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Effective Use of Policing Systems: A Two-Stage Study of the Shakedown Period of System Implementation

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Index Terms

Effective use, representation theory, policing systems, police occupation, shakedown period.

Abstract

With the rising demand for national security and the expanding role of police forces, police agencies have invested heavily in information technologies to support their expanded mandates. However, the link between investment in information technology and police performance remains unclear. In this study, we examine the effective use of a police system in the context of system implementation. We develop and test an effective use model based on representation theory and adapt it to the specific occupation culture of law enforcement agencies. The model discerns effective use into three dimensions based on different interactions among user, task, and system, with each dimension exerting an impact on performance. To contextualize the model and enrich its relevance, two salient occupation traits of police – autonomy and loyalty to peers – are operationalized and incorporated as a dimension of effective use. The model is tested using data collected before and after the rollout of a police command and control system in a major city in Asia. The empirical findings are consistent with the theoretical predictions. This work contributes to the ongoing discussion of effective use in general and provides insights into law enforcement systems, which have major societal impacts but have received little attention from researchers.

I. INTRODUCTION

With demand for national security rising and the role of police expanding beyond law enforcement to include community development and crime prevention, police agencies have invested heavily in information technology (IT) to support their enlarged mandates [1], [2]. The adoption of IT has exerted a profound impact on the manner in which police agencies deliver their services and the perception of these services by the public and legislators [3]. New initiatives such as CompStat, hot-spot policing, and information sharing among agencies depend critically on whether they are embraced by police officers in the delivery of their duties.

Despite this heavy investment in technology, findings regarding the effectiveness of police IT systems have been mixed. Garicano and Heaton [2] recently reported that investments in IT by police agencies show little correlation with general productivity measures such as case solution, clearance and conviction rates. However, they also found that agencies that implemented CompStat[1] had lower crime rates, which suggests that 'police agencies, like firms, appear likely to enjoy the benefits of computerization only when they identify the specific ways in which new information and data availability interact with existing organizational practices and make adjustments accordingly' (p. 196). It has become apparent that simple correlation of IT investment with territory-wide crime rates is unlikely to reveal the chain of causal factors that could be latent but important in assessing the effectiveness of a police IT system.

To assess the link between a police IT system and its impact on officer performance, it is necessary to study how effectively the system is being used. System usage has been studied extensively by information systems (IS) researchers on the basis of various conceptualizations. Earlier works conceptualize use as the amount of time spent and the number of features used [4], [5]. This view is being increasingly challenged because these measures do not account for the context of use, which

[1] CompStat is a data-driven management model that facilitates law enforcement and resource deployment based on systematic collection and analysis of crime and disorder data. It emphasizes a problem-solving orientation and is performance driven. It was first introduced to the New York Police Department in 1994.

naturally has a strong bearing on the extent of use and its correlates [6], [7]. Another perspective focuses on users' motivation to embrace a new system as reflected in the notion of continuous system usage [8], [9]. Under this framework, research questions are centred on the antecedents of continuous usage of a system, which to a large extent is under users' volitional control. Many studies have addressed continuous usage in isolation from the reasons for and outcomes of use, which are goal-driven.

Burton-Jones and Grange [10] advanced a theory of effective use that is grounded in representation theory [11] and highlights the interaction among task, user, and system [12]. It provides an integrated view of use with two distinct features. First, instead of focusing on a single trait of use (e.g., the time spent on a system), representation theory highlights the various dimensions of an IS in relation to its use and the hierarchical structure. Specifically, the theory highlights the relationships among interface (surface components), application domain (representational fidelity) and tasks enabled by the representations (informed actions), as well as their effects on user performance. Second, it emphasises the context of use and allows for different ways of operationalizing constructs of the model. This allows researchers a greater degree of freedom to incorporate specific environmental, organizational and occupational considerations into the model.

The representation-based theory offers a novel approach to integrate concepts developed independently, such as data quality [13], task-technology fit [14] and information success [15], [16], into a single framework of effective use. Although theoretically appealing, the Burton-Jones and Grange model has not been assessed empirically. The authors provided suggestions on the operationalization of some of the constructs but did not empirically test the model. In this study, we adopt the model and empirically assess the various hypothesized links in the context of a police system implementation project.

Research on IS has focused largely on their usage in commercial settings. While findings derived from commercial settings may be applicable to the government sector, they tend to be general and do not address the unique settings of government agencies. Furthermore, few studies have examined law enforcement IT systems, which are underpinned by a strong occupation culture and have major social and legal implications. The rising demand for accountability triggered by recent controversial incidents involving use of force by police officers attests to the challenges that face the police occupation [17]. On one hand, police activities are becoming increasingly transparent, and public scrutiny is inevitable. On the other hand, officers are facing an increasingly hostile work environment [18]. The manner in which police agencies use IT solutions to perform their duties and to enforce a safe environment for citizens remains an important question that has significant implications at the societal level. Most studies of police IT systems are grounded in a criminology, legal or public administration perspective.

Because security and law enforcement continue to rank high on national agendas, it is important to study the use of police systems and how it affects officer performance. IS research offers a theoretical lens through which to study this phenomenon and can draw on the rich literature in the discipline. As suggested by Orlikowski and Iacono [7], no single conceptualization of technology can be applied in all usage contexts. Contextual factors that have a direct effect on usage have great importance in IS research [6], [7].

In addition to its policy relevance, studying the effective use of police IT systems adds to findings that are derived largely from studies of commercial systems in IS research. Adoption and usage models such as the Technology Acceptance Model rest upon the assumption of volitional user behaviour [19]. The users of commercial systems have a high degree of volitional control and are relatively free to alter system usage to suit their own needs. Managerial oversight is generally less stringent in non-government sectors as long as users are able to complete their tasks. However, for law enforcement IT systems, user discretion is very much constrained, if not non-existent, due to strict procedural regulations and compliance requirements. In these situations, mandated usage may show little correlation with attitude, which was shown to be a mediator of usage behaviour in previous studies

[20], [21]. Police systems are located at the extreme end of the volition usage spectrum dimensions, which have received little attention in the literature.

To fill this research gap, our study was performed to achieve three objectives:

1. To address the effective use of policing systems, which is characterized by a unique occupational culture and whose monolithic nature is matched only by that of the military.
2. To define the multi-dimensional aspects of effective use by adapting a representation theoretical framework that highlights interactions among user, task, and system.
3. To empirically validate the model in two stages of a police system implementation project over a period of 18 months.

We decided to situate the study in the shakedown period of a major command and control (C&C) system upgrade for an economy-wide police department (PD) in Asia. This enables us to more saliently capture the relationships among the representation components and user performance suggested by Burton-Jones and Grange [10]. By assessing the hypothesized relationships 1 month and 18 months after rollout, we can validate the model at two different points in time that represent roughly the beginning and end of the shakedown period of system implementation. The relationships between the variables and their temporal differences can provide useful insight into effective use over time.

The of the paper proceeds as follows. Section 2 provides an overview of the related literature, with a focus on effective use, the police culture and the various stages of system implementation. Section 3 presents the two-stage model and the hypothesized relationships. Section 4 outlines the method, followed by a report on data analysis in Section 5. Section 6 presents the theoretical and practical implications of the findings, followed by a discussion of the study's limitations and directions for future study. Section 7 concludes the paper.

II. THEORETICAL BACKGROUND

A police force's IS system has many facets, and it is not our intention to provide a comprehensive overview here. Given our focus on the effective use of police systems and their impact on officer performance, we adopt a theoretical lens that intersects at three major concepts: (1) the notion of effective use, (2) operationalization of effective use in the context of policing and (3) effective use in various stages of implementation of a police IS. We discuss the theoretical underpinnings of each.

A. Effective Use

The use of information systems has been a key research area for many years. The central focus of this line of research is on the development of a conceptualization of IS use and an assessment of its impacts on individual and organizational outcomes. As Orlikowski [22] remarked, 'Technology per se can't increase or decrease productivity of workers' performance, only use of it can' (p. 425).

Despite many years of research, a generally accepted conceptualization of use has yet to emerge [23], [24]. Earlier studies focused on system use (e.g., the time spent and the number of system features used) and found mixed evidence on the link between use and performance [14], [25]. Garicano and Heaton [2] reported that IT investments by police departments do not correlate significantly with crime-related performance indicators. An alternative to direct measurement of use is to assess the attitudinal response to IS use. Continuous usage (or the intention to do so) is a widely adopted outcome variable in post-implementation studies [26].

The existing IS use models tend to examine a single aspect of usage. This limited view fails to reflect the rich context of interaction among system, task, and user [23] and provides little insight on how effectively user's goals are attained. Drawing on representation theory [11], [12], Burton-Jones and Grange [10] proposed a general theory that defines effective use as a hierarchy of three dimensions with each dimension capturing a unique interaction between user, system, and task and having a direct impact on user performance. The theory also stipulates that coping with uncertainty and other exogenous factors requires users to adapt and find ways to improve these use dimensions over time.

Unlike previous studies that defined IS use as a single construct, Burton-Jones and Grange proposed effective use as a multi-dimensional concept that involves various components of an IS and their relationships with user performance. Specifically, use of an IS includes three dimensions: (1) physical and surface structures, (2) representation of a real-world domain of interest and (3) actions informed by the underlying representation. Representation is accessed through the physical and surface structures. To carry out meaningful tasks using the IS, representation must be faithful in the sense that it accurately represents the real-world domain that it intends to capture.

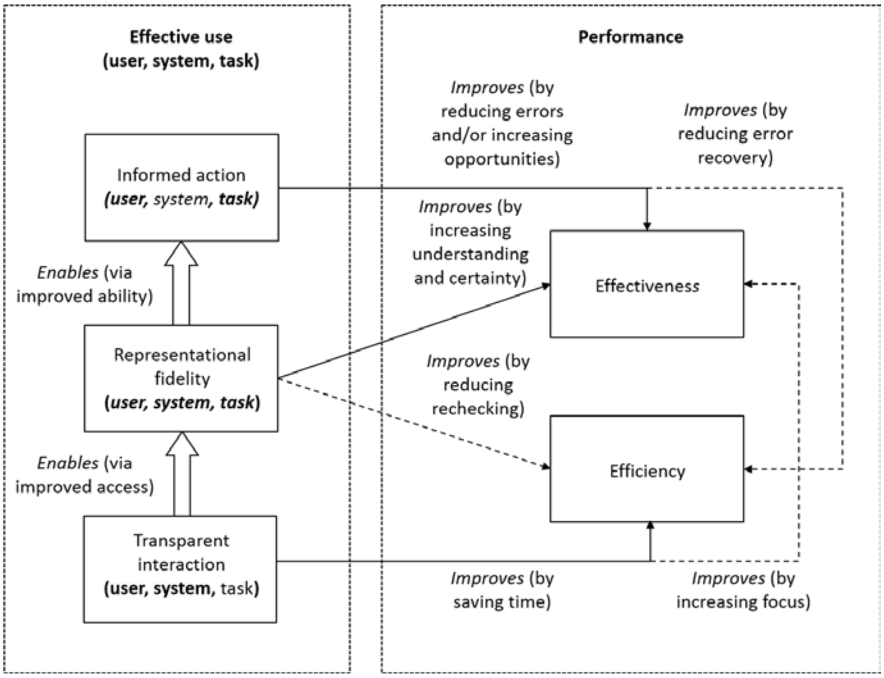

Fig. 1. Effective use and its effect on performance (from Burton-Jones and Grange [10] Fig. 5).

The original theory is general and all-encompassing. To reflect our research objectives and facilitate empirical assessment, we focus on the link between effective use and its impact on performance, as illustrated in Fig. 1 (which is based on Fig. 5 from Burton-Jones and Grange [10]). The lowest level of the hierarchy is *transparent interaction*, which focuses on how easy and transparent it is for users to access the representation using the IS's physical and surface structures. For example, a user interface that is easy to use helps reduce input errors and navigation time, and such an interface has a direct effect on performance and facilitates access to the representation of the real-world domain. In the context of police IT systems, a user interface refers to the devices and interfaces used by officers to carry out their duties.

The middle level of the hierarchy is *representational fidelity*, which captures the extent to which the representation reflects the underlying real-world domain. It is based on the characterisation of an IS by Wand and Weber [11], [12] and Weber [27] to have a deep structure that serves as the specification of a domain captured by an IS. In the case of law enforcement, the representation could be automobile registration records, information on suspects, incident reports, citizen identification, geo-location information and other command and control instructions that enable officers to carry out their duties. One of the key building blocks of the successful CompStat police management model is timely and accurate information [28], so it follows that representation must be accurate and reliable. As shown in Fig. 1, the model stipulates that transparent interaction enables representational fidelity via improved access, which exerts a positive effect on user performance. In addition to accurately reflecting the underlying domain, the representation must also be easily and reliably accessible to users to affect performance.

At the top level lies *informed actions*. These are not representation components per se but tasks enabled by the underlying representations. These tasks are related to the users' goals and can be translated into performance measures. The users interact with the system to access the domain representation and perform tasks that lead to the attainment of a set of goals. Unlike transparent interaction and representational fidelity, the definition of informed actions in the original theory is quite flexible and context-dependent [10]. In the current context of law enforcement, our treatment of informed tasks deviates from the original formulation, which implies listing all possible actions. Instead, we focus on two key occupation traits of the police culture that underpin a wide spectrum of police tasks. Both are discussed in the next section after a general review of the police culture.

B. Police Culture

Culture is an important contextual factor in IS research and was reviewed by Leidner and Kayworth [29], who stated that most IS research related to culture resides at the organization or national level. However, an occupational culture can exert its influence across organizations in the same industry or even across national boundaries. According to Manning [30], 'Occupational cultures contact accepted practices, rules, and principles of conduct that are situationally applied and generalized rationales and beliefs' (p. 472). However, few studies of IS have incorporated occupational culture as an important context of study.

Police culture has been at the heart of law enforcement and criminology research for decades [18], [31]. The existence of a strong police culture manifests in a set of norms, attitudes and behaviours that are shared by officers in many police agencies. Previous research has identified three major functions of policing: (1) order maintenance, (2) law enforcement, and (3) service provision [31], [33]. The police culture has a profound effect on officers in delivering these functions. This culture has been studied since the 1950s, and the body of literature is largely built upon the seminal study by Westley [34].

The traditional view of police culture highlights the mechanisms adopted by officers to cope with a number of occupational uncertainties and strains, including (1) the danger presented by the job environment [35], [36], (2) the coercive authority that police officers wield [31], [34], (3) unpredictable and punitive supervisory oversight [30], [37] and (4) the ambiguity of the police role [37], [38]. These coping mechanisms symbolise the cultural elements of police, which include being suspicious of the public, maintaining an edge, lying low within the administration and possessing a crime-fighter orientation [18], [31]. These coping mechanisms are passed on from one generation of officers to the next via a socialisation process that begins at the academy and is reinforced through the delivery of police services throughout one's career.

The outcomes of these coping behaviours are two salient occupation traits: loyalty among police officers and a desire for autonomy. Brown [37] remarked that 'loyalty and individualism are the opposite sides of the coin: the police culture demands loyalty but grants autonomy' (p. 85). Loyalty highlights the bond between officers who share the same attitudes and values and adopt the same set of coping mechanisms to mitigate the dangers of their work environment [35], [36]. Paoline [31] observed that 'officers depend on one another for both physical and emotional protection because of the danger, uncertainty and anxiety found in the occupational environment' (p. 203).

Officers often work as a team when carrying out their duties, and any IT system that supports team operation must be aligned with the groups' perceptions of its usefulness. The system must be perceived as useful and effective by individual officers and by those with whom they work. The system will not function as intended if officers hold conflicting views regarding its effectiveness, especially if it provides the backbone C&C functions for all policing tasks.

The desire for autonomy allows police officers to cope with administrative scrutiny [18], [36] and the danger presented by their work environment. This desire manifests in police discretion and leads to a reliance on subjective decision-making [39]. Police IT systems have fuelled this desire because officers are increasingly being monitored and their actions regularised. Some officers feel that IT has limited their discretion [40]. Only when officers begin to believe that police IT systems can enhance their autonomy and empower them will these systems be well received and thus have the ability to improve performance.

These two occupation traits, when framed under the effective use model presented earlier, drive a wide spectrum of an officer's informed tasks. Instead of listing all possible tasks of an officer, which can be numerous, as suggested by the original theory, we focus on these two key enablers of informed tasks. Our argument is based on the reasoning that even if a system is easy to use and provides a fair representation of the underlying domain, it is unlikely to have a positive effect on performance if it does not empower individual officers and instil a shared positive view of the system that is critical to team operation. A model that incorporates these two occupation traits is presented in the next section.

C. Multiple Stages of IT implementation

Advanced technologies have created a push phenomenon that constantly injects IT innovations into all aspects of policing [1], [41], resulting in regular system migrations every few years. These system migrations create considerable stress and tension in the participating police officers. Because our research focus is on the effective use of police IT systems, we look to previous studies of IS implementation for insight regarding the time dimension of effective use.

IS implementation is conceived as a multistage process [42], [43]. Markus and Tanis [44] suggested that IS implementation consists of four phases: chartering, development, shakedown and onward/upward. Holland and Light [45] presented a maturity model for enterprise resource planning (ERP) systems that includes three stages: project initialisation, system implementation and organizational integration. Saeed and Abdinnour [46] further divided the post-adoption period into three stages: routinization, infusion and extension. According to Cooper and Zmud [42], an implementation effort can be divided into six stages: initiation, adoption, adaptation, acceptance, routinization, and infusion. Despite the various means of characterisation, these implementation models each include a shakedown period that is volatile and adaptive before the system stabilises.

The shakedown period has a profound effect on the course of IS implementation [47]. It is generally reported that when implementing a system, user performance will deteriorate before improving [48]-[50]. The phenomenon is so prevalent that Ross [51] suggested that managers should expect a dip in performance shortly after ERP rollout. Hakkinen and Hilmola [50] measured users' evaluations of system quality during two post-implementation phases: the shakedown phase and 2 years after system implementation. They found that user evaluations were more negative during the shakedown phase; similar findings were reported by [52], [53].

Because the phenomenon of a performance dip is task-related, effective use should be the focal variable in the shakedown stage. In assessment, it is important to measure effective use at the beginning and end of the shakedown period. This echoes the general theory proposed by Burton-Jones and Grange [10] that effective use evolves as users adapt and learn in the migration process. In this study, we assess the effective use of a new police C&C system 1 month and 18 months after rollout by considering the residual effects of the various use dimensions and performance over time.

III. RESEARCH MODEL AND HYPOTHESES

To study the effective use of policing systems and to assess its impact on officer performance, we develop a model based on the representation theoretical approach advanced by Burton-Jones and Grange [10] and tailor it to the context of policing. Specifically, we develop constructs to operationalize the various concepts proposed in the original theory and to test the model during two different stages of IS implementation.

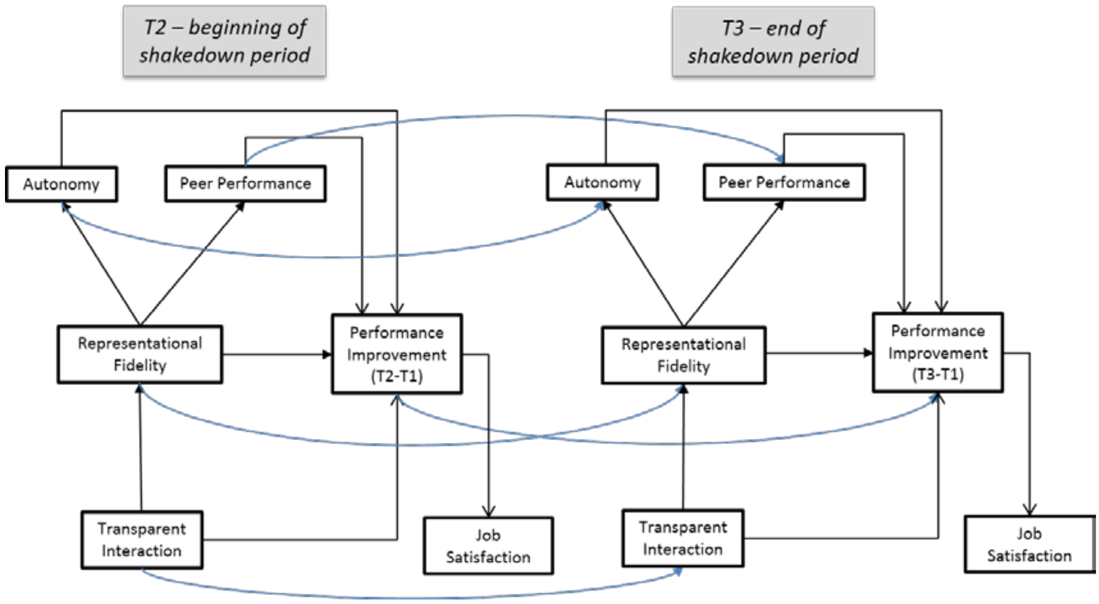

Fig. 2. Research model.

Fig. 2 depicts the proposed research model. To empirically validate the effective use model over time as shown in Fig. 1, we repeat it in two stages of a system migration project: 1 month (T2) and 18 months (T3) after rollout. These two time points correspond roughly to the beginning and end of the shakedown period of a system migration project. We also measure self-evaluated performance 1 month before rollout (T1) to serve as a benchmark to assess performance improvement in individual officers. The same variables are linked over the two stages, representing the residual effect over time. Effective use of the police system is characterized by a hierarchy of three use dimensions: transparent interaction, representational fidelity, and informed actions, which are described below.

A. Transparent Interaction

At the lowest level of the hierarchy, transparent interaction is hypothesized to enable representational fidelity. This component captures the interaction between user and system. Because the domain representation must be accessed through the system and the surface components, the ability of the users to interact effectively with the device and its interface (e.g., radio transmitters and mobile devices) has implications for the next level of effective use (i.e., representational fidelity). In the case of a C&C system, each officer is equipped with a device for communication and information retrieval as part of the standard equipment provision. The size, materials, weight and functions were meticulously researched with wide consultation with officers before the tender specifications were crafted. One example of this enhancement is that officers are not required to input data using fixed command codes and syntax that must be memorised. The third-generation C&C system (C&CIII) allows officers to input text directly, and the prototypes were developed and field-tested in various environmental conditions. No assessment of transparent interaction has been performed, but Burton-Jones and Grange [10] suggested that 'construct specification can start with measures of perceived ease of use' [19] (p. 654). We follow their advice and adopt items related to the perceived ease of use in defining transparent interaction, which leads us to the following hypothesis:

H1: Transparent interaction is positively correlated with representational fidelity.

B. *Representational Fidelity*

The next level of the hierarchy is representational fidelity, which pertains to the extent to which a user can obtain representations that faithfully reflect the domain of interest. High representational fidelity provides users with accurate and reliable information on the underlying domain. In the context of a C&C system, the underlying domain is law enforcement and crime-related information, including citizen identification, vehicle registrations, crime information, instructions and other related data. Lindsay et al. [54] remarked that a key concern for police officers is the quality of the police system's information. As with transparent interaction, no measurement exists for representational fidelity. A closely related concept is data quality. In fact, Burton-Jones and Grange [10] suggested that 'construct specification can start with the aspects of data quality' (p. 654).

Data quality has different dimensions [55], [56]. Here, we focus on two: accuracy and reliability. The two dimensions reflect one of the four core components[2] of the Compstat police management model [28]. Accuracy refers to the precision of the representation in its reflection of the underlying real-world domain. Officers require accurate information to carry out policing functions. For example, when conducting identification checks, officers need to retrieve the most up-to-date information about a citizen. In executing an operation, knowledge of the exact locations of individual officers in real time is important. In crowd control, access to accurate traffic information and closed-circuit television images is essential for officers to take effective actions. Representational fidelity shows a clear and direct link to the notion of data accuracy.

Another dimension of representational fidelity is reliability, which refers to the extent to which the representation reflects the current state of the real-world domain and its availability. The availability of the real-world domain implies the need for officers to access the representation anytime and anywhere. It also implies that distortions will be controllable and will have a minimal effect on

[2] The CompStat model includes four core components: timely and accurate information, rapid deployment of resources, effective tactics and relentless follow-up.

operation. To handle an incident in any environmental conditions, including hazardous ones, officers rely on the C&C system to carry out their tasks. A reliable system enables the officers to focus on their duties and to act on the data retrieved from the system without hesitation.

To allow for theoretical consistency and to reduce the model's complexity [57], we operationalize representational fidelity as a hierarchical construct based on the two first-order constructs of accuracy and reliability, as shown in Fig. 3. Jarvis et al. [58] stated that measures can be specified as formative (1) if they use different aspects and may not be interchangeable, (2) if the direction of causality is from the measures to their construct and (3) if they do not necessarily co-vary. Because the two dimensions of representation are conceptually distinct and form the higher-order construct, it is appropriate to model representational fidelity as a second-order latent variable with formative first-order dimensions. We believe that such operationalization of representational fidelity is appropriate for the current context of a C&C system for a police force. High representational fidelity can reasonably be expected to have a high level of accuracy and reliability.

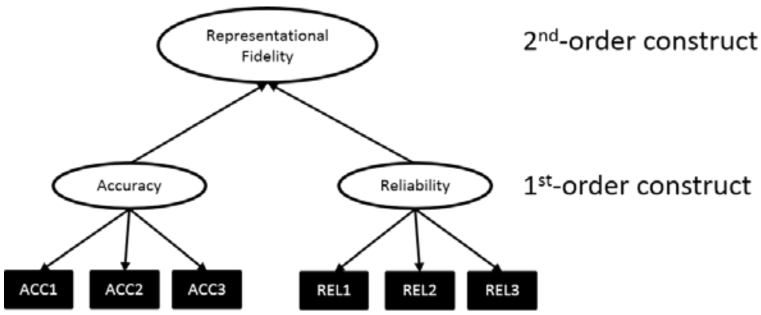

Fig. 3. Hierarchical construct.

C. *Informed Actions and Police Culture*

At the highest level of the hierarchy are informed actions. These are actions informed by the system that allow the users to improve their current status. In the case of commercial systems such as ERP, consumer relationship management and supply chain management, the IT system helps users to make business decisions to improve upon a wide range of performance indicators relevant to their roles and responsibilities. In the context of policing, officers must access the C&C system to discharge their duties. As discussed in the previous section, the original conceptualization of informed actions is rather flexible and context-dependent, so we could adapt it to policing. Our conceptualization deviates from the original model, which suggests that most, if not all, goal-related tasks be listed. As explained earlier, we focus on two factors originating from two core occupational traits of police culture that underpin all policing tasks. In other words, instead of listing each of the numerous tasks (e.g., vehicle registration check, crowd control, incident handling, etc.), we focus on two traits of police culture that exert a significant effect on officer performance in general. Such a formulation yields a manageable number of constructs but retains a broad impact on performance.

Officers have traditionally identified discretion as a symbolic element of police culture. Cockcroft [18] stated that police officers have 'traditionally valued discretion as an emblem of their professionalism' and that 'discretion has emerged as an integral element of our understanding of police work.' (p. 46). In addition, studies of the police culture have suggested that officers maintain, to a large extent, a negative view toward procedural rules and regulations [31], [40]. This may seem incongruent with the public perception that police institutions are hierarchical and disciplined entities [59], yet the desire for discretion and autonomy has prevailed for decades within police culture. It arises from the officers' perception of role ambiguity and their resentment of supervisory scrutiny [60], [61]. Officers must be allowed to act decisively in uncertain and hostile situations, and they require discretion in discharging their tasks. Neyroud and Beckley [62] identified four categories of decisions that require discretion: (1) scope decisions, (2) interpretive decisions, (3) priority decisions, and (4) tactical decisions. These decisions underpin almost all police tasks. It follows from this occupational trait that an accurate and reliable representation (i.e., high representational fidelity) will empower an officer in decision making, which leads us to the following hypothesis:

H2: Representational fidelity is positively correlated with autonomy.

Another important element of the police culture is loyalty among officers [18], [63]. Richards used an example based on game theory to illustrate how loyalty among officers prevents poor collective outcomes when individual officers are left to act on their own, even though their individual decisions are rational [63]. Loyalty bonds individuals together, and such a bond is deeply imprinted within police culture. In an early study, Savitz [64] found that mutual assistance among officers is a salient dimension of loyalty and remarked that 'the police are really a big brotherhood' (p. 696). This occupational trait has remained largely symbolic of police culture in recent decades despite continuous changes in the social demographic profile [31]. This desire for loyalty was summarized by Brown [37] as follows: 'the Police culture demands of a patrolman unstinting loyalty to fellow officers, and he receives, in return, protection and honor.' (p. 83).

Loyalty affects the effective use of a police system in significant ways. Many police tasks are team-based and require seamless coordination and communication between officers. Not only must the individual officers take effective action informed by the representation, they must also be sure that their peers feel the same way about using the C&C to accomplish group tasks. For example, in a team effort to handle an incident, the locations of the participating officers are important to map an action plan. If an officer believes that some of his or her peers are hesitant to use the GIS function to coordinate, he or she must rely upon the less effective audio channel to relay his or her position, and the results will have a negative effect on performance. In contrast, if officers in the same group share the belief that the system has high interaction transparency and the representation is accurate and reliable, they will have more options from which to choose when confronting a situation. This shared belief of the representation contributes to the effectiveness of decision making and the efficiency of task completion. It follows that representational fidelity exerts a positive effect not only on the officer himself or herself but also on the performance of his or her peers. Thus, we make the following hypothesis:

H3: Representational fidelity is positively correlated with peer performance.

D. Officer Performance

One important outcome of effective use is performance. As discussed above, the literature on police performance measurement focuses on aggregate crime-related indicators at the institutional or jurisdictional level, and most of these studies are published in criminology, justice and public policy journals. Little work on police performance has been done from an IS perspective.

In the original model, as shown in Fig. 1, Burton-Jones and Grange [10] defined performance with two dimensions: effectiveness and efficiency. In this study, we adopt a single performance measure that aligns with the longitudinal nature of our empirical assessment and links to the objective of system migration. Instead of measuring the performance level at a particular time, we measure the improvement in performance enabled by a new system 1 month and 18 months after its rollout.

While we deviate from the original model by consolidating efficiency and effectiveness into one measure and focus on incremental changes in the context of system migration, our model maintains the effects of the three dimensions of effective use on performance. Specifically, we surveyed officers regarding self-reported performance 1 month before rollout and 1 and 18 months afterward and calculated the differences (T2 minus T1 and T3 minus T1). The effects of these components on performance improvement are hypothesized below:

H4: Transparent interaction is positively correlated with performance improvement.

H5: Representational fidelity is positively correlated with performance improvement.

H6: Autonomy is positively correlated with performance improvement.

H7: Peer performance is positively correlated with performance improvement.

E. Residual Effects

The model shown in Fig. 1 is a part of the overall theory of effective use, which stipulates that users will show continuous improvement in the various use dimensions via training and adaption. To specify these corrective actions lies beyond the scope of this paper. Nevertheless, the multi-stage setup of our model allows the residual impact of each construct to be assessed over time. Previous IS studies have reported the residual effects of beliefs over time [46], [65]. In the current context, beliefs about transparent interaction, representational fidelity, autonomy and peer performance that are developed shortly after rollout will not only have immediate effects on officer performance, they will also determine future beliefs. As with previous results, these residual effects are specified as positive reinforcing links over time. One important implication is that smooth system migration allows effective use early in the shakedown period, so one would expect more effective use and hence greater performance improvement at a later stage.

We hypothesize that beliefs regarding each dimension that are developed at the beginning of the shakedown period will exert a residual effect on beliefs at the end of the period. Similarly, we expect that performance improvement up to T2 will exert a residual impact on performance improvement up to T3, which leads us to the following hypotheses:

H8: Transparent interaction at T2 is positively correlated with transparent interaction at T3.

H9: Representational fidelity at T2 is positively correlated with representational fidelity at T3.

H10: Autonomy at T2 is positively correlated with autonomy at T3.

H11: Peer performance at T2 is positively correlated with peer performance at T3.

H12: Performance improvement at T2 is positively correlated with performance improvement at T3.

F. Job Satisfaction

Although the original theory focuses on the link between effective use and job performance, we believe that performance affects another important job outcome: job satisfaction [66]. Hackman and Oldham [67] proposed a model of job characteristics and verified their effects on job satisfaction. Based on the Job Characteristics Model [67], Morris and Venkatesh [68] demonstrated that the implementation of an ERP would moderate the relationship between job characteristics and job satisfaction. They showed that the effects of skill variety, autonomy and feedback on job satisfaction were negatively moderated by ERP implementation. Bala and Venkatesh [48] reported a significant correlation between job satisfaction before and after implementation (6 months after rollout).

This decline in job satisfaction and the emergence of a negative affective state among users during the shakedown period are caused by the stress and anxiety that accompany the change. In contrast, if the users see an improvement in performance with the new system, their affective state will be positively influenced. In the case of a C&C system, it is expected that performance improvement has a positive impact on job satisfaction as follows:

H13: Performance improvement is positively correlated with job satisfaction.

In the next section, we outline our research design to validate the proposed model (Fig. 2). Specifically, the model will be empirically tested with data collected at three time points during the implementation of a police C&C system in a major economy in Asia.

IV. METHODOLOGY

A. Research Context

The target organization is the police department (PD) of an Asian economy with a staff of over 35,000. Like many large police agencies, the PD is a highly centralised authority that operates within a formal hierarchy that values technical efficiency and discipline [69]. According to Nogala [70], the most important aspect of police work is ‘information work’, which is vital for actions and decisions. The PD’s operational priority is to leverage advanced IT to enhance operational efficiency.

In the late 20th century, the PD introduced its first-generation C&C system (C&CI) based on analogue radio transmission and a basic computer system. The second-generation C&C system (C&CII) was later introduced to replace C&CI. C&CII consisted of a digital radio communication system, an emergency services telephone system and an enhanced computer-assisted command and control system. However, C&CII encountered maintenance problems and operational deficiencies and was unable to adequately support law enforcement tasks to cope with the expansion of police functions. The government thus approved the development of the third-generation C&C system (C&CIII) in the late 2000s. C&CIII was designed with more advanced features intended to provide better information support, improve officers' control, regulate actions and enhance cooperation. The new enhancements were believed to equip police officers with useful information in a more effective manner to enable them to make more informed decisions while discharging their duties[3].

B. Measurement

We operationalized the measurements of constructs from existing scales and adapted them to our research context. We measured transparent interaction using items from Davis et al. [71]. C&CIII was expected to provide police officers with better information support. We measured representational fidelity as a hierarchical construct (Fig. 3) based on two first-order constructs: accuracy and reliability. The former indicates the extent to which the information provided by C&CIII is accurate, and the latter denotes the extent to which the system is available when the officers need it. We measured these two constructs with items adapted from Goodhue [72].

Guided by the extant literature on police culture and input from the senior management and police constables of the PD, we identified two occupational traits that underpin a wide range of informed actions: autonomy and peer performance. Autonomy is defined as the degree to which an officer believes that the use of C&CIII enhances his or her decision-making and self-determination in initiating and regulating actions. In addition, police officers place a strong emphasis on teamwork, and they believe that their peers' performance when using C&CIII will inevitably affect them. Peer performance is thus defined as the degree to which an officer believes that his or her colleagues can carry out their duties effectively when using C&CIII. We measured autonomy with three items that refer to self-determination in empowerment as proposed by Spreitzer [73]. The items for peer performance mirror those for self-performance (discussed in the next paragraph) and reflect the officer's beliefs regarding C&CIII's enhancement of the performance of his or her peers.

[3] According to the PD document, the C&CIII system includes an Integrated Communication System (ICS) that replaces the beat radio system, a new Emergency Telephone System (ETS), an Automatic Vehicle Location System and Geographic Information System (AVLS & GIS) that track resources and display geographic information, a Mobile Computing sub-System (MCS) that provides computing facilities in police vehicles and communication of messages between C&CIII sub-systems.

To operationalize performance, we conducted qualitative interviews with senior management and police constables to determine their performance expectations in the PD. Eisenberger and Fasolo [74] noted that police officers typically lack discretionary control over many kinds of performance, such as how many times they are called to the scene of an emergency or the amount of time they spend in court waiting to testify. We referred to the principle that system use and related performance should be defined in the context of the user, the system and the task [23]. A four-item construct was developed to operationalize officer performance in relation to C&CIII. In addition, we measured job satisfaction with items adapted from Janssen [66].

The constructs were measured on a 7-point Likert scale ranging from 1 (‘strongly disagree’) to 7 (‘strongly agree’). The detailed measurement items are shown in Appendix A. The questionnaires were administered in the local language (Chinese) based on a back-to-back translation process [75]. The constructs were pilot tested with a small group of officers and showed acceptable reliability and validity. In the main study, we randomized the sequence of measures in the questionnaire to minimize any potential bias due to contextual effects [76]. The literature indicates that performance may vary across individuals depending on their educational attainment, tenure and service experience [77]. We controlled for factors that might influence effective use and performance in the research model, including age, gender, educational attainment, years with the PD and experience with a system change (i.e., whether the officer had experienced the system migration from C&CI to C&CII).

C. Data Collection

We conducted the longitudinal study at three time points during the C&CIII implementation process: 1 month before rollout (T1), 1 month after rollout (T2) and 18 months after rollout (T3). With the help of the PD, we recruited a random sample of subjects to complete the surveys. The subjects were officers whose daily duties required them to use C&CIII. Souvenirs were given to the participants as incentives. The participants were assured that the data collected were for academic research only.

At T1, we measured the officers' job performance when using C&CII. The constructs related to effective use, performance when using C&CIII and job satisfaction were measured at T2 and T3.

The sample in the first survey comprised 800 police officers who differed in experience, age and gender. We received 542 valid responses, resulting in an effective response rate of about 68% for the first survey (T1). The second survey was conducted 1 month after the rollout (T2), and only included those who had returned a valid response to the first survey. After eliminating the responses with missing values, 420 valid responses were remained from the two surveys. A third survey was distributed 18 months after the rollout (T3) to those who had returned valid responses to both the first and second surveys. Because there was a 17-month gap between T2 and T3, after excluding the responses with missing data, 271 valid responses to all three surveys were collected for empirical analysis. Because some subjects dropped out during the survey period, we compared the distributions of the valid responses in the three surveys in terms of the participants' age, gender, educational attainment and years with the PD. We found no significant difference in their profiles (see Table 1), which suggests that response bias was unlikely.

Table 1. Sample comparison.

	T1 (N=542)		T2 (N=420)		T3 (N=271)		Total		*ANOVA*[4]
	Mean	Std. D.	Mean	Std. D.	Mean	Std. D.	Mean	Std. D.	P-value
Age	3.62	1.60	3.70	1.56	3.74	1.52	3.68	1.57	0.55
Gender	0.76	0.43	0.74	0.44	0.72	0.45	0.75	0.44	0.54
Education	1.25	0.71	1.24	0.70	1.21	0.68	1.24	0.7	0.73
Working Years	15.14	8.59	15.56	8.55	15.91	8.11	15.45	8.47	0.45

Note: 1. Age: (1) < 25, (2) 26-30, (3) 31-35, (4) 36-40, (5) 41-45, (6) > 45; 2. Gender: (1) male, (0) female; 3. Educational: (1) secondary school, (2) diploma, (3) bachelor's degree, (4) master's degree or above; 4. We also performed Tukey's test and found no significant difference for pairwise comparisons.

V. DATA ANALYSIS AND RESULTS

A. *Measurement Model*

We measured each construct except representational fidelity as reflective. As explained above, we treated representational fidelity as a second-order construct with formative first-order dimensions. To evaluate the effects of the use of C&CIII on officers' performance improvement, we created a new construct labelled 'performance improvement' by calculating the differences between the officers' self-evaluated performance at T2 and T1 (T2 minus T1) and those at T3 and T1 (T3 minus T1). A positive value indicates that the officer performed better at T2 or T3 than at T1. We used these results as the new indicators to evaluate the measurement model.

Table 2. Descriptive statistics and inter-construct correlations.

	TI (T2)	ACC (T2)	REL (T2)	AUT (T2)	PP (T2)	PI (T2)	JS (T2)	TI (T3)	ACC (T3)	REL (T3)	AUT (T3)	PP (T3)	PI (T3)	JS (T3)
Mean	4.63	4.52	4.49	4.30	4.33	-0.38	5.26	4.95	4.79	4.87	4.53	4.51	-0.14	5.38
Std. D.	1.11	1.32	1.31	1.15	1.17	1.45	1.13	1.23	1.20	1.23	1.17	1.09	1.45	1.18
Composite Reliability	0.90	0.97	0.97	0.96	0.97	0.95	0.95	0.96	0.97	0.97	0.95	0.96	0.95	0.97
Cronbach's α	0.79	0.95	0.95	0.94	0.96	0.92	0.92	0.91	0.95	0.96	0.93	0.94	0.92	0.95
AVE	0.83	0.91	0.91	0.89	0.89	0.81	0.87	0.92	0.91	0.92	0.87	0.86	0.81	0.90
Constructs at T2														
TI	0.91													
ACC	0.48	0.95												
REL	0.49	0.81	0.95											
AUT	0.55	0.60	0.59	0.94										
PP	0.64	0.65	0.65	0.73	0.94									
PI (T2-T1)	0.40	0.54	0.51	0.60	0.64	0.90								
JS	0.40	0.32	0.34	0.45	0.42	0.19	0.93							
Constructs at T3														
TI	0.17	0.27	0.22	0.23	0.18	0.19	0.18	0.96						
ACC	0.16	0.33	0.29	0.24	0.21	0.19	0.20	0.72	0.95					
REL	0.14	0.30	0.28	0.23	0.22	0.18	0.19	0.65	0.82	0.96				
AUT	0.12	0.17	0.15	0.26	0.19	0.15	0.02	0.62	0.64	0.62	0.93			
PP	0.17	0.21	0.21	0.30	0.28	0.17	0.16	0.66	0.67	0.67	0.72	0.93		
PI (T3-T1)	0.03	0.12	0.08	0.17	0.08	0.53	0.01	0.51	0.55	0.53	0.55	0.56	0.90	
JS	0.02	0.13	0.11	0.09	0.13	0.08	0.22	0.53	0.54	0.55	0.45	0.57	0.37	0.95

Note: 1. TI=Transparent Interaction; ACC=Accuracy; REL=Reliability; AUT=Autonomy; PP=Peer Performance; PI=Performance Improvement; JS=Job Satisfaction; 2. Diagonal represents square root of the AVE (average variance extracted).

The constructs with reflective measures exhibited acceptable reliability and validity. As shown in Table 2, the composite reliabilities were all greater than 0.90. The standardized path loadings on each construct were significant and greater than 0.707[4], and all instances of the average variance extracted (AVE) exceeded 0.5. The convergent validity of reflective constructs is thus supported. Also, as shown in Table 2, the square root of AVE for each construct exceeds the correlations between the construct and other constructs, thus demonstrating an acceptable level of discriminant validity. We also compared the cross-loadings with the loadings on each construct. The only concern is the somewhat

[4] Because of page limitations, the item loadings and cross-loadings will be provided upon request.

high correlation between accuracy and reliability. Because they were modelled as the sub-dimensions of a higher-order construct, their co-variation is acceptable, and they are likely to share similar antecedents and consequences[5]. Therefore, the evidence above suggests acceptable psychometric properties for the reflective constructs in our research model. Moreover, we compared the loadings between the same construct at T2 and T3, and their patterns suggested measurement invariance.

We examined the weights for representational fidelity, which possess formative first-order dimensions. The scores of lower-order latent variables can be obtained by partial least squares path analysis. We then used them as manifest variables for higher-order latent variables [57, 78]. As shown in Table 3, the weights for representation are positive and significant. Accuracy and reliability make similar contributions to the composite score for representational fidelity at T2 and T3.

Table 3. Weights of the formative items.

Item	Representational Fidelity-T2		Representational Fidelity-T3	
	Weight	*P value*	Weight	*P value*
Accuracy	0.511	0.000	0.507	0.000
Reliability	0.513	0.000	0.514	0.000

Because we conducted multiple surveys, the common method bias should not be a big concern because the constructs were measured at different time intervals [79]. When conducting the surveys, we randomized the sequence of the measurement items to alleviate potential contextual threats. Nevertheless, considering that our data was collected from a single source, we used two methods to assess common method bias. First, we performed Harman's single-factor test [80], and were unable to find a single factor that could account for the majority of covariance. Second, we conducted the common method variance factor test [79] for the constructs measured in the same survey. The results showed that all factor loadings remained stable across the original measurement model and the model

[5] We also tested the model in which accuracy and reliability were treated as two reflective sub-dimensions of representational fidelity. The results of this structural model showed the same significance level and direction of path coefficients. Because accuracy and reliability are conceptually distinct and indicate two different aspects of representational fidelity, we decided to use the formative model.

with the common method variance factor (see Appendix B). The results of both tests suggest that common method bias is not a serious threat in our study.

B. Structural Model

We estimated the model parameters using partial least squares (PLS), which is a method of component-based structural equation modelling that maximizes the explained variance of endogenous variables without distributional assumptions [81]. Unlike covariance-based structural equation modelling, PLS is robust to the inclusion of both formative and reflective constructs [82]. Fig. 4 presents our structural model with the path coefficients and R^2. We performed bootstrapping with 500 samples to determine the path significance. The results of the hypothesis testing are discussed below.

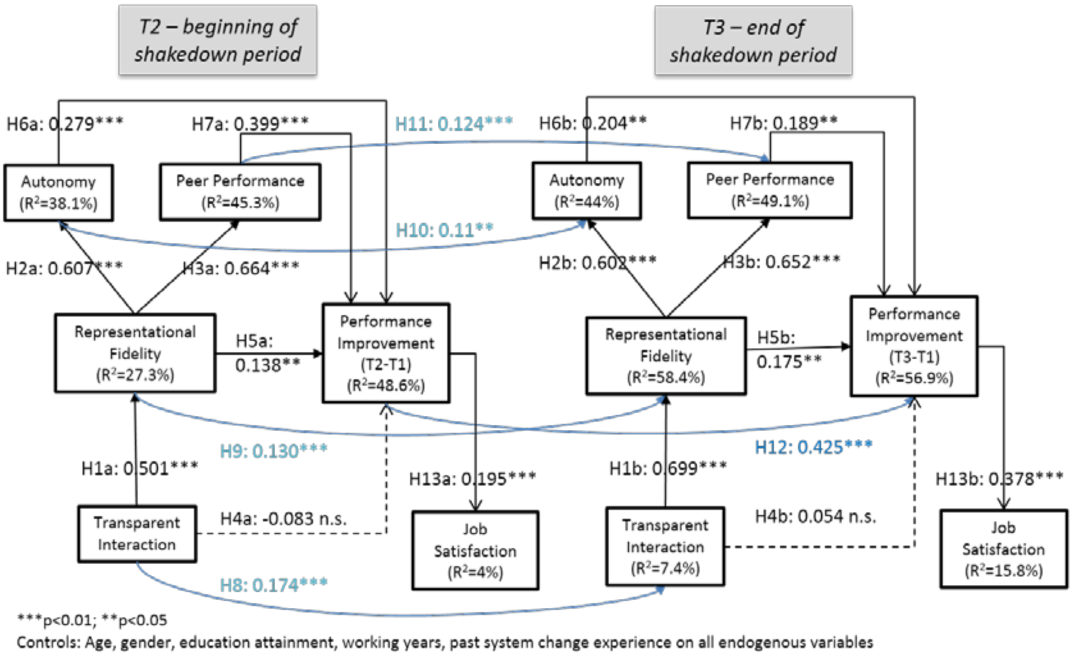

Fig. 4. Partial least squares results.

Consistent with our prediction, transparent interaction exerts a strong influence on representational fidelity, which is then leveraged by informed actions. The impact of transparent interaction on representational fidelity is 0.501 at T2 and becomes even stronger at T3. Thus, H1 (a) and (b) are supported. Furthermore, representational fidelity was found to improve police officers' decisions and actions by enabling autonomy and peer performance. The impact remains stable with magnitudes exceeding 0.6 at T2 and T3. H2 and H3 are supported.

As for the links between each dimension of effective use and performance improvement, representational fidelity and informed actions were found to exert significant effects on the officers' performance change from before (T1) to after implementation (T2/T3). The informational advantages provided by the system have a direct positive effect on performance by 'improving users' understanding of the domain being represented and reducing their uncertainty' (from Burton-Jones and Grange [10], p. 644). In addition, informed actions can improve performance by increasing opportunities for task closure. In our case, officers can handle incident calls effectively and efficiently if they have reliable access to accurate information, independent control and discretion over their decisions and actions and strong support from their colleagues. Interestingly, the impact of representational fidelity on performance improvement is greater at T3 than at T2, while the effects of autonomy and peer performance are relatively smaller at T3 than at T2. H5, H6 and H7 are thus all supported. However, we do not find a direct effect of transparent interaction on performance improvement at T2 or T3. Rather, its impact on performance is mediated by representation fidelity. H4 (a) and (b) are thus not supported.

We examined the residual effects of the effective use dimensions over time. Each dimension of effective use at T2 has a positive impact on the same dimension at T3. H8 through H11 are thus all supported. In addition, improvement in performance from T1 to T2 shows a strong correlation with that over a longer period (T2 to T3), which supports H12. Moreover, improvement in performance with the use of C&CIII shows a positive relationship with job satisfaction at both T2 and T3. The long-term improvement (i.e., from T1 to T3) has a stronger effect on job satisfaction at T3 than at T2. H13 (a) and (b) are thus supported.

Overall, the model accounts for 48.6% of the variance in performance improvement between T1 and T2 period and 56.9% of the variance in performance improvement between T1 and T3. In addition, about 4% of job satisfaction at T2 and 15.8% of job satisfaction at T3 are explained by performance improvement. These findings indicate that more effective use of the system will alleviate the users' performance dip and improve their job satisfaction during system implementation.

VI. DISCUSSION AND LIMITATIONS

This paper examines the effective use of policing systems in the context of a system implementation project. Our theoretical lens integrates the representation theoretical approach of IS and the peculiar traits of the police culture into a testable model. The theoretical and managerial implications of our findings are discussed below.

A. Theoretical Implications

System use has been a rigorous research topic for decades. Several approaches have been advanced, but a commonly accepted conceptualization has yet to emerge. We adapt a conceptualization of effective use [10] based on a multi-dimensional representation approach that highlights the interaction among user, task, and system. To the best of our knowledge, our study is the first to operationalize the constructs of the model and validate it empirically with multi-stage data collected in a system implementation project. Our findings confirm the hypothesized links between the dimensions in the hierarchy. First, transparent interaction has a positive effect on representational fidelity, which in turn supports informed actions. Second, the path coefficients between the components are all significant and exceed 0.5, thus indicating a strong magnitude of impact. Furthermore, these coefficients remain relatively stable over time, as shown in Fig. 4. By collecting data at various time points and revalidating the model, we demonstrate its robustness and confirm the validity of the multi-dimensional conceptualization of effective use.

The interaction between user, task and system at various levels of the hierarchy is hypothesized to be linked to performance improvement. This hypothesis is largely confirmed in our empirical analysis. Instead of measuring performance at a single point in time, we extend the original model to performance improvement brought about by a new system over time. Improvement is calculated as the difference in the same performance measure before and after the rollout of the new system. Although most of the hypothesized links between the dimensions of effective use and performance are confirmed in both stages, the effects of transparent interaction on performance improvement (H4a and b) is found to be insignificant. We found this finding intriguing. The impact of transparent interaction on performance improvement is not direct but is rather mediated via representation fidelity. An easy-to-use device and interface does not necessarily lead to better performance. However, the ability to access an accurate and reliable representation of the domain of interest (representational fidelity) is positively linked to performance.

Another interesting finding is that factors of informed actions exert a more salient impact on performance improvement than representational fidelity. The ability to act with discretion and a shared view among peers towards the system drive the performance improvement. Jackson et al. [83] remarked that 'IT has the potential to affect productivity in complex ways, and the match between its availability and how it is actually used will drive outcomes' (p. 5). The task plays an increasingly salient role in the user-system-task interaction as one moves further up the hierarchy. Our findings demonstrate that performance is related more to what and how goal-oriented tasks are supported by an IS than to the system's feature characteristics.

We hypothesize that beliefs formed shortly after system rollout will have a lasting effect. This hypothesis is supported empirically and is consistent with the findings of Bhattacherjee and Premkumar [65] based on three non-mandated studies that focused on continuous usage intention. Our findings shed light on the underlying change in belief during the shakedown period. In particular, we demonstrate that beliefs developed during the early stage after implementation will have an effect on later beliefs, which is empirically supported by the reinforcing links of transparent interactivity, representational fidelity, autonomy and peer performance. The implication is that users may experience distress and frustration as a result of heightened job demand and reduced job control [48], thus leading to a performance dip. However, if system implementation is done properly, the favourable beliefs developed by the users towards each component at the beginning will continue to exert their effects at the end of the shakedown period. Carrying a positive and realistic attitude both before and after implementation will enable users to overcome distress and anxiety during the initial performance dip.

B. Managerial Implications

This study contributes to our understanding of the critical shakedown period of system implementation. Our period of investigation coincides with the most severe disruption of job processes and the most rapid decline in user performance (i.e., 1 month after rollout). The success of a new system depends critically upon the user reaction after rollout. Our findings suggest that, to facilitate the effective use of IS, improving the three dimensions of effective use is of paramount importance during the rollout stage. Change management programs such as training and simulations will help to improve transparent interaction. Wide consultation during the system specification stage could help to ensure that the requested data elements and their interface and access mechanism (i.e., representational fidelity) are embraced by the officers. Positive word of mouth by officers in the areas of decision empowerment and teamwork support (i.e., factors that underpin informed actions) are critical to obtain the necessary buy-in from the remaining officers. Any mechanisms designed to cope with and mitigate the initial performance dip after a system rollout will have a significant bearing on how quickly and thoroughly the new system is integrated into an organization's culture and business. It is important for management to help users develop positive beliefs and attitudes towards the system to the greatest extent possible.

The policing context of this study provides a unique setting in which to incorporate occupational characteristics into the use of an IS, which is lacking in the literature. According to Brown [84], '92% of an officer's time is spent acquiring, coalescing or distributing information in one form or another'

(p. 352). Many novel policing approaches such as CompStat, hotspot policing and crime mapping [2], [83] are information-intensive and depend critically on the underlying IS.

Unlike systems that allow a high level of usage flexibility, the use of policing systems is tightly integrated with law enforcement tasks that carry significant legal implications. The notion of altering system usage to suit individual tasks does not exist. Our study offers a rare perspective from which to understand the mandatory use of IS that has received limited attention in the literature [21]. Previous studies tended to focus on isolated systems within an organization. Little empirical research has been done regarding the implementation of economy-wide government systems. Although commerce and business continue to constitute the bulk of the IT budget worldwide, government IT spending to meet social welfare, health and security obligations is on the rise. For example, in the United States Government's 2014 IT budget proposal, the IT budget for homeland security ranked second only to that for health care[6]. The C&CIII system in this study is a typical example of government systems. The lack of research could be attributed to data sensitivity, especially in law enforcement and national defence. The findings of this study could help to enrich our understanding of technology management in government IT systems.

C. Limitations and Future Directions

This study has several limitations. First, the findings are derived from mandated use in a single setting. While we believe that the model is applicable to other mission-critical systems with regulated use, further testing in other contexts, including voluntary adoption and commercial settings, is needed to confirm this belief. Furthermore, although the C&C system is the core infrastructure for law enforcement, other systems that provide specific functions (e.g., crime analysis, surveillance) are used by special units of the police agencies. It would be interesting to validate the current model for these specialized systems.

[6] Read "FY 2014 IT Budget Priorities" from https://cio.gov.

Second, although the current model draws upon the work of Burton-Jones and Grange [10], it does not replicate their theoretical framework in its entirety. Instead, it focuses upon the various dimensions of effective use and their effects on performance. We also deviate from the original treatment of informed actions (which could be numerous) to consider the factors that underpin informed actions based on two salient occupational traits of the police culture. While we believe that the current operationalization aligns with the generative nature of model development suggested by the authors, other approaches to operationalize the constructs likely exist depending on the context and stage of implementation. A future study should explore various operationalization and application domains to seek further validation.

Third, the current model captures two stages of a system implementation project. A future study should extend the two-point analysis to multi-point data collection to capture more accurately the nonlinearity of the changes in beliefs and performance over time. For example, Bala and Venkatesh [48] used the latent growth model to investigate the change pattern of job control and job demand from before to after implementation and demonstrated the dynamics of changes in job characteristics in an implementation. A longitudinal study that involves multiple points of data collection would enable incorporation of the feedback loop of adaptation and learning suggested in the original theory into a set of testable hypotheses.

Fourth, although we controlled for gender, age and experience with change in our analysis, this study did not consider users' dispositional characteristics. Studies of change management have reported that personal dispositions such as self-efficacy and openness to experience moderate the coping behaviour of employees towards organizational changes [85], [86]. One interesting extension of the model would be to include the relevant dispositions in moderating the relationships between beliefs and usage.

Finally, our model is intended to be generative with a focus on the relationship between effective use and performance improvement after rollout. A future study should incorporate management interventions (e.g., training, change management program) before and after the rollout and examining their effects on performance.

VII. CONCLUSIONS

The effective use of IS has been a key research area for many years. The central focus of this line of research is on the development of a conceptualization of IS use and an assessment of its effects on individual and organizational outcomes. The notion of performance is tightly linked to how and to what extent the intended goals are achieved. It must also account for organizational and occupational factors that are relevant to these goals and the means to achieve them. In this paper, we examine the effective use of a police system during the shakedown period of its implementation. This study contributes to the literature by testing a multi-dimensional effective use model that originated from representation theory and adapting it to the policing context. It is also a pioneering work in IS to integrate effective use and occupational culture. Although parsimonious usage models are useful to reveal the general antecedents of usage, more study is needed to incorporate contextual factors, especially occupational and organizational traits, to enrich our understanding and to identify actionable strategies relevant to organizations and government.

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Appendix A. Constructs and measures.

Construct		Measurement Item
Transparent Interaction	TI1	The equipment and interface of C&CIII are friendly to interact with.
	TI2	I find C&CIII easy to use.
Accuracy	ACC1	I feel the information provided by C&CIII is accurate.
	ACC2	I am satisfied with the accuracy of C&CIII.
	ACC3	I find the information provided by C&CIII dependable.
Reliability	REL1	I feel the functions provided by C&CIII are reliable.
	REL2	I can count on C&CIII to be up and available when I need it.
	REL3	C&CIII is a reliable system.
Autonomy	AUT1	I have significant autonomy in determining how I do my job after using C&CIII.
	AUT2	I can decide on my own how to go about doing my work after using C&CIII.
	AUT3	After using C&CIII, I have considerable discretion in how I do my job.
Peer Performance	PP1	My colleagues can make good judgments when using C&CIII to handle incident calls.
	PP2	My colleagues can make firm decisions when using C&CIII to handle incident calls.
	PP3	My colleagues can make deployment decisions swiftly when using C&CIII to handle incident calls.
	PP4	My colleagues can arrive at the scene quickly when using C&CIII to handle incident calls.
Performance (T1 / T2&T3)	SP1	When using C&CII/C&CIII to handle incident calls, I can make good judgments.
	SP2	When using C&CII/C&CIII to handle incident calls, I can make firm decisions.
	SP3	When using C&CII/C&CIII to handle incident calls, I can make deployment decisions swiftly.
	SP4	When using C&CII/C&CIII to handle incident calls, I can arrive at the scene quickly.
Job Satisfaction	JS1	In general, I am satisfied with my job.
	JS2	In general, I like my job.
	JS3	In general, I am satisfied working in the police force.

Appendix B. Common method variance test results.

Construct	Item	Constructs at T2		Constructs at T3	
		Original Loadings	Loadings with CMV	Original Loadings	Loadings with CMV
Transparent Interaction	TI1	0.918	0.914	0.959	0.959
	TI2	0.899	0.904	0.958	0.958
Accuracy	ACC1	0.945	0.944	0.951	0.950
	ACC2	0.960	0.961	0.962	0.963
	ACC3	0.952	0.953	0.944	0.944
Reliability	REL1	0.962	0.962	0.963	0.963
	REL2	0.950	0.949	0.949	0.949
	REL3	0.949	0.950	0.964	0.964
Autonomy	AUT1	0.947	0.947	0.926	0.925
	AUT2	0.947	0.949	0.928	0.930
	AUT3	0.932	0.930	0.943	0.943
Peer Performance	PP1	0.956	0.957	0.933	0.932
	PP2	0.950	0.951	0.950	0.950
	PP3	0.935	0.935	0.914	0.915
	PP4	0.928	0.927	0.905	0.904
Performance Improvement (T2-T1 or T3-T1)	PI1	0.928	0.929	0.921	0.923
	PI2	0.941	0.942	0.934	0.936
	PI3	0.852	0.854	0.885	0.884
	PI4	0.884	0.881	0.866	0.862
Job Satisfaction	JS1	0.918	0.916	0.938	0.941
	JS2	0.961	0.960	0.971	0.971
	JS3	0.915	0.919	0.942	0.939

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