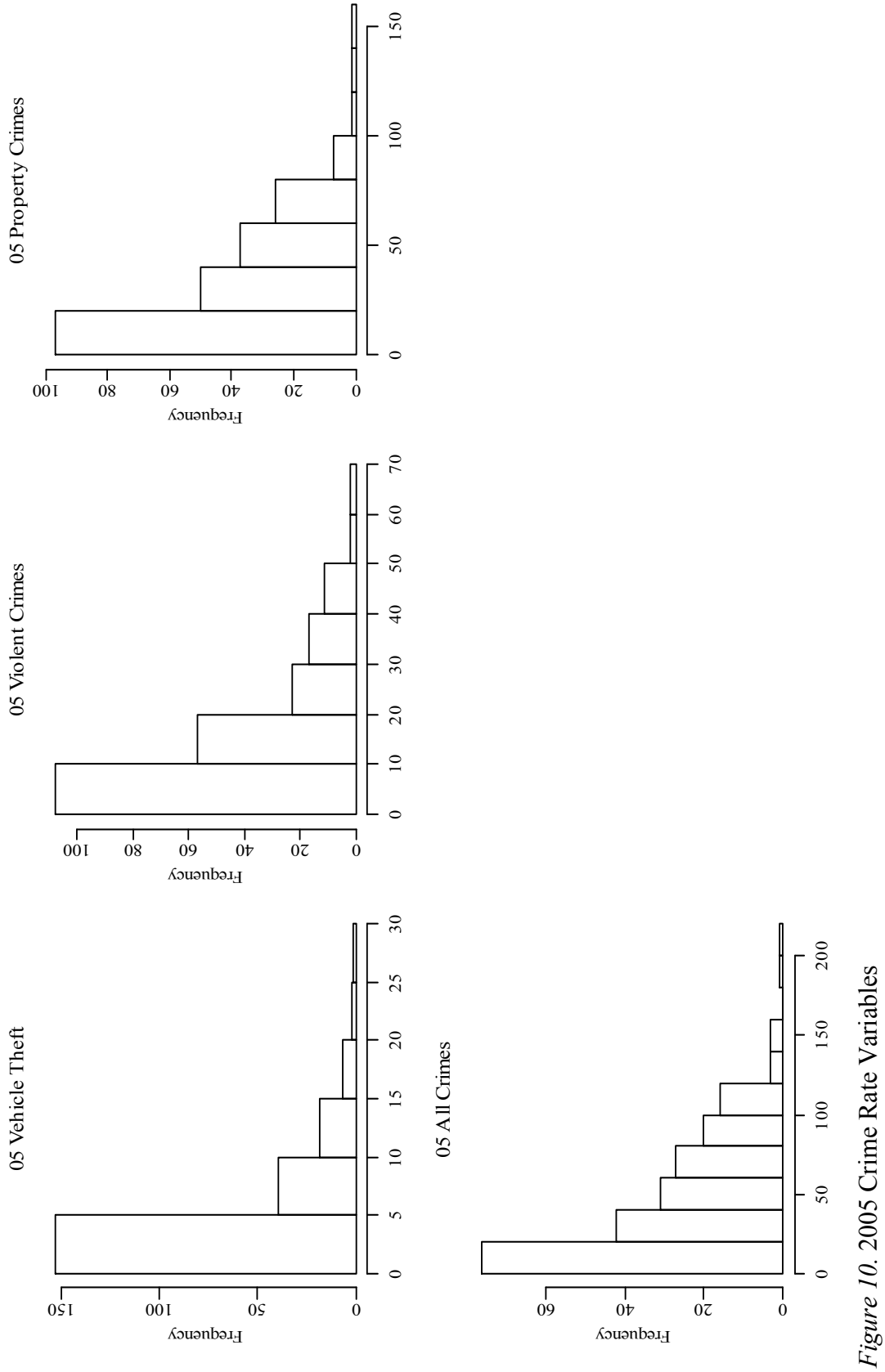


*Figure 10.* 2005 Crime Rate Variables

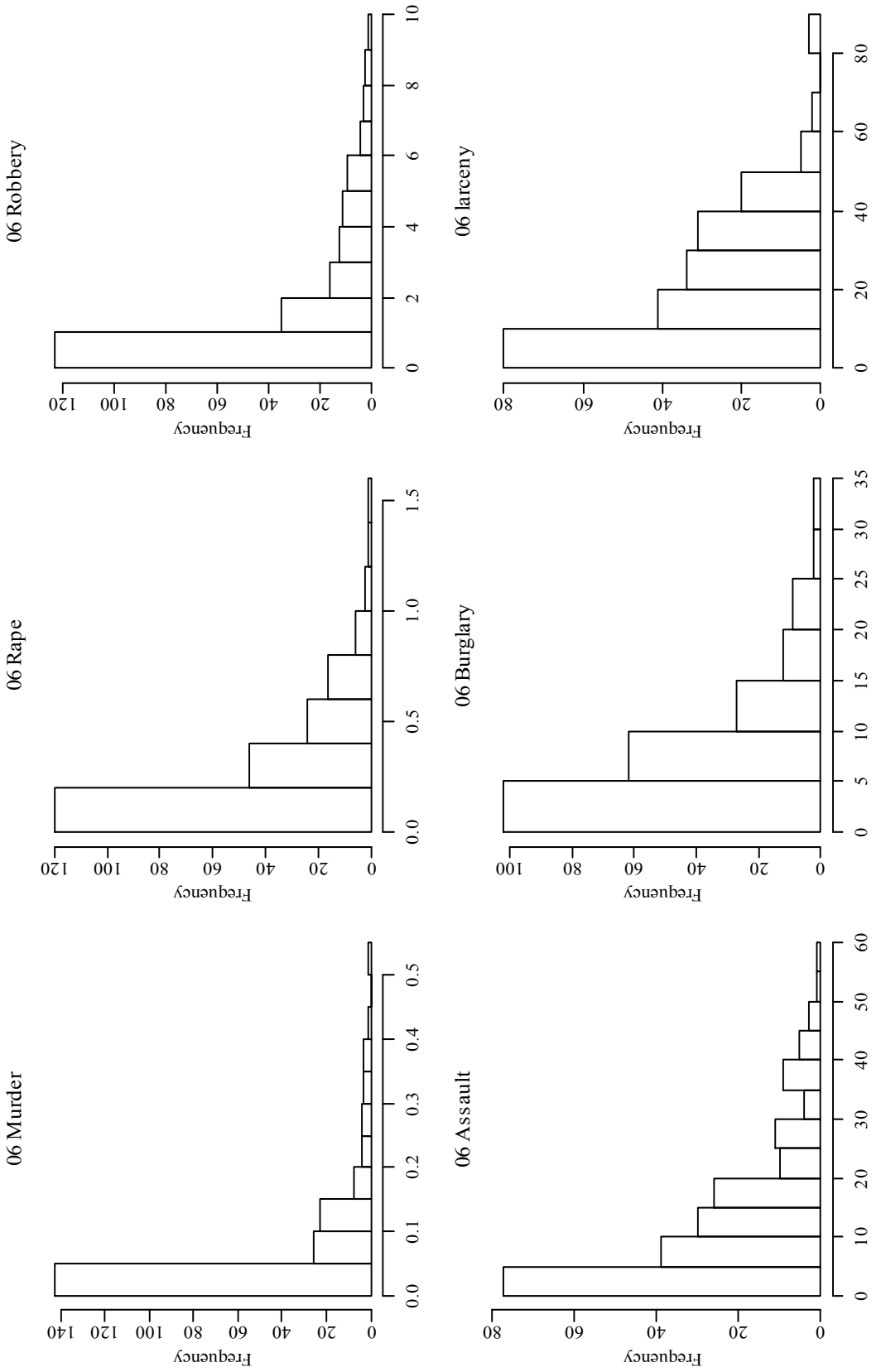


*Figure 11.* 2006 Crime Rate Variables

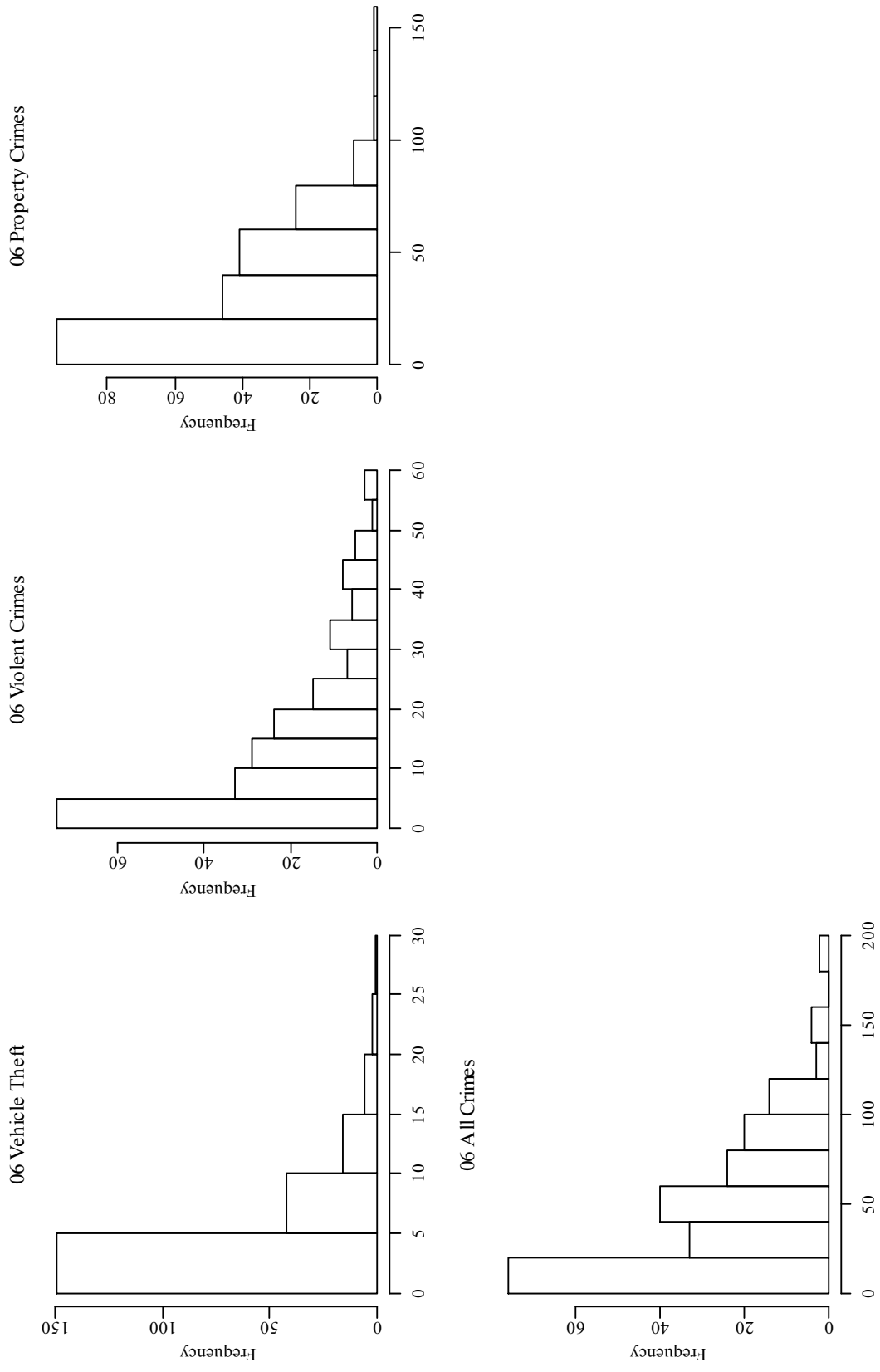


*Figure 12.* 2006 Crime Rate Variables

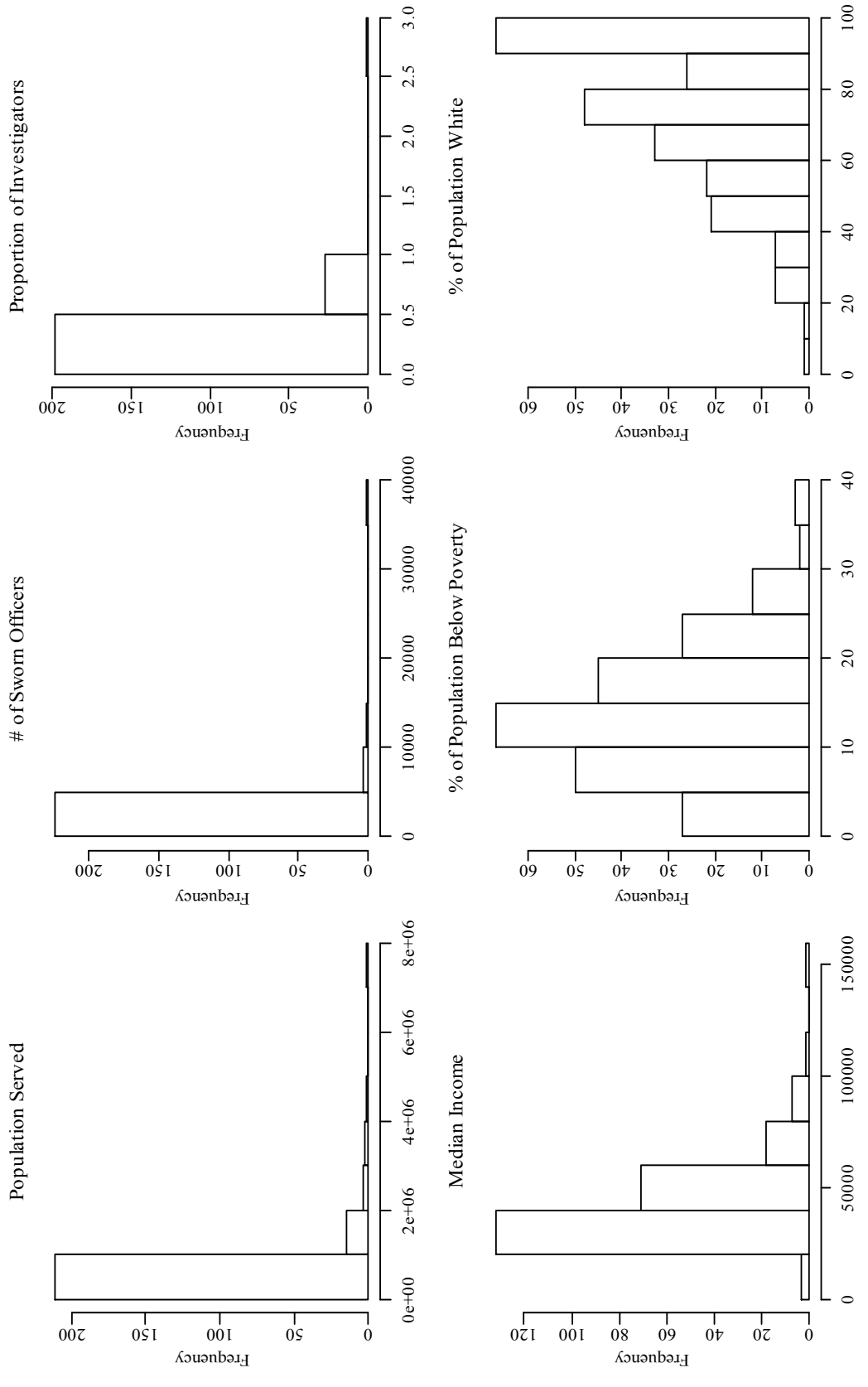


*Figure 13.* Control Variables

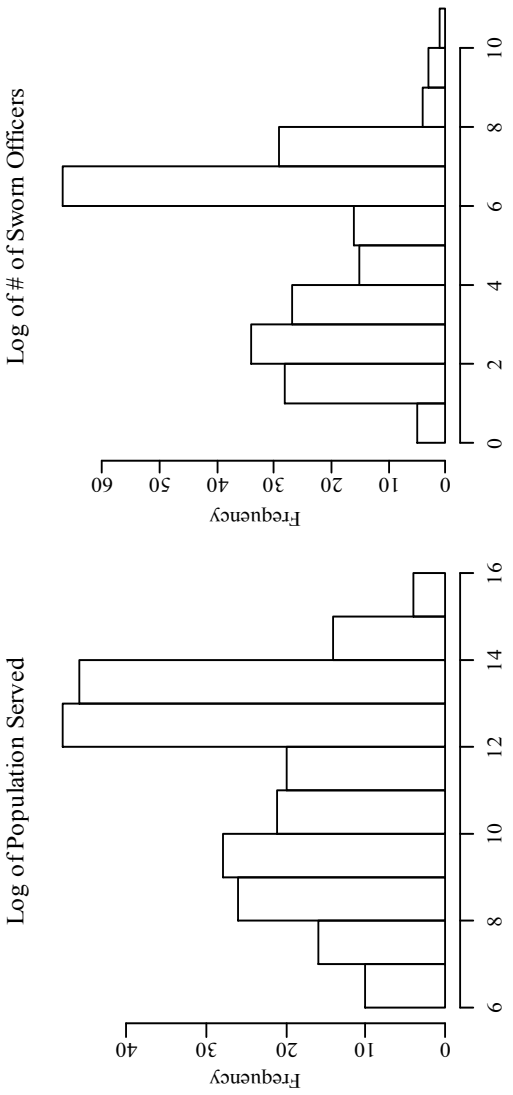


*Figure 14.* 2005 Logged Control Variables

APPENDIX F: CORRELATION ANALYSIS RESULTS

Table 1.
*Correlation Coefficients of Use of IT Scale and 2005 Square Rooted Clearance Rates*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crimes | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Use of IT | .013 | .176* | .017 | -.009 | .075 | .072 | -.090 | -.031 | .009 | -.009 |
| N | 111 | 137 | 147 | 171 | 170 | 173 | 166 | 171 | 173 | 173 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 2.
*Correlation Coefficients of Use of IT Scale and 2006 Square Rooted Clearance Rates*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crimes | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Use of IT | .031 | .252** | .202* | -.029 | .122 | .042 | -.078 | -.037 | .025 | -.031 |
| N | 109 | 135 | 147 | 167 | 168 | 168 | 162 | 168 | 169 | 169 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 3.
*Correlation Coefficients of Use of IT Scale and Six Control Variables*

| | Logged # of Officer | Logged Population | Median Income | % Below Poverty | % White | Prop. Of Invest. |
|---|---|---|---|---|---|---|
| Use of IT | 0.627** | 0.62** | 0.178* | -0.164* | -0.272** | -0.08 |
| N | 195 | 199 | 199 | 199 | 199 | 193 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 4.
*Correlation Coefficients of 2005 Square Rooted Clearance Rates and Six Control Variables*

| | Logged # of Officer | Logged Population | Median Income | % Below Poverty | % White | Prop. Of Invest. |
|---|---|---|---|---|---|---|
| Murder | -.028 | .019 | -.074 | -.072 | .188* | .021 |
| N | 126 | 127 | 127 | 127 | 127 | 124 |
| Rape | .195* | .132 | .059 | -.019 | -.055 | -.041 |
| N | 153 | 155 | 155 | 155 | 155 | 151 |
| Robbery | -.235** | -.212** | .109 | -.151 | .314** | .076 |
| N | 165 | 167 | 167 | 167 | 167 | 163 |
| Assault | -.137 | -.108 | .215** | -.185** | .244** | .083 |
| N | 195 | 197 | 197 | 197 | 197 | 193 |
| Burglary | -.188** | -.179* | .124 | -.129 | .184** | .324** |
| N | 194 | 196 | 196 | 196 | 196 | 192 |
| Larceny | -.040 | -.032 | .117 | -.137 | .161* | .123 |
| N | 197 | 199 | 199 | 199 | 199 | 194 |
| Vehicle Theft | -.245** | -.200** | .145* | -.211** | .294** | .150* |
| N | 188 | 190 | 190 | 190 | 190 | 186 |
| Violent Crimes | -.178* | -.149* | .216** | -.198** | .279** | .083 |
| N | 195 | 197 | 197 | 197 | 197 | 193 |
| Property Crimes | -.207** | -.194** | .140* | -.189** | .270** | .181* |
| N | 197 | 199 | 199 | 199 | 199 | 194 |
| All Crimes | -.161* | -.143* | .101 | -.155* | .243** | .138 |
| N | 197 | 199 | 199 | 199 | 199 | 194 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 5.
*Correlation Coefficients of 2006 Square Rooted Clearance Rates and Six Control Variables*

| | Logged # of Officer | Logged Population | Median Income | % Below Poverty | % White | Prop. Of Invest. |
|---|---|---|---|---|---|---|
| Murder | -.286** | -.182* | -.035 | -.124 | .338** | -.008 |
| N | 121 | 122 | 122 | 122 | 122 | 119 |
| Rape | .220** | .220** | .009 | .056 | -.086 | .108 |
| N | 150 | 152 | 152 | 152 | 152 | 147 |
| Robbery | .007 | .011 | .156* | -.148 | .267** | -.154 |
| N | 163 | 165 | 165 | 165 | 165 | 161 |
| Assault | -.189** | -.158* | .199** | -.216** | .273** | -.001 |
| N | 189 | 191 | 191 | 191 | 191 | 187 |
| Burglary | -.025 | -.005 | .182* | -.115 | .100 | .012 |
| N | 189 | 191 | 191 | 191 | 191 | 187 |
| Larceny | -.057 | -.044 | .054 | -.082 | .153* | .048 |
| N | 190 | 192 | 192 | 192 | 192 | 187 |
| Vehicle Theft | -.228** | -.172* | -.001 | -.118 | .277** | .091 |
| N | 183 | 185 | 185 | 185 | 185 | 181 |
| Violent Crimes | -.159* | -.130 | .223** | -.254** | .320** | .015 |
| N | 191 | 193 | 193 | 193 | 193 | 188 |
| Property Crimes | -.087 | -.071 | .077 | -.119 | .212** | .036 |
| N | 191 | 193 | 193 | 193 | 193 | 188 |
| All Crimes | -.054 | -.036 | .054 | -.132 | .239** | .007 |
| N | 192 | 194 | 194 | 194 | 194 | 189 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 6.
*Correlation Coefficients of 2005-2006 Crime Rates and use of IT scale*

| | 2005 | 2006 |
|---|---|---|
| | Use of IT | Use of IT |
| Murder | .271** | .264** |
| N | 189 | 186 |
| Rape | .205** | .114 |
| N | 189 | 186 |
| Robbery | .251** | .261** |
| N | 189 | 186 |
| Assault | .130 | .135 |
| N | 189 | 186 |
| Burglary | .108 | .135 |
| N | 189 | 186 |
| Larceny | .139 | .138 |
| N | 189 | 186 |
| Vehicle Theft | .297** | .289** |
| N | 189 | 186 |
| Violent | .155* | .161* |
| N | 189 | 186 |
| Property | .169* | .175* |
| N | 189 | 186 |
| All Crimes | .170* | .176* |
| N | 189 | 186 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

APPENDIX G: MODERATE AND HIGH IT DEPARTMENT COMPARISON

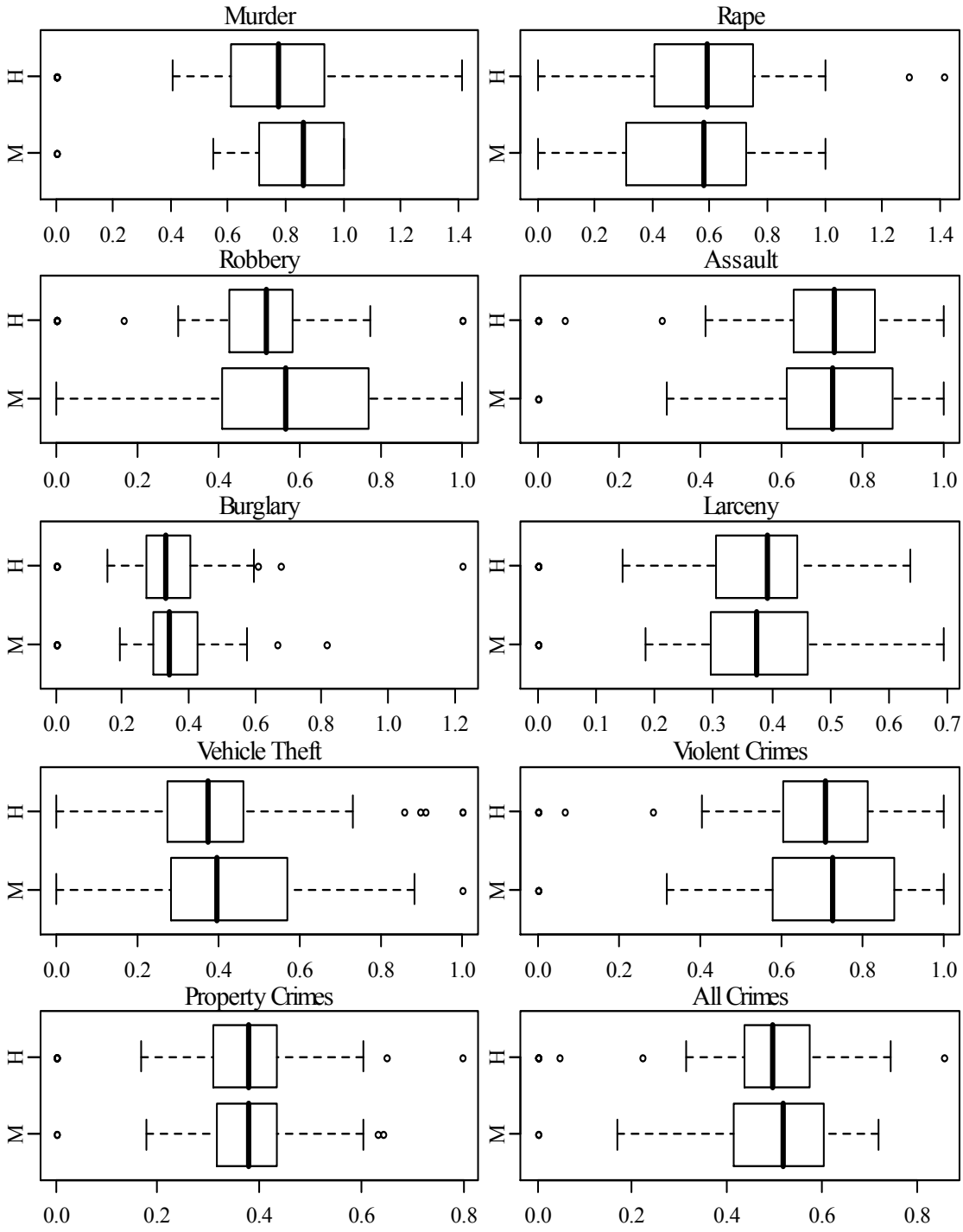


*Figure 1.* Box plot comparison of 2005 square rooted clearance rates between low and high IT departments

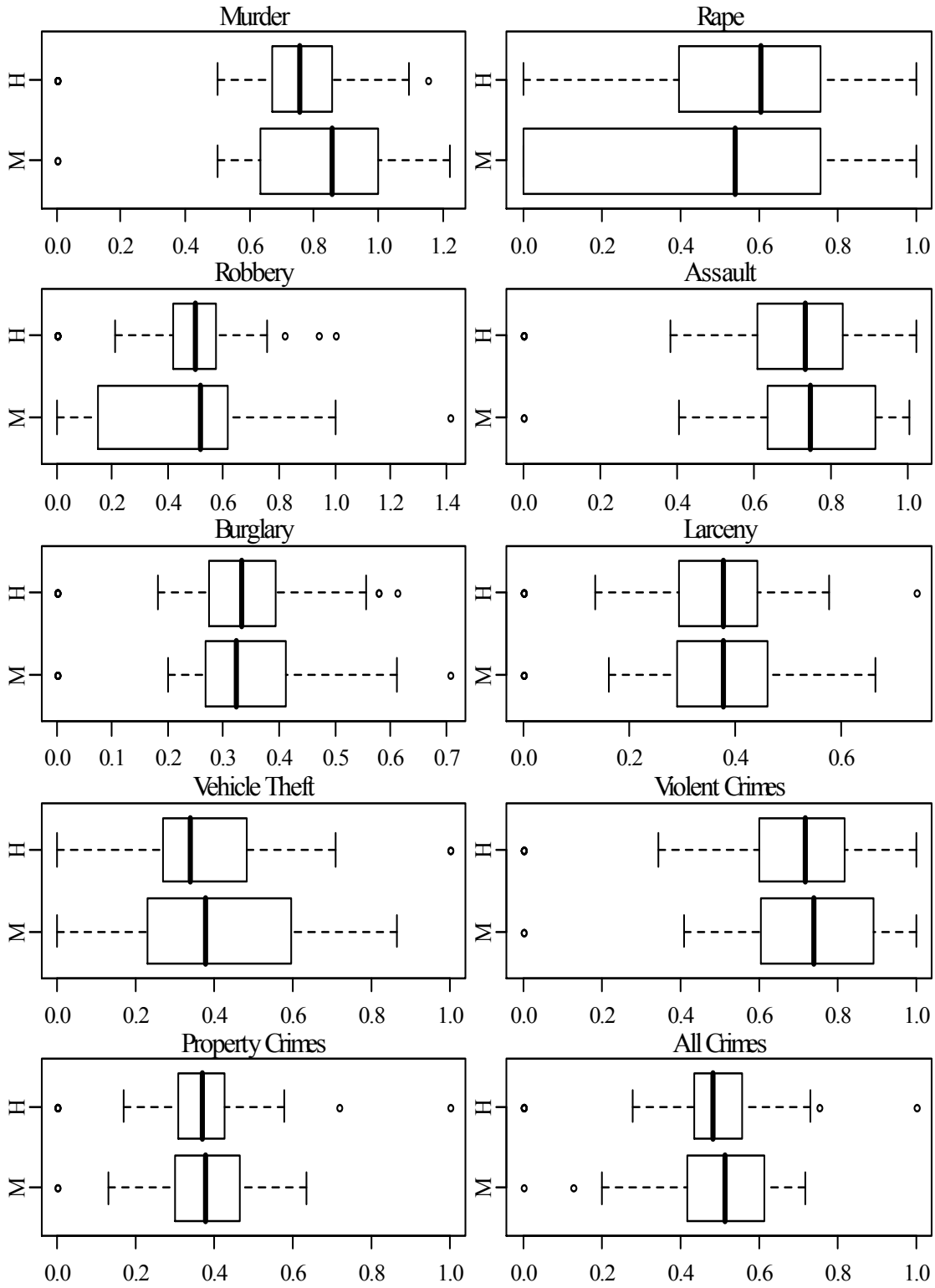


*Figure 2.* Box plot comparison of 2006 square rooted clearance rates between low and high IT departments

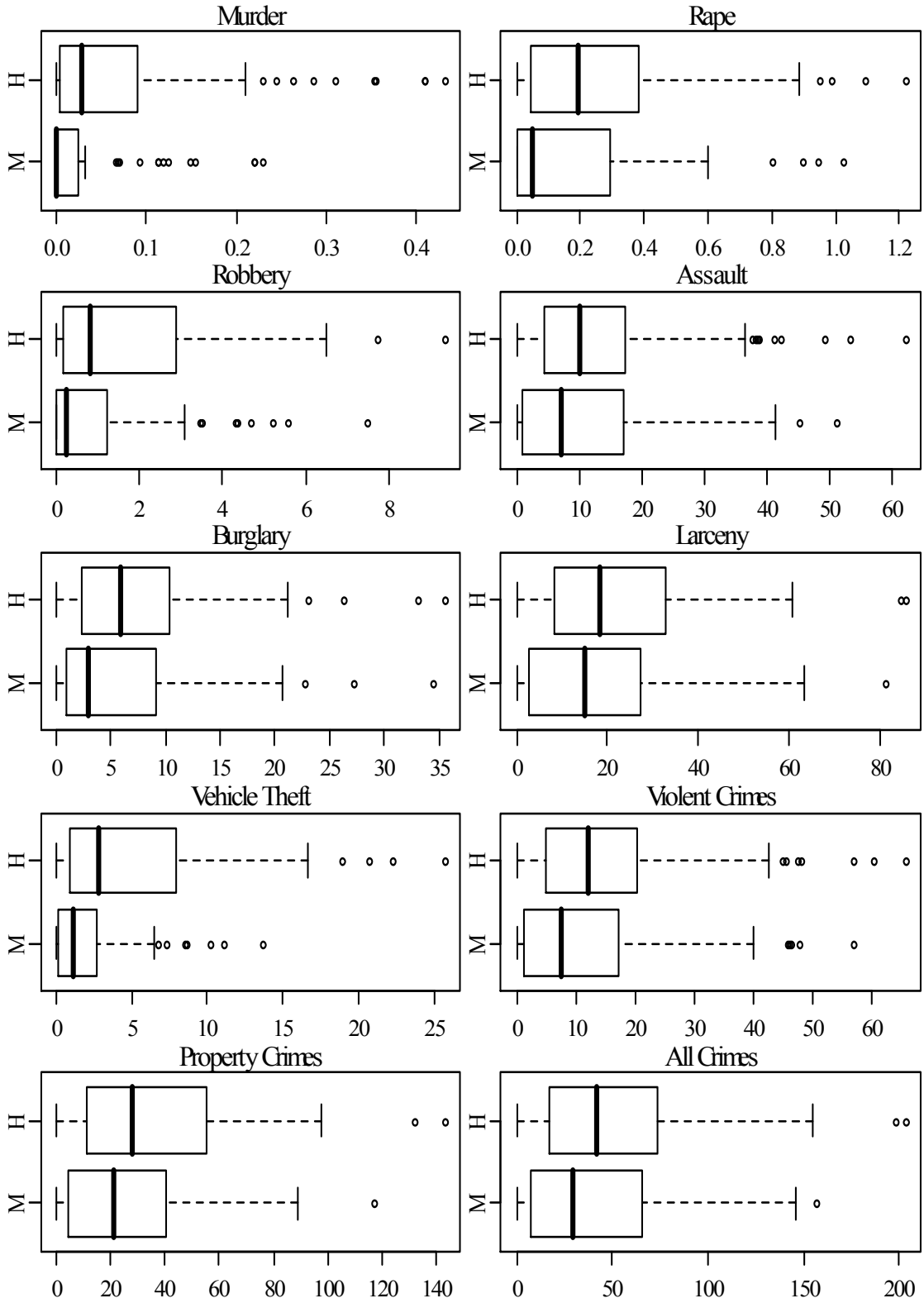


*Figure 3.* Box plot comparison of 2005 crime rates between low and high IT departments

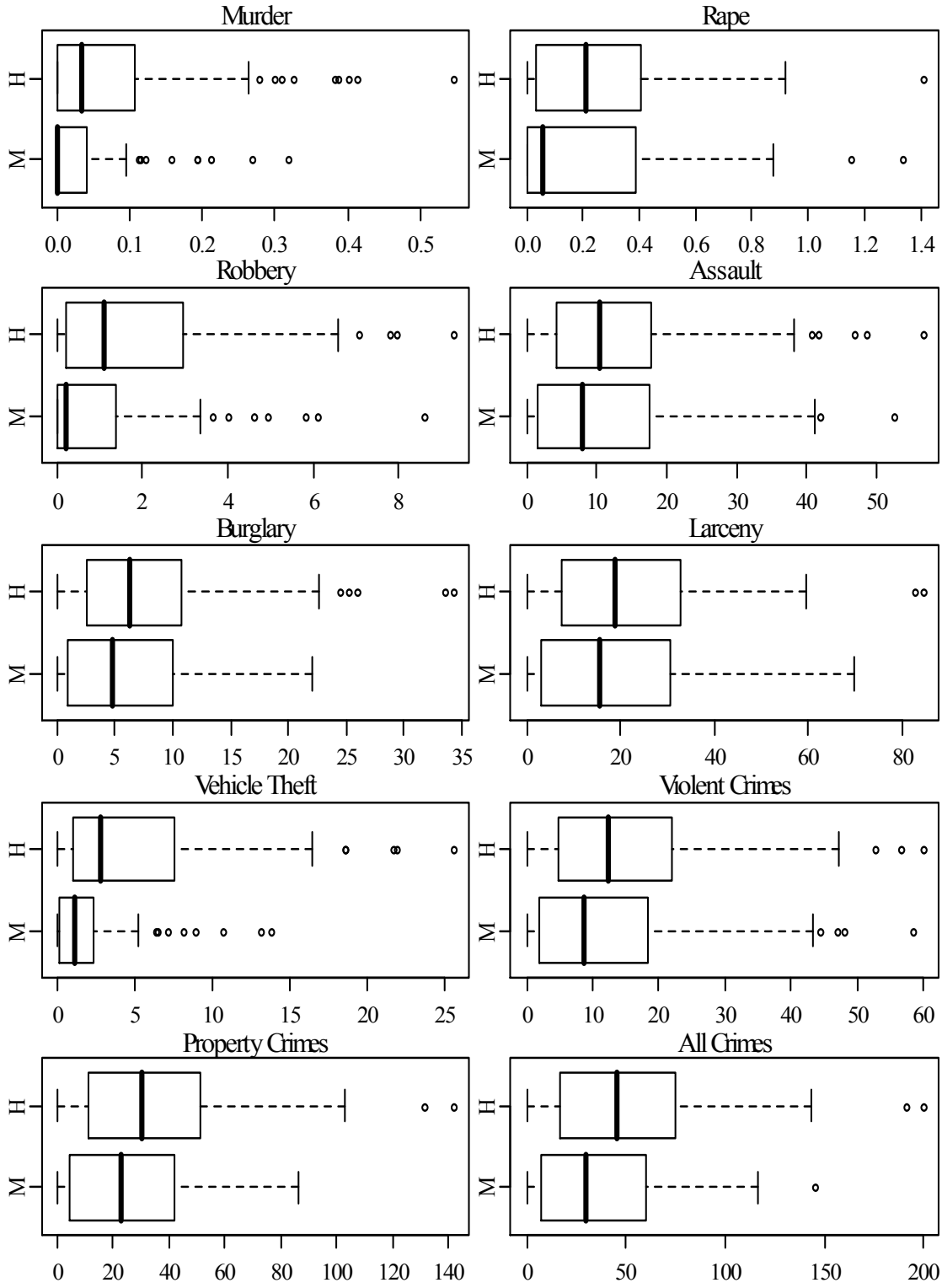


*Figure 4.* Box plot comparison of 2005 crime rates between low and high IT departments

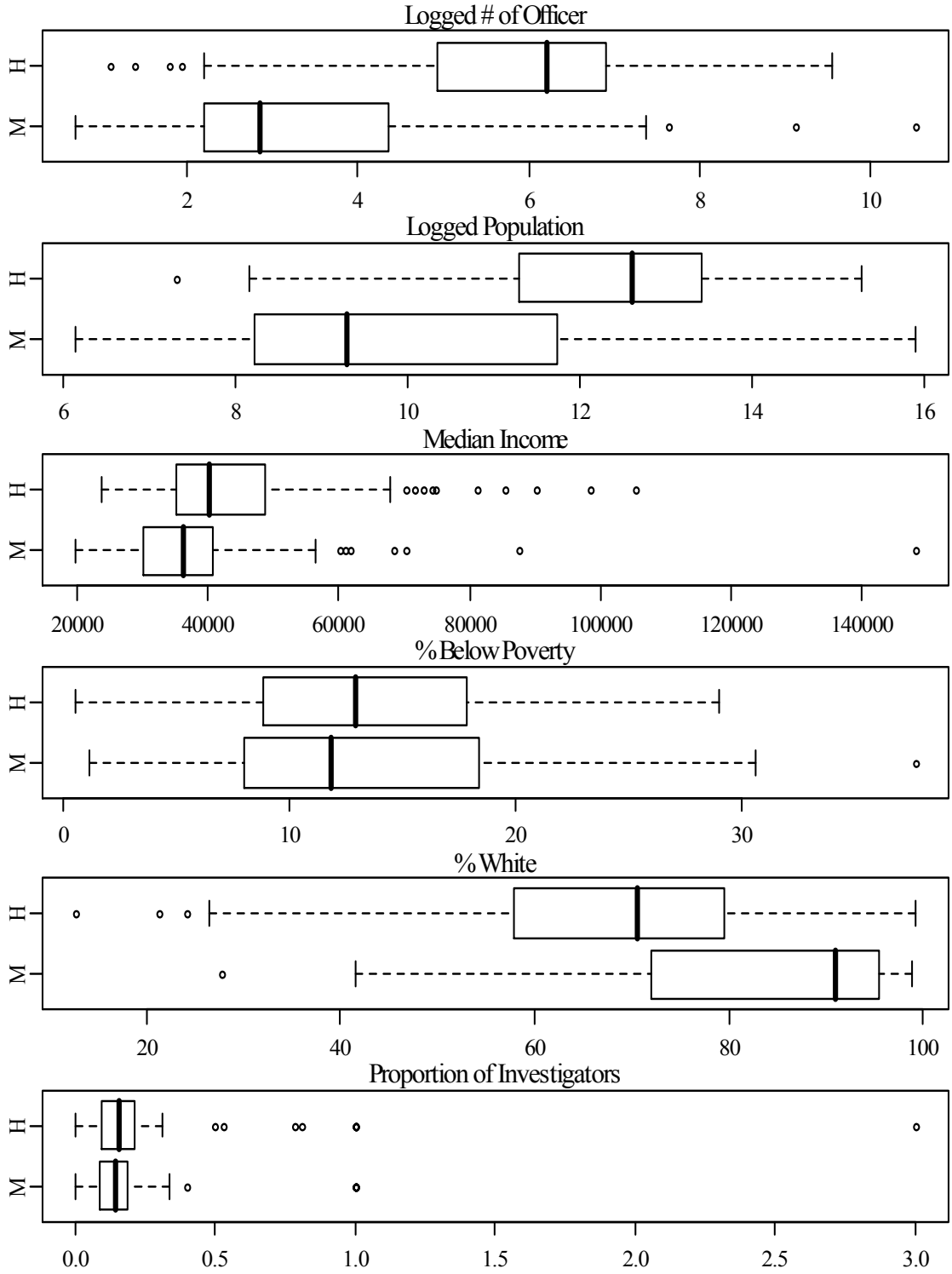


*Figure 5.* Box plot comparison of six control variables between low and high IT departments

# APPENDIX H: DECILES OF USE OF IT SCALE

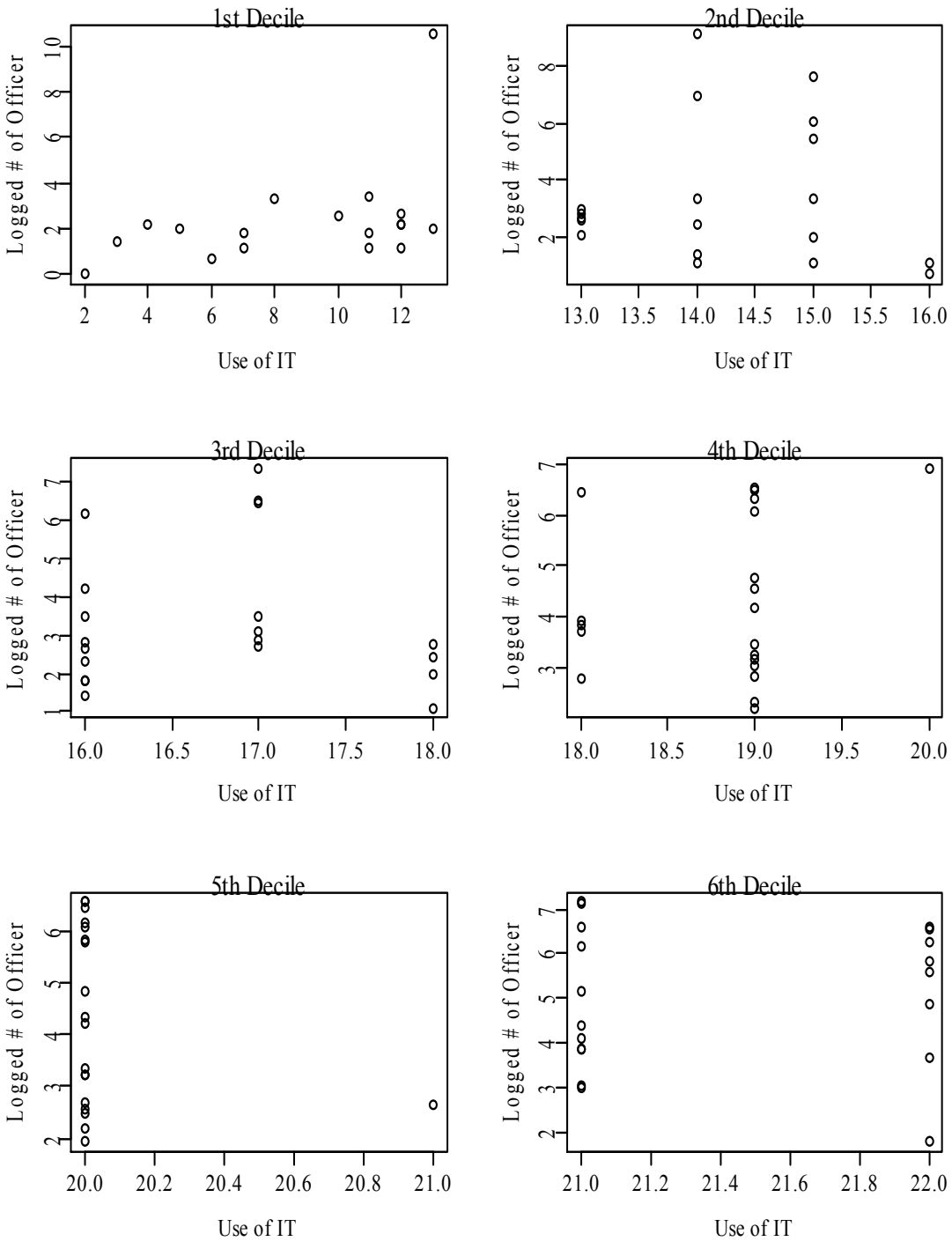


*Figure 1.* Scatter plots of logged number of officer and use of IT scale variable (1-6)

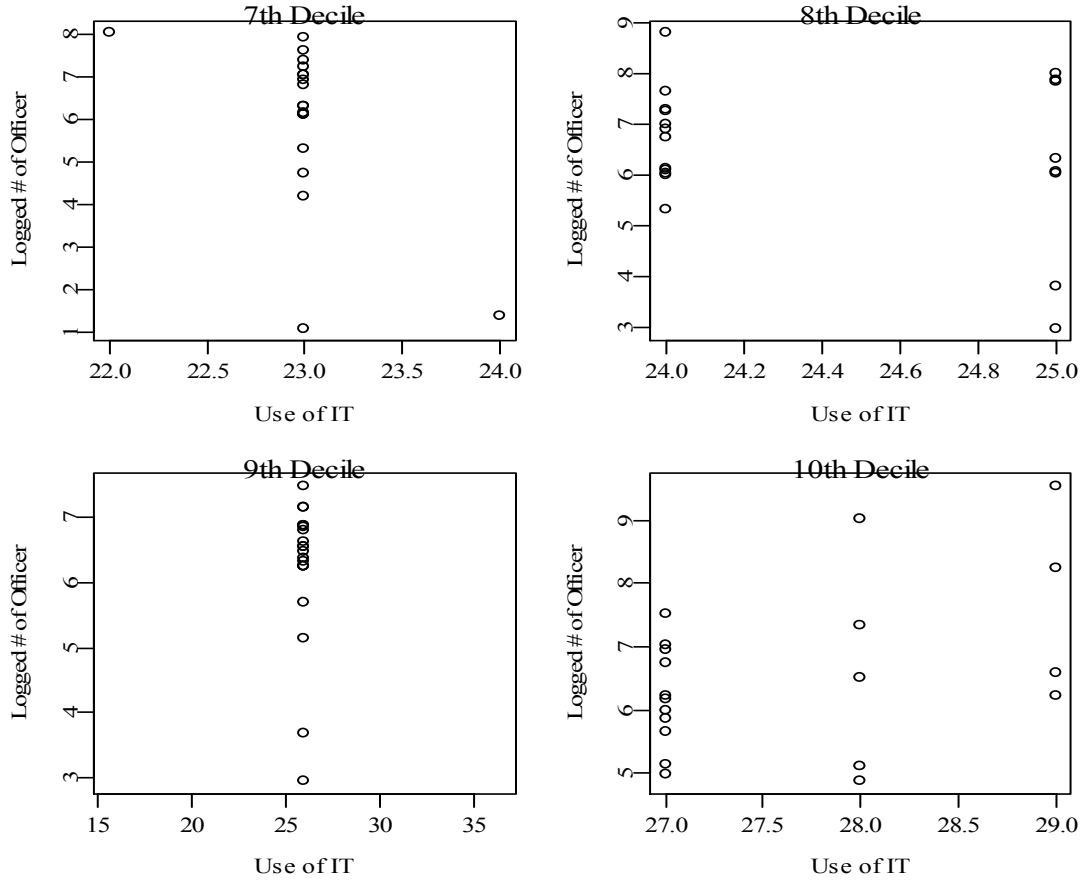


*Figure 2.* Scatter plots of logged number of officer and use of IT scale variable (7-10)

APPENDIX I: TEN GROUPS OF LOGGED NUMBER OF OFFICERS

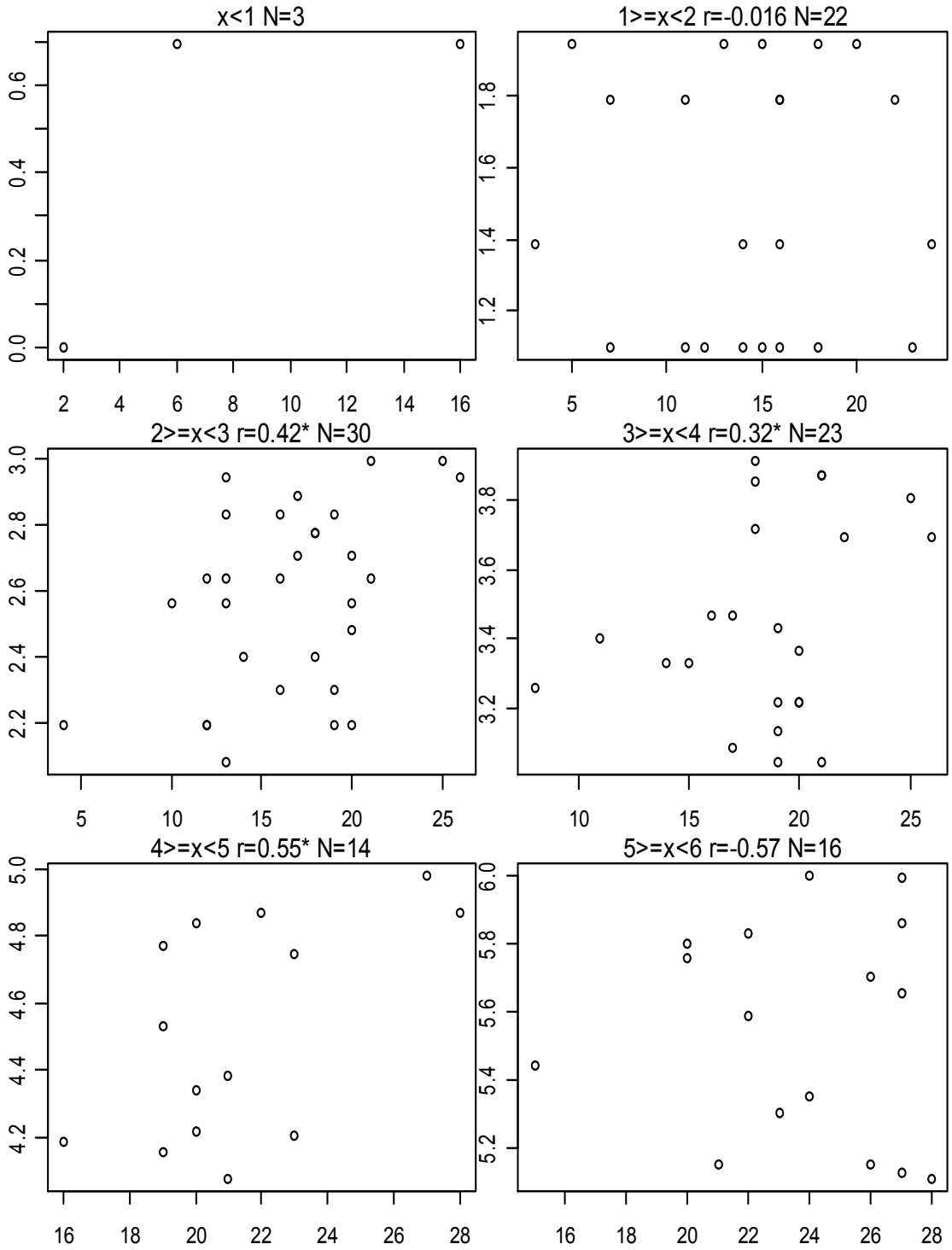


*Figure 1.* Correlations and scatterplots of number of officer and use of IT variables (1-6)

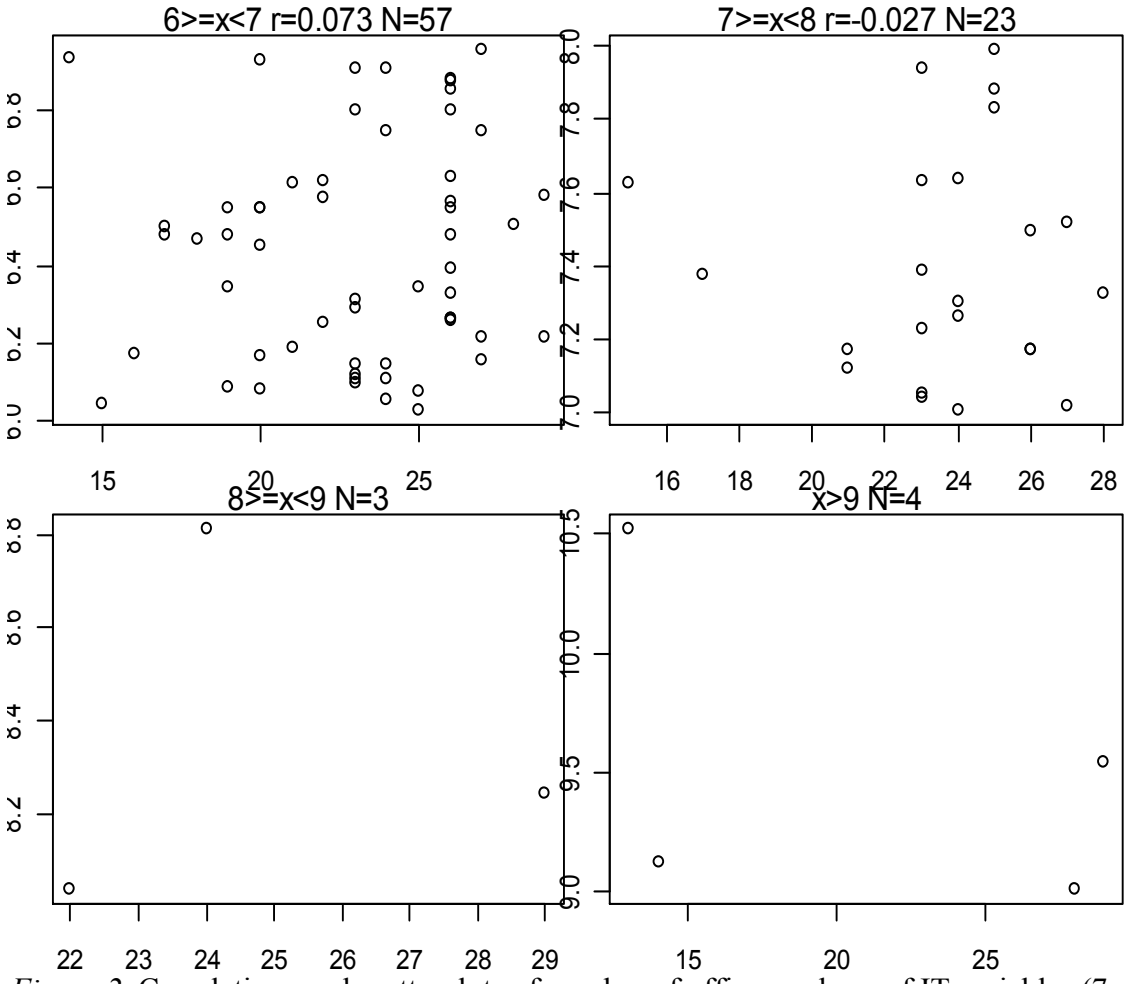


*Figure 2.* Correlations and scatterplots of number of officer and use of IT variables (7-10)

APPENDIX J: REGRESSION ANALYSIS RESULTS

TABLE 1
*Reduced Model Fitted to 2005 Data*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Thef | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 0.769 | 0.245 | 0.527 | 0.715 | 0.293 | 0.324 | 0.484 | 0.719 | 0.368 | 0.497 |
| Use of IT | 0.002 | 0.007 | 0.008 | 0.005 | 0.008** | 0.005 | 0.004 | 0.005 | 0.006** | 0.005 |
| Log of # Officer | -0.015 | 0.025 | -0.035* | -0.024* | -0.024*** | -0.012 | -0.035* | -0.028** | -0.025 | -0.021* |
| F | 0.252 | 3.119* | 3.686* | 3.133* | 6.602** | 2.230 | 7.397*** | 4.313 | 9.634*** | 5.132** |
| DF Reg | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| DF Res | 107 | 132 | 142 | 3 | 165 | 168 | 161 | 166 | 168 | 168 |
| R | -0.014 | 0.031 | 0.036 | 0.025 | 0.063 | 0.014 | 0.073 | 0.038 | 0.092 | 0.046 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

TABLE 2
*Complex Model Fitted to 2005 Data*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 0.008 | -0.177 | -0.054 | 0.239 | 0.036 | 0 | 0.134 | 0.244 | 0.06 | 0.202 |
| Use of IT | 0.004 | 0.009 | 0.008 | 0.003 | 0.006* | 0.003 | 0.003 | 0.003 | 0.005* | 0.003 |
| Log of # Officer | 0.011 | 0.026 | -0.016 | -0.006 | -0.008 | 0.005 | -0.013 | -0.01 | -0.008 | -0.003 |
| Median Income | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| % Below Poverty | 0.007 | 0.007 | 0.007 | 0.002 | 0.002 | 0.001 | 0.003 | 0.002 | 0.002 | 0 |
| % White | 0.007* | 0.002 | 0.004* | 0.003* | 0.002** | 0.002* | 0.002 | 0.003* | 0.002** | 0.002* |
| Prop. of Invest. | 0.076 | -0.004 | 0.12 | 0.063 | 0.184 | 0.086* | 0.096 | 0.06 | 0.09** | 0.091* |
| Crime Rate | 0.126 | 0.009 | -0.004 | 0.003* | 0.001 | 0.001 | -0.006 | 0.002 | 0 | 0 |
| F | 1.429 | 1.040 | 2.352* | 3.457** | 6.607 | 3.34** | 4.306*** | 3.876*** | 5.696*** | 3.644** |
| DF Reg | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| DF Res | 101 | 126 | 136 | 160 | 159 | 161 | 155 | 160 | 161 | 161 |
| R | 0.027 | 0.002 | 0.062 | 0.093 | 0.191 | 0.089 | 0.125 | 0.108 | 0.164 | 0.099 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

TABLE 3
*Reduced Model Fitted to 2006 Data*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 0.962 | 0.159 | 0.259 | 0.748 | 0.257 | 0.339 | 0.455 | 0.737 | 0.354 | 0.514 |
| Use of IT | 0.007 | 0.011 | 0.015** | 0.008* | 0.006* | 0.004 | 0.005 | 0.007 | 0.004 | 0.003 |
| Log of # Officer | -0.06** | 0.023 | -0.023 | -0.038*** | -0.01 | -0.012 | -0.036*** | -0.038*** | -0.014* | -0.016* |
| F | 5.641** | 5.369** | 4.667* | 8.302*** | 2.489 | 2.048 | 7.371 | 9.03*** | 2.670 | 2.860 |
| DF Reg | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| DF Res | 105 | 130 | 142 | 162 | 163 | 163 | 157 | 163 | 164 | 164 |
| R | 0.080 | 0.062 | 0.048 | 0.082 | 0.018 | 0.013 | 0.074 | 0.089 | 0.020 | 0.022 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

TABLE 4
*Reduced Model Fitted to 2006 Data*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 0.603 | 0.379 | -0.555 | 0.461 | 0.008 | 0.09 | 0.416 | 0.422 | 0.161 | 0.313 |
| Use of IT | 0.006 | 0.012 | 0.018*** | 0.006 | 0.005 | 0.003 | 0.002 | 0.006 | 0.003 | 0.002 |
| Log of # Officer | -0.032 | 0.025 | -0.02 | -0.025* | -0.003 | 0.001 | -0.01 | -0.028* | -0.006 | -0.006 |
| Median Income | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| % Beci Poverty | 0 | -0.006 | 0.01 | -0.001 | 0.003 | 0 | -0.005 | -0.001 | 0 | -0.001 |
| % White | 0.004 | 0 | 0.006*** | 0.002 | 0.001 | 0.002* | 0.002 | 0.003* | 0.002* | 0.002* |
| Prop. of Invest. | -0.023 | 0.164 | -0.19* | 0.002 | 0.007 | 0.04 | 0.119* | 0 | 0.027 | 0.016 |
| Crime Rate | -0.045 | 0.007 | 0.02 | 0.004** | 0 | 0.002** | -0.006 | 0.003* | 0.001* | 0.001** |
| F | 2.726* | 2.081 | 4.558*** | 4.65*** | 1.889 | 2.505* | 4.371*** | 5.552*** | 3.161** | 3.098** |
| DF Reg | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| DF Res | 99 | 123 | 136 | 156 | 157 | 156 | 151 | 156 | 157 | 157 |
| R | 0.102 | 0.055 | 0.148 | 0.136 | 0.037 | 0.061 | 0.130 | 0.164 | 0.084 | 0.082 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

APPENDIX K REGRESSION ANALYSIS OF MODERATE/HIGH IT GROUPS

Table 1
*2005 Moderate IT Reduced Model*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 0.272 | -0.050 | 0.303 | 0.477 | 0.249 | 0.251 | 0.267 | 0.478 | 0.287 | 0.367 |
| Use of IT | 0.035 | 0.022 | 0.025 | 0.019 | 0.010 | 0.010 | 0.014 | 0.019 | 0.010 | 0.012 |
| Log of # Officer | -0.021 | 0.040 | -0.035 | -0.019 | -0.016 | -0.008 | -0.019 | -0.022 | -0.015 | -0.013 |
| F | 0.704 | 1.931 | 1.687 | 1.709 | 1.539 | 0.823 | 1.016 | 1.968 | 2.088 | 1.651 |
| DF Reg | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| DF Res | 16 | 32 | 38 | 51 | 50 | 51 | 48 | 51 | 51 | 51 |
| R | -0.034 | 0.052 | 0.033 | 0.026 | 0.020 | -0.007 | 0.001 | 0.035 | 0.039 | 0.024 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 2
*2005 Moderate IT Complex Model*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | -1.911 | 1.160 | 0.877 | -0.044 | 0.093 | 0.056 | -1.008 | 0.007 | 0.013 | 0.116 |
| Use of IT | 0.049 | 0.006 | 0.027 | 0.021 | 0.019 | 0.014 | 0.032* | 0.021 | 0.016 | 0.017 |
| Log of # Officer | 0.047 | 0.043 | -0.012 | -0.010 | -0.024 | -0.002 | -0.007 | -0.016 | -0.013 | -0.010 |
| Median Income | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| % Below Poverty | 0.009 | -0.016 | -0.009 | 0.006 | 0.005 | 0.000 | 0.031** | 0.005 | 0.004 | 0.003 |
| % White | 0.014 | 0.000 | -0.001 | 0.002 | -0.001 | 0.000 | 0.004 | 0.002 | 0.000 | 0.001 |
| Prop. of Invest. | 0.438 | -0.433 | 0.174 | 0.146 | 0.110 | 0.203 | 0.017 | 0.133 | 0.114 | 0.136 |
| Crime Rate | 1.994 | -0.120 | -0.043 | 0.002 | -0.003 | 0.000 | -0.036* | 0.002 | -0.001 | 0.000 |
| F | 0.453 | 1.188 | 0.940 | 0.998 | 0.941 | 1.039 | 2.162 | 0.987 | 1.197 | 0.775 |
| DF Reg | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| DF Res | 10 | 26 | 32 | 45 | 44 | 45 | 42 | 45 | 45 | 45 |
| R | -0.291 | 0.038 | -0.011 | 0.000 | -0.008 | 0.005 | 0.142 | -0.002 | 0.026 | -0.031 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 3
*2006 Moderate IT Reduced Model*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | -0.304 | -0.140 | -0.260 | 0.548 | 0.378 | 0.160 | 0.512 | 0.494 | 0.284 | 0.369 |
| Use of IT | 0.077** | 0.029 | 0.049* | 0.021 | -0.001 | 0.015 | -0.001 | 0.023 | 0.009 | 0.013 |
| Log of # Officer | -0.036 | 0.037 | -0.014 | -0.036** | -0.007 | -0.009 | -0.027 | -0.038** | -0.013 | -0.017 |
| F | 7.44** | 1.933 | 3.417* | 4.797* | 0.254 | 2.031 | 1.402 | 5.763** | 1.583 | 2.437 |
| DF Reg | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| DF Res | 19 | 35 | 40 | 51 | 51 | 51 | 49 | 51 | 51 | 51 |
| R | 0.380 | 0.048 | 0.103 | 0.125 | -0.029 | 0.037 | 0.016 | 0.152 | 0.022 | 0.051 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 4
*2006 Moderate IT Complex Model*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | -0.712 | -0.239 | -0.536 | 0.609 | 0.329 | 0.074 | 0.284 | 0.511 | 0.243 | 0.339 |
| Use of IT | 0.070 | 0.030 | 0.041 | 0.017 | -0.001 | 0.013 | 0.001 | 0.020 | 0.007 | 0.011 |
| Log of # Officer | 0.016 | 0.062 | -0.014 | -0.036 | -0.004 | -0.003 | -0.011 | -0.038 | -0.007 | -0.012 |
| Median Income | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| % Below Poverty | -0.003 | -0.006 | 0.002 | -0.003 | 0.000 | -0.002 | 0.006 | -0.003 | -0.002 | -0.002 |
| % White | 0.008 | 0.002 | 0.003 | -0.001 | -0.001 | 0.001 | 0.003 | 0.000 | 0.000 | 0.000 |
| Prop. of Invest. | 0.373 | 0.605 | -0.276 | 0.060 | 0.055 | 0.070 | -0.043 | 0.059 | 0.082 | 0.074 |
| Crime Rate | -0.012 | 0.099 | 0.016 | 0.002 | -0.003 | 0.001 | -0.014 | 0.001 | 0.000 | 0.000 |
| F | 2.226 | 1.665 | 1.535 | 1.399 | 1.719 | 0.827 | 1.010 | 1.705 | 0.827 | 0.724 |
| DF Reg | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| DF Res | 13 | 29 | 34 | 45 | 45 | 45 | 43 | 45 | 45 | 45 |
| R | 0.300 | 0.115 | 0.084 | 0.051 | 0.088 | -0.024 | 0.001 | 0.087 | -0.024 | -0.039 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 5
*2005 High IT Reduced Model*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 0.819 | 0.361 | 0.705 | 0.782 | 0.298 | 0.376 | 0.465 | 0.805 | 0.427 | 0.549 |
| Use of IT | -0.003 | 0.005 | -0.001 | 0.003 | 0.009 | 0.003 | 0.009 | 0.002 | 0.005 | 0.004 |
| Log of # Officer | -0.004 | 0.014 | -0.032* | -0.026 | -0.031** | -0.016 | -0.049*** | -0.03* | -0.032*** | -0.027** |
| F | 0.051 | 0.440 | 2.616 | 2.036 | 5.141** | 1.652 | 9.14*** | 2.921 | 8.896*** | 4.450* |
| DF Reg | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| DF Res | 88 | 96 | 99 | 108 | 108 | 110 | 107 | 108 | 110 | 110 |
| R | -0.022 | -0.012 | 0.031 | 0.018 | 0.070 | 0.012 | 0.130 | 0.034 | 0.124 | 0.058 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 6
*2005 High IT Complex Model*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | -0.023 | -0.499 | -0.032 | 0.419 | 0.137 | 0.168 | 0.611 | 0.442 | 0.286 | 0.398 |
| Use of IT | -0.007 | 0.007 | -0.003 | 0.000 | 0.004 | -0.002 | 0.002 | -0.002 | 0.000 | -0.002 |
| Log of # Officer | 0.024 | 0.020 | -0.015 | -0.003 | -0.006 | 0.004 | -0.021 | -0.007 | -0.010 | -0.003 |
| Median Income | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| % Below Poverty | 0.015 | 0.016 | 0.009 | -0.002 | -0.002 | 0.000 | -0.012* | -0.002 | -0.002 | -0.002 |
| % White | 0.008 | 0.003 | 0.005*** | 0.003* | 0.002* | 0.003** | 0.001 | 0.003* | 0.002* | 0.003** |
| Prop. of Invest. | 0.057 | 0.162 | 0.118 | 0.057 | 0.215*** | 0.085* | 0.122* | 0.057 | 0.099** | 0.091* |
| Crime Rate | -0.026 | -0.035 | 0.008 | 0.003 | 0.001 | 0.001 | -0.003 | 0.003* | 0.000 | 0.000 |
| F | 1.477 | 0.870 | 3.911*** | 2.928** | 7.716*** | 3.096** | 6.873*** | 3.495** | 6.129*** | 3.675** |
| DF Reg | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| DF Res | 83 | 91 | 94 | 103 | 103 | 104 | 102 | 103 | 104 | 104 |
| R | 0.036 | -0.009 | 0.168 | 0.109 | 0.299 | 0.117 | 0.274 | 0.137 | 0.244 | 0.144 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 7
*2006 High IT Reduced Model*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 0.860 | 0.109 | 0.354 | 0.786 | 0.214 | 0.354 | 0.588 | 0.813 | 0.451 | 0.577 |
| Use of IT | 0.011 | 0.015 | 0.011 | 0.006 | 0.008 | 0.003 | 0.003 | 0.003 | 0.000 | -0.001 |
| Log of # Officer | -0.063* | 0.013 | -0.024 | -0.037** | -0.015 | -0.013 | -0.048*** | -0.036** | -0.013 | -0.013 |
| F | 3.246* | 1.484 | 1.476 | 3.848* | 1.920 | 1.136 | 9.659*** | 4.012* | 1.513 | 1.203 |
| DF Reg | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| DF Res | 83 | 90 | 97 | 104 | 105 | 105 | 102 | 105 | 106 | 106 |
| R | 0.050 | 0.010 | 0.010 | 0.051 | 0.017 | 0.003 | 0.143 | 0.053 | 0.009 | 0.004 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 8
*2006 High IT Complex Model*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 0.264 | 0.407 | -0.457 | 0.472 | 0.097 | 0.162 | 0.573 | 0.457 | 0.285 | 0.406 |
| Use of IT | 0.009 | 0.017 | 0.011 | 0.003 | 0.007 | -0.001 | -0.004 | 0.003 | 0.001 | 0.000 |
| Log of # Officer | -0.041 | 0.003 | -0.021 | -0.023 | -0.008 | 0.002 | -0.017 | -0.027 | -0.009 | -0.007 |
| Median Income | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| % Below Poverty | 0.009 | -0.006 | 0.013* | -0.001 | 0.001 | 0.000 | -0.006 | -0.001 | -0.002 | -0.002 |
| % White | 0.005 | -0.001 | 0.006*** | 0.003* | 0.001 | 0.002* | 0.002 | 0.003* | 0.002* | 0.002* |
| Prop. of Invest. | -0.060 | -0.033 | -0.107 | -0.005 | 0.029 | 0.050 | 0.115* | -0.005 | 0.031 | 0.013 |
| Crime Rate | -0.013 | -0.006 | 0.016 | 0.004* | 0.001 | 0.002* | -0.005 | 0.004** | 0.001* | 0.001** |
| F | 1.643 | 0.553 | 3.652* | 3.061** | 0.885 | 2.044 | 6.369*** | 3.632** | 2.782* | 2.551* |
| DF Reg | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| DF Res | 78 | 84 | 92 | 99 | 100 | 99 | 97 | 99 | 100 | 100 |
| R | 0.050 | -0.036 | 0.158 | 0.120 | -0.008 | 0.064 | 0.265 | 0.148 | 0.104 | 0.092 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

APPENDIX L: REGRESSION ANALYSIS OF TEN GROUPS

Table 1
*2005 Third Group Reduced Models*

| | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|
| Intercept | 0.55 | 0.381 | 0.357 | 0.136 | 0.585 | 0.423 | 0.419 |
| Use of IT | 0.016 | 0.009 | 0.013* | 0.005 | 0.015 | 0.011* | 0.009 |
| Log of # Officer | -0.029 | -0.073 | -0.078 | 0.088 | -0.042 | -0.083 | -0.022 |
| F | 1.398 | 0.682 | 2.919 | 0.350 | 1.285 | 3.331 | 1.315 |
| DF Reg | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| DF Res | 23 | 22 | 23 | 21 | 23 | 23 | 23 |
| R | 0.031 | -0.027 | 0.133 | -0.060 | 0.022 | 0.157 | 0.025 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 2
*2005 Third Group Complex Models*

| **3** | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|
| Intercept | -0.865 | 0.419 | -0.135 | -0.655 | -0.857 | 0.022 | -0.183 |
| Use of IT | 0.028* | 0.006 | 0.018* | 0.02 | 0.028* | 0.014* | 0.015* |
| Log of # Officer | -0.045 | -0.011 | -0.06 | -0.059 | -0.059 | -0.053 | -0.024 |
| Median Income | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| % Below Poverty | 0.033 | -0.012 | 0.009 | 0.033 | 0.034 | 0.004 | 0.013 |
| % White | 0.008 | -0.001 | 0.001 | 0.006 | 0.008 | 0.001 | 0.003 |
| Prop. of Invest. | 0.251 | -0.018 | -0.055 | 0.251 | 0.252 | -0.009 | 0.064 |
| Crime Rate | -0.004 | 0.013 | 0.003 | -0.087 | -0.004 | 0.002 | 0 |
| F | 1.115 | 0.479 | 1.782 | 0.783 | 1.118 | 1.553 | 0.781 |
| DF Reg | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| DF Res | 18 | 17 | 18 | 16 | 18 | 18 | 18 |
| R | 0.031 | -0.179 | 0.180 | -0.071 | 0.032 | 0.134 | -0.065 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 3
*2005 Fourth Group Reduced Models*

| **4** | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|
| Intercept | 1.611 | 0.294 | 0.44 | 0.008 | -0.156 | 0.313 | 0.082 | 0.022 |
| Use of IT | 0.019 | 0.012 | 0.012 | 0.01 | 0.026 | 0.013 | 0.016 | 0.012 |
| Log of # Officer | -0.379 | 0.073 | -0.089 | 0.063 | 0.052 | 0.058 | 0.011 | 0.081 |
| F | 0.7387807 | 1.19679 | 0.99096 | 0.95033 | 2.28151 | 1.17717 | 1.81029 | 1.99788 |
| DF Reg | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| DF Res | 13 | 16 | 16 | 16 | 15 | 16 | 16 | 16 |
| R | -0.036086 | 0.0214 | -0.001 | -0.0055 | 0.13101 | 0.01931 | 0.0826 | 0.09981 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 4
*2005 Fourth Group Complex Models*

| | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0.267 | 0.217 | 0.149 | -0.471 | -1.04 | 0.264 | -0.232 | -0.24 |
| Use of IT | 0.039 | 0.012 | 0.014 | 0.009 | 0.027 | 0.013 | 0.015 | 0.012 |
| Log of # Officer | -0.442 | 0.152 | -0.1 | 0.023 | 0.191 | 0.16 | -0.002 | 0.115 |
| Median Income | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| % Below Poverty | 0.024 | -0.011 | 0.004 | 0.002 | -0.006 | -0.013 | -0.003 | -0.007 |
| % White | 0.015 | 0.001 | 0.003 | 0.002 | 0.008 | 0.001 | 0.001 | 0.002 |
| Prop. of Invest. | -1.587 | 0.425 | -0.132 | 1.689 | 0.063 | 0.266 | 1.42 | 0.937 |
| Crime Rate | -0.11 | -0.001 | -0.003 | 0.001 | 0.003 | -0.001 | 0.001 | 0 |
| F | 0.7995851 | 0.61149 | 0.40097 | 0.77726 | 1.02231 | 0.70865 | 0.77901 | 0.9027 |
| DF Reg | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| DF Res | 8 | 11 | 11 | 11 | 10 | 11 | 11 | 11 |
| R | -0.103177 | -0.178 | -0.3037 | -0.0948 | 0.0091 | -0.1278 | -0.094 | -0.0393 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 5
*2005 Seventh Group Reduced Models*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 1.258 | 0.983 | 0.694 | 0.907 | 0.353 | 0.45 | 0.766 | 0.938 | 0.456 | 0.731 |
| Use of IT | -0.005 | 0 | -0.001 | 0 | 0.004 | 0 | 0.005 | 0 | 0.001 | -0.001 |
| Log of # Officer | -0.063 | -0.07 | -0.029 | -0.031 | -0.017 | -0.011 | -0.081 | -0.038 | -0.02 | -0.032 |
| F | 0.2892159 | 0.15912 | 0.07937 | 0.05192 | 0.48524 | 0.02503 | 1.24907 | 0.08411 | 0.1342 | 0.14362 |
| DF Reg | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| DF Res | 51 | 50 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 |
| R | -0.027561 | -0.0334 | -0.0346 | -0.0357 | -0.0191 | -0.0368 | 0.00898 | -0.0345 | -0.0325 | -0.0321 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 6
*2005 Seventh Group Complex Models*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 0.559 | 0.902 | 0.278 | 0.165 | 0.196 | 0.453 | 0.202 | 0.254 | 0.427 | 0.549 |
| Use of IT | -0.004 | -0.012 | -0.007 | -0.005 | 0.001 | -0.005 | 0.003 | -0.007 | -0.003 | -0.006 |
| Log of # Officer | -0.04 | -0.001 | 0.008 | 0.03 | -0.013 | 0.027 | -0.051 | 0.022 | 0.008 | -0.007 |
| Median Income | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| % Below Poverty | 0.009 | -0.015 | -0.001 | -0.003 | 0.001 | -0.009 | 0.008 | -0.004 | -0.006 | -0.005 |
| % White | 0.007* | -0.002 | 0.004 | 0.004 | 0.002 | 0.002 | 0.004 | 0.004 | 0.002 | 0.003 |
| Prop. of Invest. | 0.062 | 0.282 | 0.098 | 0.043 | -0.027 | 0.048 | 0.016 | 0.042 | 0.028 | -0.007 |
| Crime Rate | 0.032 | 0.11 | -0.002 | 0.004* | 0 | 0.001 | -0.012* | 0.004* | 0 | 0.001 |
| F | 1.1013946 | 1.60272 | 2.13397 | 2.519* | 1.28004 | 1.73095 | 3.474** | 2.855* | 1.80434 | 1.55946 |
| DF Reg | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| DF Res | 46 | 45 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 |
| R | 0.0132148 | 0.07505 | 0.12612 | 0.16203 | 0.03441 | 0.08511 | 0.2395 | 0.19102 | 0.09286 | 0.06647 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 7
*2005 Eighth Group Reduced Models*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 2.459 | 1.732 | 0.791 | 0.715 | 0.83 | 0.378 | 0.669 | 0.706 | 0.55 | 0.714 |
| Use of IT | 0.009 | 0.018 | 0.013 | 0.026 | 0.012 | 0.012 | 0.002 | 0.024 | 0.008 | 0.015 |
| Log of # Officer | -0.257 | -0.214 | -0.089 | -0.087 | -0.106 | -0.037 | -0.051 | -0.085 | -0.053 | -0.082 |
| F | 1.4921966 | 1.16693 | 0.8674 | 2.20292 | 2.4016 | 1.34015 | 0.12064 | 2.10157 | 0.99213 | 1.75856 |
| DF Reg | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| DF Res | 19 | 18 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 |
| R | 0.0447769 | 0.01642 | -0.0128 | 0.10279 | 0.11777 | 0.03138 | -0.0914 | 0.09495 | -0.0008 | 0.06738 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 8
*2005 Eighth Group Complex Models*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 2.193 | -1.182 | -0.831 | -0.715 | 0.712 | 0.215 | 1.031 | -0.678 | 0.429 | 0.329 |
| Use of IT | 0.011 | 0.06 | 0.027 | 0.034 | 0.01 | 0.011 | -0.014 | 0.035 | 0.005 | 0.018 |
| Log of # Officer | -0.337 | -0.109 | -0.046 | -0.052 | -0.136 | -0.072 | -0.087 | -0.052 | -0.087 | -0.097 |
| Median Income | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| % Below Poverty | 0.009 | 0.025 | 0.018 | 0.017 | 0.007 | 0.007 | -0.002 | 0.016 | 0.006 | 0.007 |
| % White | 0.007 | 0.004 | 0.007* | 0.008* | 0.003 | 0.004* | 0.004 | 0.007* | 0.004* | 0.005 |
| Prop. of Invest. | 0.104 | -0.218 | -0.132 | -0.199 | 0.222 | 0.097 | -0.04 | -0.192 | 0.071 | -0.014 |
| Crime Rate | 0.099 | 0.384 | 0.028 | 0.005 | 0.001 | 0 | -0.003 | 0.004 | 0 | 0 |
| F | 1.2785664 | 1.0579 | 1.37125 | 1.83144 | 2.12269 | 1.94026 | 1.05699 | 1.87618 | 1.70383 | 1.19337 |
| DF Reg | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| DF Res | 13 | 12 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| R | 0.0888368 | 0.02089 | 0.115 | 0.22541 | 0.2821 | 0.24761 | 0.01956 | 0.23469 | 0.19765 | 0.06339 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 9
*2006 Third Group Reduced and Complex Models*

| | LarcenyR | Larceny | Vehicle TheftR | Vehicle Theft | Violent CrimesR | Violent Crimes | Property CrimeR | Property Crime | All CrimesR | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 0.614 | 0.238 | 0.465 | -0.288 | 0.636 | -0.609 | 0.576 | 0.261 | 0.581 | -0.045 |
| Use of IT | 0.009 | 0.011 | -0.011 | -0.013 | 0.016 | 0.025 | 0.006 | 0.007 | 0.006 | 0.011 |
| Log of # Officer | -0.149 | -0.084 | 0.05 | 0.176 | -0.056 | -0.037 | -0.108 | -0.065 | -0.061 | -0.037 |
| Median Income | | 0 | | 0 | | 0 | | 0 | | 0 |
| % Below Poverty | | 0.002 | | -0.01 | | 0.022 | | 0.001 | | 0.009 |
| % White | | 0 | | 0.006 | | 0.007 | | 0.001 | | 0.003 |
| Prop. of Invest. | | -0.04 | | 0.366 | | 0.207 | | 0.002 | | 0.067 |
| Crime Rate | | 0.004* | | 0.156 | | 0 | | 0.002 | | 0.001 |
| F | 1.420 | 1.199 | 0.239 | 1.497 | 1.316 | 0.984 | 0.859 | 0.638 | 0.516 | 0.522 |
| DF Reg | 2 | 7 | 2 | 7 | 2 | 7 | 2 | 7 | 2 | 7 |
| DF Res | 23 | 18 | 21 | 16 | 23 | 18 | 23 | 18 | 23 | 18 |
| R | 0.033 | 0.053 | -0.071 | 0.131 | 0.025 | -0.004 | -0.011 | -0.113 | -0.040 | -0.155 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 10
*2006 Fourth Group Reduced Models*

| | Rape | Robbery | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|
| Intercept | 1.07 | -1.068 | 0.094 | -0.175 | -0.484 | 0.728 | -0.068 | 0.168 |
| Use of IT | 0.039 | 0.025 | 0.009 | 0.005 | 0.002 | 0.016 | 0.007 | 0.008 |
| Log of # Officer | -0.381 | 0.297 | 0.032 | 0.133 | 0.25 | -0.083 | 0.092 | 0.052 |
| F | 1.903 | 1.652 | 1.395 | 1.324 | 0.829 | 1.328 | 1.434 | 0.946 |
| DF Reg | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| DF Res | 13 | 13 | 17 | 17 | 16 | 17 | 17 | 17 |
| R | 0.107 | 0.080 | 0.040 | 0.033 | -0.019 | 0.033 | 0.044 | -0.006 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 11
*2006 Fourth Group Complex Models*

| | Rape | Robbery | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|
| Intercept | -0.147 | -1.166 | -0.007 | -0.657 | -0.975 | 0.657 | -0.464 | -0.255 |
| Use of IT | 0.046 | 0.027 | 0.012 | 0.004 | 0.015 | 0.012 | 0.008 | 0.007 |
| Log of # Officer | -0.12 | 0.262 | -0.003 | 0.203 | 0.215 | 0.038 | 0.135 | 0.143 |
| Median Income | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| % Bedort Poverty | -0.009 | -0.018 | 0.003 | 0 | 0.005 | -0.012 | 0.002 | -0.005 |
| % White | 0.005 | 0.006 | 0.001 | 0.003 | 0.006 | 0 | 0.002 | 0.003 |
| Prop. of Invest. | 0.438 | -0.447 | 0.019 | 0.211 | -0.558 | 0.279 | 0.137 | 0.184 |
| Crime Rate | 0.369 | 0.114 | -0.01 | 0 | -0.019 | -0.002 | -0.001 | 0 |
| F | 1.053 | 0.902 | 2.402 | 0.875 | 1.408 | 1.159 | 1.106 | 1.098 |
| DF Reg | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| DF Res | 8 | 8 | 12 | 12 | 11 | 12 | 12 | 12 |
| R | 0.024 | -0.048 | 0.341 | -0.048 | 0.137 | 0.055 | 0.037 | 0.035 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 12
*2006 Seventh Group Reduced Models*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 0.688 | 0.842 | 0.459 | 0.704 | 0.117 | 0.342 | 0.289 | 0.716 | 0.295 | 0.554 |
| Use of IT | -0.001 | 0.001 | 0.003 | -0.001 | 0.004 | -0.001 | 0.006 | 0 | 0.001 | -0.001 |
| Log of # Officer | 0.013 | -0.055 | -0.01 | 0.001 | 0.02 | 0.007 | -0.013 | -0.005 | 0.004 | -0.006 |
| F | 0.018 | 0.096 | 0.137 | 0.003 | 0.440 | 0.023 | 0.710 | 0.002 | 0.059 | 0.022 |
| DF Reg | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| DF Res | 50 | 51 | 52 | 53 | 53 | 52 | 52 | 53 | 53 | 53 |
| R | -0.039 | -0.035 | -0.033 | -0.038 | -0.021 | -0.038 | -0.011 | -0.038 | -0.035 | -0.037 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 13
*2006 Seventh Group Complex Models*

| | Murder | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|---|
| Intercept | 0.811 | 1.725 | 0.698 | 0.651 | 0.397 | 0.557 | 0.15 | 0.745 | 0.587 | 0.799 |
| Use of IT | -0.005 | -0.012 | 0.001 | -0.003 | 0.002 | -0.005 | 0.004 | -0.004 | -0.002 | -0.005 |
| Log of # Officer | 0.022 | 0.013 | -0.031 | 0.016 | 0.013 | 0.028 | -0.004 | 0.004 | 0.01 | -0.004 |
| Median Income | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| % Below Poverty | -0.004 | -0.031 | -0.003 | -0.007 | -0.005 | -0.009 | 0.003 | -0.008 | -0.008 | -0.008 |
| % White | 0.003 | -0.004 | 0.004 | 0.002 | 0.001 | 0.001 | 0.003 | 0.002 | 0.001 | 0.002 |
| Prop. of Invest. | -0.025 | 0.079 | -0.197 | -0.196 | -0.092 | -0.053 | -0.083 | -0.199 | -0.067 | -0.132 |
| Crime Rate | -0.266 | 0.171 | -0.002 | 0.005* | 0 | 0.001 | -0.009* | 0.004* | 0 | 0 |
| F | 0.613 | 0.839 | 2.079 | 1.312 | 0.685 | 1.113 | 1.511 | 1.361 | 0.866 | 0.967 |
| DF Reg | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| DF Res | 45 | 46 | 47 | 48 | 48 | 47 | 47 | 48 | 48 | 48 |
| R | -0.055 | -0.022 | 0.123 | 0.038 | -0.042 | 0.014 | 0.062 | 0.044 | -0.017 | -0.004 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 14
*2006 Eighth Group Reduced Models*

| | Rape | Robbery | Assault | Burglary | Larcen | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|
| Intercept | 1.995 | 1.151 | 0.534 | 1.241 | 0.351 | 0.719 | 0.535 | 0.607 | 0.635 |
| Use of IT | 0.015 | 0.016 | 0.026 | 0.009 | 0.01 | 0 | 0.025 | 0.007 | 0.014 |
| Log of # Officer | -0.237 | -0.143 | -0.066 | -0.156 | -0.031 | -0.057 | -0.066 | -0.058 | -0.07 |
| F | 0.790 | 2.381 | 1.863 | 3.197 | 0.920 | 0.123 | 1.798 | 0.683 | 1.304 |
| DF Reg | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| DF Res | 51 | 52 | 53 | 53 | 52 | 52 | 53 | 53 | 53 |
| R | -0.025 | 0.127 | 0.083 | 0.188 | -0.008 | -0.102 | 0.078 | -0.035 | 0.031 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

Table 15
*2006 Eighth Group Complex Models*

| | Rape | Robbery | Assault | Burglary | Larceny | Vehicle Theft | Violent Crimes | Property Crime | All Crimes |
|---|---|---|---|---|---|---|---|---|---|
| Intercept | 0.737 | -0.64 | -1.35 | 0.485 | -0.167 | 0.679 | -1.495 | 0.038 | -0.436 |
| Use of IT | 0.032 | 0.037* | 0.04 | 0.013 | 0.014 | -0.013 | 0.043* | 0.007 | 0.023 |
| Log of # Officer | -0.235 | -0.136 | -0.034 | -0.145 | -0.064 | -0.082 | -0.036 | -0.077 | -0.074 |
| Median Income | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| % Below Poverty | 0.021 | 0.023* | 0.023 | 0.012 | 0.013 | 0.003 | 0.023 | 0.012 | 0.016 |
| % White | 0.005 | 0.007* | 0.008* | 0.004* | 0.004 | 0.005 | 0.008* | 0.005* | 0.005 |
| Prop. of Invest. | -0.118 | -0.088 | -0.171 | -0.022 | 0.113 | -0.059 | -0.174 | 0.022 | -0.018 |
| Crime Rate | -0.186 | 0.031* | 0.008 | 0.002 | 0.001 | 0.001 | 0.008 | 0.001 | 0.001 |
| F | 0.482 | 5.041** | 1.628 | 1.747 | 1.446 | 1.430 | 1.977 | 1.389 | 1.259 |
| DF Reg | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| DF Res | 46 | 47 | 48 | 48 | 47 | 47 | 48 | 48 | 48 |
| R | -0.293 | 0.611 | 0.196 | 0.225 | 0.148 | 0.143 | 0.275 | 0.131 | 0.092 |

*Note.* ***p< 0.001, **p< 0.01, *p< 0.05

APPENDIX M: ITEMS WITH OVERLAPPING AGENCY SIZE

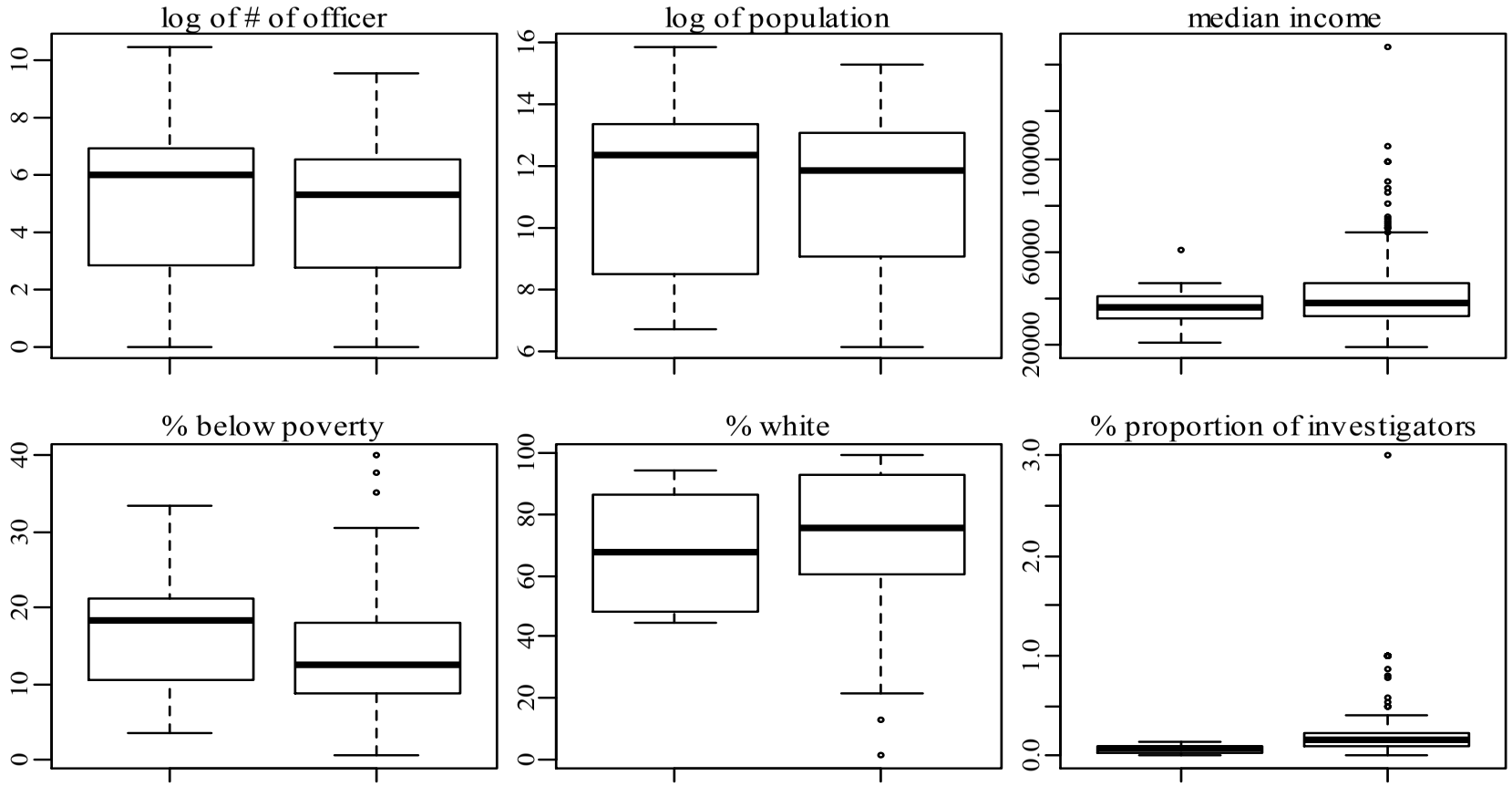


*Figure 1.* Does your department use "Cellular / Mobile Phones" technology? No=9, Yes=224

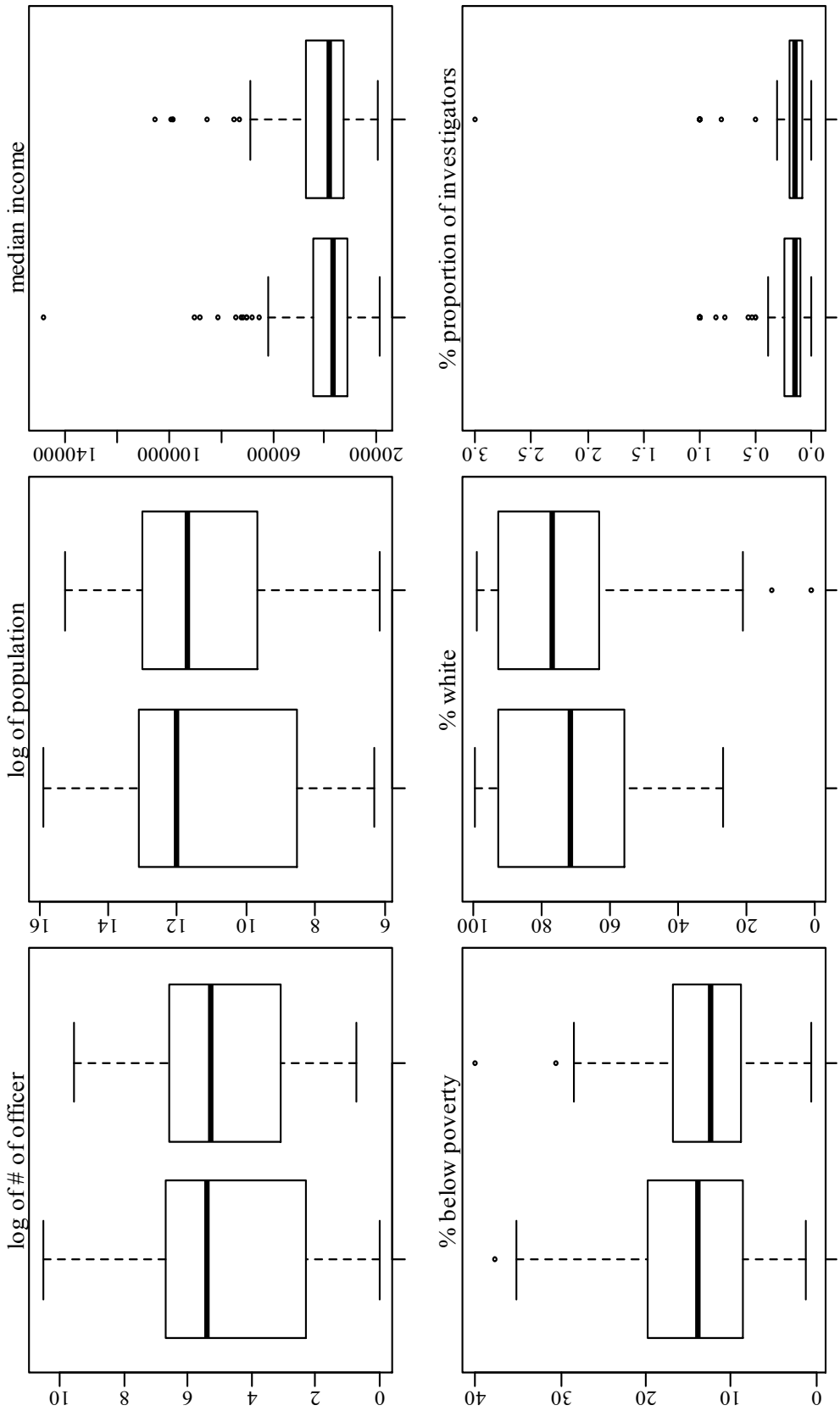


*Figure 2*. Does your department use "RISS" for investigative purposes? No=114, Yes=119

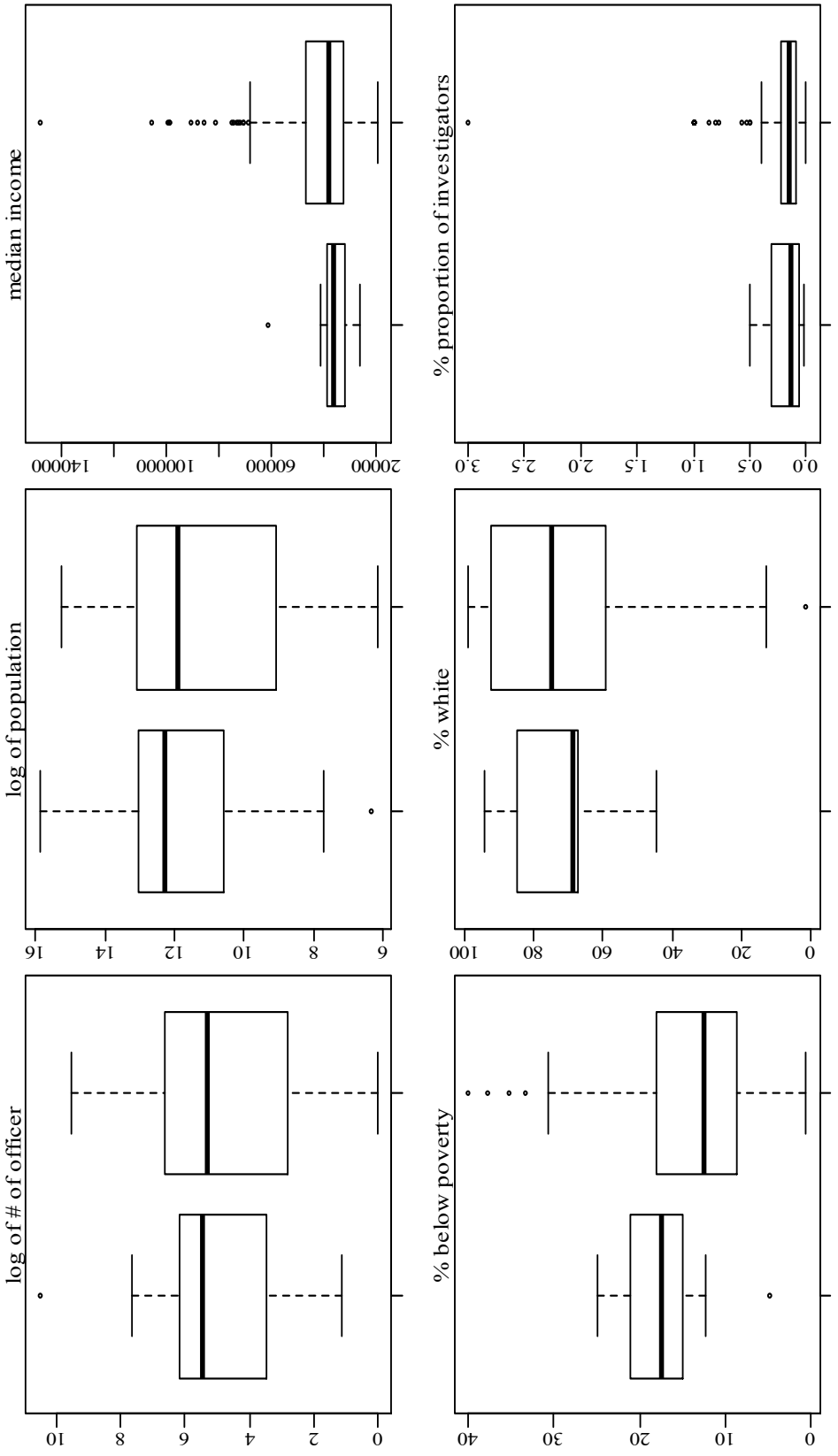


*Figure 3*. Does your department use "NCIC" for investigative purposes? No=9, Yes=224

APPENDIX N: ITEMS WITH NO OR POOR OVERLAPPING AGENCY SIZE

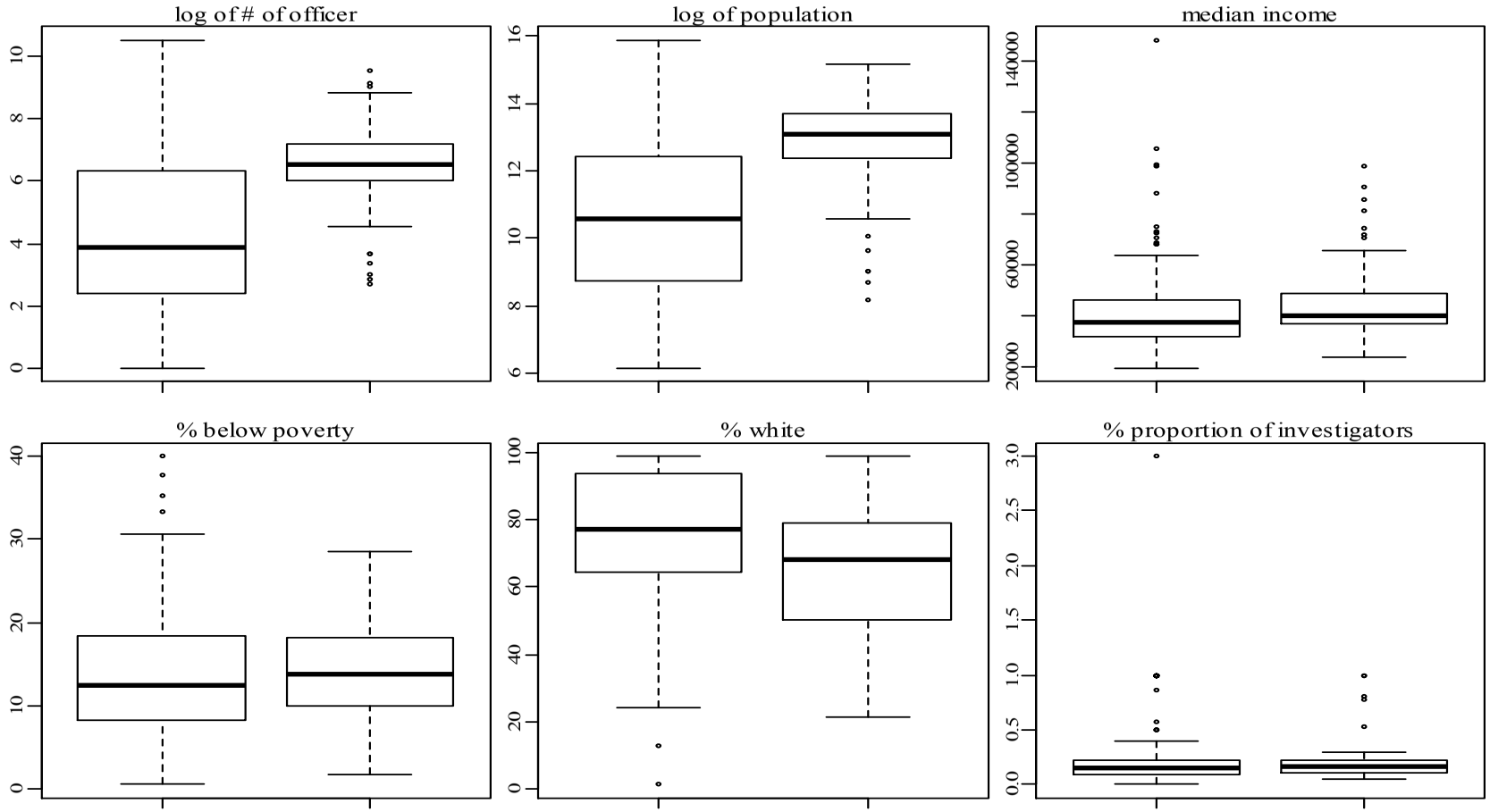


*Figure 1.* Does your department use "Blackberry" technology? No=175, Yes=58

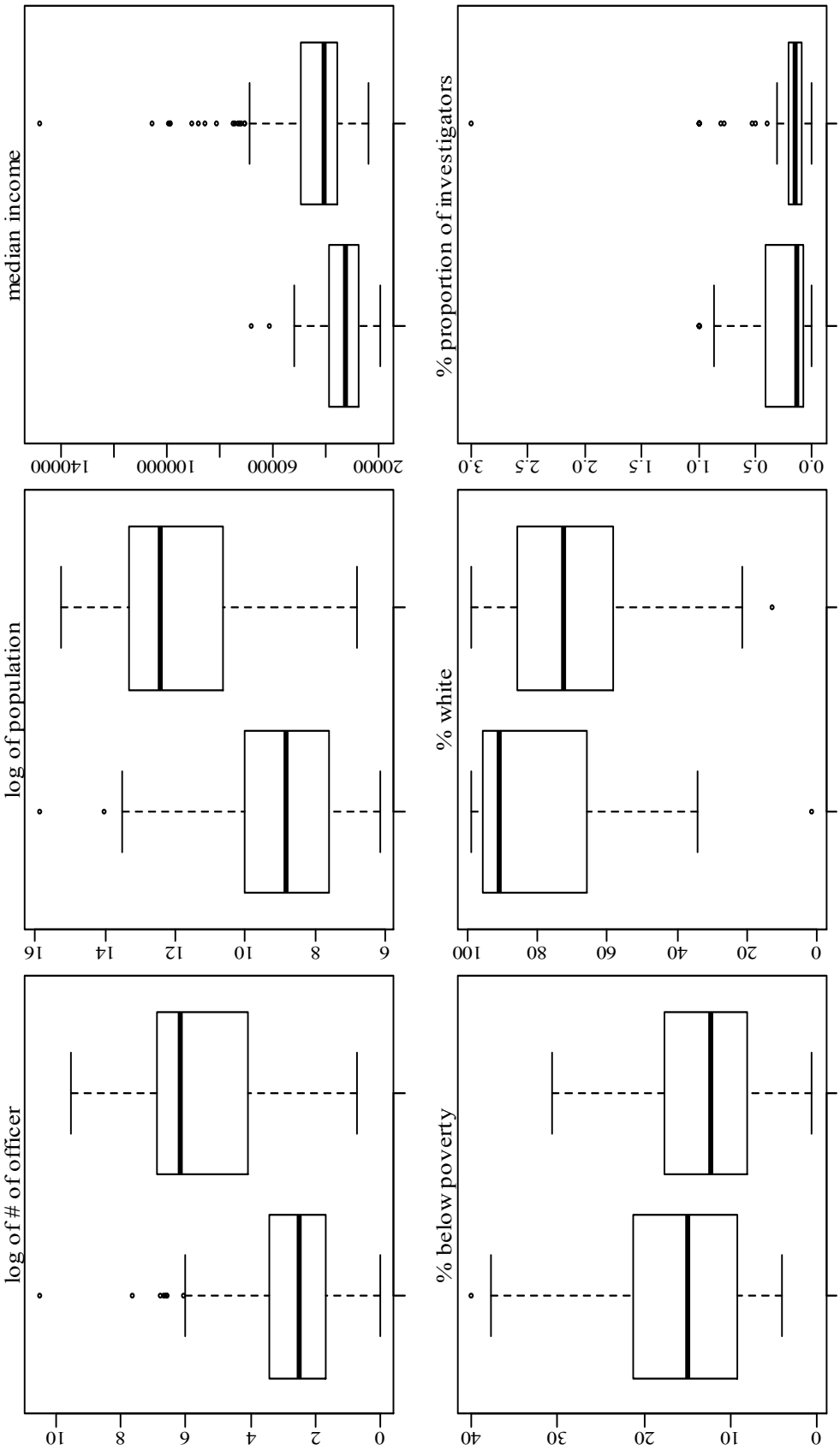


*Figure 2.* Does your department use "MDC / MDT" technology? No=65, Yes=168

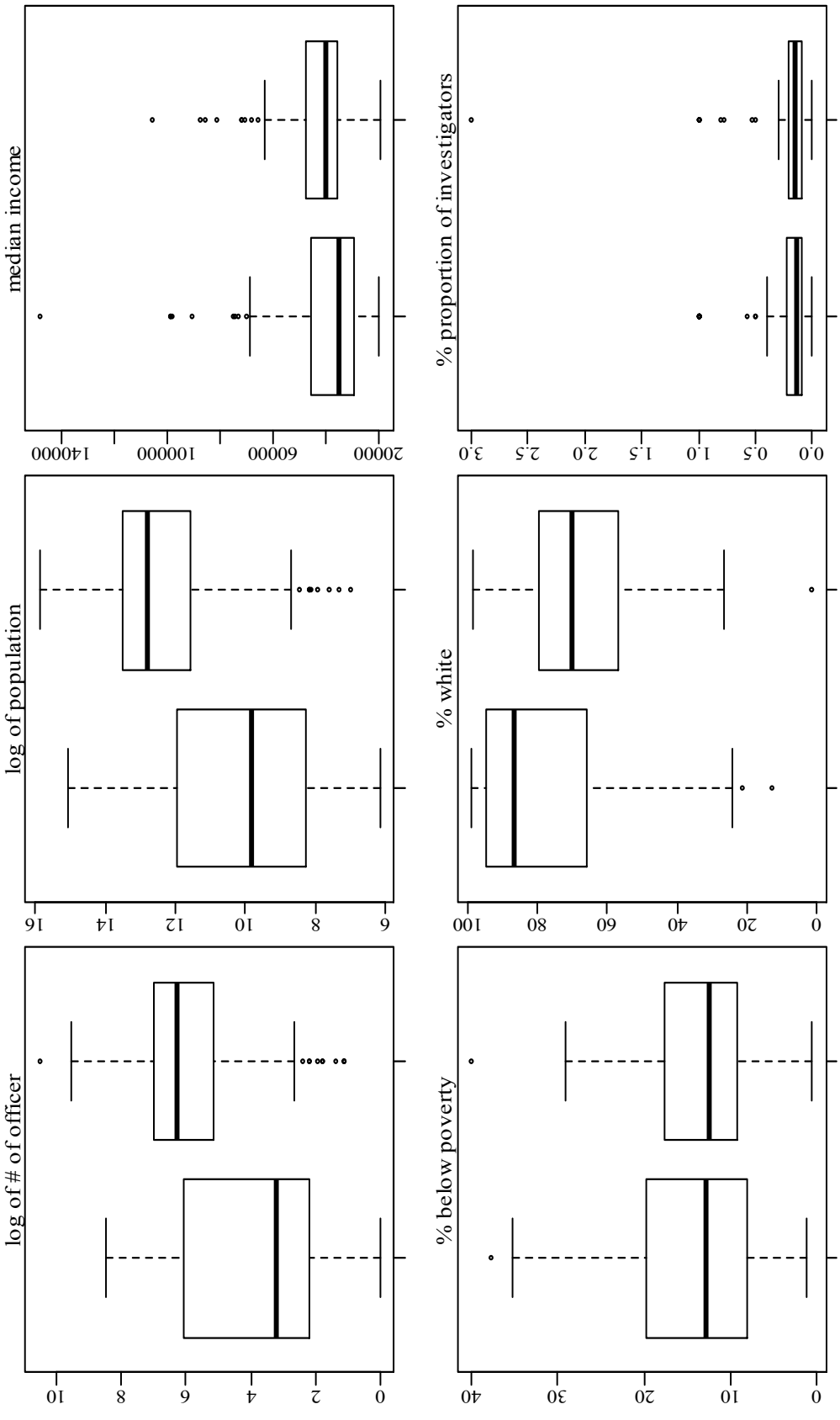


*Figure 3.* Please identify the availability of "Fingerprints" for criminal investigations purposes. No=108, Yes=120

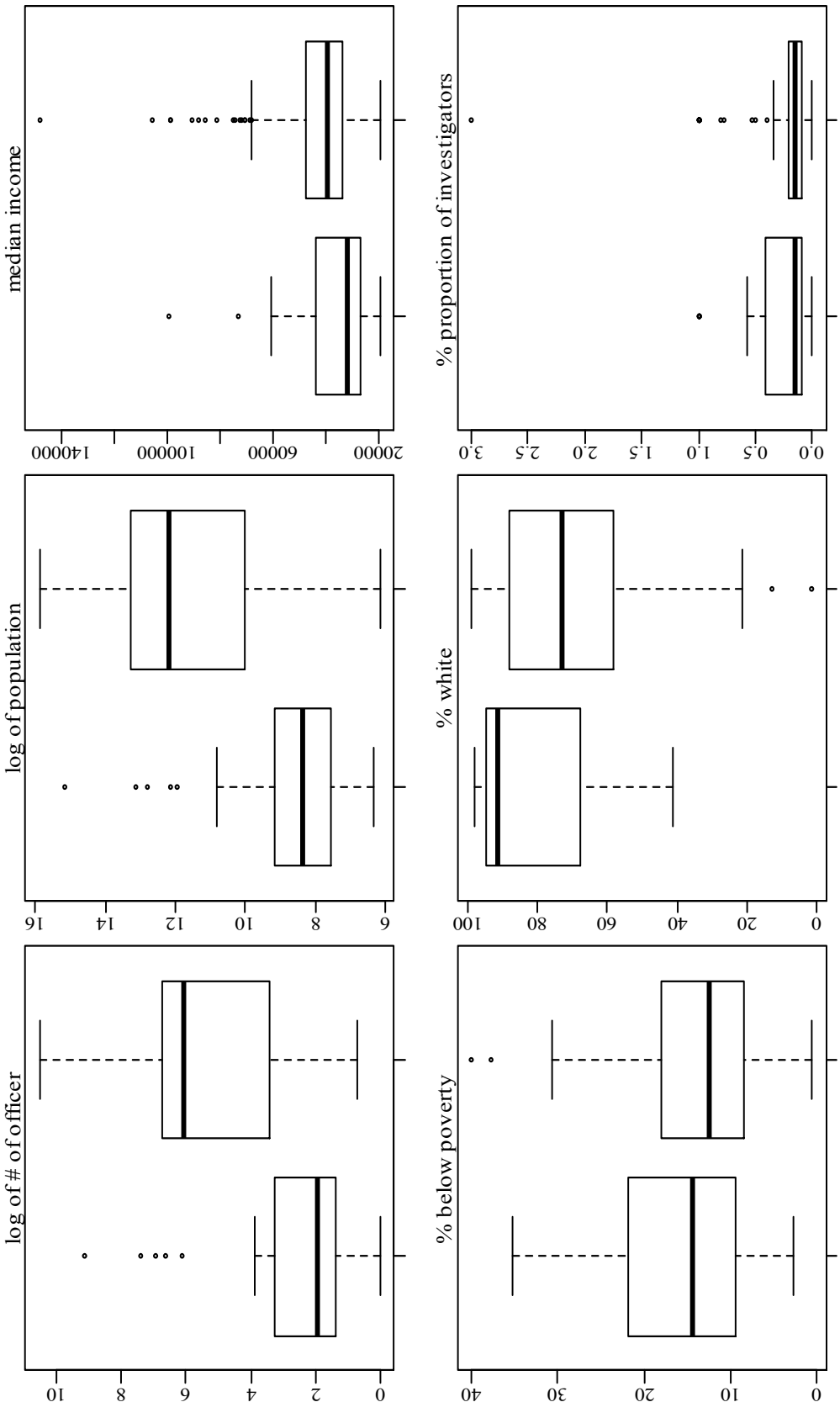


*Figure 4.* Please identify the availability of "Mug Shot" for criminal investigations purposes. No=36, Yes=192

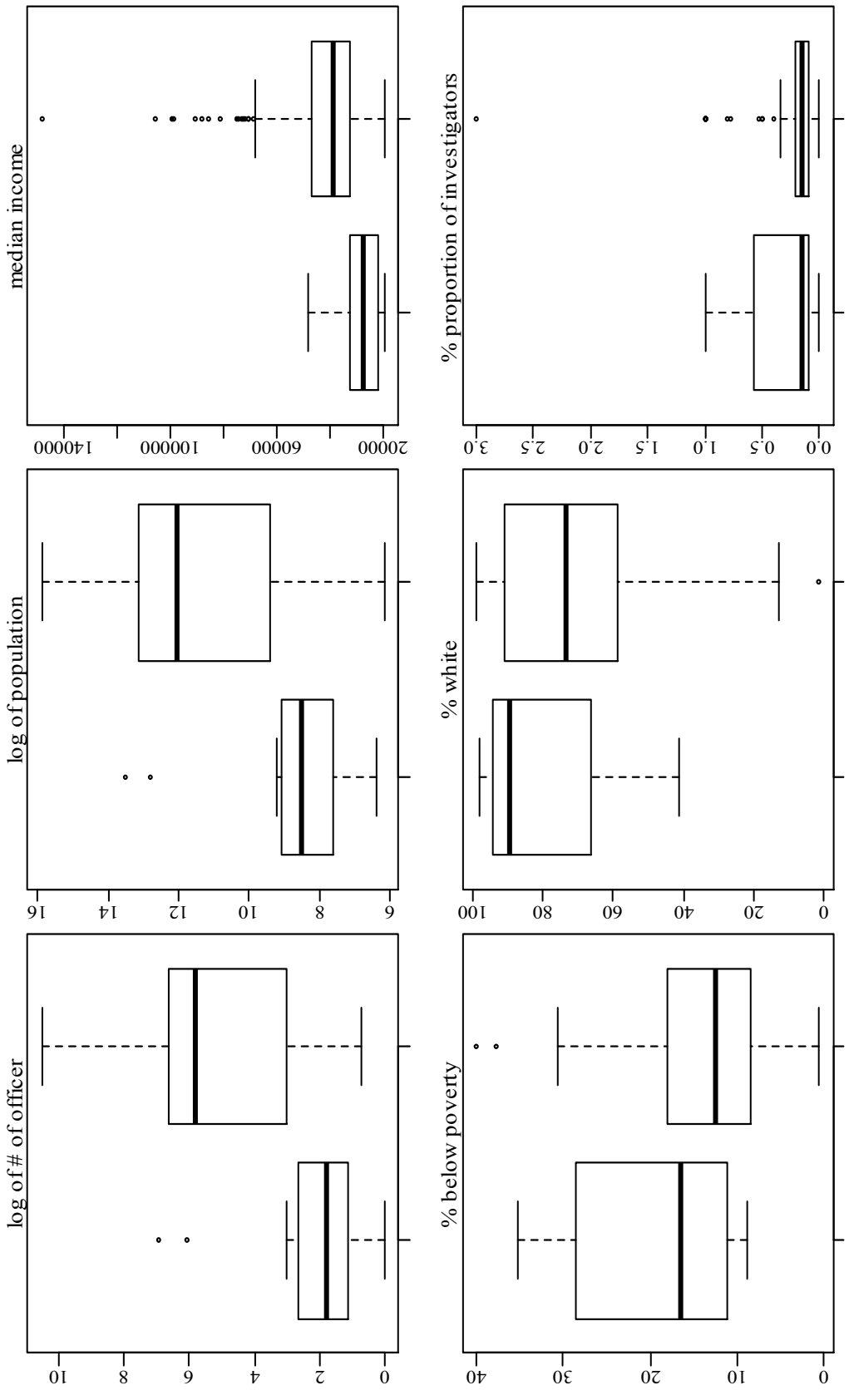


*Figure 5*. Please identify the availability of "Stolen Vehicles" for criminal investigations purposes. No=13, Yes=215

APPENDIX O: REGRESSION COEFFICIENTS OF USE OF IT ITEMS

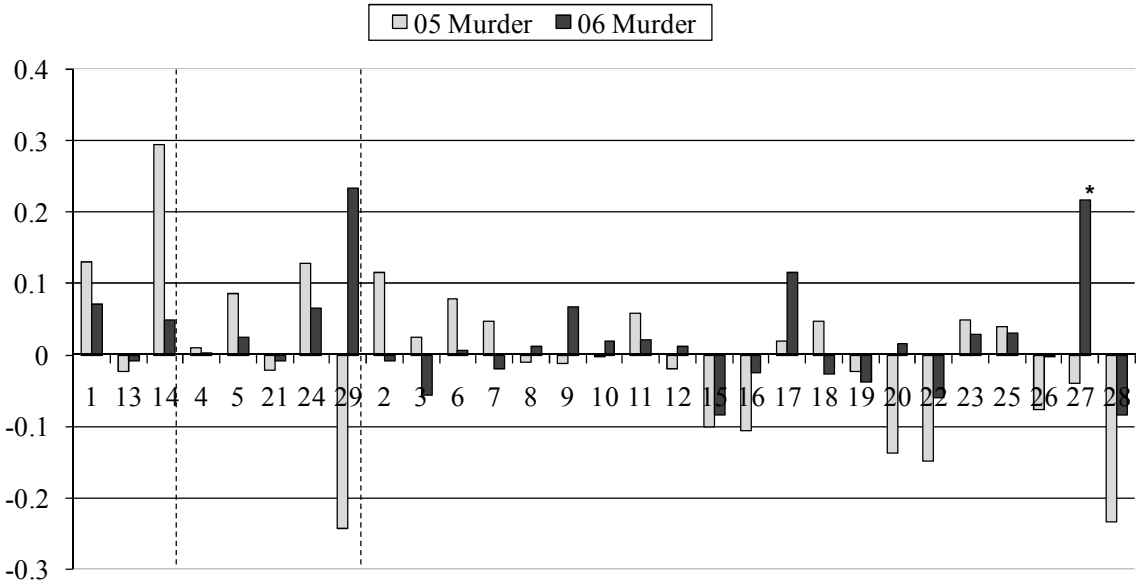


*Figure 1.* 2005-2006 murder clearance and use of IT items (***p< 0.001, **p< 0.01, *p< 0.05)

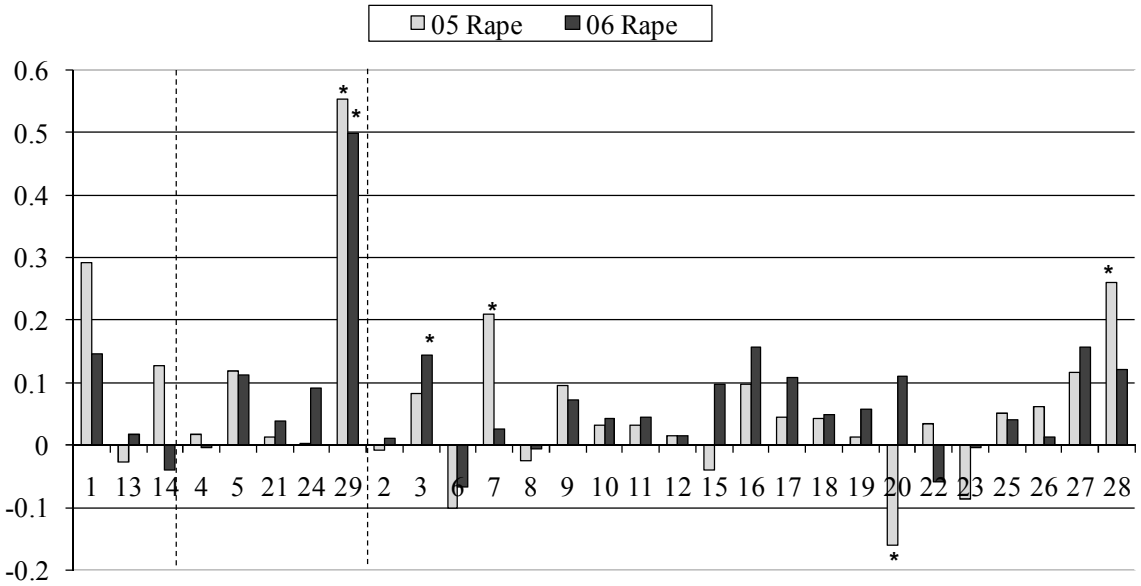


*Figure 2.* 2005-2006 rape clearance and use of IT items(***p< 0.001, **p< 0.01, *p< 0.05)

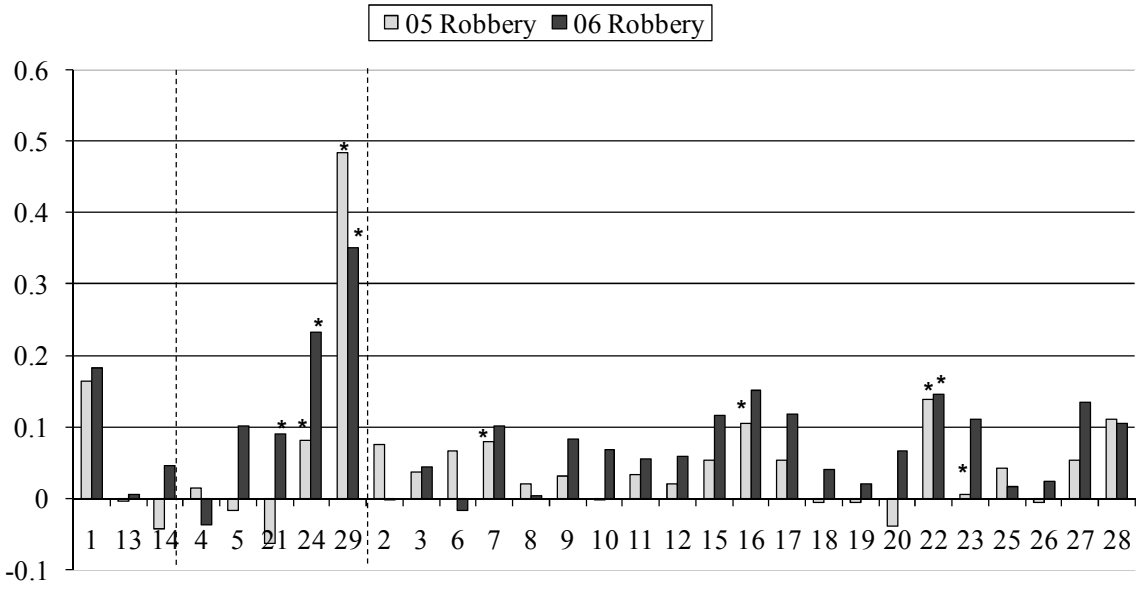


*Figure 3.* 2005-2006 robbery clearance and use of IT items (***p< 0.001, **p< 0.01, *p< 0.05)

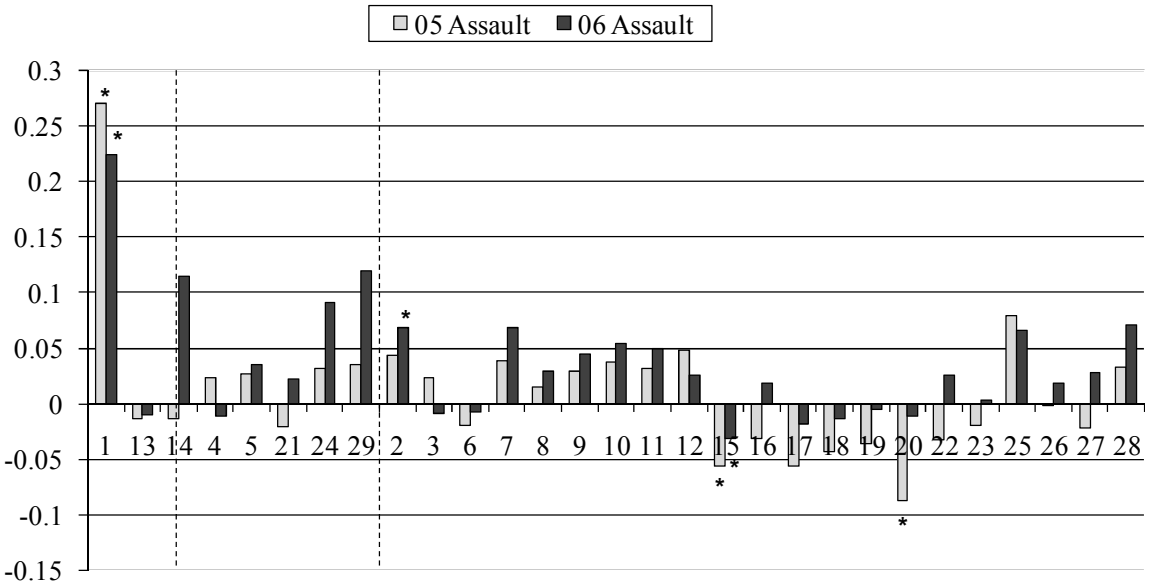


*Figure 4.* 2005-2006 assault clearance and use of IT items(***p< 0.001, **p< 0.01, *p< 0.05)

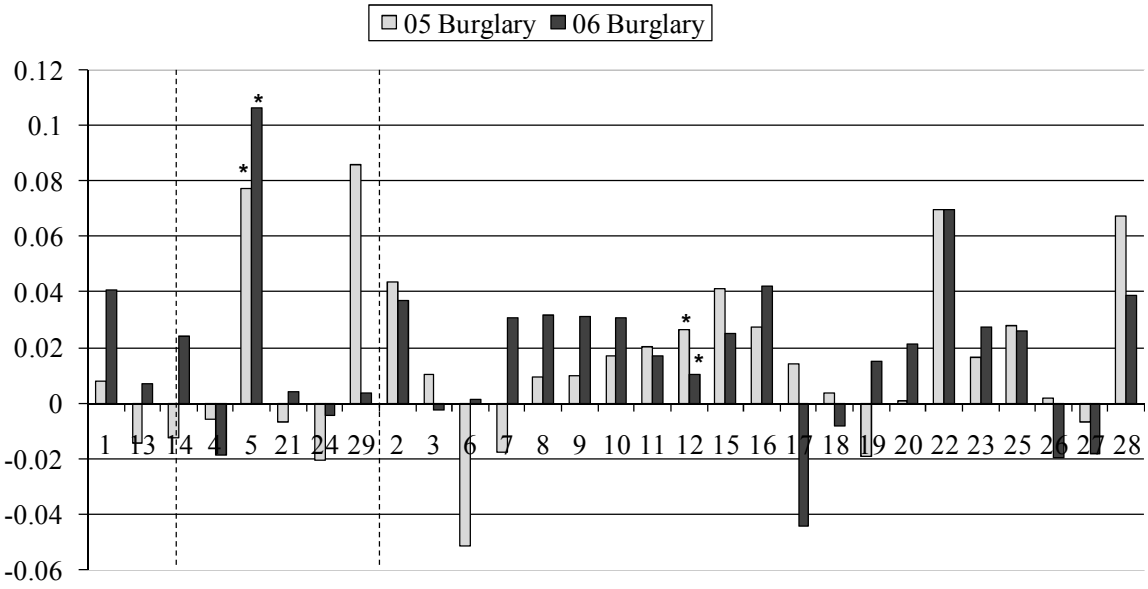


*Figure 5.* 2005-2006 burglary clearance and use of IT items (***p< 0.001, **p< 0.01, *p< 0.05)

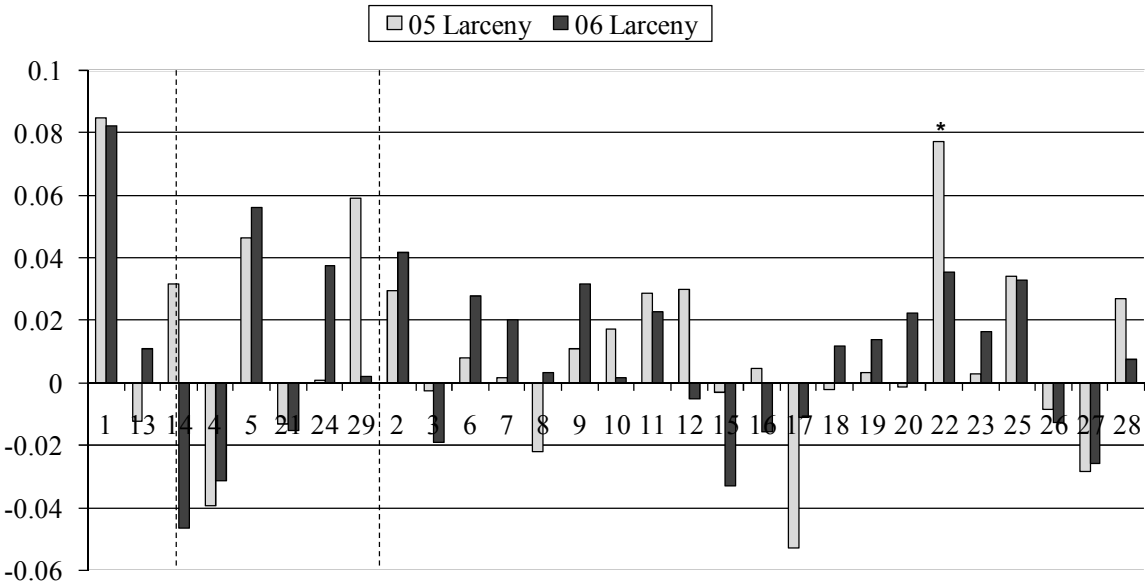


*Figure 6.* 2005-2006 larceny clearance and use of IT items (***p< 0.001, **p< 0.01, *p< 0.05)

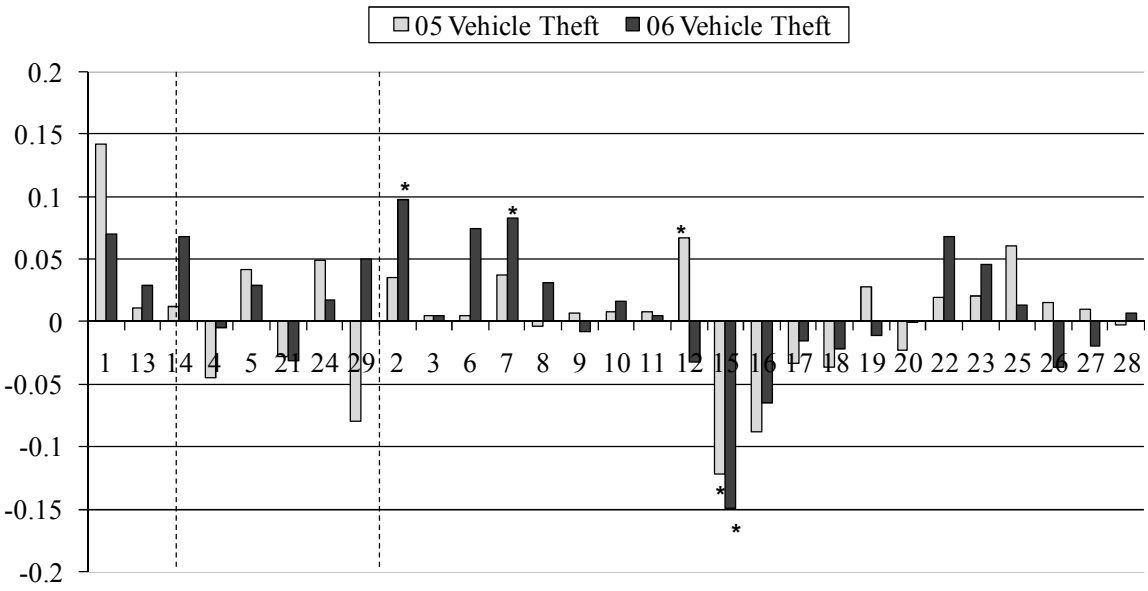


*Figure 7.* 2005-2006 vehicle theft clearance and use of IT items (***p< 0.001, **p< 0.01, *p< 0.05)

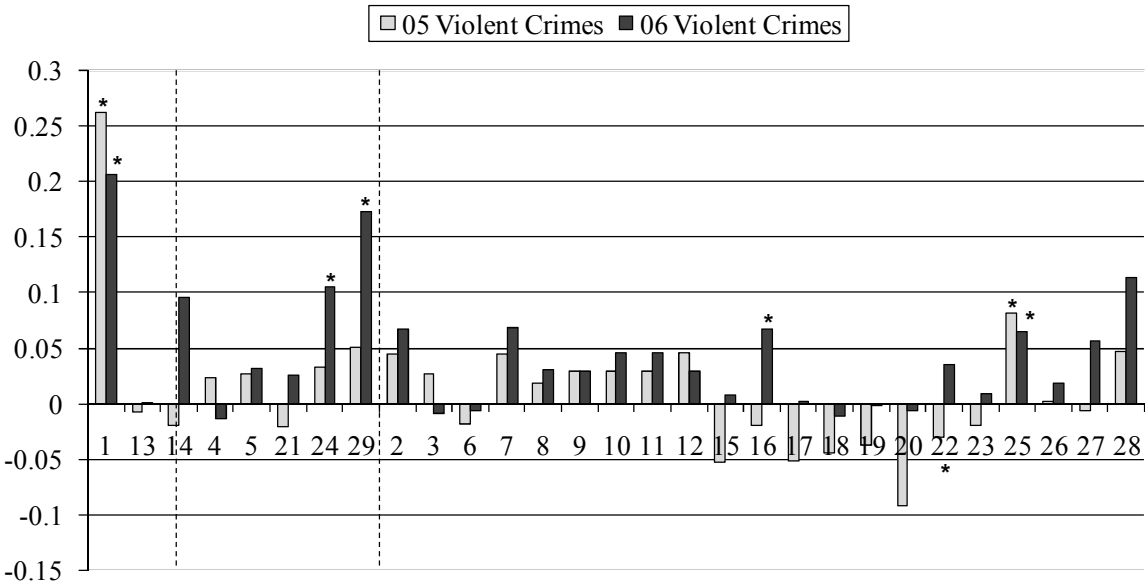


*Figure 8.* 2005-2006 violent crimes clearance and use of IT items (***p< 0.001, **p< 0.01, *p< 0.05)

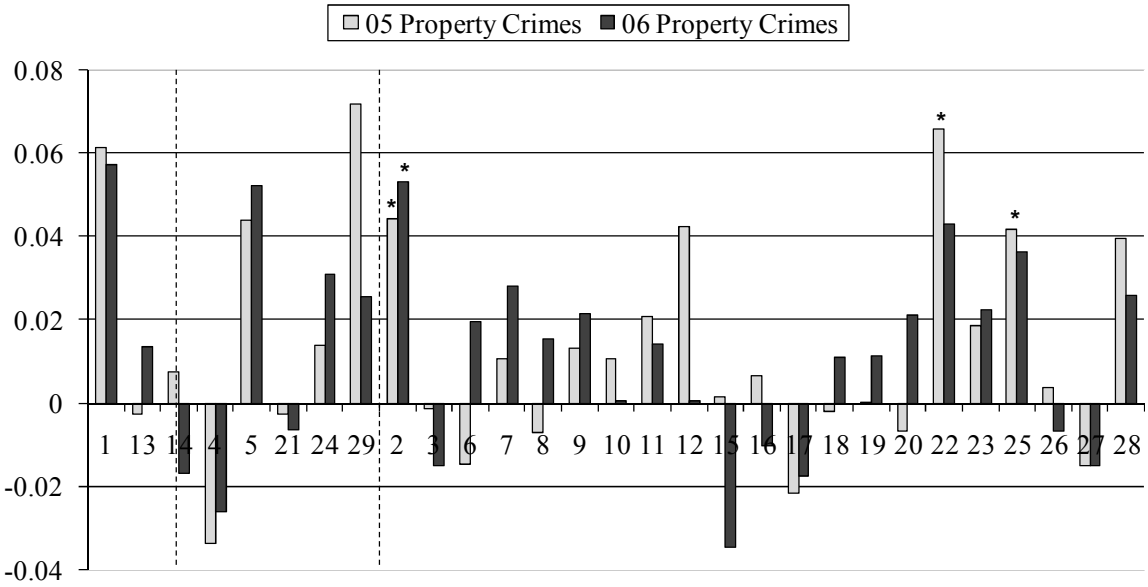


*Figure 9.* 2005-2006 property crimes clearance and use of IT items (***p< 0.001, **p< 0.01, *p< 0.05)

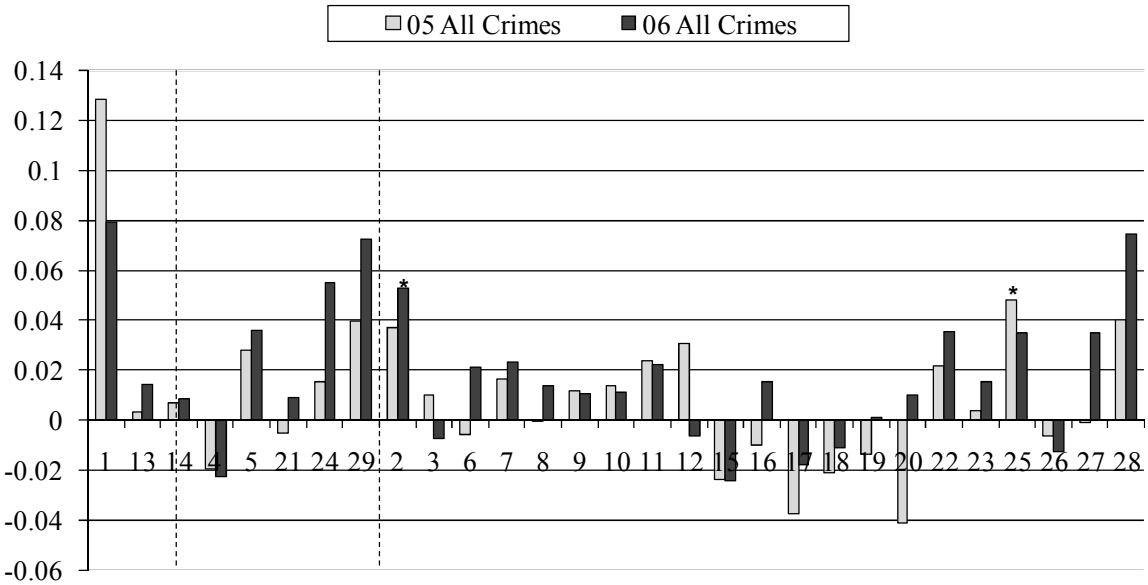


*Figure 10.* 2005-2006 all crimes clearance and use of IT items (***p< 0.001, **p< 0.01, *p< 0.05)