EMPOWERING PHYSICIANS WITH ELECTRONIC HEALTH RECORD SYSTEMS: FROM SYSTEM CAPABILITIES TO ADOPTION INTENTION

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SUMMARY

In recent years, many countries have taken a keen interest in developing a more integrated healthcare system and specifically Electronic Health Record (EHR). EHR is the critical foundational technology through which the interoperability and exchange of health information can take place. With various capabilities for clinical management and administrative support, EHR systems are expected to empower healthcare providers towards improved patient care, reduced medical errors and lowered care costs. Despite these potential benefits, the adoption of EHR systems among physicians has been very slow in most countries. Notably, adoption rates tend to be dependent on capabilities of the systems, with lower rates for EHR systems having more capabilities/functions. Without wide adoption of more comprehensive EHR systems by physicians, the full potential of EHR for integrated healthcare might not be realized. Therefore, it is imperative to investigate factors influencing physicians' adoption of EHR systems. With a particular interest in the influence from capabilities/functions of the systems, this thesis aims at exploring whether and how perceptions about different EHR capabilities/functions exert different influences on physicians' adoption intention.

Drawing upon empowerment theory and structurational models of technology, this thesis establishes a theoretical linkage between capabilities of an EHR system and physicians' intention to adopt the EHR system, through the mediation of psychological empowerment. Specifically, it posits that perceived existence of four EHR capabilities, namely, workflow automation, communication, decision

support, and administrative support, changes physicians' anticipated psychological empowerment (meaning, competence, self-determination and impact dimensions) associated with the use of an EHR system through different mechanisms, and that anticipated psychological empowerment dimensions subsequently influence physicians' intention to adopt the EHR system. The proposed theoretical model was tested using field survey data from 248 primary care physicians from Singapore.

The results show that two psychological empowerment dimensions, meaning and self-determination, significantly predicted physicians' intention to adoption an EHR system. The four EHR capabilities shaped psychological empowerment differently. Specifically, the existence of workflow automation capability in an EHR system positively affected physicians' anticipated meaning and competence; the existence of connectivity capability positively affected physicians' anticipated meaning, competence and self-determination; the existence of decision support capability negatively affected physicians' anticipated self-determination; and the existence of administrative support capability positively affected physicians' anticipated competence, self-determination and impact. This research offers a fresh perspective on mechanisms through which IS capabilities influence IS adoption intention at the individual level. Implications for EHR developers, promoters and policy makers are discussed.

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CHAPTER 1. INTRODUCTION

While the practices of 20th century healthcare were based largely on paper, there is a broad consensus that realizing an vision of 21st century healthcare will require intensive use of information technologies (IT) to acquire, manage, analyze, and disseminate healthcare information and knowledge (Stead and Lin 2009). Many nations, including the United States, Canada, Australia, Denmark, and Singapore, have moved towards the adoption and implementation of Electronic Health Record (EHR) (Häyrinen et al. 2008; Wong et al. 2009), a critical foundational technology through which the interoperability and exchange of health information can take place (Anderson et al. 2007).

Despite the potential of EHR for controlling medical costs, decreasing medical errors, and increasing care quality, the adoption of EHR systems has been very slow in most countries. This lack of universal adoption of EHR directly inhibits the realization of its benefits. Researchers have thus been urged to explore the topics of EHR adoption and usage in healthcare before turning to the outcomes of EHR implementation (Davidson and Heineke 2007).

For a better understanding of factors that influence physicians' adoption of EHR systems, this thesis seeks to investigate the impact of primary care physicians' perceptions about system capabilities on their intention to adopt EHR systems, from an empowerment perspective. This chapter starts with the background knowledge of EHR systems, including its definition, functionality and potential benefits. Following that is the adoption of EHR systems, including the universal adoption status as well as extant adoption research and gaps. It then points out the limitations in current information systems (IS) research regarding the impact of system capabilities on IS adoption, and discusses the potential of empowerment perspective for improving knowledge of this area. After that, it presents the research objectives and the scope of this thesis, and its contributions to both theory and practice. Lastly, it introduces the structure of the thesis.

1.1 Electronic Health Record Systems: Definition, Functionality and Benefits

This section introduces background knowledge of EHR systems, in terms of definitions, functionality, and potential benefits.

1.1.1 Definitions of EHR and EHR Systems

Electronic Heath Record

There has been no consensus about the definition of EHR (Häyrinen et al. 2008). EHR has traditionally been used interchangeably with other types of health records, such as Electronic Medical Record (EMR) or Electronic Patient Record (EPR), in certain contexts. To be more generalizable, this thesis adopts the global definition of EHR developed by the International Organization for Standards (ISO), and differentiates EHR from other commonly studied types of health record.

ISO defined EHR in the basic generic form and then specified two categories of it (ISO/TR 2005) (as shown in Figure 1.1). The *Basic-generic EHR* is "a repository of information regarding the health status of a subject of care (i.e., patient), in computer processable form" (ISO/TR 2005, pp2). The most important characteristic of the EHR and one of the greatest potential benefits of the EHR is its ability to share EHR information. Despite this, *Non-sharable EHR* exists in practice. At present, the majority of EHRs are based on proprietary information models within EHR systems[1], with little or no interoperability between EHR systems. *Sharable EHR* is "an EHR with a commonly agreed logical information model" (ISO/TR 2005, pp5). EHR information can be shared at three different levels. Level 1: between different clinical users (e.g., between doctors and nurses) who may be using the same application, requiring different or ad hoc organization of EHRs; Level 2: between different applications at a particular location where the EHR is stored and maintained; and Level 3: across different EHR locations and/or different EHR systems (ISO/TR 2005). When Level 3 is achieved and the object of the EHR is to support integrated care across health organizations, the EHR is called an *Integrated Care EHR*. It is defined as "a repository of information regarding the health status of a subject of care in computer processable form, stored and transmitted securely, and accessible by multiple authorised users" (ISO/TR 2005, pp2).

[1] The term "EHR system" is different from "EHR". The definition of EHR systems will be discussed in the next section.

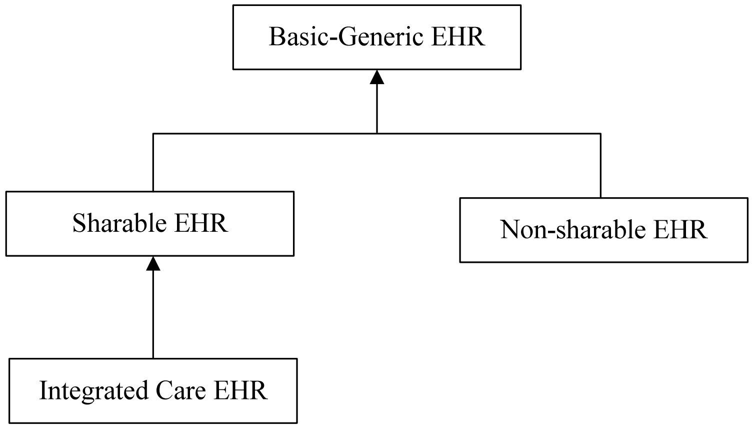

Figure 1.1 Specialization of the Basic-Generic EHR (by ISO)

To further understand EHR, it is necessary to compare EHR with other terms commonly used to describe different types of health records in an electronic form. Table 1.1 provides list of such terms (including EHRs) and their descriptions. Although some of these terms have been formally defined by some organizations (e.g., England's National Health Service, Japanese Association of Healthcare Information Systems, and Canada Health Infoway), their usage has generally been inconsistent across different countries and healthcare sectors (ISO/TR 2005). In general, these terms may have both similarity and subtle differences with EHR. For example, *EMR* could be considered a special case of the EHR but is restricted in scope to the medical domain. It is widely used in North America and a number of other countries such as Japan. Some organizations (e.g., the U.S. National Alliance for Health Information Technology) also noted that the term EMR signifies standalone systems that are shared only within a single organization involved in an individual's health and care (e.g., a physician's office, or a hospital) (Amatayakul 2009). *Electronic patient record* (EPR) typically relates to the healthcare provided by acute care hospitals or specialist units (NHS 1998).

Personal health record (PHR) focuses on the maintenance and control of the health record by the subject of care, but can still have exactly the same record architecture (i.e., standard information model) as the health provider EHR. Moreover, *clinical data repository* (CDR) can be considered a source system for the EHR, as data from a CDR can be fed to the EHR.

EHR Systems

An EHR system is defined as a system for recording, retrieving, and manipulating information in electronic health records (CEN/TC 2000). According to ISO, a clear distinction between the EHR (the record itself) and an EHR system is crucial for the purpose of the interoperability of information in the EHR and interoperability of EHR systems which exchange and share such information (ISO/TR 2005).

In terms of the settings in which EHR is created, stored and used, EHR systems can be categorized into two main types: local-EHR system, and shared-EHR system (ISO/TR 2005). A *local-EHR system* is mainly built to support the care of a patient within a single health facility (e.g., family physician practice, hospital, or community nursing home). In most health systems, individual health facilities maintain their own local patient health records. These health records contain detailed health information on the patient collected during encounters with that particular health provider, and may also contain externally sourced materials such as diagnostic results and referrals, but access to the information in the local-EHR system is usually restricted to authorized health professionals within the facility

(ISO/TR 2005). A *shared-EHR system* on the other hand is purposely built to facilitate integrated shared care within a “community of care” (consisting of a range of health facilities attended by the patient on a regular or episodic basis) and supports the exchange of extracts and integrated workflow (ISO/TR 2005). Shared-EHR systems may go beyond the community level to a regional or even national level. In fact, state or province-level shared-EHR systems are already being planned and built in a number of countries (see Häyrinen et al. 2008).

The different types of EHR systems do not necessarily imply different types of EHRs used in these systems (ISO/TR 2005). For instance, an integrated care EHR will be naturally stored in a shared-EHR system but may also reside in a local-EHR system. This could occur when the family physician is the custodian of the EHR which is maintained on the family physician’s local-EHR system but is nevertheless an integrated care EHR (ISO/TR 2005). A summary of the differences between the two types of EHR systems is presented in Table 1.2.

Table 1.1 EHR and Other Types of Health Record (to be continued)

Term	Description	Source/Reference
Basic-generic EHR	A repository of information regarding the health status of a subject of care, in computer processable form.	(ISO/TR 2005)
• Non-sharable EHR	An EHR with little or no ability to share EHR information beyond the immediate boundary of a single health organization.	(DesRoches et al. 2008; Jha et al. 2009b)
• Sharable EHR	An EHR with a commonly agreed logical information model which is independent of EHR systems.	(ISO/TR 2005; Protti et al. 2009)
• Integrated care EHR	An EHR stored and transmitted securely, and accessible by multiple authorised users. It has a standardised or commonly agreed logical information model which is independent of EHR systems.	(ISO/TR 2005)
Electronic medical record (EMR)	A special case of the EHR, restricted in scope to the medical domain or at least very much medically focused. EMRs for hospitals may have different types:	(Protti et al. 2009)
• Departmental EMR	contains a patient's medical information entered by a single hospital department (e.g. pathology, radiology, and pharmacy)	(JAHIS 1996; Makoul et al. 2001)
• Inter-departmental EMR	contains a patient's medical information from two or more hospital departments	(JAHIS 1996; Nielsen et al. 2000)
• Hospital EMR	contains all or most of a patient's clinical information from a particular hospital	(JAHIS 1996; Nahm and Poston 2000)
• Inter-hospital EMR	contains a patient's medical information from two or more hospitals	(JAHIS 1996)
Electronic patient record (EPR)	An electronic record of periodic healthcare of a single individual, provided mainly by one institution (typically acute care hospitals or specialist units).	(Meade et al. 2009; NHS 1998)
Computerized patient record (CPR)	Also referred to as a computer-based patient record. It has a wide range of meanings which may encompass the EMR or EPR.	(Patel et al. 2000; Studney and Hakstian 1983)

Table 1.1 EHR and Other Types of Health Records (cont'd)

Term	Description	Source/Reference
Electronic healthcare record (EHCR)	It was commonly used in Europe. It is now rapidly replaced by the term EHR.	(CEN/TC 2000; Naszlady and Naszlady 1998)
Electronic client record (ECR)	A special case of the EHR where the scope is defined by the non-medical health professional group utilising the record within their health discipline (e.g., physiotherapist, chiropractor, and social worker).	-
Virtual EHR	It usually refers to an EHR which is assembled "on the fly" through a process of federation of two or more EHR nodes.	-
Personal health record (PHR)	A heath record under the control of the subject of care. The information it contains is at least partly entered by the subject.	(Denton 2001; Lafky et al. 2006)
Digital medical record (DMR)	A web-based record maintained by a healthcare provider or health plan. It can have the functionality of the EMR, EPR, or EHR.	(Waegemann 2002)
Clinical data repository (CDR)	An operational data store that holds and manages clinical data collected from service encounters at point of service locations (e.g. hospitals, and clinics). Data from a CDR can be fed to the EHR.	(Infoway 2003)
Computerized medical record (CMR)	A computerized record created by image scanning or optical character recognition of a paper-based healthcare record.	(Waegemann 2002)
Population health record (PHR)	It contains aggregated and usually de-identified data. It may be obtained directly from EHRs or created from other electronic repositories.	-

Table 1.2 A Summary of Differences between Two Types of EHR System

EHR System Type	Local-EHR Systems	Shared-EHR Systems
Scope and purpose	Individual local health providers	Local care communities, regional or national
Type of EHR	Non-sharable EHR, or Sharable EHR (Integrated Care EHR)	Integrated Care EHR
Type of data	Detailed local data	Shared data
Granularity of data	Fine	Coarse (selected or summary data)
Custodian/maintainer	Healthcare facility (family physician practice, or hospital)	Local health authority, family physician custodian, etc.

Source: Adapted from ISO/TR (2005).

EHR and EHR System in this Thesis

This thesis focuses on local-EHR systems which create and maintain sharable EHRs. Specifically, the EHR system under study is located in a single health facility (e.g., family physician practice, hospital, or community nursing home), and the primary purpose is the care of a patient within the facility. However, it is an interoperable system that has the ability to exchange information interoperably. Such EHR is the critical foundational technology through which a national EHR as well as the interoperability and exchange of health information can take place.

1.1.2 Purposes of EHR and Functions of EHR Systems

The primary purpose of EHR is to provide a record of care that supports current and future care by the same or different clinicians (ISO/TR 2005). This record provides a means of communication among clinicians that contribute to a patient's care. Any other purpose of EHR is considered secondary, such as quality management, billing/finance/reimbursement, health service management, public and population health, education, and policy development. All these purposes could be achieved through capabilities and functions of EHR systems.

To facilitate and guide the implementation of EHR systems and the establishment of an IT infrastructure for healthcare, the Institute of Medicine (IOM) of the U.S. proposed core functions of EHR systems for four settings—hospital, ambulatory care, nursing home and care in the community. The core functions include: health information and data (i.e., patient information needed to make sound clinical decisions), results management (i.e., ability to manage results of all types electronically), order entry/management (i.e., entry of medication and other care orders, as well as ancillary services, directly into a computer), decision support (i.e., computer reminders and prompts to improve prevention, diagnosis and management of patient disease), electronic communication and connectivity (i.e., online communication between the healthcare team, other care partners and patients), patient support (i.e., education and self-testing), administrative processes (i.e., electronic scheduling, billing and claims management), and reporting and population health management (i.e., clinical data collection to meet public, private and institutional requirements) (IOM 2003). Table 1.3 shows key elements for each of the functions. For specific care settings, functional requirement for these functions could be tailored to the settings (IOM 2003).

Alternatively, an expert panel on behalf of the Office of the National Coordinator for Health Information Technology (ONCHIT) in the U.S. recommended that an electronic system should have four core functions in order to be considered an

EHR system: health information and data, results management, physician order entry, and decision support (Blumenthal et al. 2006).

Table 1.3 Core Functions of EHR Systems by the IOM (to be continued)

Core Functions	Key Elements
Health Information and Data: patient information needed to make sound clinical decisions	medical and nursing diagnoses, medication lists, allergies, demographics, clinical narratives and test results
Results Management: ability to manage results of all types electronically	computerized laboratory test results and radiology procedure result reports, automated display of previous and current test results
Order Entry Management: entry of medication and other care orders, as well as ancillary services, directly into a computer	computerized physician order entry (CPOE); patient laboratory, microbiology, pathology, radiology orders; electronic prescribing of medication orders; nursing orders; ancillary service and consult referrals
Decision Support: computer reminders and prompts to improve prevention, diagnosis and management of patient disease	screening for correct drug selection, dosing and interactions with other medications; preventive health reminders for vaccinations, breast cancer screening, colorectal screening and cardiovascular risk detection; clinical guidelines and pathways for patient treatment; management of chronic diseases
Electronic Communication and Connectivity: online communication between the healthcare team, other care partners and patients	electronic communication tools—including integrated health records, e-mail and Web messaging—for use among healthcare team members, between physicians, laboratories, radiology and pharmacies and with patients; telemedicine or electronic communications between providers and patients who reside in remote areas; home telemonitoring for the elderly or others with chronic diseases
Patient Support: education and self-testing	computer-based patient education; home telemonitoring for patients with chronic diseases

Source: IOM (2003)

Table 1.3 Core Functions of EHR Systems by the IOM (cont'd)

Core Functions	Key Elements
Administrative Processes: electronic scheduling, billing and claims management	electronic scheduling systems for hospital admissions, inpatient and outpatient procedures and visits; validation of insurance eligibility, claim authorization and prior approvals; identification of patients eligible for clinical trials
Reporting and Population Health Management: clinical data collection to meet public, private and institutional requirements	clinical data represented with standardized terminology and in a machine-readable format to meet federal, state, local and public health reporting requirements; also to meet organizational reporting requirements for key quality indicators

Source: IOM (2003)

1.1.3 Potential Benefits of EHR Systems

With the capabilities or functions discussed in the previous section, EHR systems are expected to empower healthcare providers in both outpatient and inpatient settings towards more timely and precise information, improved patient care, reduced medical errors, and lowered care costs (Bates 2000; Bates 2005; Bates et al. 2001; Menachemi et al. 2007c). For example, a study conducted by the U.S. RAND Health Information Technology Project team estimates that, at 90% adoption rate, the potential EHR-enabled efficiency savings for both outpatient and inpatient care average over $77 billion per year, with the most important sources of the savings from reducing hospital lengths-of-stay, nurses' administrative time, drug usage in hospitals, and drug and radiology usage in the outpatient setting; EHR systems with computerized physician order entry could eliminate 200,000 adverse drug events and save $1 billion per year once used in all hospitals, while widespread use of such systems in the outpatient setting might avoid about 200,000 preventable adverse drug events due to avoided office visits, hospitalizations, and other care (Johnston et al. 2004), and generate annual savings of $3.5 billion at the national level (Bigelow et al. 2005); furthermore, EHR systems can be used to deliver preventive care at a modest cost and reduce acute care by chronic disease management (see Hillestad et al. 2005).

1.2 Slow Adoption of EHR Systems

1.2.1 Adoption Status

Despite the powerful functionality and potential benefits of EHR systems, healthcare professionals, primary care physicians in particular, have been very slow to embrace the systems, with the exception of those in some European and Oceania countries (DesRoches et al. 2008; Jha et al. 2009a; Simon et al. 2007a). What is worse is that EHR systems which have been adopted may have fewer functions than those proposed by the IOM or even the ONCHIT expert panel. For example, in the U.S., the combination of the Commonwealth Fund survey and several other high quality surveys estimated EHR adoption in ambulatory care: it is likely that 24% to 28% of ambulatory care physicians use some form of an EHR system (Audet et al. 2004; Burt et al. 2006; Gans et al. 2005; Schoen et al. 2006), and that approximately 10% use a system with computerized physician order entry (Burt et al. 2006; Jha et al. 2006). The rate of EHR use in primary care of Canada is comparably low. The Commonwealth Fund study suggests that in 2006, 23% of Canadian physicians were using an EHR system and merely 11%

were prescribing medications electronically (Schoen et al. 2006). In Singapore, who takes a leading role in health IT utilization in Asia, only 26% of general practitioner (GP) clinics had some form of computerized systems (Yeo 2008) which were mostly used for billing and patient administration, and yet few clinics have used a system for clinical documentation, clinical prescription, or decision support.

1.2.2 Do EHR Capabilities Matter?

Although less complete EHR (or basic) systems might nevertheless convey benefits for patients' care, more capable EHR (or comprehensive) systems offer greater benefits. A U.S. national survey found that among primary care physicians who had fully functional EHR systems (i.e., with key functions of health information and data, results management, order entry, and clinical decision support), most physicians reported a positive effect of the system on clinical decision quality (82%), timely access to medical records (97%), prescription refills (95%), avoidance of medication errors (86%), communication with other providers (92%) and patients (72%), and the delivery of long-term and preventive care that meets guidelines (85% and 82%, respectively) (DesRoches et al. 2008). However, the magnitudes of effects were generally smaller for physicians having basic EHR systems (i.e., with a minimum set of functions that merit the term "EHR", namely, health information and data, results management, and certain order entry features) (DesRoches et al. 2008). Another study by the U.S. Healthcare Information and Management Systems Society (HIMSS) linked EMR adoption level to care outcomes at 107 University HealthSystem Consortium

(UHC) hospitals. They found that more sophisticated EMR systems led to improved care and increased revenues, when pay-for-performance financial incentives championed by Medicare (HIMSS 2006). These findings can be interpreted from two aspects. First, the path to financial benefits and quality improvement lies in getting the largest number of physicians to use EHR for as many of their daily tasks as possible (Miller and Sim 2004). Second, EHR capabilities directly related to increased care quality, improved patient safety and averted cost are usually those advanced functions, such as clinical decision support, electronic prescribing of medications, preventive service reminders, or access to reference materials (Menachemi et al. 2007a). Therefore, without the wide adoption of more comprehensive EHR systems by physicians, the full potential of EHR for integrated healthcare might not be realized.

1.2.3 EHR Adoption Research and Gaps

A rich body of medical informatics (MI) research has been conducted to understand the adoption and use of EHR and other related systems (such as EMR systems) by physicians in various care setttings (e.g., Bates et al. 2003; Ford et al. 2006; Gans et al. 2005; Loomis et al. 2002; Middleton et al. 2005; Miller and Sim 2004). With few exceptions, most of the research is descriptive in nature and lacks theoretical underpinnings. Nevertheless, it provides rich contextual analyses of barriers and facilitators of EHR adoption, and the types of EHR functions that have been adopted. It shows that physician adoption of EHR systems could be influenced by many factors, including financial factors (e.g., uncertainty about return on investment), technical issues (e.g., system complexity, or interconnectivity/standardization), work practice issues (e.g., productivity loss and workload increase), change management (e.g., physician participation/involvement), social factors (e.g., doctor-patient communication), legal issues (e.g., privacy or security concerns), and organizational characteristics (e.g., organization size) (DesRoches et al. 2008; Earnest et al. 2004; Gans et al. 2005; Jha et al. 2009b; Loomis et al. 2002; Menachemi et al. 2007b; Middleton et al. 2005; Miller and Sim 2004; Paré et al. 2006; Randeree 2007; Vishwanath and Scamurra 2007). These findings, however, provide limited implications for the adoption and implementation of comprehensive EHR systems, due to the fact that definitions or functions of EHR systems in these studies may be unspecified (e.g., Loomis et al. 2002; Middleton et al. 2005), or inconsistent across studies (e.g., Gans et al. 2005; Miller and Sim 2004), depending on what were available from vendors and what had been implemented in the context under study.

Surprisingly, there is a lack of empirical studies investigating prominent factors that influence physicians' intention to adopt comprehensive EHR systems. Increasing number of studies have investigated functions of EHR systems adopted or used by the target physicians (Christensen et al. 2009; DesRoches et al. 2008; Gans et al. 2005; Jha et al. 2008; Meade et al. 2009; Menachemi et al. 2007a; Miller et al. 2004; Protti et al. 2009; Reed and Grossman 2004; Sequist et al. 2007; Wang et al. 2003), which signals the importance of system capabilities/functions for EHR adoption and use. Nevertheless, it is still unknown how physicians' perceptions regarding EHR capabilities/functions would affect their adoption intention or whether different EHR capabilities/functions would exert different effects. Such knowledge is imperative for designing or implementing EHR systems with appropriate capabilities/functions that will be utilized by physicians. For example, capabilities that are more favorable than others can be the “booster” and be highlighted for adoption, while capabilities/functions that hamper adoption need careful consideration before incorporation into the EHR.

To fill such a research void, this thesis seeks to answer two research questions: (1) What are primary care physicians’ perceptions of capabilities (or functions) of an EHR system? (2) How would such perceptions affect their intention to adopt EHR systems?

1.3 Prior Research on Information Systems Adoption

Information systems (IS) researchers have extensively studied how and why individuals adopt new IS. Traditional theoretical models or theories such as Theory of Reasoned Action (TRA) (Ajzen 1985), Technology Acceptance Model (TAM) (Davis 1986), Theory of Planned Behavior (TPB) (Ajzen 1991), Innovation Diffusion Theory (IDT) (Moore and Benbasat 1991), and Social Cognitive Theory (Compeau et al. 1999) identify a number of cognitive and affective factors that would affect user adoption of IS, including attitude toward using the IS, subjective norm, perceived behavior control, perceived usefulness, perceived ease of use, compatibility, trialability, visibility, results demonstrability, affect, anxiety, and so on.

This set of fundamental models or theories have been refined or extended by complementing each other. Notably, the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh et al. 2003) is an integration of various models/ theories discussed above. Further, the fundamental models/theories are enhanced by drawing insights from other theories, such as trust theory, Task-technology Fit theory (Goodhue and Thompson 1995), Motivational Theory (Calder and Staw 1975; Deci 1975; Deci 1971; Pinder 1976; Vallerand 1997), and Elaboration-Likelihood Model (Petty and Cacioppo 1986; Petty et al. 1981).

Beyond the fundamental models/theories and their extensions, IS adoption research has been informed by several work motivation theories. For example, Self-determination Theory (Gagné and Deci 2005), which distinguishes different types of extrinsic motivation, is fruitful for deciphering various extrinsic motivation factors for individual acceptance of workplace IS (Malhotra et al. 2008). Organizational Commitment Theory (Allen and Meyer 1990; Allen and Meyer 1996; Meyer and Herscovitch 2001) sheds light on how personal commitment with organizations motivates employees to embrace changes within the organization, such as accepting a new IS (Keeton 2008; Malhotra and Galletta 2005). Furthermore, Organizational Justice Theory (Colquitt 2001) provides a framework for analyzing how employee acceptance of IS is affected by perceived fairness of organizational interactions, processes, and outcomes associated with the introduction of new IS within organizations.

From different perspectives, the models and theories discussed above provide a list of prominent motivational variables for IS adoption or use, and have significantly improved our knowledge about why individuals adopt a variety of information systems in various settings, including the healthcare sector. For example, a group of researchers have applied some of the models/theories to study health information systems (HIS), such as telemedicine, EMR, EHR, and Internet-based health applications (Anderson et al. 2007; Angst and Agarwal 2009; Bhattacherjee and Hikmet 2007; Chau and Hu 2001; Chismar and Wiley-Patton 2003; Hennington and Janz 2007; Ilie et al. 2009; Trimmer et al. 2008; Tulu et al. 2006; Walter and Lopez 2008). These studies have apparently complemented MI research on HIS adoption with theoretical underpinnings and empirical validity.

However, all these models and theories have largely focused on intermediate-level predictors, with little attention to the fundamental role of IS capabilities or functions. Even Innovation Diffusion Theory, which highlights the salience of seven innovation attributes for innovation adoption, concentrates on generic attributes of various IS rather than specific IS capabilities. Consequently, there is limited theoretical understanding about why and how specific capabilities of IS affect individual adoption of the IS.

1.4 Potential of an Empowerment Perspective

In order to address the above knowledge gap, this thesis draws insights from the empowerment theory and structurational models of technology, to seek a theoretical linkage between capabilities of an EHR system and individual intention to adopt the system.

Psychological empowerment (Thomas and Velthouse 1990) is an individual's experience of intrinsic task motivation manifested in four cognitions reflecting the individual's orientation to his/her work role: meaning, self-determination, competence, and impact. It has been viewed as the mechanism through which *empowering structures and practices* (i.e., organizational, political and social contextual factors) affect work-related outcomes, such as job effectiveness, job satisfaction, innovative behavior, organization commitment, and organizational citizen behavior (Quinn and Spreitzer 1997; Spreitzer 1995; Spreitzer 1996; Thomas and Velthouse 1990). For example, in a study on middle managers, psychological empowerment mediated the effects of work context variables (i.e., information and rewards) on managerial effectiveness and innovative behaviors (Spreitzer 1995). Therefore, psychological empowerment, being an intrinsic motivation factor, has potential for mediating the influence of *external factors* on individual attitude and behavior towards using IS in the workplace.

Can capabilities of IS be the external factors? In order words, would IS capabilities be associated with psychological empowerment, and how would the association be like? *Structurational models of technology* posits that a technology embodies *social structures* (i.e., rules and resources built in by designers during technology development) in its structural features, and these social structures are then appropriated by users during their use of the technology (Barley 1986; DeSanctis and Poole 1994; Orlikowski 1992; Orlikowski and Robey 1991; Poole and DeSanctis 1990; Poole and DeSanctis 1992; Walsham and Han 1991). Since empowering structures is a particular type of the social structures, it is reasonable to believe that a technology may embody empowering structures in its capabilities and features. Through these empowering structures, technology capabilities and features will be able to change individuals' psychological empowerment once the individuals appropriate the technology.

1.5 Research Objectives and Scope of the Thesis

To summarize, the goal of this thesis is to build up a linkage from perceived EHR capabilities to EHR adoption intention through the mediation of psychological empowerment. Specifically, it proposes and tests a theoretical model examining (1) the effect of *perceived existence of four EHR capabilities* on *four dimensions of psychological empowerment* of primary care physicians, and (2) the effects of the empowerment dimensions on physicians' *intention to adopt EHR*. The theoretical model is tested using survey data from primary care physicians.

This thesis focuses on the adoption of EHR systems by primary care physicians working in physician practices, due to the fundamental role of primary care in the healthcare delivery and the relative low adoption rates of EHR systems in the primary care setting. EHR used in secondary or tertiary care settings (e.g., specialized clinics, or hospitals) is beyond the scope of this thesis. Adoption of EHR systems by other care providers (e.g., nurses) in the primary care setting is not central to this thesis, either.

1.6 Theoretical and Practical Contributions

The thesis contributes to both theoretical and practical arenas. In terms of theory development, there are several contributions. First, it advances IS adoption research by demonstrating the role of psychological empowerment in affecting one's reactions to IS. Second, it provides implications to traditional adoption models (e.g., the TAM) by suggesting the possible boundary conditions. Third, it establishes a connection between IS artifact and IS adoption intention. Furthermore, it adds to the empowerment literature with a dimensional analysis of antecedents and consequences of psychological empowerment. Lastly, it contributes to the MI literature by providing a rigorous analysis of how capabilities of an EHR system could affect physicians' intention to adopt the EHR system.

In terms of practice, findings of this thesis offer important implications for EHR developers, promoters and policy setters. It reveals the types of EHR capabilities which would facilitate and/or impede physician adoption of EHR systems. An understanding of this enables the EHR practitioners to make informed decisions about which capabilities to include in the system, or which capabilities to improve before incorporating into the system, so that the system might be accepted by more physicians.

1.7 Thesis Structure

The subsequent chapters of the thesis are organized as follows.

Chapter 2 reviews extant research on the adoption of HIS, based on both the MI literature and the IS literature. The MI literature provides the state of the art of the EHR/EMR adoption, while the IS literature suggests theoretical perspectives for studying HIS adoption and areas for improvement.

Chapter 3 presents the theoretical foundation for this thesis, including the empowerment theory and strucurational models of technology. It helps to establish the linkage between IS capabilities and psychological empowerment, as well as that between psychological empowerment and IS adoption intention.

Chapter 4 introduces a research model for physicians' adoption intention for EHR systems based on their perception of EHR capabilities existing in the system, and presents the formulation of the hypotheses.

Chapter 5 presents the research methodology adopted for the thesis. It includes the operationalization of independent, dependent and control variables of the model and the assessment of concept validation. It also describes the survey administration and the demographics of respondents.

Chapter 6 presents the results of the analysis of the field survey data for the model. It includes the evaluation of measurement model and structural model.

Chapter 7 presents the interpretation of results, limitation of the thesis, direction of future research, as well as implications of the thesis for both theory and practice.

Chapter 8 summarizes and concludes the thesis.

CHAPTER 2. REVIEW ON ADOPTION OF HEALTH INFORMATION SYSTEMS

This chapter provides a comprehensive reivew of extant research on the adoption of HIS, based on two relevant literatures: the MI literature and the IS literature. The two literatures have their own characteristics and merits. The MI literature is largely practical oriented and descriptive in nature. It offers rich contextual analyses of issues related to HIS adoption, such as HIS capabilities, benefits of HIS use, barriers and facilitators of HIS adoption. The IS literature has a strong theoretical focus and is rich in empirical validations. It provides a wide choice of models or theories for understanding HIS adoption, such as the Technology Acceptance Model, Theory of Planned Behavor, Innovation Diffusion theory, Unified Theory of Acceptance and Use of Technology Model, and work motivation theories. In the past decade, MI research has complemented IS research by informing it about the unique characteristics of healthcare sector and physician profession. I believe that the prominent phenomena of EHR adoption raised in MI research, for example, the potential impact of EHR capabilities on the universal adoption of EHR systems among physicians, are great opportunities for IS research in terms of both theoretical development and practical contributions.

2.1 Medical Informatics Literature

The MI literature contains a large body of research pertaining to the adoption and use of health information systems (e.g., EHR systems, EMR systems, electronic patient record systems, clinical decision support systems, and computerized physician order entry systems) by physicians. Studies could be quantitative, qualitative, mixed qualitative-quantitative research, or concept-mapping research. The context covers a wide range of care settings, such as primary care, ambulatory care, emergency care, acute care, long-term care, and community care. With few exceptions (Kijsanayotin et al. 2009; Paré et al. 2006; Tsiknakis and Kouroubali 2009), most of the work is descriptive in nature and lacks theoretical underpinnings (Hennington and Janz 2007). Nevertheless, these studies provide rich analyses of benefits of EHR/EMR[1] use, barriers and facilitators of EHR/EMR adoption by physicians, as well as the functions of EHR/EMR systems.

2.1.1 Benefits of EHR/EMR Use

Prior literature suggests multiple benefits of EHR/EMR use, which motivate the adoption and use of EHR/EMR systems in healthcare organizations. These benefits fall into three major categories: improved provider efficiency and savings, reduced care cost (to payers), and improved care quality. Table 2.1 demonstrates the specific benefits under each category and reference studies.

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[1] As "EHR" has traditionally been used interchangeably with "EMR" in both research and practice, studies about EHR and EMR will be reviewed together.

Table 2.1 Benefits of EHR/EMR Use

Category	Benefits	References
Provider efficiency and savings	Better documentation of clinical information	(Schade et al. 2006)
	Timely access to clinical information	(DesRoches et al. 2008; Gans et al. 2005)
	Improved drug refill capabilities	(DesRoches et al. 2008; Gans et al. 2005)
	Improved claim submission process	(Gans et al. 2005)
	Improved communication with patients	(DesRoches et al. 2008; Gans et al. 2005; Simon et al. 2007b)
	Improved communication with other providers	(DesRoches et al. 2008; Simon et al. 2007b)
	Improved coding levels and charge capture	(Barlow et al. 2003; Gans et al. 2005; Miller et al. 2005; Schade et al. 2006; Wang et al. 2003)
	Reduced medical record staff expense	(Barlow et al. 2003; Gans et al. 2005; Miller et al. 2005; Welch et al. 2007)
	Reduced medical record storage costs	(Barlow et al. 2003; Gans et al. 2005; Welch et al. 2007)
	Reduced transcription costs	(Barlow et al. 2003; Gans et al. 2005; Wang et al. 2003)
Patient care cost (to payers)	Reduced medication cost by suggesting alternative effective drugs	(Walton et al. 1997; Wang et al. 2003)
	Reduced drug usage	(Hillestad, et al., 2005)
	Decreased radiology utilization	(Wang et al. 2003)
	Decreased laboratory utilization	(Wang et al. 2003)
Patient care quality	Increased adherence to guidelines	(Bates et al. 1999b; DesRoches et al. 2008; Eslami et al. 2007; Gans et al. 2005; Oren et al. 2003; Siegel et al. 1984; Simon et al. 2007b; Walton et al. 1997)
	Reduced medication errors	(Bates et al. 1999b; DesRoches et al. 2008; Eslami et al. 2007; Gans et al. 2005; Oren et al. 2003; Simon et al. 2007b)
	Reduced adverse drug events	(Hillestad et al. 2005; Oren et al. 2003; Wang et al. 2003)
	Delivery of preventive care that meets guidelines	(DesRoches et al. 2008; Hillestad et al. 2005)
	Delivery of chronic-illness care that meets guidelines	(DesRoches et al. 2008; Hillestad et al. 2005)

Provider Efficiency and Savings

Studies consistently reported that EHR/EMR use can improve provider efficiency, by which they meant both improved operations and better use of time (Schade et al. 2006). It is worth noting that the use of EHR/EMR systems does not necessarily save physician time. Observations of EMR usage in fact showed that physicians worked longer hours for a certain period of time after the system was implemented, ranging from one to twelve months (Miller et al. 2005). This is mostly because of the time invested in making complementary process changes, entering clinical data during patients' initial visits after implementation, and getting familiar with the system (Miller et al. 2004; Miller et al. 2005). Nevertheless, efficiency is indeed gained from EHR/EMR use, partly attributed to the capability of EHR/EMR systems for better documenting, organizing, locating and transmitting of clinical information compared with paper-based systems (Anderson 1997). Studies reported better documentation of clinical information (Schade et al. 2006), timely access to clinical information (DesRoches et al. 2008; Gans et al. 2005), improved claim submission process (Gans et al. 2005), and improved drug refill capabilities (DesRoches et al. 2008; Gans et al. 2005) by using the systems.

Efficiency gains from EHR/EMR use also come from improved communication with patients and with other providers. For example, in a survey of medical group practices' adoption of EHR, improved communication with patients was among the top three benefits of EHR use perceived by physicians (Gans et al. 2005). In another U.S. national survey on ambulatory care physician use of EHR, more than half of the respondents reported positive effects of the EHR on communication with other providers and patients, with the magnitudes of positive effects generally larger for physicians with a fully functional EHR system than with a basic EHR system (DesRoches et al. 2008).

Operational efficiency further leads to positive net financial return through operational expense reduction and revenue gains (Miller et al. 2005). There is evidence from different settings (e.g., outpatient multi-specialty clinic setting and ambulatory primary care setting) that the EHR use had a positive financial impact on the practices since the first year of operation (Barlow et al. 2003; Wang et al. 2003). The financial impact included savings from reduced need for (physician notes) transcription services, savings from decreased costs for paper chart creation and maintenance, as well as revenue generated from improved charge capture of performed procedures (Barlow et al. 2003; Wang et al. 2003). Financial benefits would increase when more EHR functions are used and when the time is lengthened (Wang et al. 2003).

Patient Care Cost

EHR/EMR use also saves care cost for payers (i.e., patients, and insurers). Clinical decision support reminders and alerts in an EHR system can decrease resoure utilization by suggesting alternatives to expensive medications, reducing the usage of medications, as well as decreasing the usage of laboratory and radiology tests (Bates et al. 1998; Bates et al. 1999a; Harpole et al. 1997; Rothschild et al. 2000; Tierney et al. 1987; Tierney et al. 1990). Wang et al (2003) estimated net financial benefit of use per primary care physican for a 5-year period: alternative drug suggestion reminders would save about 15% of total drug costs per year, while desicsion support alerts would cut down about 8.8% of laboratory charges and 14% of radiology ordering per year. The potential savings, as highlighted by researchers, would start only after a successful implementation with associated process changes (Hillestad et al. 2005).

Patient Care Quatliy

The potential benefits of EHR/EMR use for paient care quality include increased adherence to guidelines, improved patient safety, and health benefits. The first benefit is closely related to the later two, such that adherence to guidelines could lead to safety and health. For *increased adherence to clinical guidelines* and *improved patient safety*, researchers mainly focus on the effects of recommendations, alerts, reminders, and other features of the computerized physcian order entry (CPOE) function of an EHR/EMR system on 1) increasing physician compliance with evidence-based guidelines and 2) avoiding medication errors and preventable adverse drug events (Bates et al. 1999b; DesRoches et al. 2008; Eslami et al. 2007; Gans et al. 2005; Hillestad et al. 2005; Oren et al. 2003; Simon et al. 2007b; Wang et al. 2003). CPOE makes information available to physicians at the time of an order entry, for example, recommendations of drug treatments for a patient’s case or warnings about potential interactions of the ordered drug with a patient’s other drugs. If the physician endorses the recommendations or warnings, his/her compliance with clinical practice guidelines increases. Once an order is entered, the system can further track the steps involved in the execution of the order, providing "an additional mechanism for identifying and eliminating errors" (Hillestad et al. 2005, pp1109).

Health benefits mainly refer to the use of EHR/EMR systems for the delivery of preventive care and chronic disease management (DesRoches et al. 2008; Hillestad et al. 2005), due to the system capabilities of communication, coordination, measurement, and decision support. First, an EHR/EMR system can integrate evidence-based recommendations for preventive services (e.g., health screening) with patient data (e.g., age, gender, and family history) to identify patients that need specific services, and can remind physicians to offer the service during paients' routine visits as well as remind patients to schedule care (Hillestad et al. 2005). Reminders to patients have been suggested to increase their compliance with preventive care recommendations (Burack and Gimotty 1997). Second, an EHR/EMR system can be instrumental throughout the chronic disease management process (Hillestad et al. 2005): the system can identify patients with a potential or active chronic disease through its embedded predictive-modeling algorithms; it can consistently record disease-specific clinical results with its embedded condition-specific encounter templates; it can offer efficient means of sending reminders to patients and responding to patient inquiries with its electronic messaging features; furthermore, it can promise great benefits for patients that have multiple chronic diseases and receive care from multiple providers with its health information exchange feaures.

2.1.2 Barriers and Facilitators of EHR/EMR Adoption

Although the commonly cited potential of EHRs/EMRs for efficiency, care cost and care quality justifies and drives the enthusiasm for EHRs/EMRs in the healthcare sector, such enthusiasm does not simply lead to universal adoption of such systems among physicians. Physician adoption of EHR/EMR systems is a more complex issue, influenced by a lot of factors. Factors that have been identified by the literature mainly fall into seven categories: (1) financial factors, (2) technical factors, (3) work practice issues, (4) change management issues, (5) social factors, (6) legal issues, and (7) organizational characteristics. Table 2.2 shows factors under each category and the reference studies.

Financial Factors

Financial factors refer to monetary issues involved in adopting and using EHR/EMR systems. In general, physicians are concerned about whether the costs of implementing and using an EHR/EMR system are bearable and whether they can gain a financial return from it. First, *high start-up costs*, including the expense of selecting, purchasing and installing EHR/EMR hardware and software, are frequently mentioned barriers to the adoption of EHR/EMR systems in physician practices (Davidson and Heslinga 2007; DesRoches et al. 2008; Loomis et al. 2002; Miller and Sim 2004; Randeree 2007). Second, the significant *ongoing costs*, including the long-term expenditures for monitoring, upgrading and maintaining an EHR/EMR system, make physicians unwilling to adopt the system (Jha et al. 2009b; Meade et al. 2009; Menachemi et al. 2007b; Valdes et al. 2004;

Vishwanath and Scamurra 2007). Moreover, *uncertainty over return on investment* results in reluctance to adopt EHR/EMR systems. In spite of claims from EHR/EMR vendors that the benefits outweigh the costs, physicians are not yet convinced (DesRoches et al. 2008; Kemper et al. 2006; Menachemi et al. 2007b; Randeree 2007; Valdes et al. 2004; Vishwanath and Scamurra 2007). They worry that it would take years to obtain a return on the investment and their practices would face substantial financial risks (Miller and Sim 2004).

Technical Factors

Technical factors are regarding the technical skills of the physicians, technical support of the suppliers, and technical issues of the EHR/EMR systems. First, *physicians' computer skills* directly affect their adoption of EHR/EMR systems. Studies consistently reported that physicians had insufficient IT knowledge and skills, such as typing skills for entering patient information, notes and prescriptions, to use EHR/EMR systems, resulting in resistance (Jha et al. 2009b; Kemper et al. 2006; Laerum et al. 2001; Ludwick and Doucette 2009; Meade et al. 2009; Menachemi et al. 2007b; Simon et al. 2007a; Terry et al. 2008). Second, the availability of *technical training and support* is crucial for EHR/EMR adoption. Many physicians reported inadequate vendor service, such as poor follow ups with technical problems and insufficient training for system usage (Ludwick and Doucette 2009; Randeree 2007; Simon et al. 2007a), which make them reluctant to use EMR systems. Third, *complexity of the system* is a barrier. As suggested by researchers, most physicians considered EMR systems to be "challenging to use because of the multiplicity of screens, options and navigational aids" (Miller and

Sim 2004, pp120). Fourth, *customizability of the system* is of great consideration. One reason for not adopting EHR/EMR systems is that physicians cannot find a system that meets their special needs or can be customized to meet their needs (DesRoches et al. 2008; Kemper et al. 2006; Loomis et al. 2002; Randeree 2007; Vishwanath and Scamurra 2007). Furthermore, *reliability of the system* is a concern. Physicians are concerned about the loss of access to patient information once viruses attack, computers crash, or the power fails (Kemper et al. 2006; Menachemi et al. 2007b; Randeree 2007). Finally, *interconnectivity and standardization* is an issue. On the one hand, EHR/EMR systems are mostly incompatible with the existing billing or clinical systems in physician practices; on the other hand, physicians are reluctant to get rid of existing functional systems for an integrated EMR/EHR (Davidson and Heslinga 2007; Kemper et al. 2006). In addition, data exchange between different EHR/EMR systems (i.e., probably hundreds of unique types of systems) in use is difficult if not impossible, largely due to a lack of consistent data standards (Kemper et al. 2006; Meade et al. 2009; Menachemi et al. 2007b; Miller and Sim 2004; Simon et al. 2007a; Vishwanath and Scamurra 2007).

Work Practice Issues

The introduction of EHR/EMR systems tends to disrupt a physician's existing work practice. Therefore, work practice issues are prominent factors for physicians' adoption of EHR/EMR systems. First, EHR/EMR adoption is affected by physicians' concerns about *productivity loss and workload increase*. Reported productivity loss and workload increase resulted from EHR/EMR adoption are mainly attributed to the additional time required (1) to select, purchase, and implement a system (Jha et al. 2009b; Ludwick and Doucette 2009; Meade et al. 2009; Menachemi et al. 2007b), (2) to learn and master the system (Simon et al. 2007a), (3) to convert patient records from a paper-based system to an electronic one (Davidson and Heslinga 2007), and (4) to enter data into the system (Kemper et al. 2006; Laerum et al. 2001; Loomis et al. 2002; Ludwick and Doucette 2009; Menachemi et al. 2007b; Valdes et al. 2004). Second, EHR/EMR adoption is affected by physicians' need for *work control/autonomy*. With the implementation of EHR/EMR systems, physicians are worried about the loss of control over patient information and working processes (Vishwanath and Scamurra 2007). Furthermore, EHR/EMR adoption is affected by *physician skepticism* about the benefits of EHRs/EMRs for their work practice. Studies found that physicians without EHR/EMR systems are skeptical about the claims that the systems can improve the quality of medical practices (Jha et al. 2009b; Kemper et al. 2006; Simon et al. 2007a; Vishwanath and Scamurra 2007), which creates personal resistance to system adoption.

Change Management

As implementing EHR/EMR systems results in a major change for physicians with their unique working styles developed over years (Boonstra and Broekhuis 2010), change management is a challenge for physician adoption of EHR/EMR systems. First, *personal incentives* are necessary to motivate physicians to adopt the systems. Unless they see some personal benefit, either financial or non-financial, from using EHR/EMR systems, physicians might be unwilling to change their traditional working procedures (Miller and Sim 2004; Vishwanath and Scamurra 2007). Incentives considered in prior studies have been largely financial ones. Whether there are other types of personal incentives for physicians seems to be an area worth future investigation (Boonstra and Broekhuis 2010). Furthermore, *physician participation/involvement* is important. Research shows that through active involvement or participation in the implementation process, physicians developed feelings of ownership toward the system (Paré et al. 2006), which contributed to their adoption of the system. Lastly, *leaders or champions* play a crucial role in the success of EHR/EMR adoption. With the strong believe that EHR/EMR systems will bring benefits, leaders/champions would be willing to bear the costs for generating the benefits (Miller and Sim 2004), and can motivate others (such as physicians) to participate in the change process and adopt the system.

Social Factors

Physicians usually work together with other parties in the industry, such as nurses, patients, administrative staff, managers, subsidizers, insurance companies, and vendors. Therefore, physicians' decision-making process over EHR/EMR adoption is influenced by these parties. To begin with, *support from external parties* has been suggested to motivate EHR/EMR adoption among physicians (Burt and Sisk 2005; Davidson and Heslinga 2007; Earnest et al. 2004; Simon et al. 2007a; Vishwanath and Scamurra 2007). For example, it is reported that physicians in small practices were waiting until the costs of adopting EHR/EMR were covered by subsidies (Davidson and Heslinga 2007). In addition, a lack of specific policies of insurance companies to support the EMR use inhibited physicians' decisions on EMR adoption (Vishwanath and Scamurra 2007). Second, *uncertainty about the vendor* is a barrier to adoption. EHR/EMR systems are still relatively new on the market (Randeree 2007). Physicians fear that vendors are not qualified, or will go out of business, resulting in a lack of technical support and a big financial loss (Davidson and Heslinga 2007; Kemper et al. 2006; Randeree 2007). Furthermore, *doctor-patient communication* is an important consideration. A few studies reported that physicians feared that EHR/EMR use would interfere their interaction with patients during clinical encounters (Loomis et al. 2002; Pizziferri et al. 2005; Shachak et al. 2009), because of more computer screen gaze time and less eye-contact and conversion with patients. Research on post-implementation EHR/EMR usage, nevertheless, suggests contrasting findings. For example, a time-motion study found that EHR usage did not result in additional physician time for a primary care clinic session, and overall physicians took slightly less time (0.5 min) per patient by using the system (Pizziferri et al. 2005). Another study on a patient-accessible EMR showed that physicians in the pre-trial stage anticipated that using the EMR might distort their clinical interactions and increase their workload, but physicians in post-trial interviews reported and no adverse consequences and no change in workload, and they ultimately supported EMR use (Earnest et al. 2004). Researchers further suggested that interference with physician-patient communication may not be an issue for EHR/EMR use once physician had experience with the systems and used better communication strategies (Pizziferri et al. 2005; Shachak et al. 2009). More empirical research is necessary to investigate this issue in the future. Finally, *support from colleagues* facilitates adoption. In face of EHR/EMR adoption, factors such as insufficient technical skills, workload increases, and resistance to system usage also apply to physicians' colleagues, such as nurses and administrative staff. Therefore, whether there is support from these colleagues will further influence physicians' adoption of the system (Randeree 2007; Vishwanath and Scamurra 2007).

Legal Issues

Privacy or security concerns have been reported as barriers to the adoption and use of EHR/EMR systems (Earnest et al. 2004; Gans et al. 2005; Jha et al. 2009b; Kemper et al. 2006; Loomis et al. 2002; Menachemi et al. 2007b; Valdes et al. 2004; Vishwanath and Scamurra 2007). Physicians doubt whether an EHR/EMR system is secure for storing patient records, and worry that data in the system may be accessed by unauthorized parties, because inappropriate disclosure of patient data might lead to legal issues (Boonstra and Broekhuis 2010). It is suggested that physicians were even more concerned than the patients about this issue (Simon et al. 2007a).

Organizational Characteristics

As physicians work in healthcare organizations (e.g., medical practices or hospitals), organizational characteristics, such as organizational culture, organizational size and organizational type, could influence physician adoption of EHR/EMR systems. First, an EHR/EMR-friendly *organizational culure* will support organization-wide use of EHR/EMR systems. If the culture change required to accompany the switch from a paper system to an EMR system does not occur, slow adoption of the system would occur (Randeree 2007). Second, a larger *organizational size* seems be advantageous to physician adoption of EHR/EMR systems, due to more organizational resources (e.g., management expertise, financial resources, practical experience, and supporting staff). Survey studies showed that physicians from larger medical practices had a higher EHR/EMR adoption rate than those from smaller practices (Burt and Sisk 2005; Miller and Sim 2004; Simon et al. 2007a), and physicians from larger practices were more likely to utilize available functions in their EHR/EMR systems than those from smaller practices (Simon et al. 2007b). In term of *organizational type*, it was found that affiliation to a hospital was an important predictor of EMR adoption in medical practices (Simon et al. 2007a). Physicians employed by a medical practice were more likely to adopt an EMR system than those having their own practices (Burt and Sisk 2005).

Table 2.2 Factors Influencing Physician Adoption of EHR/EMR Systems (to be continued)

Categories	Factors	References
Financial Factors	High start-up costs	(Davidson and Heslinga 2007; DesRoches et al. 2008; Loomis et al. 2002; Miller and Sim 2004; Randeree 2007)
	High ongoing costs	(Jha et al. 2009b; Meade et al. 2009; Menachemi et al. 2007b; Valdes et al. 2004; Vishwanath and Scamurra 2007)
	Uncertainty about return on investment	(DesRoches et al. 2008; Kemper et al. 2006; Menachemi et al. 2007b; Miller and Sim 2004; Randeree 2007; Valdes et al. 2004; Vishwanath and Scamurra 2007)
Technical Factors	Computer skills of physicians	(Jha et al. 2009b; Kemper et al. 2006; Laerum et al. 2001; Ludwick and Doucette 2009; Meade et al. 2009; Menachemi et al. 2007b; Simon et al. 2007a; Terry et al. 2008)
	Technical training and support	(Ludwick and Doucette 2009; Randeree 2007; Simon et al. 2007a)
	Complexity of the system	(Miller and Sim 2004)
	Customizability of the system	(DesRoches et al. 2008; Kemper et al. 2006; Loomis et al. 2002; Randeree 2007; Vishwanath and Scamurra 2007)
	Reliability of the system	(Kemper et al. 2006; Menachemi et al. 2007b; Randeree 2007)
	Interconnectivity/ standardization of the system	(Davidson and Heslinga 2007; Kemper et al. 2006; Meade et al. 2009; Menachemi et al. 2007b; Miller and Sim 2004; Simon et al. 2007a; Vishwanath and Scamurra 2007)
Work Practice	Productivity loss and workload increase	(Davidson and Heslinga 2007; Jha et al. 2009b; Kemper et al. 2006; Laerum et al. 2001; Loomis et al. 2002; Ludwick and Doucette 2009; Meade et al. 2009; Menachemi et al. 2007b; Simon et al. 2007a; Valdes et al. 2004)
	Work control/autonomy	(Vishwanath and Scamurra 2007)
	Physician skepticism	(Jha et al. 2009b; Kemper et al. 2006; Simon et al. 2007a; Vishwanath and Scamurra 2007)

Source: Adapted from a recent review by Boonstra and Broekhuis (2010).

Table 2.2 Factors Influencing Physician Adoption of EHR/EMR Systems (cont'd)

Categories	Factors	References
Change Management	Personal incentives	(Miller and Sim 2004; Vishwanath and Scamurra 2007)
	Physician Participation/involvement	(Paré et al. 2006)
	EMR leadership/champion	(Miller and Sim 2004; Terry et al. 2008)
Social Factors	Uncertainty about the vendor	(Davidson and Heslinga 2007; Kemper et al. 2006; Randeree 2007)
	Support from external parties	(Burt and Sisk 2005; Davidson and Heslinga 2007; Earnest et al. 2004; Simon et al. 2007a; Vishwanath and Scamurra 2007)
	Doctor-patient communication	(Earnest et al. 2004; Loomis et al. 2002; Pizziferri et al. 2005; Shachak et al. 2009)
	Support from colleagues	(Randeree 2007; Vishwanath and Scamurra 2007)
Legal Issues	Privacy or security concerns	(Earnest et al. 2004; Gans et al. 2005; Jha et al. 2009b; Kemper et al. 2006; Loomis et al. 2002; Menachemi et al. 2007b; Valdes et al. 2004; Vishwanath and Scamurra 2007)
Organizational Characteristics	Organizational culture	(Randeree 2007)
	Organization size	(Burt and Sisk 2005; Loomis et al. 2002; Miller and Sim 2004; Simon et al. 2007a)
	Organization type	(Burt and Sisk 2005; Simon et al. 2007a)

Source: Adapted from a recent review by Boonstra and Broekhuis (2010).

2.1.3 Capabilities of EHR/EMR Systems

Systems capabilities or functions have been taken into consideration in a few studies on the adoption and usage of EHR/EMR systems (sample studies are shown in Table 2.3). Contexts of these studies include both outpatient and inpatient settings, and primary care and tertiary care. Most of the studies are conducted in the U.S. (e.g., DesRoches et al. 2008; Gans et al. 2005; Jha et al. 2009b; Menachemi et al. 2007a; Miller et al. 2004; Reed and Grossman 2004; Wang et al. 2003), a few in the Europe (e.g., Norway) (Christensen et al. 2009; Lærum et al. 2001; Lærum and Faxvaag 2004; Meade et al. 2009), and some cover two or more countries (Jha et al. 2008; Protti et al. 2009). However, studies done in Asian countries are rare.

There seems to be no consensus among studies on what capabilities constitute the essential elements to define an EHR system. This is partly due to the differences in the care settings (e.g., outpatient EHR vs. inpatient EHR), the sophistication of EHR systems (i.e., basic EHR vs. comprehensive EHR), and the abstraction level of the system functionality (general capabilities vs. specific features) (e.g., Lærum et al. 2001; Lærum and Faxvaag 2004; Protti et al. 2009; Reed and Grossman 2004). Nevertheless, the list of key functions provided by IOM and the ONCHIT expert panel provide guidelines for researchers to define EHR functionality that fits the specific contexts. For example, based on the IOM functional framework, Menachemi et al. (2007a) identified 22 functions for evaluating the adoption rate of EHR systems by physicians working in medical practices, while DesRoches et al. (2008) defined 16 functions falling into 4 key capabilities for a *fully functional*

EHR system used in the outpatient setting. Based on the ONCHIT set of functions, Jha et al. (2009a) defined 24 functions falling into 4 categories for *comprehensive EHR systems* adopted in hospitals.

Some researchers differentiated EHR/EMR systems in terms of the sophistication level and defined system capabilities accordingly. For example, when evaluating the net benefits of EMR use in ambulatory primary care settings, Wang et al. (2003) defined a "*full EMR*" system as having 4 major capabilities (i.e., online patient chart, electronic prescribing, radiology order entry, laboratory order entry, ectronic charge capture) and differentiated it with "*medium EMR"* and "*light EMR"* systems that include only subsets of the full functionality. DesRoches et al. (2008) distinguished a *fully functional EHR* and a *basic EHR* system in their study on the adoption and use of outpatient EHR systems. Jha et al. (2009a) defined functionalities for EHR systems at three levels adopted in hospitals, namely *comprehensive EHR systems*, *basic EHR systems with clinician notes*, and *basic EHR system without clinician notes*. Consistently, the *fully functional EHR system* in DesRoches et al. (2008) and *comprehensive EHR system* in Jha et al. (2009a) share the same capabilities, namely health information and data, order-entry management, results management, and clinical decision support.

Table 2.3 Sample Studies on Capabilities/Functions of EHR/EMR Systems (to be continued)

Studies	Context	Capabilities/Functions
(Wang et al. 2003)	Evaluation of the net benefits of EMR use in ambulatory primary care settings (U.S.)	• *Light EMR system*: Online patient chart • *Medium EMR system*: (1) Online patient chart, and (2) Electronic prescribing • *Full EMR system*: (1) Online patient chart, (2) Electronic prescribing, (3) Laboratory order entry, (4) Radiology order entry, and (5) Electronic charge capture
(Lærum et al. 2001; Lærum and Faxvaag 2004)	Evaluation of EMR use by clinicians in Norwegian hospitals	• EMR in support of 24 tasks: (1) Review the patient's problems, (2) Seek out specific information from patient records, (3) Follow results of a test or investigation over time, (4) Obtain results from new tests or investigations, (5) Enter daily notes, (6) Obtain information on investigation or treatment procedures, (7) Answer questions about general medical knowledge, (8) Produce data reviews for specific patient groups, (9) Order clinical biochemical laboratory analyses, (10) Obtain results from clinical biochemical lab analyses, (11) Order X-ray, ultrasound or CT, (12) Obtain the results from X-ray, ultrasound, or CT investing, (13) Order other supplementary investigations, (14) Obtain results from other supplemental investigations, (15) Refer the patient to other departments or specialists, (16) Order treatment directly, (17) Write prescriptions, (18) Complete sick-leave forms, (19) Collect patient data for various medical declarations, (20) Give written specific information to patients, (21) Give written general information to patients about the illness, (22) Collect patient information for discharge reports, (23) Check and sign typed dictations, and (24) Register codes for diagnoses or performed procedures.
(Miller et al 2004)	EMR use in physician practices (U.S.)	• 8 capabilities of EHR systems: (1) Viewing, (2) Documentation, (3) Prescribing and Ordering, (4) Billing and other administrative, (5) Care Planning and Management, (6) Analysis and Reporting, (7) Patient-directed, and (8) Performance reporting.
(Reed and Grossman 2004)	Adoption of IT by physicians in traditional practice settings (U.S.)	• IT in support of 5 clinical functions: (1) Accessing patient notes, (2) Writing prescriptions, (3) Obtaining treatment guidelines, (4) Generating treatment reminders, and (5) Exchanging clinical data with other physicians.
(Gans et al. 2005)	EHR Adoption in medical practice groups (U.S.)	• 18 features of EHR systems : (1) Patient demographics, (2) Encounter notes, (3) Patient medications/prescriptions, (4) Presenting complaint, (5) Physical exam/review of systems, (6) Medical history, (7) Problem lists, (8) Procedure/operative notes, (9) Laboratory results, (10) Drug interaction warnings, (11) Radiology/imaging results, (12) Consult/reports from specialists, (13) Referrals to specialists, (14) Drug reference information, (15) Immunization tracking, (16) Drug formularies, (17) Clinical guidelines and protocols, and (18) Integration with practice billing systems.

Table 2.3 Sample Studies on Capabilities/Functions of EHR/EMR Systems (cont'd)

Studies	Context	Capabilities/Functions
(Menachemi et al. 2007a)	Adoption rate of EHR systems by physicians in medical practices in Florida (U.S.)	• 23 functions of EHR systems: (1) Clinical notes, (2) Patient demographics, (3) Medication list, (4) Diagnosis, (5) Allergies, (6) Problem list, (7) Procedures, (8) Patient scheduling, (9) Electronically available lab data/results, (10) Electronic prescribing of medications, (11) Electronically available X ray results, (12) Electronic order entry (labs, X rays), (13) Patient education materials, (14) Off-site access/log-in capability, (15) Access to reference material, (17) Electronic connection to pharmacy info, (17) Coding advice to physicians, (18) Preventive service reminders, (19) Growth charting, (20) Weight-based dosing calculation, (21) Clinical decision support, (22) Advance directives, and (23) Auto-updated insurance coverage info.
(DesRoches et al. 2008)	Physicians' adoption and use of outpatient EHR systems (U.S.)	• *Fully functional EHR system*: (1) Health information and data, (2) Order-entry management, (3) Results management, and (4) Clinical-decision support • *Basic EHR system*: (1) Health information and data, (2) Orders entry (only for prescriptions), and (3) Results management
(Jha et al. 2008)	EHR Use in ambulatory care and hospital settings in seven nations	• 4 core functions of EHR systems: (1) Electronic documentation of providers' notes, (2) Results management, (3) Physician order entry, and (4) Decision support.
(Christensen et al. 2009)	Use of 3 EPR system by Norwegians GPs	• EPR in support of 23 clinical tasks: (1) Review the patient's problems, (2) Seek out specific information from patient records, (3) Follow results of a test or investigation over time, (4) Obtain results from new tests or investigations, (5) Enter daily notes, (6) Obtain information on investigation or treatment procedures, (7) Answer questions about general medical knowledge, (8) Produce data reviews for specific patient groups, (9) Order clinical biochemical laboratory analyses, (10) Obtain results from clinical biochemical lab. analyses, (11) Order X-ray, ultrasound or CT, (12) Obtain the results from X-ray, ultrasound, or CT investigations, (13) Order other supplementary investigations, (14) Obtain results from other supplemental investigations, (15) Refer the patient to other hospital/ department/specialists, (16) Order treatment directly, (17) Write prescriptions, (18) Write sick-leave notes, (19) Collect patient data for various medical declarations, (20) Give written specific information to patients, (21) Give written general information to patients, (22) Claim reimbursement, and (23) Check and sign typed dictations

Table 2.3 Sample Studies on Capabilities/Functions of EHR/EMR Systems (cont'd)

Studies	**Context**	**Capabilities/Functions**
(Jha et al. 2009a)	EHR adoption in the U.S. hospitals	• *Comprehensive EHR system*: (1) Clinical documentation, (2) Test and imaging results, (3) Computerized provider-order entry, and (4) Decision support • *Basic EHR system with Clinician Notes*: (1) Clinical documentation, (2) Test and imaging results, (3) Computerized provider-order entry (only for medications) • *Basic EHR system without Clinician Notes*: (1) Clinical documentation (without Physicians' notes and nursing assessments), (2) Test and imaging results, (3) Computerized provider-order entry (only for medications)
(Jha et al. 2009b)	EHR adoption in physician practices (U.S.)	• 4 main functions of EHR systems: (1) Health information and data, (2) Result management, (3) Order management, and (4) Electronic communication and connectivity
(Meade et al. 2009)	EPR adoption/use by Irish GPs	• EPR in support of 9 clinical tasks: (1) Patient registration, (2) Vaccination records, (3) Repeat prescriptions, (4) Referral letters, (5) Consultation notes, (6) Acute prescriptions, (7) Administration, (8) Accounts, and (9) Recall
(Protti et al. 2009)	EMR/EHR use by primary care physicians in Denmark and Andalucía	• 5 main functions of EMR/EHR systems: (1) Patient administration, (2) Medications, (3) Clinical notes, (4) Placing orders, and (5) Receiving results
(Sequist et al. 2009)	EHR use by primary care clinicians (U.S.)	• 9 key functions of EHR systems: (1) Bill capturing, (2) Problem list, (3) Medication list, (4) Template-based models, (5) Immunization documentation, (6) Medication order entry, (7) Radiology order entry, (8) Lab order entry, and (9) Clinical reminders.

All these studies, due to the descriptive nature, offer limited understanding about how perceptions about EHR capabilities/functions would affect physicians' adoption intention. Nevertheless, the investigation of EHR/EMR capabilities and functions provided this thesis with good sources of core capabilities of EHR systems designed for physician practices.

2.2 Information Systems Literature

Drawing insights from several reference disciplines, the IS literature has established a variety of models or theories for explaining and predicting individual adoption of a variety of information systems. Some of these models or theories, such as the Technology Acceptance Model, Unified Theory of Acceptance and Use of Technology Model, and work motivation theories, have proven to be fruitful for examining the adoption of HIS, with necessary adaptation to the unique context of healthcare. However, extant adoption models and theories provide limited value for understanding the impact of IS capabilities/functions, due to the fact that they largely focus on intermediate-level predictors while treating the target IS as a "black box".

2.2.1 Models and Theories for User Adoption of Information Systems

Fundamental Models and Theories

Information systems (IS) researchers have extensively studied how and why individuals adopt new IS. Theoretical models or frameworks abound in the literature. For example, *Theory of Reasoned Action* (TRA) (Ajzen 1985), as one of the most fundamental and influential theories of human behavior, proposes two factors influencing IS adoption: attitude toward using the IS, and subjective norm. Attitude is the degree to which a person has a favorable (or unfavorable) evaluation of using the IS, and it is determined by beliefs about consequences of using the IS and the evaluations of these consequences. Subjective norms refers to the perceived social pressure to use the IS, and is determined by normative beliefs, such as a person's perception about expectations of specific individuals, and his or her motivation to comply with these expectations. *Theory of Planned Behavior* (TPB) (Ajzen 1991) extends TRA by adding perceived behavior control as a third factor, which is a person's belief concerning how difficult or easy it is to use the IS, and could be affected by factors internal (e.g., abilities, knowledge, planning or skills) or external (e.g., time, opportunity or other people's cooperation) to the individual. Moreover, *Technology Acceptance Model* (TAM) (Davis 1986), as the most well-known framework tailored to IS context, specifies two major perceptual factors for IS adoption: perceived usefulness (PU) (i.e., a person's belief that using the IS would be advantageous to performing his/her task), and perceived ease of use (PEOU) (i.e., a person's belief that using the IS would be free of effort). Both of the two beliefs are determined by information that comes from external variables. Further, *Innovation Diffusion Theory* (IDT) (Moore and Benbasat 1991) identifies seven beliefs about general attributes of innovation as predictors of innovation adoption: relative advantage, compatibility, ease of use (complexity), trialability, visibility, results demonstrability, and image. For example, relative advantage is a person's beliefs that innovation can offer an advantage over previous ways of performing the same task, while image is the belief that using the innovation can enhance his/her image or status. While earlier models concentrate on beliefs or cognitive factors, later models take into account affective factors. An example is *Social Cognitive Theory* (Compeau et al. 1999; Compeau and Higgins 1995) adapted from Bandura (1977). It links computer use with two groups of factors: cognitive factors (self-efficacy, performance-related outcome expectations, and personal outcome expectations), and affective factors (affect and anxiety). Although the original model studied computer use, the nature of the model and the underlying theory "allow it to be extended to acceptance and use of IS in general" (see Venkatesh et al. 2003, p. 432).

These fundamental models or theories have been further refined by integrating each other. For example, TPB has been extended by deriving a comprehensive set of salient beliefs (for attitude, subjective norm and perceived behavioral control) from TAM and IDT (Pavlou and Fygenson 2006). TAM has been extended to TAM2 (Venkatesh and Davis 2000) by incorporating theoretical constructs spanning social influence processes (i.e., subjective norm, voluntariness, and image) and cognitive instrumental processes (i.e., job relevance, output quality, and result demonstrability) mainly based on TRA, TPB and IDT. Notably, the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh et al. 2003) integrates various models and theories discussed above, which posits that behavioral intention is mainly affected by four core constructs: performance expectancy (i.e., similar to PU), effort expectancy (i.e., similar to PEOU), social influence (i.e., similar to subjective norm), and facilitating conditions (i.e., the degree to which a person believes that an organizational and technical infrastructure exists to support the use of the IS).

These models and theories have also been augmented by drawing insights from other theories, such as trust theory, Task-technology Fit theory (Goodhue and Thompson 1995), Motivational Theory (Calder and Staw 1975; Deci 1975; Deci 1971; Pinder 1976; Vallerand 1997), and Elaboration-Likelihood Model (Petty and Cacioppo 1986; Petty et al. 1981). For example, to address the lack of task specification in the TAM, researchers includes task-technology fit belief (i.e., the degree to which an IS assists a person to perform his or her portfolio of tasks) based on *Task-technology Fit* theory to the model (Dishaw and Strong 1999; Klopping and McKinney 2004). To study information systems that involve transactional relationship and especially contain the element of risk (e.g., e-commerce or e-government services), trust beliefs are incorporated into the model as an antecedent of behavior intention (Carter and Bélanger 2005; Gefen et al. 2003). Moreover, *Motivational Theory* adds to the prediction of IS adoption and behavior over and above cognition and extrinsic motivation. Given that the original model merely considers extrinsic motivation (PU), TAM has been incorporated with intrinsic motivation variables, such as perceived enjoyment (Davis et al. 1992; Kim and Forsythe 2007), playfulness (Hsu and Chiu 2004), cognitive absorption (Wakefield and Whitten 2006), and feeling (Kim et al. 2007). Furthermore, *Elaboration-Likelihood Model* contributes to the adoption models by elaborating how processes of external influence shape IS acceptance among potential users. Researchers link the two alternative influence routes, specifically, the central route and the peripheral route, to perceptions (e.g., PEOU) and attitude about IS use (Bhattacherjee and Sanford 2006).

Work Motivation Theories

Besides the fundamental models/theories and their extensions, the IS adoption literature has drawn upon several work motivation theories. One such theory is *Self-determination Theory* (SDT) (Gagné and Deci 2005). Similar to Motivational Theory, Self-determination Theory is also based on two broad classes of motivation to perform an activity — *extrinsic motivation* (i.e., the performance of an activity for achieving valued outcomes that are distinct from the activity itself) and *intrinsic motivation* (i.e., the performance of an activity for no apparent reinforcement other than the process of performing the activity per se) (Calder and Staw 1975; Deci 1975; Deci 1971; Pinder 1976). However, Self-determination Theory advocates a more general conceptualization of extrinsic motivation, which is more applicable to behaviors in work settings. The theory distinguishes *autonomous motivation* and *controlled motivation*. The former refers to acting with a sense of volition, while the later refers to acting with a sense of having to engage in the actions. They are both intentional, and together they are in contrast to amotivation (i.e., a lack of intention and motivation). Intrinsic motivation is an example of autonomous motivation. However, extrinsic motivation can vary in the extent to which it is controlled versus autonomous. It includes four types, with the degree of autonomy increasing: external regulation, introjected regulation, identified regulation, and integrated regulation. While the first two are controlled and moderately controlled motivations, the last two are moderately autonomous and autonomous motivations. Differentiating extrinsic motivation into types has been particularly useful for explaining individual acceptance of workplace IS. For example, researchers found that the endogenous psychological feelings of volition, freedom, conflict, and external pressure could predict user intentions for using a web-based educational platform at a large university (Malhotra et al. 2008).

Furthermore, Organizational Commitment Theory and Organizational Justice Theory have offered new perspectives for understanding individual adoption of IS in groups or organizations. *Organizational Commitment Theory* conceptualizes commitment in terms of three dimensions: affective, continuous, and normative (Allen and Meyer 1990; Allen and Meyer 1996; Meyer and Herscovitch 2001). Affective commitment refers to the identification with, involvement in, and emotional attachment to the organization (Jaros et al. 1993). Continuous commitment deals with the necessity aspects of working for an organization, and specifically refers to the various costs associated with leaving the organization (Allen and Meyer 1990). Normative commitment is about social norms, moral obligations, and one's perceived responsibility to the organization (Allen and Meyer 1996). A person with high commitment to his/her organization has been found to hold a positive regard for decisions made by the organizations and is more willing to follow rules, regulations, and guidelines set by the organizations (Allen and Meyer 1990; Irving et al. 1997). Although the three commitment dimensions may play different roles in individual acceptance of workplace IS, prior studies generally find that that people who are committed with their organization are less likely to resist change within the organization, and thus are more willing to accept IS that the organization is implementing and to supporting IS available to them (Keeton 2008; Malhotra and Galletta 2005).

Organizational Justice Theory provides a framework for predicting perceptions about fairness of organizational interactions, processes, and outcomes associated with certain activities (e.g., introduction or implementation of new IS) within organizations. Justice includes three aspects: distributive justice (i.e., the extent to which a person feel appropriately rewarded for his/her efforts in the workplace), procedural justice (i.e., the extent to which a person feels that the procedures followed by organizational decision-makers are appropriate for assuring fair outcomes), and interactional fairness (i.e., the extent to which a person believes that he/she has been treated with honesty, sincerity, and respect by organization decision-makers) (Bies and Moag 1986; Colquitt 2001; Leventhal 1976; Leventhal 1980; Shapiro et al. 1994; Thibaut and Walker 1975). Applying this framework, Turel et al. (2008) examined how justice dimensions and trust influence user adoption of e-customer services, and found justice affected trust and acceptance. Other studies on technology reactions investigated the role of procedural justice, and indicated that different levels of procedural justice may influence the relationship between certain conditions within the organizations (e.g., facilitating conditions) and employee intention to accept IS (Keeton 2008; Stanton 2000).

2.2.2 User Adoption of Health Information Systems

Compared with the rich body of literature on IS adoption, research conducted specifically on the adoption of HIS is scarce. This is mainly due to two reasons. First, healthcare industry lags behind other industries (e.g., manufacture, finance, or education) in harnessing IT (Hikmet and Chen 2003; Kaushal et al. 2005), so research in this area is also lagging. Second, healthcare is a complex context involving multiple parties, so relevant research is more challenging. The positive side is that the amount of work done on this area is increasing in recent years and that it proves to be a promising research area. Representative studies are shown in Table 2.4.

Research on HIS adoption at the individual level has progressed through three stages. In the early stage, studies applied fundamental IS adoption models, such as TAM, TPB, combined TAM-TPB or TAM2, to the healthcare context, with the main purpose of validating the old theories. Examples are a series of studies by Hu and colleagues on physician acceptance of telemedicine (Chau and Hu 2001; Chau and Hu 2002; Hu et al. 1999). They found that the TAM or TPB appeared to have weaker utility for explaining physicians' attitude formation and intention development, compared with prior TAM or TPB studies. The findings suggest that physicians may differ from other types of IS users with respect to IS acceptance. Specifically, physicians tend to be pragmatic, concentrating more on the usefulness of an IS than on its ease of use, considering perceived behavior control and the compatibility of IS with their traditional work routines to be crucial, and attaching limited importance to opinions from others. This difference was attributed to the characteristics of the healthcare industry and/or the nature of the physician profession, namely "specialized training, autonomous practices, and professional work arrangements" (Hu et al. 1999, pp95). These findings were confirmed by a later study on pediatrician adoption of Internet-based health applications (Wismar 2003). Wismar's study, based on TAM2, further suggested that physicians' usefulness perception regarding HIS was formed by their consideration of the system's job relevance and output quality. Overall, researchers highlighted the need for a broader exploration of factors beyond the TAM and TPB, and suggested possible approaches. One approach is to further investigate constructs (outside the original TAM or TPB) that plausibly account for the remaining variance in behavioral intention, while the alternative approach is to test other models or theories (Chau and Hu 2001).

Studies taking one of the two approaches do occur in recent literature. Acknowledging the uniqueness of the healthcare context, a group of researchers incorporated the TAM with factors that capture the *characteristics of healthcare*. The implementation and use of HIS like EHR systems would bring many changes to physicians' work. One aspect of the changes is significant changes in clinical workflows (Davidson & Chismar, 2007). For instance, these systems may require physicians to create more work or perform new tasks that may involve time-consuming activities, such as entering additional information or responding to system alerts (Campbell et al., 2006). Therefore, how the system meshes up with physicians' daily work system plays an important role in their intention to use and continue using the system. To account for such influence, researchers enhanced the TAM by adding a third construct, *work practice compatibility*, as antecedent of physicians' behavior intention in a study on online medical evaluation systems (Tulu et al. 2006). The study also specified three facets that contributed to work practice compatibility: medical task compatibility, medical work flow compatibility, and medical professional compatibility. The model explained a fairly large percent of the variance (0.645) in the dependent construct, suggesting its strong predictive power. The implementation and use of IS in healthcare may also require changes in the existing power structure (Campbell et al., 2006). Traditionally, physicians enjoy a significant level of control and autonomy based on their role and status as care providers, as well as their professional expertise as reflected by the "white coat" artifact (Blumenthal 2002; Fiol and O'Connor 2006; Tang et al. 2006). Systems like EMR or EHR may pose a threat to such professional autonomy by decreasing physicians' control over the conditions, processes, or content of their work (Walter and Lopez, 2008). Therefore, researchers investigated how such changes and threat would influence physicians' acceptance of HIS. Walter and Lopez introduced a new construct *perceived threat to professional autonomy* to the TAM and tested the model with two systems, a clinical decision support system and an EMR system. Perceived threat to professional autonomy was found to exert a negative direct impact on both perceived usefulness of an IS and intention to use that IS, and such negative effects were larger for the clinical decision support system than the EMR system. Another study integrated the TAM and the resistance to change literature (Bhattacherjee and Hikmet 2007). It elaborated the asymmetric effects of inhibiting perceptions (i.e., *resistance to change*) relative to enabling perceptions (i.e., perceived usefulness and perceived ease of use) on HIS usage intentions. It also proposed perceived threat (to control over work) as predicting resistance to change, perceived compatibility as predicting perceived usefulness, and related knowledge as predicting perceived ease of use. The model was validated with physician use of CPOE systems in a hospital setting. Aside from the influence brought by changes to workflows and power structure, HIS adoption and acceptance is also affected by technological factors through software and hardware complexity (Sicotte et al. 2006). For example, device limitations (e.g., battery life and screen size) and infrastructure concerns (e.g., implementing wireless networks to provide access to the software) are factors that have been acknowledged in the MI literature as being problematic for handheld computer use in clinical practice (Hauser et al. 2007; McAlearney et al. 2005). Therefore, IS researchers formally investigated how access to EMR hardware, software, and data would influence physicians' adoption decisions. Ilie et al. (2009) extended the TAM by incorporating a construct of *system accessibility*, which has two dimensions: physical accessibility (i.e., the availability of computers for accessing EMR) and logical accessibility (i.e., the ease of logging into EMR). They found that both dimensions of accessibility acted as barriers to EMR use intentions through their indirect influence on physicians' perceptions of EMR usefulness and ease of use. Logical access also has a direct influence on EMR use intentions.

Another group of researchers applied the UTATU to the healthcare context, for the reason that UTATU is a comprehensive synthesis of eight theories and could provide richer understanding of HIS adoption compared with the TAM or TPB. For example, based on a review of the medical and medical informatics literature on EMR adoption, Hennington and Janz (2007) identified the most commonly discussed barriers to physician adoption of EMR systems and analyzed them within the UTAUT framework. They identified and illustrated seven barriers, which fall into four categories: performance expectancy (i.e., the uncertainty of financial return on EMR investment, misalignment of EMR with existing business processes, the relationship between EMR and improved quality of care), effort expectancy (i.e., increased effort on the part of EMR users), social influence (i.e., the physician/payer relationship), and facilitating conditions (i.e., financial resource constraints, and time constraints). Although this study is conceptual in nature and is not meant to test the relationships, it extends the boundaries where the UTATU applies, and offered researchable propositions for future testing. Another study adopted an interpretivist research approach to "unpack" the understanding of resident physicians' adoption for EMR (Trimmer et al. 2008). Using the UTAUT as a theoretical lens, it interpreted the interview responses of 18 physicians completing their residency in family medicine. As found by the study, the overriding factor of intention to use an EMR was providing improved patient care (performance expectation). The availability and quality of data was consistently mentioned as one of the driving factors in their future use of EMR systems. As for effort expectation, EMR was believed to make it easy to locate data, but data input was the major issue with the system. In terms of social influence, peer influence had a big influence regarding screen modifications (e.g., templates used), but the respondents expressed an interest in having some control over the adoption of EMR systems. Finally, facilitating conditions, including the supportive nature of IT and upper management in making the system widely accessible and designing new input screens, contributed to respondents' adoption intention and reduced their concern about the mandatory use of EMR.

Researchers also investigated HIS adoption by drawing upon new theories (other than fundamental IS adoption models or theories). For example, aiming at studying individuals' attitude towards and likelihood of opting-in to an EHR system in the presence of information privacy concern, Angst and Agarwal (2009) integrated the privacy concern with the Elaboration Likelihood Model. They theorized that issue involvement and argument framing interact to influence attitude change, and that concern for information privacy moderates the influence of these variables; furthermore, likelihood of adoption is driven by concern for information privacy and attitude. Using an experiment where the framing of the arguments supporting EHR was manipulated, they confirmed the prediction that individual's information privacy concern interacted with the issue involvement and argument framing to affect attitudes toward EHR use, and attitude and concern for information privacy directly influenced opt-in behavioral intentions. Another study on EHR adoption at the physician practices utilized the motivation-ability literatures (Anderson et al. 2007), suggesting that the decision adoption is a function of the practice's ability (i.e. human capital and infrastructure) and motivation (i.e. internal beliefs and external pressure). Particularly, it expanded on the motivation component by applying Self-determination Theory to identify one form of intrinsic motivation (i.e., intrinsic perceived value) and two forms of extrinsic motivation (i.e., extrinsic coercive pressure, and extrinsic normative pressure). The model was tested and validated by a survey of small and medium-sized physician practices in the U.S. Although this study focused on the practice level, the ability-motivation model can be adapted and applied to the individual level (e.g., physicians). As one more example, Jensen and Aanestad (2007) reported a case study concerning how a group of orthopaedic surgeons reacted to the adoption and mandatory use of an electronic patient record system in a Danish hospital. With the concepts of hospitality and hostility, they drew our attention to the interaction between the host (i.e., the surgeons) and the guest (i.e., the system) and how the boundaries between them evolved in the everyday work practices. The findings suggested an alternative thinking about an adoption process, which is relevant to managers striving for a successful HIS adoption.

Table 2.4 Representative IS Studies on Individual-level Adoption of HIS

Study	Target System	Target User	Theoretical Bases	Key Factors
(Hu et al. 1999)	Telemedicine	Physician	TAM	PU, PEOU, attitude
(Chau and Hu 2001)	Telemedicine	Physician	TAM, TPB, Decomposed TPB	Attitude, subjective norms, perceived behavior control, PU, PEOU, compatibility
(Chismar and Wiley-Patton 2003)	Internet-based health applications	Pediatrician	TAM2	PU, PEOU, subjective norm, image, job relevance, result demonstrability, output quality
(Tulu et al. 2006)	Online medical evaluation system	Physician	TAM, Compatibility	PU, PEOU, work practice compatibility
(Jensen and Aanestad 2007)	Electronic patient record	Physician	Organizational implementation	Hospitality, hostility (interactions between users and technology)
(Anderson et al. 2007)	EHR	Physician practice	Motivation (Self-determination theory)–Ability framework	Practice motivation (extrinsic coercive pressure, extrinsic normative pressure, intrinsic perceived value); Practice ability (IT Infrastructure, IT-related intangibles, physician/staff IT readiness)
(Hennington and Janz 2007)	EMR	Physician	UTAUT	Performance expectancy, effort expectancy, social influence, facilitating conditions
(Bhattacherjee and Hikmet 2007)	Computerized physician order entry	Physician	TAM, User resistance to change	PU, PEOU, resistance to change, perceived threat, perceived compatibility, related knowledge
(Walter and Lopez 2008)	Clinical decision support, EMR	Physician	TAM, Perceived threat	PU, PEOU, perceived threat to professional autonomy
(Trimmer et al. 2008)	EMR	Physician	UTAUT	Performance expectancy, effort expectancy, social influence, facilitating conditions, gender, age, experience, voluntariness of use
(Angst and Agarwal 2009)	EHR	Individual patient or consumer	Elaboration likelihood model, Information privacy	Argument framing, issue involvement, attitude, concern for privacy
(Ilie et al. 2009)	EMR	Physician	TAM, Accessibility	PU, PEOU, physical accessibility, logical accessibility

2.2.3 The Role of Information System Capabilities

Grounded in various models and theories discussed in previous sections, IS adoption research has largely focus on intermediate-level predictors, such as ease of use, usefulness, and perceived behavior control, without specifying the IS nuances involved. Particularly, less attention has been given to the role of IS capabilities, functions, or features. Even Innovation Diffusion Theory, which is concerned with several attributes of IS, concentrates on generic attributes of IS, such as relative advantage, without referring to specific capabilities or features of IS. Consequently, there is limited theoretical understanding about how IS capabilities or features matter in individual adoption of the IS.

The need to consider IS capabilities/features in IS research has been noted by some researchers. In their work about the IS identity crisis, Benbasat and Zmud (2003) pointed out that IS researchers should avoid treating IS either as a "black box" or as synonym of a more generic entity (e.g., innovation, or Internet). Instead, they suggested researchers bring the IS aspects of the phenomena being examined to the forefront so as to make clear the unique contributions of IS scholarship. I believe that one of the effective approaches to open the "black box" is to take a more fine-grained, feature-based approach.

Studies taking such a feature-based approach have suggested that IS features or capabilities matter in the whole processes, from users' initial comprehension of IS to subsequent acceptance or usage of the IS, and finally to the success of the IS. For example, Griffith (1999) regarded IS as a combination (constellation) of features (distinct parts, aspects, and qualities) that get noticed by users and then can be socially constructed into an organizational system. He emphasized that IS features played the role of “triggering” users’ initial sensemaking process, which preceded the actual process of IS use. He also suggested that differences in understanding between users and implementers of an IS played a role in the success of the IS. Focusing on user resistance to IS implementation, Lapointe and Rivard (2005) found that users in a group first assessed a newly-introduced system in terms of the interplay between system features and individual and/or organizational-level initial conditions, and then made projections about the consequences of system use. If expected conditions were threatening, resistance behaviors would result (Lapointe and Rivard 2005). Concerned about IS usage, Markus (2005) viewed IS features as specific technological capabilities which have the potential to impose constraints on users, and called for research to identify how IS features matter in the IS usage pattern in organizations. In response to such a call, Dutta (2008) conceptualized IS features as a set of characteristics of the IS under examination that enables the users to achieve their work and personal goals, and postulated that differences in IS features may be associated with differences in technology use pattern and the resultant social outcome.

The focuses of these studies have been IS sensemaking, IS implementation and IS use, while IS adoption is beyond the scope of them. However, IS features or capabilities are believed to matter in the process of user adoption as well, because when considering whether to adopt an IS users rely on the sensemaking process which is triggered by features or capabilities of the IS (Griffith 1999).

CHAPTER 3. THEORETICAL FOUNDATION: EMPOWERMENT THEORY AND STRUCTURATIONAL MODELS OF TECHNOLOGY

This chapter turns to two research streams, empowerment theory and structurational models of technology, to establish the theoretical foundation of this thesis. Based on *empowerment theory*, psychological empowerment is an intrinsic task motivation which is affected by empowering structures (contextual variables) and potentially affects individual adoption of IS in the workplace. *Structurational models of technology* help to build up the linkage between IS capabilities and psychological empowerment. Specifically, information systems embody social structures, such as empowering structures, in their capabilities and features, so IS capabilities and features could influence individuals' psychological empowerment through the embodied empowering structures.

3.1 Empowerment Theory

Empowerment theory has roots in substantive issues such as intrinsic motivation, social learning theory, participative decision making, job design, and self-management in the organizational management area (Liden and Tewksbury 1995). The empowerment literature has developed both a macro perspective that focuses on *empowering structures* as organizational structures, practices and policies that bring about employee empowerment, and a micro perspective that focuses on *psychological empowerment* as individuals' psychological experience of empowerment. The two perspective can be integrated in such a way that psychological empowerment mediated the relationships between empowering structures and work-related outcomes (Seibert et al. 2004).

3.1.1 Psychological Empowerment as an Intrinsic Task Motivation

Psychological empowerment is defined as an individual's experience of intrinsic task motivation manifested in a set of four cognitions about himself/herself in relation to his/her work role: meaning, self-determination (choice), competence, and impact (Thomas and Velthouse 1990). Building on Thomas and Velthouse's conceptual work, Spreitzer (1995) defines the psychological empowerment cognitions as follows: *Meaning* is the value of a work goal or purpose, judged in relation to an individual's own ideals or standards; *Competence*, or self-efficacy, is an individual's belief in his/her capability to perform activities with skill; *Self-determination* is an individual's sense of having a choice in initiating and regulating actions; *Impact* is the degree to which an individual can influence strategic, administrative, or operating outcomes at work (Spreitzer 1995, p. 1443-1444). Together, the four dimensions reflect a proactive orientation to one's work role.

Much of psychological empowerment research is on articulating the process of empowerment: an individual's work context (i.e., organizational, political and social contextual factors) and personality characteristics shape his/her empowerment cognitions, which in turn motivate individual behavior (Thomas and Velthouse 1990). Consequences of psychological empowerment include job effectiveness, job satisfaction, (reduced) job-related strain, innovative behavior, creativity, organizational commitment, and organizational citizen behavior (Bordin et al. 2007; Seibert et al. 2009; Seibert et al. 2004; Spreitzer et al. 1997). For example, in Spreitzer's (1995) study on middle managers, psychological empowerment mediated the effects of two work context variables (i.e., access to mission and performance information, and rewards) on managerial effectiveness and innovative behaviors. In Bordin et al's (2007) study on front-line, white-collar professional workers, four work contextual variables (i.e., access to information, supervisory social support, employee participation, and job security) predicted psychological empowerment, and empowerment increased organizational commitment and job satisfaction. With a dimensional analysis, Spreitzer et al's (1997) study on both middle managers and lower-level employees found that the four dimensions of psychological empowerment affected three work-related outcomes (i.e., effectiveness, work satisfaction, and job-related strain) differently: while meaning and self-determination mainly contributed to the affective domain (work satisfaction and job-related strain), competence and impact mainly contributed to the performance domain (effectiveness).

3.1.2 Relevance of Psychological Empowerment to Health Information Systems Adoption

Psychological empowerment is relevant to physician adoption of HIS. At the general level, IS adoption research has attached importance to intrinsic motivation for predicting individual adoption and use of IS. Factors such as perceived enjoyment (Davis et al. 1992; Kim and Forsythe 2007), playfulness (Hsu and Chiu 2004), cognitive absorption (Wakefield and Whitten 2006), and feeling (Kim et al. 2007) are examples of intrinsic motivation. Psychological empowerment, as an individual's experience of intrinsic task motivation, could be one more intrinsic motivation factor that affects the adoption of workplace IS.

At the specific level, HIS adoption research has implied the potential influence of psychological empowerment on physician adoption of EHR/EMR systems. As discussed in Chapter 2, psychological factors, such as physician skepticism, physician resistance, psychological ownership, and need for control/autonomy, play an important role in physician acceptance of EMR/EHR systems by influencing their perceptions of the systems (Bhattacherjee and Hikmet 2007; Jha et al. 2009b; Kemper et al. 2006; Paré et al. 2006; Simon et al. 2007a; Vishwanath and Scamurra 2007). Psychological empowerment, as a psychological factor, might also play its role. Moreover, this literature demonstrates that physicians are concerned about any change to their work practice when facing the choice of adopting EHR/EMR or not. For example, physicians may worry about the productivity decrease due to time needed to learn to use the systems or enter additional data (Kemper et al. 2006; Laerum et al. 2001; Loomis et al. 2002;

Ludwick and Doucette 2009; Menachemi et al. 2007b; Simon et al. 2007a; Valdes et al. 2004), but they may also look forward to productivity increase once they have mastered the systems (Meade et al. 2009). Physicians may worry about the distorted interaction with patients during clinical encounters because of more computer screen gaze time (Loomis et al. 2002; Pizziferri et al. 2005; Shachak et al. 2009), but they may also expect improved communication with patients because of more accurate patient information variable at hand (DesRoches et al. 2008; Simon et al. 2007b). Physicians may worry about the loss of control over patient information and work processes as relevant data will be shared with others (Vishwanath and Scamurra 2007), but they may also anticipate increased control of patient care (e.g., delivery of preventive care or chronic-illness care) attributed to wider and faster access to patient information (DesRoches et al. 2008; Hillestad et al. 2005). Therefore, psychological empowerment associated with EHR/EMR use, which is regarding a physician's work role in terms of meaning, self-determination, competence, and impact upon the usage of EHR/EMR systems, is believed to affect his/her adoption of the systems.

3.1.3 Empowering Structures and Practices

The empowerment literature has focused on *empowering structures and practices*, which are work contextual variables that affect employees' psychological empowerment (Seibert et al. 2004). For example, in her structural theory of organizational empowerment, Kanter (1977; 1993) proposed two components of empowering structures that enable employees to accomplish their work in meaningful ways: (1) power structure, the ability to access resources, information, and support from one's position in the organization to get the work done successfully, and (2) opportunity structure, growth, mobility, and the chance to increase one's knowledge and skills required for the work. Menon (1995) suggested several work environment factors that would lower empowerment, such as perceived uncertainty of the job, centralization, formalization, poor communications, role conflict, and non-contingent reward systems. Spreitzer (1995; 1996) further identified social structure characteristics that predict empowerment, including access to information (mission and performance), access to resource, role ambiguity, span of control, sociopolitical support, participant unit climate, and rewards. A recent meta-analysis highlighted four major groups of factors positively associated with psychological empowerment: (1) job design characteristics (i.e., task variety, task significance, task identity, autonomy, feedback), (2) high performance managerial practices (information sharing, training, knowledge, decentralized decision making, and rewards), (3) supportive work unit climate, and (4) leader-member relationship (Seibert et al. 2009). While a majority of studies treat psychological empowerment as a single overall construct, few studies examine empowering structures in relation to different empowerment dimensions (e.g., Kraimer et al. 1999). Table 3.1 is a summary of empowering structures and practices identified by prior studies. These empowering structures and practices lay the foundation for this study in linking EHR capabilities to physicians' psychological empowerment.

Table 3.1 Studies on Empowering Structures and Practices

Studies\ Empowering Structures and Practices	Access to resources	Access to information (general)	Access to mission information	Access to performance information	Access to support	Opportunity structure ①	Proposition structure ②	Rewards	Formalization	Centralization	Role ambiguity	Role conflict	Job uncertainty	Job control/autonomy	Job meaningfulness	Task identity	Task variety	Task significance	Communications	Team accountability	Participative unit/org climate	Supervisory style/ behaviors
Kanter (1977)	√	√			√	√																
Spreitzer (1995)			√	√				√														
Menon (1995)								√ (g)	√	√	√	√	√						√			
Spreitzer (1996)	√	√			√ (c)						√			√							√	
Appelbaum and Honeggar (1998)	√	√	√	√	√	√	√	√ (h)														√
Kraimer et (1999)				√ (a)										√	√							
Seibert et al. (2004)		√												√ (i)						√		
Drake et al.(2007)				√ (b)				√ (h)														
(Bordin et al. 2007)			√	√	√ (d)			√													√ (j)	√ (k)
Seibert et al. (2009)				√	√ (e)	√ (f)		√ (g)		√				√		√	√	√				√ (l)

① Opportunity structure refers to opportunity of growth, mobility, and to increase knowledge and skills;
② Proposition structure refers to social composition (e.g., gender or race) of people in about the same situation in the work environment;
(a) The study referred to it as task feedback;
(b) The study referred to it as performance feedback;
(c) The study referred to it as socio-political support;
(d) The study referred to it as supervisor social support;
(e) The study referred to it as supervisor support and social-political support;

(f) The study referred to it as knowledge and training;
(g) The study referred to it as contingent rewards;
(h) The study referred to it as performance-based rewards;
(i) The study referred to it as autonomy through boundaries
(j) The study referred to it as employee participation
(k) The study referred to it as supervisor social support;
(l) The study referred to it as positive leadership behavior.

3.2 Structurational Models of Technology

3.2.1 Information Systems as Embodying Structures

The past decade has witnessed the development of a lot of structurational models of technology, which have generated numerous insights into the role of IS in organizations (Barley 1986; DeSanctis and Poole 1994; Orlikowski 1992; Orlikowski and Robey 1991; Poole and DeSanctis 1990; Poole and DeSanctis 1992; Walsham and Han 1991). Drawing on the ideas of social shaping and inscription, these models posit IS as *embodying structures* (i.e., rules and resources built in by designers during IS development), which are then appropriated by users during their use of the IS. Specifically, prior to the development of an advanced IS, structures (i.e., rules and resources as the basis for human activity) are found in institutions, such as organizational knowledge, reporting hierarchies, and standard operating procedures. Designers incorporate some of these structures into the IS. The structures may be reproduced to mimic their non-technology counterparts, or may be modified, enhanced, or combined with manual procedures, therefore creating new structures within the technology (DeSanctis and Poole 1994, pp125). Once completed, the IS present an array of social structures for possible use in interpersonal interaction, including resources (e.g., display screens and stored data) and rules (e.g., voting procedures), which could enable or constrain interaction in the workplace (DeSanctis and Poole 1994).

Adaptive structuration theory (DeSanctis and Poole 1994), one of the most well-known structurational models of technology, further suggests two ways to describe the social structures provided by an IS. One is the *structual features* of a given IS, which are the specific types of capabilites, rules, and resources offered by the system. Structual features within a group decision support system, for example, might include anonymous recoding of ideas, periodic pooling of comments, or alternative voting algorithms for making group choices (DeSanctis and Poole 1994). They govern exactly how information can be gathered, manipulated, and managed by users. In this way, feataures bring meaning (what Giddens calls "significance") and control ("domination") to group interaction (see Orlikowski and Robey 1991). The other way to describe structures provided by an IS is the *spirit of the feature set*, which is the general intent regarding values and goals underlying a given set of structual features. Spirit can be identified based on analysis of (a) the features it incorporates and how they are named and presnted, (b) the nature of the user interface, (c) the design metaphor underlying the system, (d) the training material and online guidance facilities, and (e) other training or help provided with the system (DeSanctis and Poole 1994). Spirit provides what Gidden (1979) calls "legimination" to the system by providing a normative frame regarding behaviors that are approprite in the context of the system. It also functions as a means of "signification", as it helps users interpret the meaning of the system. It also contributes to processes of "domination", as it presents the types of influence moves to be used with the system, which may privilege some users (DeSanctis and Poole 1994).

In sum, information systems embody social structures into their structual features. These structural features would be perceived, understood, and appropriated by users, which would subsequently exert impact in the workplace. Given that empowering stuctures are part of the social structures, a question rises: Do IS embody empowering stuctures in their structual features? For this question, the literature on the empowering characteristics of IS provides some evidence.

3.2.2 Information Systems Embody Empowering Structures

The examination of the empowering characteristics of IS belongs to a larger discussion of the role that IS plays in the control of work (Clement 1994). Some researchers hold a positive view. For example, in a work on computer diffusion, Frans (1993) proposed that more advanced phases of the organizational computer diffusion were associated with higher levels of empowerment among social workers, although such relationship might only be established for specific types of computer applications. In another study on low-level users, computers were regarded as contributing to employee empowerment as powerful tools that brought relevant information to the front line person, implemented the action decided on, and then provided monitoring feedback (Clement 1994).

Other researchers hold a paradoxical view. Lucas and Olson (1994), for example, noted that IS provided the capability for more flexible organizational structures by increasing the speed of response and allowing greater variety in the time and place of work and (which facilitates empowerment), but simultaneously constrained flexibility by embedding routines which are not easy to change (which impairs empowerment). Sia et al. (2002) found similar mixed impacts of an ERP system on the traditional power structure between management and rank and file workers in a hospital. The process orientation of ERP and its capability to provide expanded access to information gave users more job discretion and reduced procedural formality (thus increasing empowerment), while the capability of ERP to facilitate gathering, tracking, reporting and analysis of work behavior enhanced visibility to peers/management and reinforced standardization (thus decreasing empowerment) (Sia et al. 2002).

Our interpretation of these findings is that IS capabilities and features do embody *empowering structures*, such as access to information, access to resource, access to support, formalization, and standardization. Applying IS in an organization would therefore bring about changes to organizational members' psychological empowerment.

3.3 Conclusion of Theoretical Foundation

Once a new IS is introduced into the workplace, capabilities and features of the system would trigger individuals' initial sensemaking process that precedes the adoption and use process. Individuals tend to sense the system's potential to empower them, with regard to specific system capabilities or features. The anticipated changes in their psychological empowerment might play a critical role in individuals' reactions (e.g., attitude and intention) towards using the IS. This is the rationale for building our research model.

CHAPTER 4. TOWARDS A RESEARCH MODEL FOR PHYSICIAN ADOPTION OF EHR SYSTEMS

Based on empowerment research and a discussion of empowering structures embodied in IS, we build a research model, as shown in Figure 4.1. I propose that perceived existence of four major capabilities of an EHR system— *workflow automation, connectivity, decision support,* and *administrative support* — affects physicians' anticipated psychological empowerment associated with the use of the EHR system, which subsequently affects their *intention to adopt the EHR system*

4.1 Psychological Empowerment associated with EHR Use and Adoption Intention

Psychological empowerment of interest in this study is *relative*, rather than *absolute,* empowerment. Specifically, psychological empowerment is individual physicians' anticipation of enhanced or diminished meaning, self-determination, competence, and impact associated with the use of EHR systems, compared with the use of a non-EHR system (e.g., a paper-based system). This definition is in line with the spirit that psychological empowerment reflects the ongoing ebb and flow of individuals' perceptions about themselves in their work environment (Bandura 1989).

A growing body of research supports the contention that psychological empowerment leads to better job performance and more job satisfaction (Liden et al. 2000; Spreitzer et al. 1997; Spreitzer 1995). As defined earlier, psychological empowerment comprises a set of cognitions making up intrinsic motivation. Intrinsically motivated people are more likely to persist in pursuit of work goals, anticipate problems, and be creative in solving those problems (Spreitzer 1995). Specifically, feelings of competence result in greater effort, persistence, and goal accomplishment (Bandura 1989). Self-determination results in higher interest, task commitment, learning, and resilience in the face of obstacles (Deci and Ryan 1987). Impact is also associated with greater engagement and performance (Ashforth 1989). Moreover, individuals who pursue goals that are more meaningful to them and consistent with their values feel a greater degree of reward from the goals accomplished and satisfaction with their jobs (Hackman and Oldham 1980). Therefore, physicians who anticipate higher levels of psychological empowerment associated with EHR use tend to anticipate improved job performance and enhanced job satisfaction when using the system, leading to higher intention to adopt EHR systems. Thus, we expect a positive relationship between psychological empowerment dimensions and adoption intention.

H1, 2, 3, 4: Psychological empowerment dimensions (meaning, competence, self-determination, and impact) associated with the use of an EHR system has a positive influence on physicians' intention to adopt the EHR system.

4.2 Linking EHR Capabilities to Psychological Empowerment

Next, we explore the effects of perceived EHR (system) capabilities on psychological empowerment associated with EHR (system) use. By *EHR* *capabilities,* we mean the extent to which a physician perceives certain capabilities existing in an EHR system. Our focus is on *perceived existence* rather than *actual existence* of EHR capabilities, because physicians need to have noticed and become aware of the existence of the capabilities, so as to revise their psychological states after exposure to an EHR system. In other words, the mere existence of an EHR capability is not adequate for influencing a potential adopter. Instead, its existence must be perceived to create any possible impact on a physician's belief.

In order to identify a comprehensive list of capabilities for an EHR system used in physician practices, an extensive review of the IS and the EHR/EMR literature (e.g., Blumenthal et al. 2006 ; DesRoches et al. 2008; Gans et al. 2005; IOM 2003; Jha et al. 2009a; Jha et al. 2009b; Jha et al. 2008; Mandl and Kohane 2009; Meade et al. 2009; Menachemi et al. 2007a; Miller et al. 2004; Reed and Grossman 2004; Sequist et al. 2007; Stohr and Zhao 2001; Wang et al. 2003), and close observations of a number of EHR systems in practice were conducted. Based on Stead and Lin's (2009) categorization of four domains of healthcare information technology[1] (i.e., automation, connectivity, decision support, and data-mining capabilities), we identified four high-level EHR capabilities: (1) **Workflow automation**, the capability of an EHR system to perform tasks with little human intervention; (2) **Connectivity**, the capability of an EHR system to connect people (care providers or patients) to systems and to each other; (3)

[1] The categorization is made by Committee on Engaging the Computer Science Research Community in Healthcare Informatics, National Research Council, U.S.

Decision support[1], the capability of an EHR system to provide information at a high conceptual level to facilitate or improve decisions made about healthcare; and (4) **Administrative support**[2], the capability of an EHR system to support administrative activities in the physician practices.

I further identified possible lower-level functions for each of the four capabilities[3] (Blaser et al. 2007; Chim et al. 2003; CHKS 2009; Grossman and Pham 2008; Mu¨ller et al. 2003; Mullinsa et al. 2006; Smith 2006; Winthereik et al. 2007). **Connectivity** may manifest itself in four functions: (a) *clinical information repository* (i.e., an EHR system consolidates patient information from a variety of clinical sources, and enables easy access to and retrieval of data for a patient), connecting care providers in physician practices to patient data; (b) *vertical information sharing* (i.e., an EHR system enables the sharing of critical patient information between the focal physician practice and hospitals or ancillary departments), connecting care providers in physician practices with care providers in hospitals or ancillary departments; (c) *horizontal information sharing* (i.e., an EHR system enables the sharing of critical patient information between the focal physician practice and other physician practices), connecting care providers from different physician practices with one another; (d) *communication with patients*

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[1] In this study, decision support capability includes data mining. It will be further explained in the next section.

[2] While administrative support is not covered by Stead and Lin (2009), it is included as a fourth capability of EHR in our study. The reason is that, according to IOM (2003), administrative processes are part of the personal healthcare services that must be supported by EHR (other personal healthcare services include care delivery, care management, and care support processes).

[3] This study focuses on care delivery functions, and does not address infrastructure functions, such as database management and the use of healthcare data standards (e.g., terminology, messaging standards, and network protocols).

(i.e., an EHR system supports communication between care providers and patients), connecting care providers in physician practices to patients. **Decision Support** might be enabled by two functions: (a) *clinical practice guidelines* (i.e., an EHR system provides nationally standardized recommendations for treatment methods regarding diagnoses and procedures), providing support for clinical decision making; and (b) *data mining* (i.e., an EHR system uses knowledge discovery techniques to analyze various similar or dissimilar data sets to recognize known or unknown relationships), providing inputs needed for decision support[1] (Stead and Lin 2009). **Administrative Support** may manifest itself in three functions: (a) *performance measuring and feedback* (i.e., an EHR system facilitates the measurement of work performance and provides feedback to work), supporting the administrative task of performance evaluation; (b) *audit trail* (i.e., an EHR system maintains a running log of decisions relating to the treatment of a patient, and tracks each access or alteration to specific data in the system), supporting the administrative task of internal or external audit; (c) *external reporting* (i.e., an EHR system enables physician practices to report to external constituents, such as government and insurers, by employing uniform data standards), supporting the administrative task of external reporting. A mapping of lower-level functions and higher-level capabilities of an EHR system is shown in Table 4.1. The identified EHR capabilities and functions cover the core functions of an EHR system established by the IOM and the ONCHIT expert panel, and were validated by physician experts in our study.

[1] For this reason, the data mining function is considered as belonging to the decision support category in this study, rather than being an independent category.

Having established the set of EHR capabilities, the four high-level EHR capabilities were linked to the four dimensions of psychological empowerment through one or more empowering structures embodied in the capabilities, including *access to information, access to support, standardization, communication*, *performance feedback,* and *task significance* (in Table 4.2).

Table 4.1 Capabilities and Functions of an EHR System

EHR Capabilities (High Level)	EHR Functions (Low Level)	Description of Functionality	Relevant IOM Functions*
Workflow automation	Workflow automation	An EHR system performs tasks with little human intervention.	(2), (3), (7)
Connectivity	Clinical information repository	An EHR system consolidates patient information from a variety of clinical sources, and enables easy access to and retrieval of data for a patient.	(1), (2)
	Vertical information sharing	An EHR system enables the sharing of critical patient information between the focal physician practice and hospitals or ancillary departments.	(5)
	Horizontal information sharing	An EHR system enables the sharing of critical patient information between the focal physician practice and other physician practices.	(5)
	Communication with patients	An EHR system supports communication between care providers and patients.	(5), (6)
Decision support	Clinical practice guidelines	An EHR system provides nationally standardized recommendations for treatment methods regarding diagnoses and procedures.	(4)
	Data mining	An EHR system uses knowledge discovery techniques to analyze various similar or dissimilar datasets to recognize known or unknown relationships, so as to support decisions.	
Administrative support	Performance measuring and feedback	An EHR system facilitates the measurement of work performance and provides feedback to work.	(8)
	Audit trail	An EHR system maintains a running log of decisions relating to the treatment of a patient, and tracks each access or alteration to specific data in the system.	
	External reporting	An EHR system employs uniform data standards to enable practices to respond to reporting requirements of external constituents (e.g., government and insurers).	(8)

*This column shows the relevance of the identified EHR capabilities and functions to the eight core functions established by the IOM:
(1) health information and data, (2) results management, (3) order entry/management, (4) decision support, (5) electronic communication and connectivity, (6) patient support, (7) administrative processes, and (8) reporting and population health management.

Table 4.2 EHR Capabilities, Embodied Empowering Structures, and Empowerment Changes

EHR Capabilities	Embodied Empowering Structures	Empowerment Changes
Workflow automation	Task significance	• Meaning (+)
	Access to support	• Competence (+)
Connectivity	Access to information	• Competence (+) • Self-determination (+)
	Communication	• Meaning (+) • Competence (+)
Decision support	Access to information	• Competence (+) • Self-determination (+)
	Standardization	• Self-determination (-)
Administrative support	Access to information	• Competence (+) • Self-determination (+)
	Performance feedback	• Impact (+)
	Access to support	• Competence (+)

Note: Symbols in the bracket mean the changes (increase or decrease) of empowerment.

4.2.1 From Workflow Automation to Empowerment Dimensions

The workflow automation capability of an EHR system would affect empowerment through two empowering structures: (1) **task significance** and (2) **access to support**. **Task significance** refers to the degree to which the job tasks have a substantial impact on the lives or work of others (Hackman and Oldham 1975). As one dimension of the key job characteristic of task meaningfulness, task significance plays a key role in determining perceptions of meaning (Kraimer et al. 1999). An EHR system increases physicians' task significance by automating routine and trivial tasks in physician practices. For example, an EHR system automates administrative workflow by plotting graphs of blood pressure readings, issuing invoice for payment, or tracking reference; it automates clinical documentation process with auto-filling of patient data or commonly used notes and with error detection; it also automates clinical ordering and prescribing processes with pre-built order sets and electronic transfer of prescriptions. Without manual intervention of these routine and trivial tasks, physicians can focus more on influential (significant) tasks, such as talking to patients or making clinical decisions. Consequently, physicians are likely to regard their job as having more meaning upon using EHR with workflow automation capability. Thus, we hypothesize that:

> *H5a: Perceived existence of workflow automation capability in an EHR system has a positive influence on meaning associated with the use of the system.*

Access to support, as an empowering structure, is associated with the degree of formal and informal power an individual has in the organization (Kanter 1977). Support refers to sources of support that allow one to function in a way that maximizes work effectiveness, which may include guidance and feedback from subordinates, peers, and supervisors (Kanter 1977; Laschinger 1996). The workflow automation capability of an EHR system provides physicians with external support for tasks that can be repeated with little modification. When automated, tasks can be performed in a faster manner and with minimized errors, making physicians feel more competent. For example, physicians might be more confident with their ability to document visit notes with automation features like patient data auto-filling, commonly-used notes, and typographic error detection. Therefore, it is hypothesized:

> *H5b: Perceived existence of workflow automation capability in an EHR system has a positive influence on competence associated with the use of the system.*

4.2.2 From Connectivity to Empowerment Dimensions

The connectivity capability of an EHR system also affects empowerment through two empowering structures: (1) **access to information** and (2) **communication**. **Access to information** means access to data, knowledge and expertise necessary to carry out one's job (Kanter 1977; Laschinger 1996). The content of information may include workflow, customers, external environment, competition, and firm strategy. Support for a general relationship between access to information and empowerment abounds in prior literature. First, access to information enhances the *competence* dimension of empowerment, because it facilitates both self-efficacy (a concept related to competence) (Gist and Mitchell 1992) and sensemaking (important for a sense of competence) (Weick 1979). Second, access to information enhances the *self-determination* dimension, because sharing information freely across levels and functions is a critical ingredient for individual autonomy (Spreitzer 1996). The other empowering structure **communication** is related to access to information, as communication cannot occur without information. However, communication is different from access to information in that the former emphasizes the exchange of thoughts, messages, or information (between other parties and the focal person), while the latter focuses on a unidirectional flow of information (from external to the focal person). Past research shows that poor communications in the work environment lead to reduced perceptions of control and empowerment (Menon 1995), and technological improvements in communications are the key to employee empowerment (Malone 1997). Though the literature has not differentiated the impact of communication on empowerment dimensions, we believe that enhanced communication in physician practices would mainly change two empowerment dimensions for physicians: (1) enhance *meaning* in their job as they can better understand their patients and have better rapport with patients; and (2) increase their *competence* level for patient care due to better understanding of patients and greater ability to treat them.

Four functions of the connectivity capability enable greater **access to information** and enhanced **communication**. Specifically, *clinical information repository*, with a longitudinal collection of electronic health information for and about patients (e.g., demographics, clinical notes, problem lists, past medications and allergies) gives physicians immediate electronic access to person-and population-level information (IOM 2003). *Horizontal information sharing* gives physicians access to critical patient information in other physician practices, and facilitates the communication between different physician practices. *Vertical information sharing* gives physicians access to critical patient information in hospitals or ancillary departments, and improves their communication with these healthcare providers. In addition, *communication with patients* enhances physicians' communication with patients during visit (e.g., physicians can use electronic diagrams for illustration when explaining to patients), and before or after visit (e.g. patients can schedule visits with physicians, and physicians can remind patients of medication).

Therefore, if physicians perceive an EHR system with the capability of connectivity, they might anticipate wider, faster access to patient information and improved communication with patients, which may subsequently lead to the feelings of more meaning, more self-determination and higher levels of competence in their work. I have the following three hypotheses:

H6a: Perceived existence of connectivity capability in an EHR system has a positive influence on meaning associated with the use of the system.

H6b: Perceived existence of connectivity capability in an EHR system has a positive influence on competence associated with the use of the system.

H6c: Perceived existence of connectivity capability in an EHR system has a positive influence on self-determination associated with the use of the system.

4.2.3 From Decision Support to Empowerment Dimensions

The decision support capability of an EHR system affects empowerment through two empowering structures: (1) **access to information** and (2) **standardization**. As discussed earlier, **access to information** might enhance physicians' *competence* and *self-determination* at work. The two functions of the decision making capability enable greater access to information (data, expertise and knowledge). Specifically, *clinical practice guidelines* incorporate the best scientific evidence of effectiveness with expert opinions to provide nationally standardized recommendations for healthcare (Borkowski and Allen 2003). Examples are suggested drug dosage for each case, reminders about possible drug interactions when medication orders are entered, or alerts when abnormal results occur. Most physicians believe that guidelines are convenient sources of advice and good educational tools, and are likely to improve quality of care (Borkowski and Allen 2003). *Data mining* discovers associations among variables by analyzing various similar or dissimilar datasets. It provides rich information for new approaches to evidence-based medicine and personalized care (Stead and Lin 2009). Combining these, if physicians perceive an EHR system as having decision support capability, they might anticipate access to a wider range of information, which in turn makes them feel more confident in their ability to treat patients and experience greater self-determination in doing their work. Therefore, we hypothesize that:

> *H7a: Perceived existence of decision support capability in an EHR system has a positive influence on competence associated with the use of the system.*

However, the effect of decision support capability on *self-determination* is less straightforward, due to the influence of the other empowering structure — standardization. **Standardization** is the process of developing and agreeing upon technical standards, which would lead to perceptions of decreased control and reduced empowerment (Menon 1995). *Clinical practice guidelines* (CPG) are viewed by healthcare administrators as an important tool for reducing the variations of physicians' practice patterns by standardizing healthcare delivery (Borkowski and Allen 2003). However, physicians fear that they will become "protocol-oriented medical automatons" (Reed and Evans 1987, p.3279), and regard clinical practice guidelines as a threat to their autonomy or an inappropriate substitution for their clinical judgment (Mittman et al. 1992). Physicians also believe that clinical practice guidelines would be used for quality assurance review (i.e., associated with decreased physician autonomy) and in physician disciplinary actions (i.e., associated with malpractice liability suits) (Borkowski and Allen 2003). Therefore, perceived existence of decision support capability in an EHR system may also decrease physicians' self-determination in their work. Given such mixed effects, we hypothesize an influence of the existence of decision support capability on self-determination, but do not specify the (positive or negative) direction.

H7b: Perceived existence of decision support capability in an EHR system has an influence on self-determination associated with the use of the system.

4.2.4 From Administrative Support to Empowerment Dimensions

The administrative support capability of an EHR system, which includes the functions of *performance measuring and feedback, audit trail* and *external reporting,* could affect physicians' empowerment perceptions mainly through three empowering structures: (1) **performance feedback**, (2) **access to information**, and (3) **access to support**. **Performance feedback** means receiving information related to work performance. It is an empowerment structure different from access to information, where the information is not specific to performance information. Performance information is one type of information critical to empowerment[1] (Spreitzer 1995), therefore, performance feedback has distinct effects on empowerment and deserves special examination. According to the empowerment literature, people need to know how well they or their work units are performing so as to make and influence decisions for maintaining and improving performance in the future (Spreitzer 1995). Thus, performance information is critical to reinforcing a sense of competence and the belief that one is a valued part of an organization (Spreitzer 1995). Furthermore, personal control theory and job design research suggest that task feedback is positively related to knowledge of the actual results of work (Greenberger and Strasser 1986). Such knowledge allows individuals to have an impact in a work unit, because individuals are unlikely to be able to exert influence without knowing the results (Kraimer et al. 1999). In sum, performance feedback can increase individuals' sense of *competence* and *impact*.

The *performance measuring and feedback* function of an EHR system provides **performance feedback** to physicians. For example, physicians can use the system to conduct real-time or retrospective analysis of clinical, operational, demographic or other user-specific data (e.g., average patient waiting time, and number of bottles of drugs left). The a*udit trail* function of an EHR system provides expanded **access to information** about patient treatment, specifically, a

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[1] According to Spreitzer (1995), the other type of information critical to empowerment is information regarding an organization's mission. This type of information is not relevant to our context.

running log of decisions relating to the treatment of a patient and a track of each access or alteration to recorded information. It is the law to understand how the sensitive patient and provider data is accessed, utilized and managed, therefore, physician practices rely on the generation of an audit trail for legal reporting of their operations and protection of the patients (McFadyen 2008). Furthermore, the *external reporting* function of an EHR system lends **support** to physicians for external reporting activities. Physician practices generally need to respond to federal, state, and private reporting requirements, such as claims and chronic disease management reporting (IOM 2003). With uniform data standards in EHR, they can generate reports quickly and accurately, and send the report to external constituents electronically (IOM 2003).

In sum, if physicians perceive the administrative support capability existing in an EHR system, they are likely to anticipate timely performance feedback, greater access to information about patient treatment, and greater access to support of external reporting. As described earlier, **performance feedback** can increase physicians' sense of *competence* and *impact*, **access to support** can increase *competence*, and **access to information** can increase both *competence* and *self-determination*. Consequently, physicians might anticipate more competence, more self-determination and more impact at work upon using the EHR system. I have the following three hypotheses:

> *H8a: Perceived existence of administrative support capability in an EHR system has a positive influence on competence associated with the use of the system.*

H8b: Perceived existence of administrative support capability in an EHR system has a positive influence on self-determination associated with the use of the system.

H8c: Perceived existence of administrative support capability in an EHR system has a positive influence on impact associated with the use of the system.

4.3 Control Variables

To predict intention to adopt EHR systems, we also included a few control variables, which are potential drivers for adoption intention. Factors such as *physician age* (i.e., age of the physician), *physicians' IT knowledge* (i.e., IT knowledge of physicians in the practice), *practice size* (i.e., size of the physician practice), *practice assistants' IT knowledge* (i.e., IT knowledge of practice assistants in the practice), *incentive for EHR adoption* (i.e., the extent to which the practice received incentives for adopting EHR systems), and *incentive for quality of care* (i.e., the extent to which the practice received incentives for increasing quality of care) have been suggested as drivers of EHR adoption by primary care physicians (Simon et al. 2007a). In addition, *current use of computerized systems in the practice* (i.e., whether the physician practice is currently using any computerized systems) was also included as a control variable.

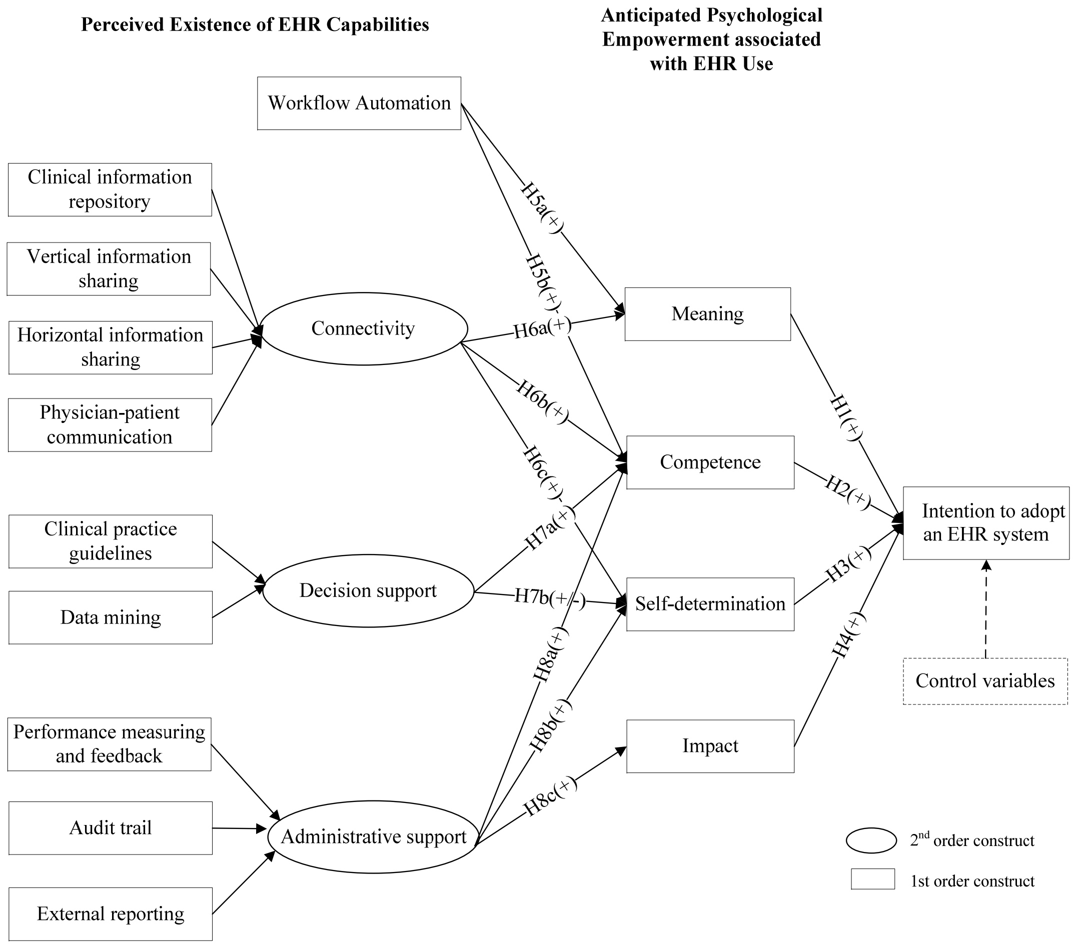

Figure 4.1 Research Model

CHAPTER 5. RESEARCH METHODOLOGY

I conducted a field study to test our model and used questionnaires as the data collection vehicle. The level of analysis is individual physicians in primary care practices. The target system is the most comprehensive EHR system available in the market[1]. Data was collected from private general practitioners (GPs) in Singapore. A literature search was first carried out within the domain of the constructs to generate sample items. Short interviews with five informants (IS researchers, medicine researchers, and GPs) were next conducted to assess face validity followed by a process of content validation. Finally, the survey instrument was administered to GPs.

5.1 Background Information: EHR Adoption in Singapore Private GP Clinics

Private GP clinics provide about 80% of the primary care in Singapore. Currently, the rate of healthcare IT adoption by clinics is low and the solutions are fragmented (Accenture 2010). Towards the vision of a national EHR, Singapore's

[1] A hypothetical EHR system, instead of a specific EHR system, is targeted for two considerations. First, this research is meant to find out how physicians' perceptions about various EHR capabilities affect their intention to adopt an EHR system, so as to further find out what constitutes a "desirable" EHR system that will be adopted by physicians. The focus is not on the adoption of a specific EHR system, and thus the response should not be constrained by a specific EHR system. Second, this approach is consistent with prior adoption studies that used hypothetical or general technologies to test research models (e.g., Brown and Venkatesh 2005; Chau and Hu 2001; Srite and Karahanna 2006; Venkatesh and Brown 2001).

Infocomm Development Authority (IDA) initiated a program in 2006, in collaboration with the Ministry of Health (MOH), to encourage EHR adoption among private GP clinics through commercial vendors that provide integrated systems through a software-as-a-service model. The government provides some seed funds as incentive; however, EHR implementation is primarily funded by the clinics themselves, driven by their own assessment of the benefits of EHR adoption. The adoption is totally voluntary, but is assumed to be facilitated by the fact that the systems integrate functions for claims submission from the MOH under its Chronic Disease Management Program (Lee et al. 2006). However, over the past few years, private GPs clinics have been slow in embracing EHR. Some of them moved from paper-based practice to a hybrid of paper and computer-based practice, but very few are using electronic systems for clinical documentation. At the time of this study, Singapore was in the process of rolling out a national EHR. In order to have a more complete electronic health record for each citizen, the adoption of EHR systems by GPs were deemed necessary and important. The adoption of clinical EHR systems by GPs was central to the success of the national EHR. Therefore, it was imperative to investigate GPs' needs and views towards EHR systems and thus, making the Singapore GP clinics a good context for this study on primary care physicians' adoption intention for EHR systems.

5.2 Construct Operationalization

Instruments for constructs were either adapted from existing scales or developed for this study. The ten low-level EHR functions (including *workflow automation*) were operationalized as formative constructs, while the three high-level EHR capabilities were operationalized as formative, second-order constructs using the corresponding low-level (first-order) functions as indicators. Measures for the ten first-order constructs were self-developed following Diamantopoulos and Winklhofer's (2001) recommendations on formative index construction. I conducted an extensive review of the EHR literature (e.g., Blumenthal et al. 2006 ; DesRoches et al. 2008; Gans et al. 2005; IOM 2003; Jha et al. 2009a; Jha et al. 2009b; Jha et al. 2008; Mandl and Kohane 2009; Meade et al. 2009; Menachemi et al. 2007a; Miller et al. 2004; Reed and Grossman 2004; Sequist et al. 2007; Stohr and Zhao 2001; Wang et al. 2003) followed by several exploratory interviews with our informants to ensure that the indicators selected cover the complete content domain of the latent variables. Each of the EHR function construct was measured with a multi-item instrument asking respondents to rate the extent to which the function exists in the most comprehensive EHR system on the market, to their best knowledge.

Measures for the four empowerment dimensions—*meaning*, *competence*, *self-determination*, and *impact*—were adopted from Spreitzer's (1995) 12-item empowerment scale. As the interest of this study is in changes in psychological empowerment associated with the use of an EHR system versus a non-EHR system (e.g., a paper system), we modified Spreitzer's scale by including a baseline comparison. *Intention to adopt EHR systems* was operationalized as a reflective construct with measures based on Azjen and Fishbein (1980). The first two items incorporate actions (intend to use), target (the most comprehensive EHR available in market[1]), context (GP clinics), and time (within 6 months), which are essential elements of intention and behavior. Items for key constructs are presented in Appendix A. For control variables, *Physicians' IT knowledge* and *practice assistants' IT knowledge* were each measured by three items adopted from Thong (1999)'s employee IT knowledge. *Incentive for EHR adoption* and *incentive for quality of care* were each measured by one item adopted from Simon et al (2007a). *Practice size* was measured as the number of physicians in the practice (Simon et al. 2007a). *Current use of computerized systems in the practice* was measured by one question asking whether the practice currently uses any computerized system that have any of the following functions: healthcare information and data, management of results, electronic ordering, clinical decision support, communication, data sharing with external providers, and administrative tools.

5.3 Content Validity Assessment

Given that items for the constructs were adapted from various sources or self-developed for this study, all items were subjected to a two-stage content

[1] As respondents may have different perceptions about EHR, we asked them to refer to the most comprehensive EHR available on the market based on their own understanding.

validation exercise according to procedures prescribed by Moore and Benbasat (1991). Four PhD students participated in the first stage (unstructured sorting) as sorters. Each sorter was given the 47 items (for key constructs) printed on cards and mixed up. They were asked to sort the items by placing related items together and providing a label to each set of related items (that made up a construct). The labels given by the sorters for the constructs corresponded closely to the names of the actual constructs. Overall, the four sorters correctly placed 90% of the items onto the intended constructs (shown in Table 5.1), which was satisfactory. I then proceeded to the second stage (structured sorting), where another four PhD students participated as sorters. Each sorter was given the 47 items printed on cards and mixed up, together with names and definitions of the 16 constructs. They were asked to sort the items by placing each item into a construct category or an "other" (no fit) category. Apart from one question for performance measuring and feedback (PfMF3) that was placed in category of the external reporting (ExtR) or clinical information repository (CIR), all sorters correctly placed all of the items into the intended constructs (shown in Table 5.2). PfMF3 was therefore removed from the questionnaire. The remaining 46 items were then consolidated into an instrument for survey administration.

Table 5.1 Results of Unstructured Sorting Exercise

Target category	**Actual Category**																**Total Qs**	**Hit Rate (%)**
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Others		
WAut[1]	12																12	100
CIR[2]		6					1		4							1	12	50
VIShare[3]			12														12	100
HIShare[4]				12													12	100
ComwP[5]					8												8	100
CPG[6]						14										2	16	87.5
DM[7]							12										12	100
PfMF[8]						2	1	12	1								16	75
AudT[9]		1						1	14								16	87.5
ExtR[10]										12							12	100
Mean[11]											12						12	100
Comp[12]												12					12	100
SelfD[13]													9			3	12	75
Impact[14]														9		3	12	75
IntA[15]															12		12	100
Average																		90

Table 5.2 Results of Structured Sorting Exercise

Target category	**Actual Category**																**Total Qs**	**Hit Rate (%)**
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Others		
WAut[1]	12																12	100
CIR[2]		12															12	100
VIShare[3]			12														12	100
HIShare[4]				12													12	100
ComwP[5]					8												8	100
CPG[6]						16											16	100
DM[7]							12										12	100
PfMF[8]		1						13		2							16	81.3
AudT[9]									16								16	100
ExtR[10]										12							12	100
Mean[11]											12						12	100
Comp[12]												12					12	100
SelfD[13]													12				12	100
Impact[14]														12			12	100
IntA[15]															12		12	100
Average																		98.8

5.4 Survey Administration

The definition of an EHR system and a description of EHR functions were included in the survey instruments to improve the validity of the responses. To better establish causality and reduce common method bias, the dependent variable and independent variables and were measured at different time points. At Time 1, a package containing a cover letter, a copy of the questionnaire (including measures for EHR capabilities, empowerment dimensions, control variables, and demographic questions) and a prepaid reply envelope was sent to potential respondents. At Time 2, calls were made to the responded physicians to collect answers for the dependent variable.

The required sample size was estimated to be 138, with a medium effect size (0.l5) and a power of 0.95 for the study (α=0.05). The sample was drawn from two directories: (1) a directory of private GPs on the Singapore Medical Association (SMA) website, which lists the name and contact information of 1244 GPs; (2) a directory of GP clinics on the MOH website, which lists the contact information of 1405 private GP clinics. A sample of 1200 respondents was randomly selected from the consolidated GP list and a survey package was sent to each of the GPs (from the GP directory) or the presiding doctor of the GP clinic (from the clinic directory). The subjects were motivated to respond because EHR was highly relevant to them. Of the 1200 questionnaires sent, 64 were returned due to changed addresses, closure for renovation or conversion to non-GP clinics, or because the GPs were no longer practicing, retired or deceased, leaving a final sample of 1136. To increase the response rate, follow-up calls were made one week after the surveys were sent, and reminder cards were sent two weeks after the follow-up calls. Once a response was received, a call was made to the responded physicians for the dependent variable questions. In all, 248 surveys were returned, of which 198 were complete, showing an effective response rate of 17.4%. This is considered adequate because the survey was unsolicited and involved GPs whose schedules are very tight. Table 4.3 presents the demographics of the respondents. Among the respondents, 75.3% are male, 82% are above 40 years old, and majority of them have more than 10 years of patient care experience. Half of the respondents are clinics owners in addition to physicians. Moreover, 70.6% of the respondents indicated that their clinics had been using certain computerized systems with at least one of the listed functions for an EHR system.

To check for non-response bias, we compared respondent characteristics between the early and late waves of the survey responses (Armstrong and Overton 1977). I detected no differences across waves in terms of physician characteristics namely age, gender, patient care experience, and home computer usage experience. The only difference was in the current use of computerized systems in the practice, the mean of which was higher for late respondents (M=0.82) than for early respondents (M=0.53) (see ANOVA results in Appendix B).

Table 5.3 Demographics of Respondents

Demographics	**Category**	**Frequency**[a]	**Percentage**
Gender	Male	180	75.3%
	Female	59	24.7%
Age	20-29	3	1.3%
	30-39	40	16.7%
	40-49	112	46.9%
	50-59	53	22.1%
	>=60	31	13%
Patient care experience	2-5 years	3	1.3%
	6-10 years	25	10.5%
	>10 years	211	88.2%
Current use of computerized systems in the practice	Yes	175	70.6%
	No	73	29.4%

[a] Given the presence of missing data, the total frequency may be less than 248.

CHAPTER 6. DARA ANALYSIS

The theoretical model is multistage, which suggests the need for a structural equation modeling technique. Partial Least Square (PLS) (SmartPLS 2.0.M3) was chosen primarily due to two reasons. First, our constructs include both formative and reflective constructs. PLS allows latent constructs to be modeled as either formative or reflective indicators. Second, this study is exploratory rather than confirmatory in nature. PLS is more suitable for exploratory studies. I followed a guideline for using PLS path modeling to access hierarchical construct models, where the second-order latent variables were built up through repeated use of the measures of the first-order latent variables (Wetzels et al. 2009).

6.1 Evaluating the Measurement Model

Table 6.1 shows the descriptive statistics. On average, *intention to adopt EHR* was below neutral [1] (M = 3.23), which means that in general physician respondents did not intend to adopt the most comprehensive EHR system in the next 6 months. This reflects the reality that GPs in Singapore are slow in embracing EHR. For empowerment dimensions, *impact* (M=4.20) and *competence* (M = 4.01) each had a mean above neutral, while *self-determination* (M = 3.75) and *meaning* (M = 3.96) had a mean below neutral. That is to say, in general the respondents felt the most comprehensive EHR system available in the market would enhance their *impact* and *competence,* but diminish their *self-*

[1] Neutral is taken as the value of 4, the center of the 7-point scale.

determination and *meaning.* Among the ten EHR functions, four had a mean above neutral, including *clinical information repository* (CIR) (M = 5.03), *audit trail* (AudT) (M=4.47), *workflow automation* (WAut) (M=4.43), and *clinical practice guidelines* (CPG) (M=4.05). That means respondents generally thought these four capabilities exist in the most comprehensive EHR. It is worth noting that some of these capabilities (e.g., CPG) were beyond the scope of the computerized systems they were using, indicating that the respondents were indeed referring to the "most comprehensive EHR system available in the market" when they responded. The other six functions had a mean below neutral, with *data mining* (DM) having the lowest (M = 3.57).

Table 6.2 shows the correlations among the studied variables. Inter-correlations were acceptable in general except those between some EHR functions (DM and CPG, and DM and PfMF), and among empowerment dimensions, which were higher than 0.71. Collinearity checks were thus conducted to see whether the high correlation is a serious issue. Using 10 as the cutoff for variance inflation factor (VIF) suggested by general statistics theory (Kleinbaum et al. 1988), the result shows that multicollinearity was not a concern (VIF < = 4.27).

Reflective constructs were assessed in terms of content validity, convergent validity and discriminant validity. Content validity was established based on the existing literature and informant opinions. Convergent validity was assessed by examining composite reliability, Cronbach's alpha, item loadings, and average variance extracted (AVE) for the measures (Hair et al. 1998). As shown in Table 6.3, all the Cronbach's alpha and composite reliability values exceeded the criterion of 0.70 (Chin 1998), and all the AVE values were above the recommended threshold of 0.50 (Hair et al. 1998). In addition, item loadings were all significant at the level of 0.01. Discriminant validity was verified by comparing the square root of AVEs with correlations among constructs. The square root of the AVE for each construct (in Table 6.3) was greater than the levels of the correlations involving the construct (in Table 6.2), confirming discriminant validity (Fornell and Larcker 1981).

Formative constructs were assessed in terms of construct validity, reliability and item weights, following guidelines for specifying formative constructs in IS (Cenfetelli and Bassellier 2009; Petter et al. 2007). For *construct validity*, principal components analysis[1] (in SPSS) was first conducted to examine the item weights for measures. All items loaded on the intended constructs except items for VIShare and HIShare loaded on the same component (Appendix C). Considering that VIShare and HIShare are conceptually different in this study, we retained them as separate constructs to preserve content validity (Bollen and Lennox 1991). For *reliability*, item collinearity was examined to see whether one's formative measures were too highly correlated. Items with a VIF greater than 10 are redundant and could be considered for elimination [2](Diamantopoulos

[1] Principal components analysis is different from common factor analysis. The former is used to find optimal ways of combining observed variables into a relatively small number of subsets, while the later is used to identify the structure underlying these observed variables and to estimate scores to measure the latent variables (factors). Given the objective of formative construct is to retain the unique variance of each measure and not just the shared variance among measures, principle component analysis, rather than common factor analysis, should be applied to evaluate the reduced dimensionality of the measures (see Petter et al. 2007, p. 641).

[2] Although some studies have suggested a lower VIF cutoff of 3.3, researchers

et al. 2008; Diamantopoulos and Winklhofer 2001; Neter et al. 1996). Most items had VIF smaller than the cutoff, except for DM items (VIF > = 10.63), VIShare items (VIF > = 11.16), and two of the HIshare items (HIShare2 and HIShare3: VIF > = 27.53). Considering that removal of correlated items would alter the conceptual meaning of the constructs, we addressed the collinearity issue using one of the approaches suggested by Petter et al (2007): modeling the construct as having both formative and reflective measurement items. Therefore, DM and VIShare were modeled as reflective constructs with their original items, and HIShare was modeled as a superordinate construct measured by HIShare1 and an emergent construct HIShare2_3 (with HIShare2 and HIShare3 as reflective indicators). After that, we specified the formative constructs in the research model and examined formative item weights (in PLS). Some items displayed significant weights while others had nonsignificant ones. Items with nonsignificant weights were removed if the nature of the corresponding construct was not changed after the removal (Diamantopoulos and Winkelhoffer 2001); otherwise, they were retained for content validity purpose (Bollen and Lennox 1991). Such process resulted in a *refined set* of measures for formative constructs. Psychometric properties for these measures, including item weights and item loadings, are shown in Table 6.4. For comparison, Table 6.4 also shows the psychometric properties for the *original set* of measures.

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recommend not to overemphasize that for constructs with formative indicators, as it is important to ensure that all of the essential aspects of the construct domain are captured by the remaining indicators and sub-dimensions (Bollen and Lennox 1991; Diamantopoulos et al. 2008; MacKenzie et al. 2010).

For the second-order EHR capabilities, secondary weights (i.e., weights of the first-order latent constructs on a second-order construct) were examined (Wetzels et al. 2009). As shown in Table 6.5, secondary weights were largely similar for original and refined set of formative measures. Weights of CIR, VIShare, HIShare and ComwP on connectivity were 0.46 0.17, 0.31 and 0.31 respectively. Weights for CPG and DM on decision support were 0.56 and 0.51, respectively. Weights for PfMF, AudT and ExtR on administrative support were 0.46, 0.25 and 0.44, respectively. All the secondary weights were significant at the level of 0.01, which provides evidence of valid measures for the second-order constructs (MacKenzie et al. 2011).

Table 6.1 Descriptive Statistics of Variables

Variables	Mean	Std Dev
Study Variables		
Workflow automation (WAut)	4.43	1.47
Clinical information repository (CIR)	5.03	1.47
Vertical information sharing (VIShare)	3.76	1.95
Horizontal information sharing (HIShare)	3.81	1.98
Communication with patients (ComwP)	3.92	1.56
Clinical practice guidelines (CPG)	4.05	1.55
Data mining (DM)	3.57	1.63
Performance measuring and feedback (PfMF)	3.77	1.46
Audit trail (AudT)	4.47	1.52
External reporting (ExtR)	3.97	1.69
Meaning (Mean)	3.96	1.31
Competence (Comp)	4.01	1.29
Self-determination (SelfD)	3.75	1.37
Impact (Impact)	4.20	1.32
Intention to adopt EHR (IntA)	3.23	1.94
Control Variables		
Age (age)	4.30	0.93
Physicians' IT knowledge (ITkDr)	4.28	1.55
Practice assistants' IT knowledge (ITkPA)	3.66	1.47
Incentive for EHR adoption(IctEHR)	2.64	1.97
Incentive for quality of care (IctQC)	3.01	1.89
Practice size (Size)	1.65	1.08
Current use of computerized systems in the practice (UCSC)	0.71	0.45

Table 6.2 Inter-correlations among Study Variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
WAut[1]	-																				
CIR[2]	0.61	-																			
VIShare[3]	0.39	0.42	-																		
HIShare[4]	0.38	0.49	0.82	-																	
ComwP[5]	0.67	0.61	0.40	0.42	-																
CPG[6]	0.58	0.58	0.62	0.58	0.64	-															
DM[7]	0.52	0.47	0.62	0.64	0.54	0.75	-														
PfMF[8]	0.54	0.46	0.54	0.55	0.56	0.67	0.74	-													
AudT[9]	0.55	0.57	0.52	0.58	0.56	0.68	0.66	0.69	-												
ExtR[10]	0.39	0.50	0.70	0.70	0.46	0.67	0.64	0.62	0.57	-											
Mean[11]	0.47	0.48	0.15	0.20	0.31	0.29	0.23	0.37	0.35	0.22	-										
Comp[12]	0.44	0.49	0.15	0.25	0.39	0.29	0.23	0.36	0.39	0.24	0.78	-									
SelfD[13]	0.43	0.43	0.14	0.23	0.38	0.27	0.24	0.40	0.38	0.22	0.75	0.80	-								
Impact[14]	0.45	0.47	0.16	0.23	0.39	0.24	0.24	0.43	0.41	0.22	0.70	0.79	0.75	-							
IntA[15]	0.26	0.20	0.04	0.10	0.22	0.08	0.09	0.21	0.23	0.10	0.44	0.40	0.45	0.36	-						
Age[16]	-0.21	-0.10	0.02	-0.03	-0.20	-0.06	-0.10	-0.16	-0.20	0.04	-0.15	-0.15	-0.10	-0.15	-0.17	-					
ITkDr[17]	0.26	0.22	-0.09	-0.03	0.28	0.09	-0.01	0.16	0.15	-0.06	0.26	0.22	0.21	0.25	0.23	-0.35	-				
ITkPA[18]	0.19	0.18	-0.02	0.03	0.22	0.06	0.02	0.23	0.13	0.05	0.29	0.25	0.30	0.28	0.36	-0.14	0.64	-			
IctEHR[19]	0.02	0.10	0.05	0.06	0.01	0.09	0.08	0.09	0.09	0.04	0.03	0.11	-0.02	0.15	0.05	-0.01	0.00	0.04	-		
IctQC[20]	0.10	0.06	0.09	0.08	0.11	0.07	0.09	0.10	0.11	0.05	0.02	0.10	-0.01	0.19	0.06	-0.13	-0.01	0.00	0.68	-	
Size[21]	0.10	0.10	-0.02	0.03	0.14	0.07	0.02	0.13	0.12	-0.01	0.19	0.16	0.18	0.16	0.23	-0.29	0.23	0.19	0.15	0.17	-
UCSC[22]	0.23	0.16	-0.11	-0.06	0.16	-0.10	-0.08	0.07	0.04	-0.11	0.29	0.32	0.28	0.31	0.29	-0.27	0.36	0.35	-0.01	0.06	0.22

Note: please refer to Table 6.1 for full terms of the variables.

Table 6.3 Convergent Validity for Reflective Constructs

Construct	Loading	t-value	Composite Reliability	Cronbach's Alpha	AVE	Squared Root of AVE
Mean1	0.98	159.46	0.99	0.98	0.97	0.98
Mean2	0.99	379.05				
Mean3	0.98	210.33				
Comp1	0.97	112.04	0.98	0.97	0.94	0.97
Comp2	0.98	165.76				
Comp3	0.97	95.35				
SelfD1	0.96	134.37	0.97	0.96	0.93	0.96
SelfD2	0.96	86.52				
SelfD3	0.97	168.60				
Impact1	0.96	88.18	0.98	0.95	0.91	0.95
Impact2	0.98	225.47				
Impact3	0.93	71.48				
IntA1	0.99	260.08	0.99	0.97	0.97	0.98
IntA2	0.99	315.59				
ITkDr1	0.81	11.90	0.91	0.85	0.77	0.88
ITkDr2	0.92	35.89				
ITkDr3	0.90	21.66				
ITkCA1	0.89	45.67	0.93	0.89	0.82	0.91
ITkCA2	0.89	52.55				
ITkCA3	0.94	97.16				

Note: please refer to Table 6.1 for full terms of the variables.

Table 6.4 Psychometric Properties for First-Order Formative Constructs

Construct	Item	Original Set				Refined Set			
		Weight	t	Loading	t	Weight	t	Loading	t
WAut	WAut1	0.42*	2.17	0.94**	22.18	0.42*	2.22	0.97**	19.28
	WAut2	0.39	1.45	0.96**	26.92	0.39	1.48	0.95**	29.13
	WAut3	0.26	1.13	0.89**	15.88	0.26	1.10	0.88**	24.17
CIR	CIR1	0.24	1.54	0.93**	23.33	0.24	1.48	0.93**	22.98
	CIR2	0.30*	2.23	0.92**	29.17	0.31*	2.26	0.93**	30.51
	CIR3	0.53**	4.18	0.97**	44.60	0.52**	4.07	0.97**	43.59
VIShare	VIShare1	0.62	1.10	0.99**	33.93	[0.34**]	85.04	[0.99**]	482.21
	VIShare2	0.52	0.99	0.99**	42.91	[0.34**]	64.40	[0.98**]	203.31
	VIShare3	-0.14	0.30	0.94**	14.91	[0.33**]	66.74	[0.98**]	141.91
HIShare	HIShare1	1.00**	5.09	0.99**	43.70	1.00	0.00	1.00	0.00
	HIShare2	0.74	1.19	0.89**	18.50	(0.90**)	42.38	NA	NA
	HIShare3	-0.76	1.17	0.86**	12.96				
ComwP	ComwP1	0.31	1.86	0.91**	21.84	0.30	1.82	0.91**	20.96
	ComwP2	0.73**	4.73	0.98**	46.52	0.74**	4.83	0.98**	52.37
CPG	CPG1	0.24	1.74	0.91**	26.21	-	-	-	-
	CPG2	0.27	1.57	0.92**	25.18	0.42**	2.59	0.93**	25.48
	CPG3	0.44**	3.09	0.93**	33.18	0.49**	3.32	0.94**	32.21
	CPG4	0.17	1.74	0.74**	12.28	0.19*	2.05	0.74**	12.19
DM	DM1	0.74**	3.46	0.99**	100.36	[0.34**]	128.45	[0.98**]	271.72
	DM2	-0.13	0.59	0.97**	52.16	[0.34**]	151.94	[0.99**]	342.99
	DM3	0.40*	2.03	0.98**	57.46	[0.34**]	152.66	[0.98**]	191.53
PfMF	PfMF1	0.24*	2.11	0.90**	28.09	0.23*	2.02	0.90**	28.08
	PfMF2	0.37**	2.63	0.93**	28.91	0.40**	3.03	0.93**	31.93
	PfMF4	0.47**	3.92	0.93**	27.23	0.45**	4.05	0.93**	27.71
AuT	AudT1	0.53**	3.37	0.94**	37.90	0.61**	6.33	0.95**	42.00
	AudT2	-0.08	0.46	0.91**	29.56	-	-	-	-
	AudT3	0.34	1.89	0.94**	32.90	-	-	-	-
	AudT4	0.28	1.84	0.90**	24.90	0.46**	4.68	0.91**	27.45
ExtR	ExtR1	0.07	0.32	0.89**	15.82	0.06	0.27	0.89**	15.74
	ExtR2	0.36	1.32	0.96**	28.87	0.37	1.27	0.96**	26.47
	ExtR3	0.60**	2.54	0.98**	46.09	0.60*	2.36	0.98**	42.95

*P<=0.05, two-tailed test; **p<=0.01, two-tailed test;

Note:

(1) Please refer to Table 6.1 for full terms of the variables.

(2) In the refined set, [ ] means that the relevant items are reflective; - means that the relevant item was removed due to non-significant weight: ( ) means that the number is the weight of the emergent construct HIShare2_3 which has HIShare2 and HIShare3 as two reflective indicators

Table 6.5 Psychometric Properties for Second-Order Formative Constructs

2nd-order Constructs	1st-order Constructs	Original Set		Refined Set	
		Weight	t	Weight	t
Connectivity	CIR	0.45**	10.38	0.46**	9.98
	VIShare	0.17**	4.45	0.17**	4.47
	HIShare	0.31**	8.11	0.31**	7.99
	ComwP	0.31**	7.72	0.31**	7.94
Decision support	CPG	0.57**	14.75	0.56**	14.67
	DM	0.50**	13.16	0.51**	13.47
Administrative support	PfMF	0.45**	9.07	0.46**	9.20
	AudT	0.25**	6.20	0.25**	6.43
	ExtR	0.44**	8.34	0.44**	8.51

*P<=0.05, two-tailed test; **p<=0.01, two-tailed test.

6.2 Evaluating the Structural Model

Subsequently, we examined the structural model in terms of path significance and explanatory power (R^2). It was worth noting that the structural modeling results were not significantly different for models based on the *original* and *refined* set of measures. This indicates that our research model is robust to the high correlations between items or nonsignificant item weights of the formative constructs. Therefore, we decided to keep the original set of formative measures for the purpose of scale completeness. The following results reported would be based on the original measures.

Statistical tests were mostly assessed at 5% level of significance using one-tailed t-tests, because hypotheses and corollaries are unidirectional in nature (Teo et al.

2003). The exception is for the relationship between decision support and self-determination, the hypothesis and corollary for which was bidirectional, so the statistical test was assessed at 5% level of significance using two-tailed t-test. Table 6.6, Table 6.7 and Figure 6.1 present the results for structural modeling analysis. For the dependent variable intention to adopt EHR, we estimated three models: the full model, the theoretical model, and the control model (Table 6.6). They were estimated to assess the true impact of the theoretical variables as well as to rule out alternative explanations (see Teo et al. 2003). A comparison between the full model and the control model shows that the full model explained an incremental variance of 11.7%, while the incremental variance derived by comparing the full model and the theoretical model amounted to 7.8 %. These results suggest that our theoretical model was substantive enough to explain a large proportion of the variance in intention to adopt EHR. An examination of the path coefficients shows that the significance of psychological empowerment dimensions remained (with the magnitude slightly decreased) after adding the control variables. *Meaning* ($\beta = 0.22$, $t = 2.34$) and *self-determination* ($\beta = 0.24$, $t = 2.48$) were significant, while *competence* ($\beta = -0.02$, $t = 0.16$) and *impact* ($\beta = -0.06$, $t = 0.70$) were not significant[1]. Therefore, H1 and H3 were supported, while H2 and H4 were not. The significance of control variables decreased once psychological empowerment dimensions were added to the model. Practice assistants' IT knowledge ($\beta = 0.33$, $t = 4.11$), practice size ($\beta = 0.13$, $t = 2.17$), and current use of computerized systems in the practice ($\beta = 0.16$, $t = 2.59$) were

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[1] The numbers are based on the full model.

significant in the control model, while only practice assistants' IT knowledge (β = 0.25, t = 2.59) was significant in the full model.

Results for the impact of EHR capabilities on empowerment dimensions are shown in Table 6.7. R^2 values of 24.1%, 28.4%, 22.3% and 18.8% were obtained for meaning, competence, self-determination and impact, respectively. *Workflow automation* had a strong effect on both meaning (β = 0.37, t = 4.69) and competence (β = 0.27, t = 3.74), supporting H5a and H5b. *Connectivity* had a significant effect on meaning (β = 0. 16, t = 1.88), competence (β = 0.34; t = 2.60), and self-determination (β = 0.35, t = 2.98), supporting H6a, H6b and H6c. *Administrative support* had a significant effect on competence (β = 0.30, t = 2.05), self-determination (β = 0.41, t = 3.46), and impact (β = 0.43; t =6.81), supporting H8a, H8b and H8c. Surprisingly, *decision support* demonstrated a strong effect (β = - 0.38; t = 3.14) on competence, but opposite to the predicted direction. H7a was thus not supported. For the relationship between *decision support* and self-determination, we did not specify the positive or negative direction. The data provides strong evidence of a negative relationship (β = - 0.33, t = 3.01) with a significance level of 0.01 (two-tailed test), validating H7b. Table 6.8 provides a summary of hypothesis testing results.

Table 6.6 Result of PLS Analysis (DV: Intention to Adopt EHR) Independent Variables

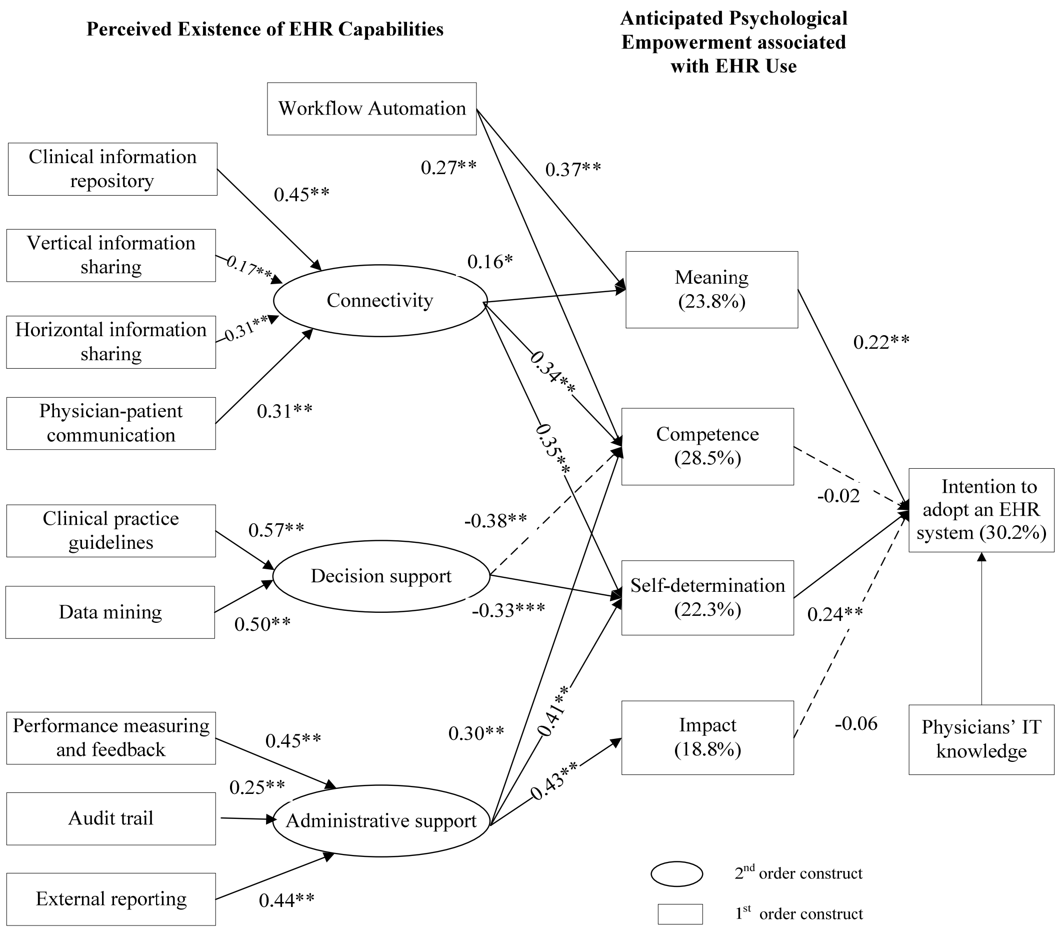
Independent Variables	Full Model		Theoretical Model		Control Model	
	Beta	**T**	**Beta**	**T**	**Beta**	**T**
Meaning	0.22*	2.34	0.25**	2.51		
Competence	-0.02	0.16	-0.02	0.22		
Self-determination	0.24**	2.48	0.28**	2.84		
Impact	-0.06	0.70	-0.001	0.08		
Age	-0.08	1.37			-0.08	1.12
Physicians' IT knowledge	-0.09	1.15			-0.10	1.20
Practice assistants' IT knowledge	0.25**	2.95			0.33**	4.11
Incentive for EHR adoption	0.01	0.10			0.001	0.02
Incentive for quality of care	0.04	0.50			-0.02	0.21
Practice size	0.08	1.40			0.13*	2.17
Current use of computerized systems in the practice	0.08	1.51			0.16**	2.59
Variance explained (R^2)	**30.2%**		**22.4%**		**18.5%**	

* $P < 0.05$, one-tailed test; ** $p < 0.01$, one-tailed test.

Table 6.7 Results of PLS Analysis (DV: Psychological Empowerment Dimensions)

Independent Variables	Dependent Variables			
	Meaning	**Competence**	**Self-Determination**	**Impact**
Workflow Automation	0.37** (t=4.69)	0.27** (t=3.74)	-	-
Connectivity	0.16* (t=1.88)	0.34** (t=2.60)	0.35** (t=2.98)	-
Decision support	-	-0.38** (t=3.14)	-0.33*** (t=3.01)	-
Administrative support	-	0.30* (t=2.05)	0.41** (t=3.46)	0.43** (t=6.81)
R^2	**24.1%**	**28.4%**	**22.3%**	**18.8%**

*$P < 0.05$, one-tailed test; ** $p < 0.01$, one-tailed test; *** $p < 0.01$, two-tailed test.



* p<=0.05, one-tailed test; ** p<=0.01, one-tailed test; *** p < 0.01, two-tailed test.

Figure 6.1 Results for PLS Tests

Table 6.8 A Summary of Hypothesis Testing Results

Hypotheses	Results
H1: Meaning→ Intention to adopt an EHR system	Supported
H2: Competence→ Intention to adopt an EHR system	Not supported
H3: Self-determination→ Intention to adopt an EHR system	Supported
H4: Impact→ Intention to adopt an EHR system	Not supported
H5a: Workflow automation → Meaning	Supported
H5b: Workflow automation → Competence	Supported
H6a: Connectivity → Meaning	Supported
H6b: Connectivity → Competence	Supported
H6c: Connectivity → Self-determination	Supported
H7a: Decision support → Competence	Not supported
H7b: Decision support → Self-determination	Supported (negative)
H8a: Administrative support → Competence	Supported
H8b: Administrative support → Self-determination	Supported
H8c: Administrative support → Impact	Supported

CHAPTER 7. DISCUSSION AND IMPLICATIONS

7.1 Discussion of Findings

7.1.1 Psychological Empowerment Dimensions Predicted Adoption Intention

This research investigates how perceived IS capabilities influence individual intention to adopt IS through the mediation of anticipated psychological empowerment. Our results show that adoption intention was indeed affected by two dimensions of psychological empowerment—self-determination and meaning. Physicians' anticipated increase in work choices associated with the use of an EHR system led to higher intention to adopt the system. This finding adds additional support to prior assertion that perceived threat of IS usage to professional autonomy or control due to work-related changes is a salient outcome belief that both directly and indirectly inhibits physician acceptance of the IS (Bhattacherjee and Hikmet 2007; Walter and Lopez 2008). Furthermore, physicians' anticipation of a more meaningful work associated with the use of an EHR system also led to higher intention to adopt the system. This finding offers new evidence that perceived consistency between the spirit of a workplace IS and personal ideals (e.g., providing better care) is a salient outcome belief that facilitates physician acceptance of the IS.

To our surprise, anticipated *competence* and *impact* associated with the use of an EHR system did not affect physicians' intention to adopt the EHR system. A plausible explanation is that physicians enjoy more privileges and have more volitional control, so they are particularly sensitive to changes in their work environment that might threaten their professional autonomy (Dowswell et al. 2001; Walter and Lopez 2008). Therefore, when faced with the decision to adopt an EHR system or not, the physician respondents were mainly concerned about decreased self-determination (M = 3.75) [1] associated with EHR use, while being indifferent to the increased competence (M = 4.01) or impact (M = 4.20) that may be brought by EHR use. Another plausible interpretation is that people tend to be risk averse (Goereea et al. 2003; Pratt 1964). As a result, they are very cautious when making choices, preferring to minimize risks even when the potential benefit of an action is large. Physicians are by no means an exception. When considering whether to adopt EHR, physicians tend to pay more attention to any potential risk, i.e., diminished meaning and self-determination in work, but pay less attention to potential gain, i.e., enhanced competence and impact in work.

7.1.2 Psychological Empowerment Shaped by Perceptions of EHR Capabilities

The results also demonstrate that physicians' anticipated empowerment associated with EHR use is shaped by their perceptions of EHR capabilities. Specifically, anticipated *meaning* was positively affected by perceived existence of *workflow automation* and *connectivity* capabilities in an EHR system. It supports our predication that the workflow automation capability of an EHR system frees

[1] The mean for self-determination was significantly lower than the neutral value 4 (T test: t = -2.89, and p = 0.004).

physicians from tedious, trivial tasks and enables them to focus on more influential tasks, making them feel more meaningful to do their work. Also, the connectivity capability in an EHR system facilitates physicians' communication with patients and external healthcare providers (in other practices, hospitals, or ancillary departments), and enables better rapport with patients, making them feel more meaningful to do their work. Secondly, anticipated *self-determination* was positively affected by perceived existence of *connectivity* and *administrative support* capabilities, but negatively affected by perceived existence of *decision support* capability. As argued, both the connectivity and administrative support capabilities of an EHR system increase physicians' self-determination by enabling greater access to patient information, while the decision support capability diminishes physicians' self-determination and volitional control through the standardization of healthcare delivery. Thirdly, anticipated *competence* was positively affected by perceived existence of *workflow automation* and *connectivity* capabilities in an EHR system. It supports our predication that the workflow automation capability of an EHR system contributes to higher levels of physician competence by providing external support for tasks that can be repeated with little modification, while the connectivity capability of an EHR system contributes to higher levels of physician competence by enabling wider, faster access to patient information. Furthermore, anticipated *impact* was positively affected by perceived existence of *administrative support* capability. As predicted, the administrative support capability of an EHR system makes physicians feel larger personal impact in work due to the performance feedback received from the system.

Contrary to our prediction that *decision support* capability increases physicians' anticipated *competence* by enabling greater access to information, our results show this capability to decrease competence. Decision support functions provide information, which includes recommendation on drug usage, and alerts for inappropriate prescriptions or abnormal test results (Borkowski and Allen 2003). Although such information is meant to specify recommendations for treatment methods regarding diagnoses and procedures, they may not necessarily improve physicians' ability in patient treatment. First, adherence to these recommendations remains suboptimal. For example, many alerts are overridden by the physicians (Eslami et al. 2007; Glassman et al. 2002; Magnus et al. 2002; Shah et al. 2006; Taylor and Tamblyn 2004; Weingart et al. 2003), primarily due to the poor specificity and irrelevance of the warnings (e.g., not applicable to the patient at hand). Second, the frequent and large number of alerts tend to disrupt physicians' work flow and distract their attention (Chim et al. 2003), which may even reduce physicians' productivity and sense of competence. Another explanation for the decreased competence may be that the decision support capability, the data mining function in particular, is a relatively new and atypical functionality of computerized systems used in physician practices[1]. Anticipated training and

[1] Data mining function has a mean of 3.57 (significantly lower than the neutral value 4; T test: $t = -4.16$, and $p < 0.001$), and clinical practice guidelines function has a mean of 4.05 (higher than the neutral value 4, but statistically non-significant; T test: $t = 0.53$, and $p = 0.60$), which means that the respondents generally think that data mining function is

learning efforts required for utilizing such functionality could make physicians feel incapable. Furthermore, feedback from our respondents shows that physicians have negative attitude towards data mining, because they consider the function as more beneficial to external agencies (e.g., government, who can use it to do population level healthcare analytics) than for themselves.

The negative impact of *decision support* capability on *self-determination* is not unexpected, as the standardization process embodied in decision support capability may result in a loss of freedom to physicians in exercising their own professional judgment in carrying out their work. One of our respondents commented that, “the tendency to use computers to replace most of our work will mean that we become less personal, even to the extent of relying on the computers to give us recommendations and help us diagnose!” Empirical studies report that many physicians ignored adverse drug reaction alerts or wanted to turn them off (Eslami et al. 2007), suggesting that physicians tried to preserve their own professional judgment. The negative relationship found by this study provides strong evidence that the decision support capability currently available in EHR systems is mainly considered by physicians to be a threat to their work autonomy.

7.1.3 Summary of Main Findings

In sum, different perceptions about capabilities included in an EHR system will lead to different anticipations of psychological empowerment associated with EHR use. If physicians anticipate more meaning or more self-determination upon

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lacking in EHR systems and the clinical practice guideline somewhat exists in EHR systems.

the use of an EHR system, they will have higher levels of intention for adopting the system. Overall, these findings serve as a vivid illustration of feature-triggered sensemaking process proposed by prior researchers (Griffith 1999; Lapointe and Rivard 2005), with the focus on the IS adoption process. Specifically, in face of a new system, potential users will make projections about the consequences of its use by assessing the interplay between the system features and individual and/or organizational-level initial conditions, including work habits, compensation system, social values, and distribution of power. If expected conditions are favorable, adoption behavior will occur; if expected conditions are threatening, adoption behavior will not occur.

7.1.4 Interesting Results about Control Variables

There are some interesting results regarding the control variables. *Practice size* and *current use of computerized systems,* which predicted physicians' intention to adopt *EHR systems,* were not significant any more when psychological empowerment dimensions were present in the model. This finding suggests that intrinsic motivation like psychological empowerment is more important than size of the physician practice and the status of computerization for leading to physicians' intention to adopt EHR systems.

It is worth noting that practice assistants' *IT knowledge,* rather than *physicians' IT knowledge*, was strong predictors of physicians' intention to adopt EHR systems. Our physician respondents explained that a deterring factor for EHR adoption is the challenge of employing, training and retaining computer literate clinic assistants. One physician even commented, “whether EHR succeeds or fails depends on the clinic assistants’ ability to use it”. This finding, together with the physician comments, provides additional evidence to prior assertion that a lack of technical skills of colleagues (e.g., nurses and administrative staff) leads to a lack of support from these colleagues, which inhibit physicians from adopting the systems (Randeree 2007; Vishwanath and Scamurra 2007). Therefore, to stimulate EHR adoption it is crucial to improve IT knowledge of practice assistants by providing training sessions or relevant courses, with the collaboration of EHR vendors or educational institutions.

7.2 Limitations and Future Research Directions

Before discussing the implications of this thesis, it is necessary to specify the limitations. First, it is the issue of generalizability. The study was conducted in Singapore, where EHR adoption is totally voluntary, and there are no government reporting requirements for public health which may favor EHR use. Hence, adoption intention of our respondents is more likely to be affected by intrinsic motivation like psychological empowerment, rather than extrinsic motivation like incentives or sanctions. Caution should therefore be taken when generalizing our findings to the adoption of EHR systems in other countries, such as countries that mandate EHR adoption or provide heavy subsidies for EHR adoption. Future research could test our model in other contexts to see if our findings could be replicated.

The second limitation is regarding the instruments for EHR capability constructs. A few formative items were highly correlated and a few had relatively low weights. While we have suggested ways to refine the instruments according to guidelines for validating formative measures, we kept the original complete set of instruments for future validation, given that our hypothesis testing results have proven to be robust to variations of the instruments. Future research could validate the instruments with new samples or with other nomological networks.

Finally, there may exist factors that could moderate the relationships in the model. The incorporation of dispositional factors has been suggested as a promising avenue for IS adoption and use research (McElroy et al. 2007). While this paper has been focused on establishing the linkage between system capabilities and adoption intention, future research could examine whether the links depend on dispositional factors, such as personal values, personality, and cognitive style. For example, growth need strength has been suggested by Job Characteristics Theory as an individual difference that moderates the effects of psychological states (e.g., meaningfulness of work) and personal or work outcomes (e.g., satisfaction and performance) (Hackman and Oldham 1975). It is a possible moderator for the relationship between psychological empowerment and adoption intention. Also, cognitive style such as cognitive complexity could influence physicians' preference and perception for certain functions, such as data mining or clinical practice guidelines. It could be a potential moderator for the relationship between certain EHR capabilities and psychological empowerment. The study of individual differences could lead to individually tailored systems (Te'eni 2001).

Future studies may examine how individual dispositional differences would moderate the relationships in our model.

7.3 Implications for Theory and Practice

7.3.1 Implications for Theory

Despite the limitations, which set the stage for future research, this thesis contributes to theory development in several ways. First, it advances IS adoption research by demonstrating the role of psychological empowerment. Prior researchers have highlighted the importance of intrinsic motivation factors, such as perceived enjoyment, affect, and affective commitment for individual adoption and use of new IS (Compeau et al. 1999; Li et al. 2009; Van der Heijden 2004). However, few studies have investigated the effect of psychological empowerment. This study is one of the first to systematically assess how anticipated psychological empowerment associated with the use of an IS affects one's reactions to workplace IS.

Third, it establishes a linkage between IS artifact and IS adoption intention. Prior researchers have pointed out that IS artifact (by IS artifact, they mean that the hardware/ software design of IS encapsulates the structures, routines, norms, and values implicit in the rich contexts within which the IS is embedded, see Benbasat and Zmud 2003, p. 186) is an essential component of IS research and call for efforts to strengthen the focus of IS research on IS artifact (Benbasat and Zmud 2003; Whinston and Geng 2004). As a response to this call, this study proposes a theoretical framework for mapping IS capabilities with empowering structures, as well as mapping empowering structures with individuals' psychological empowerment dimensions that affect their adoption intention for the IS. Results of this study provides preliminary evidence for the assertion that IS embodies social structures (Orlikowski 1992), which could enable or constrain behaviors in the workplace (DeSanctis and Poole 1994). I believe this study is an important step towards a better understanding of the impact of IS artifact on individual reactions to IS, which has received scant attention in the IS literature.

Furthermore, it adds to the empowerment literature with a dimensional analysis of antecedents and consequence of psychological empowerment. Our study highlights IS capabilities as embodying structures that predict empowerment dimensions. Although qualitative studies have suggested the impact of IS capabilities on employee empowerment (Sia and Neo 2008; Sia et al. 2002), empirical studies that test the relationship between IS capabilities and specific dimensions of empowerment (meaning, competence, self-determination, impact) are rare. Our study also demonstrates that IS adoption intention is a consequence of psychological empowerment, and is differently affected by the four empowerment dimensions. Previous studies have investigated various outcomes of empowerment dimensions, including job effectiveness, job satisfaction, and job-related strain, career intentions and organizational commitment (Kraimer et al. 1999; Spreitzer et al. 1997; Wang and Lee 2009). To our knowledge this study is one of the first to examine IS adoption as an outcome of psychological empowerment dimensions. In sum, a deeper understanding on the multidimensional nature of psychological empowerment is necessary for establishing the validity of the empowerment construct and advancing the development of empowerment theory (Spreitzer et al. 1997).

Last but not least, this study contributes to the MI literature by providing a rigorous analysis of how capabilities of an EHR system could affect physicians' intention to adopt the EHR system. Extant MI research has suggested the association between adoption rates for EHR systems among physicians and capabilities/functionalities of the systems (Audet et al. 2004; Burt et al. 2006; DesRoches et al. 2008; Gans et al. 2005; Jha et al. 2009a; Jha et al. 2006; Schoen et al. 2006). However, these studies are mostly descriptive and provide no theoretical understanding about the way they are associated and the mechanisms through which they are associated. This thesis, guided by theories from management and IS research, unveils the mediation role of physicians' psychological empowerment for the linkage from their perceptions of EHR capabilities to their intention to adopt an EHR system.

7.3.2 Implications for Practice

This study also offers important implications for EHR developers, promoters and policy setters. Physicians' perceptions of EHR capabilities do affect their adoption intention, and different EHR capabilities exert different effects. To develop EHR that could be utilized by physicians, *workflow automation*, *connectivity*, and *administrative support* should be the basic capabilities, because they will facilitate adoption by increasing physicians' meaning and self-determination in their work. The incorporation of *decision support* capability into EHR should be planned cautiously, because physicians may regard it as a threat to their competence and self-determination, which hampers adoption. To reduce the perceived threat of this capability and counter physician resistance, there are three possible ways. Firstly, design of decision support functions such as *clinical practice guidelines* should be improved to ensure that the recommendations are integrated into the workflow (e.g., appearing at appropriate times in the workflow) and are more patient-specific (e.g., applicable to the patient at hand), which could reduce physician non-adherence to the recommendations and effectively enhance physicians' decision making confidence. Secondly, more training should be provided to physicians to increase their awareness of the *data mining* function as well as to improve their skills of utilizing the function for care delivery, so physicians would be more familiar with the function and anticipate higher productivity with the use of the function. Thirdly, *decision support* capability should be designed to give the (physician) user control through increasing the levels of flexibility and interactivity, because that may enhance user perception of control and thus minimizing the perceived threat to professional autonomy (Walter and Lopez 2008).

Finally, EHR policy makers play an important role in promoting EHR. They can coordinate existing efforts to specify essential standards for the development and use of EHR for primary care. These standards may include a standard for functionalities and features of EHR systems targeted for primary care, and certification standards for data and interoperability for all EHR systems. EHR policy makers can also institutionalize the education for future and current healthcare professions regarding HIS in general and EHR systems in particular. For example, they could acculturate the future medical workforce to EHRs through medical school curriculum and residency programs, and to update current healthcare providers with the latest health information technologies through the continuing medical education requirement.

CHAPTER 8. CONCLUSION

Facing the challenge of low adoption rates of EHR systems (particularly comprehensive EHR systems) among primary care physicians in many countries, this research aims at investigating how physicians' perceptions about capabilities of EHR systems affect their intention to adopt EHR systems. Drawing insights from empowerment theory and structurational models of technology, this thesis establishes a theoretical connection from physicians' perceptions about the existence of four capabilities (workflow automation, connectivity, decision support, and administrative support) in an EHR system to physicians' anticipated psychological empowerment (meaning, competence, self-determination, and impact) associated with EHR use, and further to their intention to adopt an EHR system. Through a survey of 248 GPs in Singapore, predictions of the study were tested and validated. It is found that different perceptions about capabilities existing in an EHR system contribute to physicians' adoption intention differently. While perceived existence of workflow automation, connectivity, and administrative support capabilities contributed to adoption intention by increasing physicians' anticipated meaning and self-determination, perceived existence of decision support capability impeded adoption intention by diminishing physicians' anticipated self-determination. Overall, the results serve as a reminder that EHR systems are embedded with empowering structures, and anticipated changes in psychological empowerment are salient intrinsic motivation for physicians' reactions towards the EHR systems.

This thesis makes several contributions to research. It advances extant IS research by demonstrating the role of psychological empowerment in affecting one's adoption intention for IS, and it provides implications to the technology adoption model by suggesting possible boundary conditions. It also establishes a connection between IS artifact and IS adoption intention, which has received scant attention in the IS literature. Beyond IS research, it adds to the empowerment literature with a dimensional analysis of antecedents and consequence of psychological empowerment, and contributes to the MI literature by providing a rigorous analysis of how capabilities of an EHR system could affect physicians' intention to adopt the EHR system. The thesis also offers important suggestions for EHR practitioners on accelerating EHR adoption. Physician acceptance of EHR systems is affected by specific capabilities embedded in the systems. Therefore, EHR promoters and policy makers should move upstream in the adoption process to work closely with designers and developers to build up EHR systems that empower physicians to the greatest extent. EHR policy makers should also institutionalize the education and trainings for physicians as well as other healthcare providers regarding HIS in general and EHR systems in particular.

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APPENDICES

Appendix A. Survey on Electronic Health Record System

Section 1: Electronic Health Record System

An **Electronic Health Record (EHR) system** is a software platform that GP clinics use to create, store, update, and maintain electronic health records for patients, as well as to share key patient data with other healthcare providers. An EHR system may include **one or more** of the following functions:

- Healthcare information and data *(e.g., patient demographics, problem lists, physicians' notes)*
- Management of results *(e.g., laboratory results, radiologic reports)*
- Electronic ordering *(e.g. , e-Prescription, electronic referral)*
- Clinical decision support *(e.g. , clinical reminders, clinical practice guidelines)*
- Communication *(e.g., physician-patient communication, multispecialty team communication)*
- Data sharing with external providers *(e.g., clinics, labs, hospitals)*
- Administrative tools *(e.g. , billing)*

1. Does your clinic currently have any form of an EHR system in place?

☐ Yes. Please indicate which functionalities are implemented. (You may check more than 1)

☐ Healthcare information and data
☐ Electronic ordering
☐ Communication
☐ Administrative tools
☐ Management of results
☐ Clinical decision support
☐ Data sharing with external providers
☐ Others ______________________

☐ No

2. To what extent does/will your clinic receive incentives for adopting an EHR system?

No *incentives* | *Some incentives* | ***Heavy*** *incentives*

1	2	3	4	5	6	7

3. To what extent does/will your clinic receive incentives for increasing quality of care?

***No** incentives*			*Some incentives*			***Heavy** incentives*
1	2	3	4	5	6	7

Based on your **best knowledge of** EHR systems, please indicate the degree to which you agree with the following statements.

1. **Learning** to operate an EHR system would be **easy** for me.

Strongly disagree			*Neutral*			*Strongly agree*
1	2	3	4	5	6	7

2. I would find it **easy to get** an EHR system **to do** what I want it to do.

Strongly disagree			*Neutral*			*Strongly agree*
1	2	3	4	5	6	7

3. I would find an EHR system **easy to use**.

Strongly disagree			*Neutral*			*Strongly agree*
1	2	3	4	5	6	7

4. Using an EHR system in the clinic would enable me to **accomplish tasks more quickly**.

Strongly disagree			*Neutral*			*Strongly agree*
1	2	3	4	5	6	7

5. Using an EHR system would **improve my job performance**.

Strongly disagree			*Neutral*			*Strongly agree*
1	2	3	4	5	6	7

6. Using an EHR system would **increase my productivity**.

Strongly disagree			*Neutral*			*Strongly agree*
1	2	3	4	5	6	7

Section 2: Capabilities of an EHR System

Based on your **understanding** of **the most comprehensive EHR system available in the market (not restricted to the one in your clinic)**, please tell us **to what extent** the following capabilities exist.

[Workflow automation]

[WAut1] It automates administrative workflow *(e.g., plotting graphs of blood pressure/blood sugar readings, issuing invoice for payment, tracking referrals)*.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[WAut2] It assists/ automates clinical documentation process *(e.g., auto-filling of patient data/commonly used notes, pre-built diagnosis and procedure codes, and typographic error detection)*.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[WAut3] It assists/ automates clinical ordering and prescribing process *(e.g., pre-built order sets, or prescriptions and laboratory tests sent electronically)*.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[Clinical information repository]

[CIR1] It stores all of the critical medical information of the patients *(e.g., patient demographics, clinical notes, problem lists, past medications and allergies, etc.)*.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[CIR2] It preserves the completeness and integrity of medical information of the patients.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[CIR3] It enables me to access and retrieve (administrative or medical) information easily.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[Vertical information sharing]

[VIShare1] It enables the sharing of patient information between our clinic and hospitals or ancillary departments *(e.g., labs).*

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[VIShare2] It enables us to access patient information in hospitals or ancillary departments (e.g., labs)

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[VIShare3] It enables hospitals or ancillary departments *(e.g., labs)* to access patient information in our clinic.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[Horizontal information sharing]

[HIShare1] It enables the sharing of patient information between our clinic and other general practitioner (GP) clinics.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[HIShare2] It enables us to access patient information in other GP clinics.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[HIShare3] It enables other GP clinics to access patient information in our clinic.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[Communication with patients]

[ComwP] It facilitates communication with patients during visit *(e.g., physicians can use electronic charts/diagram when explaining to patients; physicians can provide printed patient education materials at the end of the encounter)*.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[ComwP2] It supports communication with patients before or after visit *(e.g., patients can schedule visits, or receive reminders of visit/medication, or obtain individualized educational patient care information)*.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[Clinical practice guidelines]

[CPG1] It provides patient-specific clinical practice guidelines *(e.g., recommending drug dosage)*.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[CPG2] It provides pre-built diagnosis-specific templates *(with pre-populated default values for diagnosis analysis steps)*.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[CPG3] It provides clinical reminders *(e.g., tailoring antibiotic orders based on microbiology culture results).*

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[CPG4] It triggers alerts for inappropriate prescriptions *(e.g., drug-allergy, drug-drug interaction)* or abnormal results.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[Data mining]

[DM1] It facilitates converting raw data signals into clinical variables or models.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[DM2] It facilitates discovering patterns of raw data *(e.g., administrative or clinical resource usage patterns).*

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[DM3] It facilitates inferring clinical decision from raw data.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[Performance measuring and feedback]

[PfMF1] It facilitates measuring work efficiency *(e.g., workload, productivity, etc.).*

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[PfMF2] It facilitates measuring resource usage *(e.g., courses of drug treatments).*

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[PfMF3*] It supports real-time/retrospective analysis and reporting of clinical, operational, demographic or other user-specified data *(e.g., number of patients waiting, average waiting time, and number of bottles of drug left)*.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[PfMF4] It provides feedback to work performance.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[Audit trail]

[AudT1] It maintains a running log of decisions relating to the treatment of each patient *(e.g., prescriptions, and lab tests)*.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[AudT2] It tracks each access, utilization, or alteration to specific data in the system.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[AudT3] It keeps a record of system activities and sequence of events or changes in an event.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[AudT4] It keeps a record of all system transactions.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[External reporting]

[ExtR1] It facilitates reporting to the government *(e.g., MOH, and NEA).*

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[ExtR2] It facilitates reporting claims data to insurers.

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

[ExtR3] It facilitates reporting to other external constituents *(e.g., partners, affiliations).*

Not at all			*Somewhat*			*Very much*
1	2	3	4	5	6	7

Section 3: Beliefs for Use of the EHR System

Based on your **knowledge** of the **most comprehensive EHR currently available on the market**, to what extent do you feel the EHR system **enhances** or **diminishes** the competence, autonomy and importance of yourself? Please circle the answer which best represents the blank space for each statement.

[**Meaning]**

Compared with a non-EHR system (e.g., paper-based system),…

[Mean1] using the most comprehensive EHR system will make me feel the work I do is ____important to me.

Less			*Equal/ Equally*			*More*
1	2	3	4	5	6	7

[Mean2] using the most comprehensive EHR system will make me feel my job activities are personally ____meaningful to me.

Less			*Equal/ Equally*			*More*
1	2	3	4	5	6	7

[Mean3] using the most comprehensive EHR system will make the work I do ____meaningful to me.

Less			*Equal/ Equally*			*More*
1	2	3	4	5	6	7

[Competence]

Compared with a non-EHR system (e.g., paper-based system), …

[Comp1] using the most comprehensive EHR system will give me ____confidence in my ability to do my work.

Less			*Equal/ Equally*			*More*
1	2	3	4	5	6	7

[Comp2] using the most comprehensive EHR system will make me ____self-assured about my capabilities to perform my work activities.

Less			*Equal/ Equally*			*More*
1	2	3	4	5	6	7

[Comp3] using the most comprehensive EHR system will make me ____sure that I mastered the skills necessary for my work.

Less			*Equal/ Equally*			*More*
1	2	3	4	5	6	7

[Self-determination]

Compared with a non-EHR system (e.g., paper-based system), …

[SelfD1] using the most comprehensive EHR system will give me ____autonomy in determining how I do my work.

Less			*Equal/ Equally*			*More*
1	2	3	4	5	6	7

[SelfD2] using the most comprehensive EHR system will make me ____able to decide on my own on how to go about doing my work.

Less			*Equal/ Equally*			*More*
1	2	3	4	5	6	7

[SelfD3] using the most comprehensive EHR system will give me ____opportunity for independence and freedom in how I do my work.

Less			*Equal/ Equally*			*More*
1	2	3	4	5	6	7

[Impact]

Compared with a non-EHR system (e.g., paper-based system), …

[Impact1] using the most comprehensive EHR system will give me ____control over what happens in my clinic.

Less			Equal/ Equally			More
1	2	3	4	5	6	7

[Impact2] using the most comprehensive EHR system will allow me to have____ influence over what happens in my clinic.

Less			Equal/ Equally			More
1	2	3	4	5	6	7

[Impact3] using the most comprehensive EHR system will make my impact on what happens in the clinic ____.

Smaller			The same			Larger
1	2	3	4	5	6	7

Section 4: Intention to Adopt an EHR System

Regarding **the EHR system you evaluated in the previous two sections** (i.e., the most comprehensive EHR currently available on the market), please answer the following questions.

[IntA1] I predict I would be using such an EHR system in the next 6 months.

Strongly disagree			Neutral			Strongly agree
1	2	3	4	5	6	7

[IntA2] I intend to use such an EHR system in the next 6 months.

Strongly disagree			Neutral			Strongly agree
1	2	3	4	5	6	7

[IntA3] I intend to use such an EHR system in the next ________.

a) 6 months b) 7 - 11 months c) 1 to 2 years d) More than 2 years e) Not at all

Note: * Item removed according to the sorting results.

Section 5: Individual and Clinic Information

Now please tell us something about **yourself**.

1. Your age

   ☐ <20 ☐ 20-29 ☐ 30-39 ☐ 40-49 ☐ 50-59 ☐ >=60

2. Your gender

   ☐ Male ☐ Female

3. Your job title (you can check more than one)

   ☐ Physician ☐ Clinic assistant ☐ Clinic owner

4. How much experience do you have in patient care?

   ☐ < 1 year ☐ 2 -5 years ☐ 6-10 years ☐ >10 years

5. How often do you use computers at home?

Never			*Sometimes*			*Very often*
1	2	3	4	5	6	7

Next, please tell us something about your **clinic**.

1. The number of Physicians working in the clinic

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7+

2. Which year did your clinic start operating? _________

Please circle the most appropriate answer about **clinic staff** in your clinic.

1. **Physicians** in our clinic are all computer-literate.

Strongly disagree			*Neutral*			*Strongly agree*
1	2	3	4	5	6	7

2. There is at least one **physician** in our clinic who is a computer expert.

Strongly disagree			*Neutral*			*Strongly agree*
1	2	3	4	5	6	7

3. I would rate our **physicians'** understanding of computers as very good compared with physicians in other clinics of similar type.

Strongly disagree			*Neutral*			*Strongly agree*
1	2	3	4	5	6	7

4. There is at least one **clinic assistant** in our clinic who is a computer expert.

Strongly disagree			*Neutral*			*Strongly agree*
1	2	3	4	5	6	7

5. **Clinic assistants** in our clinic are all computer-literate.

Strongly disagree			*Neutral*			*Strongly agree*
1	2	3	4	5	6	7

6. I would rate our **clinic assistants'** understanding of computers as very good compared with clinic assistants in other clinics of similar type.

Strongly disagree			*Neutral*			*Strongly agree*
1	2	3	4	5	6	7

The end

Thank you very much for your participation!

Appendix B. ANOVA Test for Non-response Bias

Factor		Sum of Squares	Mean Square	F	Sig.
Age	Between Groups Within Groups Total	2.876 211.044 213.919	1.438 .861	1.669	.191
Gender	Between Groups Within Groups Total	.119 44.845 44.964	.060 .183	.326	.722
Patient care experience	Between Groups Within Groups Total	.533 33.337 33.871	.267 .136	1.960	.143
Home PC use	Between Groups Within Groups Total	11.093 598.584 609.677	5.547 2.443	2.270	.105
Use of computerized system in the clinic	Between Groups Within Groups Total	3.951 47.561 51.512	1.975 .194	10.175	.000

Appendix C. Principal Component Analysis

Component Score Coefficient Matrix									
	Component								
	1	2	3	4	5	6	7	8	9
WAut1	-.019	-.009	**.454**	-.069	.001	-.067	-.104	.010	-.095
WAut2	.005	-.056	**.472**	-.041	-.018	-.058	-.082	.017	-.139
WAut3	-.016	-.055	**.486**	-.143	-.018	-.110	.018	.063	-.111
ComwP1	-.008	-.035	-.060	-.092	-.046	-.073	-.121	.027	**.749**
ComwP2	.018	-.033	-.058	-.021	-.091	.088	-.088	-.113	**.579**
CIR1	.004	-.060	-.088	**.480**	.017	.032	-.054	-.128	-.086
CIR2	-.040	-.038	-.135	**.454**	.060	-.085	-.019	-.030	-.001
CIR3	-.045	-.080	-.016	**.461**	-.069	.099	-.040	.014	-.185
CPG1	-.031	.001	-.073	-.036	-.137	.021	**.455**	-.094	.080
CPG2	-.053	-.024	-.073	-.032	-.068	-.032	**.421**	-.011	.087
CPG3	-.027	-.003	-.028	-.135	.137	-.199	**.356**	-.049	.141
CPG4	-.028	-.090	-.002	.058	-.101	.022	**.605**	-.077	-.306
DM1	-.049	-.037	.000	.004	**.520**	-.100	-.029	-.047	-.090
DM2	-.047	-.050	-.007	.020	**.553**	-.084	-.109	-.021	-.075
DM3	-.054	-.063	-.007	-.013	**.539**	-.079	-.094	.002	-.030
PerfM1	-.015	-.044	.031	-.057	-.203	**.565**	-.008	-.031	-.091
PerfM2	-.033	-.050	-.017	.014	-.070	**.529**	-.067	-.070	-.071
PerfM4	-.030	-.143	-.186	.072	-.067	**.542**	-.042	-.017	.128
ATrail1	.009	**.305**	-.061	.016	-.015	-.032	-.040	-.131	-.011
ATrail2	-.045	**.404**	-.036	-.054	-.005	-.138	-.036	-.007	-.037
ATrail3	-.022	**.430**	-.048	-.103	-.086	-.135	-.045	.026	.027
ATrail4	-.033	**.397**	.008	-.030	-.099	-.075	-.094	.026	-.075
ExtR1	-.068	-.026	.010	-.007	-.064	-.077	-.033	**.549**	-.043
ExtR2	-.083	-.031	.016	-.037	.025	-.058	-.106	**.566**	-.030
ExtR3	-.040	-.006	.021	-.077	-.057	.012	-.101	**.502**	-.033
HIshare1	**.204**	.017	-.038	.033	-.021	.004	-.198	-.043	.063
HIshare2	**.240**	.002	-.037	.003	.019	-.073	-.101	-.120	.048
HIshare3	**.247**	-.003	-.031	.001	.003	-.049	-.120	-.118	.043
VIShare1	**.244**	-.047	.009	-.044	-.154	.041	.073	-.133	-.007
VIShare2	**.230**	-.073	.055	-.044	-.151	.002	.112	-.093	-.052
VIShare3	**.248**	-.021	.021	-.051	-.117	-.011	.043	-.126	-.023

Appendix D. Abbreviations Used in the Thesis

Audit trail (AudT)
Clinical data repository (CDR)
Clinical information repository (CIR)
Clinical practice guidelines (CPG)
Communication with patients (ComwP)
Competence (Comp)
Computerized patient record (CPR)
computerized physician order entry (CPOE)
Computerized medical record (CMR)
Current use of computerized systems in the practice (UCSC)
Data mining (DM)
Digital medical record (DMR)
Electronic client record (ECR)
Electronic health record (EHR)
Electronic healthcare record (EHCR)
Electronic patient record (EPR)
Electronic medical record (EMR)
Enterprise Resource Planning System (ERP)
External reporting (ExtR)
General practitioner (GP)
Health information systems (HIS)
Horizontal information sharing (HIShare)
Incentive for EHR adoption (IctEHR)
Incentive for quality of care (IctQC)
Information technology (IT)
Information systems (IS)
Innovation Diffusion Theory (IDT)
Institute of Medicine (IOM)
Intention to adopt EHR (IntA)
Medical informatics (MI)
Meaning (Mean)
Office of the National Coordinator for Health Information Technology (ONCHIT)
Partial Least Square (PLS)
Perceived ease of use (PEOU)
Perceived usefulness (PU)
Performance measuring and feedback (PfMF)
Personal health record (PHR)
Physicians’ IT knowledge (ITkDr)
Population health record (PHR)
Practice assistants’ IT knowledge (ITkPA)
Practice size (Size)
Self-determination (SelfD)

Technology Acceptance Model (TAM)
Theory of Planned Behavior (TPB)
Theory of Reasoned Action (TRA)
Unified Theory of Acceptance and Use of Technology (UTAUT)
Vertical information sharing (VIShare)
Workflow automation (WAut)