POLICE USE OF INFORMATION TECHNOLOGIES IN CRIMINAL INVESTIGATIONS

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Abstract

The purpose of this study is to analyze whether information technologies contribute to the outcome of criminal investigations. The study is a cross-sectional one and its unit of analysis is U.S police departments. Clearance rates of Part I crimes are used as the outcome variable and its independent variable is an index variable constructed by using survey items. After controlling the descriptive analysis results, bivariate and multivariate analyses conducted to examine the relationship between dependent and independent variables. Results showed that the relationship between clearance rates and departmental use of information technologies is not significant. However, this result must be interpreted cautiously because first the independent variable of this study measures whether the responding police departments use or do not use particular kind of information technologies. It does not measure the variability in the quality and intensity of use. Second, the survey data is unbalanced; therefore, it introduces limitations to the multivariate analysis. On the other hand, This study shows that information technologies should be targeted to the policing fields where they would be most effective. In case of criminal investigations, primary investigation phase looks promising. It also argues that process evaluations should be conducted to ensure proper implementation and use of information technologies by police departments.

Keywords: Police information systems, criminal investigation, policing

Introduction

Investigative police work is mostly about the recovery, analysis and interpretation of information about criminal offenses (Osterburg and Ward, 2007). 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).

Despite the huge amounts of money spent on information technology (IT) each year, 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). In accordance with that claim, the link between information technologies and the outcome of criminal investigations is not an explicit one. Therefore, the purpose of this study is to examine whether information technologies make a contribution to the outcome of criminal investigations.

Literature Review
Criminal Investigation And Factors Affecting Its Outcome

Although criminal investigation is an important law enforcement activity, it is one of the least studied police functions. 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. For example, in the Department of Justice's "Managing Criminal Investigations Manual," criminal investigation is defined as: "The 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).

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). An important common point in the truth-finding and construction of truth approaches is the centrality and

importance of information for the investigative work. 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" (Innes, 2003, p. 113). 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.

Studies on criminal investigation have consistently found that the quality of preliminary investigation[123] 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 and Lang, 1973; Greenberg et al., 1977; Horvath & Meesig 1996; Isaacs, 1967; Morris & Heal, 1981; Skogan, & Antunes, 1979; Wilmer, 1970). Furthermore, some studies have stated that the single most important determinant 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; Reiss, 1971). 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; Paré, Felson & Quimet, 2007). The quality of information very much depends on the type of crime due to the "duration of personal contact between the parties" (Skogan and Antunes, 1979). 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.

Agency size and workload of investigators are two related factors. Although they were thought to be effective on the outcome of criminal investigations, studies have failed to find a significant relationship between them. Chaiken et al. (1976) found 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. Burrows & Tarling's (1982) study challenged this claim by finding consistent and negative impact of workload on clearance rates after controlling for crime and socio-economic variables. However, later studies failed to find a relationship between neither agency size nor workload of investigators and clearance rates (Cordner, 1989; Liska and Chamlin, 1984).

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[123] 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).

Forensic evidence is another factor affecting the outcome of criminal investigations. Studies show that physical evidence and forensic examination increase the effectiveness of criminal investigation (Bradbury and Feist, 2005; Peterson, Mihajlovic, and Gilliland, 1984), but it is also stated that forensic evidence is underutilized (Burrows et al., 2005; Chaiken et al., 1976; Horvath and Meesig, 1996; Jones and Weatherburn, 2004). 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 (Horvath and Meesig, 1996). Social context and victim characteristics also have an impact on officers' interpretation of incidents and execution of criminal investigations. Sanders (1977) and Ericson (1993) claimed that detectives' decision to investigate was a result of victim, case and agency related factors. Similar to them Waegel (1981, 1982) argued that detectives' decision to investigate depends on the information available about a case. Handful of other studies also found significant impact of economic and demographic variables on clearance rates (e.g., Burrows & Tarling, 1982; Pare et al., 2007; Pucket and Lundman, 2003; Swanson, 1978).

Information System's Impact On Police Work

There are not much studies evaluating performance of police information systems, and existing studies generally reveal positive contributions of information systems to the police work. Several studies examined the impact of crime analysis systems. 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) and Chen et al. (2003) evaluated the performance of the Coplink Concept Space application, which helps officers to uncover relationships between different types of information, and found that the application is highly useful for investigative purposes. Wellford and Cronin (1999) examined factors affecting homicide clearance rates and 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 and 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.

There are some studies on the effectiveness of police command and control systems. 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) found the police command control and communication systems were 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 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 18.94% more arrests/citations than the control group. There are several other studies analyzed performance of police information systems by measuring their impact on other outcomes (e.g. McRae and McDavid, 1988; Nunn & Quinet, 2002), and they found mixed results about the performance of police information systems.

Methodology

This study is an exploratory research which aims to shed more light onto the performance of police information systems. The study tries to answer the following question:

Does use of information technologies have an impact on the outcome of criminal investigations? This study expects that the investigative use of information technology increases crime control abilities of law enforcement agencies. Therefore; this research will test the following hypothesis:

H_1: As law enforcement agencies' use of information technologies for investigative purposes increases, the number of crimes cleared by those agencies also increases.

Data

This is a cross-sectional study and its unit of analysis is the law enforcement organizations. Data sources of this study are The Impact of Science and Technology Survey, UCR and US Census.

The biggest portion of the data was collected by the "National Study of the Impact of Science and Technology on the Process of Criminal Investigation in Law Enforcement Agencies" project (or shortly Impact of Science and Technology Survey) funded by National Institute of Justice. The purpose of the project 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.

The survey instruments were sent to 1) the largest 200 law enforcement agencies, 2) all the state law enforcement agencies and 3) a random sample of municipal, county and campus agencies. Four waves of mailings were used to collect the data. 630 agencies received the survey, and 280 of them responded. Table 1 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 1. *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
Largest 200	200	8	121	60.5
State	49	1	30	61.22
Total	630	16	280	44.44

As stated above, there are 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. 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 (Reaves, 2008), campus agencies are removed from the sample. Moreover, state police departments are removed from the sample too, because of their different responsibilities and priorities. As a result, after removing 47 campus and state law enforcement agencies, 233 cases remained in the sample.

The second data source of this study is the 2005 and 2006 Uniform Crime Reports (UCR) datasets. UCR data were incorporated into the analysis in three steps. 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. Crime and clearance data for those agencies were added to the Criminal Investigation Survey dataset. Although UCR data has some important limitations discussed in the literature (e.g., Barnett-Ryan, 2007; Polat & Gul, 2010), it provides one of the best measures of crime and clearance statistics. The third data source is the U.S Census Bureau's 2000 Census data. Poverty, income and race variables were taken from 2000 Census (U.S. Census Bureau, 2009).

Variables

The dependent variable of this study is the clearance rates for Part I crimes reported by the UCR Program. Violent crime and property crime clearance rate variables were calculated by using the FBI's classification used in its crime reports. According to that, the violent crime category consisted of murder and nonnegligent manslaughter, forcible rape, robbery and aggravated assault, and the property crime variable consisted of burglary, larceny-theft, and motor vehicle theft.

The independent variable of this study measures IT use by law enforcement organizations. In the survey, departments were asked whether or not they were using particular information technologies. To measure the extent of use, "use of IT scale" was constructed from the following survey items:

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
8. Computer Based Training (CBT)
9. Laptop computer
10. Crime Reports
11. Arrest reports
12. Case disposition
13. Prosecution disposition
14. Court dispositions
15. Summary crime statistics
16. Fingerprints
17. Known offender
18. M.O. file
19. Mug shot
20. Organized crime intelligence
21. Narcotics intelligence
22. Sex offender
23. Stolen property
24. Stolen vehicles
25. National Integrated Ballistics Information Network (NIBIN)
26. Integrated Ballistics Identification System (IBIS)
27. Violent Criminal Apprehension Program (ViCap)
28. Regional Information Sharing Systems (RISS)
29. National Crime Information Center (NCIC)

In order to see if there is any structure in the relationships between variables, first their correlations were examined. The correlation matrix revealed that information technology variables have generally moderate correlations with each other. Then factor analysis was conducted to uncover the structure in the relationship between the variables. The principal axis factoring method was utilized as the extraction method, and the varimax method was used as the rotation method. Factors with eigenvalues greater than one 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, but 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. The second run of factor analysis did not produce a meaningful factors either. Then the standardized alpha coefficient (or Cronbach's alpha) was calculated to see whether it is possible to combine 29 items in one variable. The standardized alpha coefficient was 0.87 for all of the variables. This showed that those items can be used to construct an index variable. Then use of IT variable has been calculated by adding responding agencies' answers to 29 questions.

Seven control variables were identified as control variables: Department size, proportion of officers working at investigative functions, population served, poverty, median income, white population and crime rates. The department size variable is measured as the total number of full-time sworn officers. As discussed in the literature review section, Chaiken, Greenwood, and Petersilia (1976) argued that staffing or workload have no appreciable effect on arrest or clearance rates, but Ostrom, Parks and Whitaker (1978) found that small and medium sized agencies perform equally or more effective than large agencies Welford & Cronin (2000) also found positive relationship between the number of sworn officers assigned to a case and clearance rates. Therefore, department size may have an impact on the clearance rates. 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.

Poverty variable is the percentage of people below the poverty threshold as provided in the census data. There are two arguments on the causal mechanism between poverty and clearance rates. The first one argues that the criminal justice system discriminates against poor and minorities by taking their offenses more seriously than others, and the second one argues that criminal justice system takes poorer people's complaints less seriously because

they have less power and status in the community (Pare et al., 2007). White population also is the percentage of white population in the community served. Several studies found significant relationship between the proportion of the nonwhite population and arrest/clearance rates (Liska & Chamlin, 1984; Pucket and Lundman, 2003; Swanson, 1978). Crime rates are the Part I crimes reported in the UCR statistics. Since the number of crimes increases the workload of the police, officers can not give adequate time to the cases. There are several studies investigated the impact of workload on clearance rates and reported mixed findings (Burrows & Tarling, 1982; Chaiken et al., 1976; Greenwood, 1970).

Results

Figure 1 shows the mean values of crime and clearance rates for Part I crimes reported in 2005 and 2006 UCR data. 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. Vehicle theft is the least prevalent crime type in property crimes. Its mean is 3.999 in 2005 and 3.882 in 2006. For the clearances, murder, assault and rape had higher clearance rates than other crimes both in 2005 and 2006. 26% of all crimes were cleared in 2005 and 25% percent of all crimes were cleared in 2006. Histogram graphics of dependent variables showed that clearance rate is not normally distributed, and transformation is necessary. Natural log transformation and square root transformation are frequently applied transformation methods. Log transformation is not suitable for clearance rate variables because there are many departments with zero clearances for some crimes. 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.
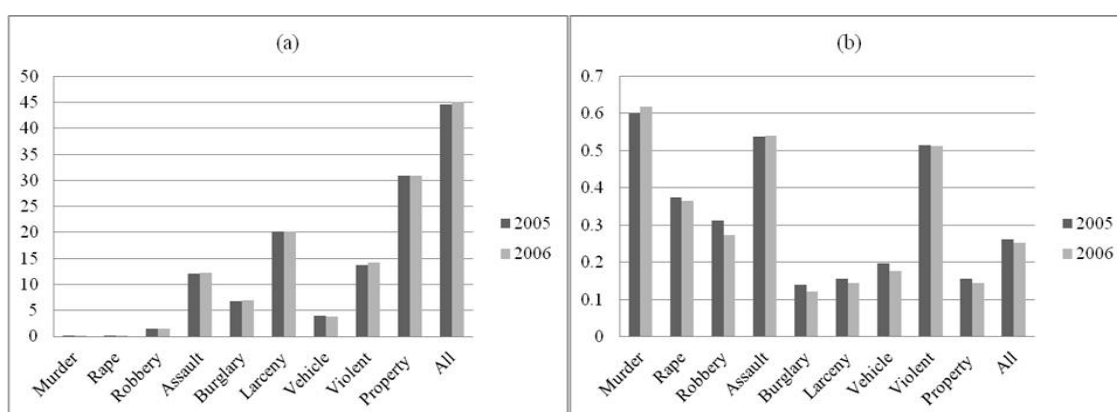
Figure 1. Mean values of (a) crime and (b) clearance rates for 2005 and 2006 data

Table 2 presents the descriptive statistics of independent variable and control variables. The mean and median of the use of IT variable is 20.186 and 21. Its histogram shows that the majority of cases are clustered between 10 and 29, and there are only a few scores below ten.

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.

Table 2. *Descriptive statistics of independent variable and control variables*

N=233	Missing	Valid N	Mean	Median	Std Dev
Use of IT	34	199	20.19	21	5.52
# of Officer	4	229	814.68	210	2,794.02
Log of # of Officer	4	229	4.80	5.35	2.26
Population	0	233	398,987.4	152,000	800,441.87
Log of Population	0	233	11.15	11.93	2.34
Median Income	0	233	41,949.23	37,954	16,587.34
% Below Poverty	0	233	13.79	12.7	7.38
% White	0	233	72	75.1	20.43
Proportion of Investigators	7	226	0.25	0.15	0.33

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.

Pearson product-moment correlation coefficients were calculated for all variables. Table 3 presents use of IT variable's correlation with the 2005 and 2006 crime clearance rates respectively. Table 4 presents correlation between use of IT variable and control variables. The use of IT variable is significantly correlated only with rape clearance rates in both 2005

and 2006 data (*r*=0.176 and *r*=0.252). Other than rape clearances, the use of IT variable is significantly related with 2006 robbery clearance rates; however, this relationship is not significant in 2005 data. The direction of all 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. However, the direction of the relationship is negative for some of the clearance rate variables.

Table 3. Correlation Between Use of IT and 2005-2006 Crime Clearance Rates

		Murder	Rape	Robbery	Assault	Burglary	Larceny	Vehicle Theft	Violent Crimes	Property Crimes	All Crimes
2005	Use of IT	.013	.176*	.017	-.009	.075	.072	-.090	-.031	.009	-.009
	N	111	137	147	171	170	173	166	171	173	173
2006	Use of IT	.031	.252**	.202**	-.029	.122	.042	-.078	-.037	.025	-.031
	N	109	135	147	167	168	168	162	168	169	169

***p< 0.001, **p< 0.01, *p< 0.05

Table 4. Correlation Between Use of IT and Control Variables

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

***p< 0.001, **p< 0.01, *p< 0.05

The use of IT variable has a strong correlation with the logged number of officers and logged 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. It shows 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 in multivariate analysis. Scatter plot of logged number of officers and use of IT scale variables shows that the sample does not have any large department which scored low on the use of IT scale, and it does not have any small department which scored high on use of IT scale. Particularly, there are very few departments scored low on the use of IT scale. This indicates an imbalance problem. Therefore, it is evident that the departments scored below 10 on the use of IT variable cannot contribute much to the analysis, so those eight departments were dropped from the sample.

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).

To see whether use of IT makes any difference between police departments, the sample is divided into two groups and compared with each other. Since the departments scored below ten were dropped, the sample is divided from the new midpoint of the use of IT scale. The sample was divided into two groups because dividing it into three or more groups would yield very little number of cases in groups, and make the comparison less meaningful. The first group consisted of the departments that scored between 10 and 19 and called as "moderate IT group;" the second group consisted of the departments that scored between 20 and 29, and called "high IT group." Figure 2 presents the box plot comparison of 2005-2006 all crime and clearance variables and the six control variables. Box plot comparison of 2005-2006 crime and clearance variables shows that there is no difference between groups in terms of both crime and clearance rates. The logged number of officers variables differs among two groups. Although they are overlapping to some degree, the population, median income and percent white variables also look different.
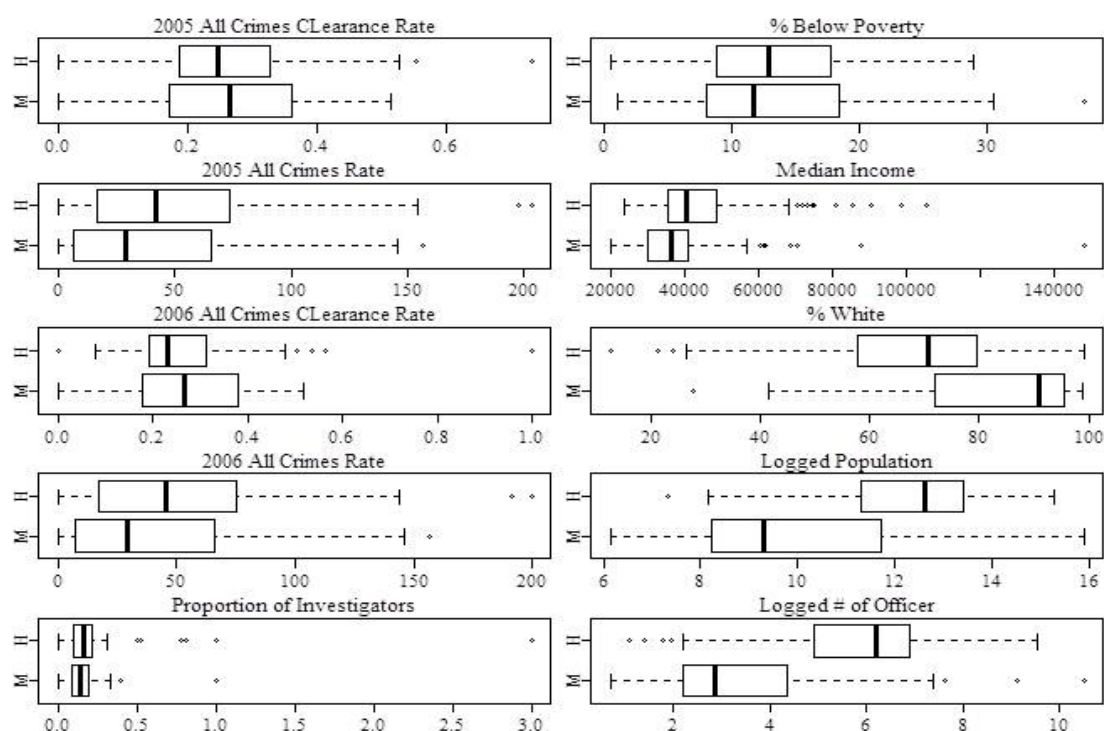
Figure 2. Box plot comparisons of variables between moderate and high IT departments

Multiple regression analysis is employed with the ordinary least squares (OLS) estimation method to investigate functional relationships among 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 officer 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:

$$\sqrt{Clearance\ Rate} = a + \beta_1(Use\ of\ IT\ Scale) + \beta_2(Logged\ Number\ of\ Officer) +$$
$$+ \beta_3(Poverty) + \beta_4(Race) + \beta_5(\Pr oportion\ of\ Investigators) + \beta_6(Crime\ Rate) + e$$

The population variable is excluded from the model because of its strong correlation with the number of officers variable (r=0.943). The median income variable is also excluded from the analysis because of its high correlation (r=0,719) with poverty variable.

Regression parameters were estimated by including all the departments into the analyses after dropping the departments scored below 10 on use of IT scale. Each of the twenty clearance rate variables (ten variables from each year) were plugged into reduced and complex models as dependent variables, so 40 models were estimated. Regression coefficients of use of IT variable for complex models are presented in Figure 3 (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 0.002 and 0.013. 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 eight 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 0.013. 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 0.000169 or % 0.02 change in clearance rates.
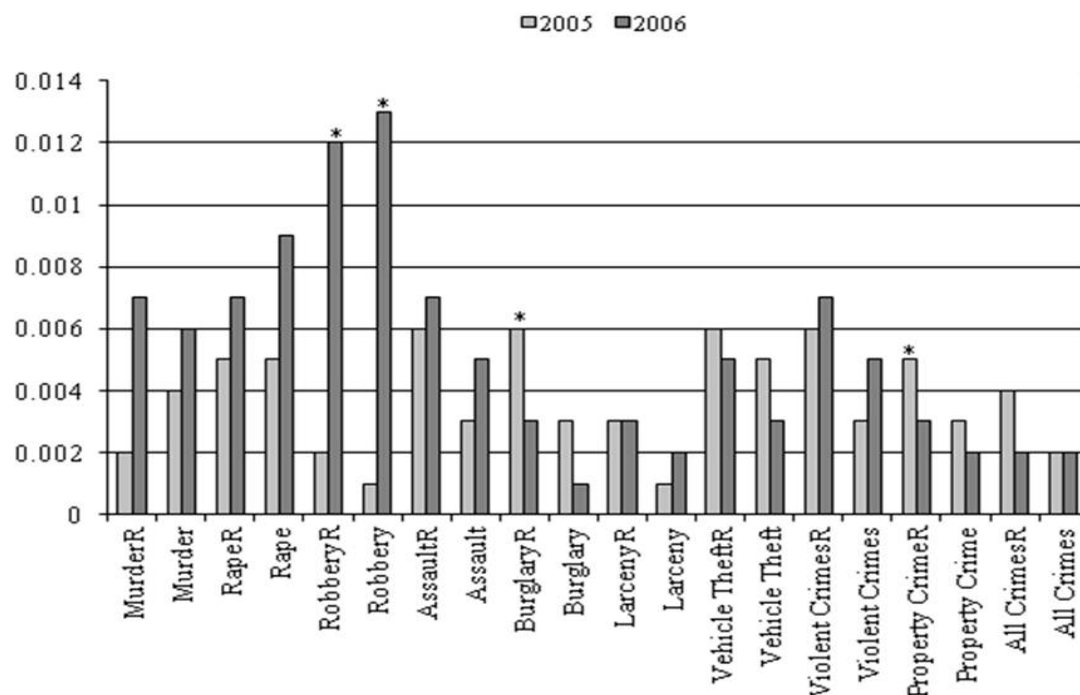
Figure 3. Regression coefficients of Use of IT scale estimated from 2005 and 2006 data (***p< 0.001, **p< 0.01, *p< 0.05)

When we take both reduced and complex models into consideration, the agency size variable (logged number of officers) was significant in 14 out of 40 models, and it has negative coefficients in 7 out of 40 models. 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 four 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.

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.

Conclusion

This study investigated the impact of use of information technologies on the outcome of criminal investigation. The relationship between clearance rates and the use of the information technology scale was investigated with both bivariate and multivariate analyses. Bivariate analysis results revealed weak relationship between use of IT variable and clearance rates. Multivariate analysis results showed that the use of information technology scale was statistically significant in only 4 of 40 models. These findings supported the argument that

there may not be a relationship between clearance rates and the use of information technology variable. Therefore, for the majority of the analyses, this study did not find a significant relationship between use of information technologies and the clearance rates.

This study has important implications for future research. Its findings showed that despite of the large investments on the information technologies by police departments, those investments may not have a direct impact on clearance rates. The review of criminal investigation literature showed that the preliminary investigation and the availability of information about the suspect are the most important determinants of outcome 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.

Another important implication is that issues related to the implementation and use of information technologies in law enforcement agencies require more attention (Harris & Romesburg, 2002). 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.

Finally, there are two variables that can be controlled for in the future studies. Departments' forensic capacity is one of them. As stated in the literature review section, physical evidence and forensic examination increase the effectiveness of criminal investigation, but it is also stated that forensic evidence is underutilized. Therefore, forensic capacity and its usage in the criminal investigations should be measured. Another variable that can be controlled for is the specialization of investigative unit. Special investigation units were reported more successful than general investigative units in some studies (Bloch and Bell, 1976; , Chaiken et al., 1976; Elliot, 1978; Greenwood, 1970). Therefore, the proportion of special investigative units might be controlled for in the future studies.

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 use or do not use 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. 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. Imbalance problem discussed in the results is another limitation of the study. This problem was mitigated to some degree by excluding departments scored low at use of IT scale. However, excluding departments scored low at IT scale limited the generalizability of this study.. 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, 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. Furthermore, as stated above, law enforcement agencies may distort the crime and clearance figures for political reasons. Finally, UCR data introduces some other problems that are well known by the criminal justice community.

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