



Knowledge barriers, knowledge transfer, and innovation competitive advantage in healthcare settings

Innovation
competitive
advantage

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Abstract

Purpose – The aim of this paper is to examine the moderating role of information communication technology (ICT) competencies in enhancing knowledge transfer and mitigating the effects of two key knowledge barriers, namely knowledge stickiness and knowledge ambiguity, thereby increasing the firm's innovation competitive advantage.

Design/methodology/approach – The study is carried out in the context of the healthcare industry in Taiwan. A total of 160 questionnaires were distributed to hospitals and 112 usable responses were received, representing a response rate of 70 percent. Hierarchical regression analysis was used to analyze the data.

Findings – The results show that ICT competencies do enhance knowledge transfer inside hospitals. Although knowledge stickiness and knowledge ambiguity have negative effects on knowledge transfer, the negative effects can be moderated by ICT competencies (defined in terms of competencies in computer-assisted instruction, interactive videoconferencing, and hand-held technology).

Practical implications – Among the three ICT competencies, computer-assisted instruction and hand-held technology have the largest and smallest effects on the relationship between knowledge barriers and knowledge transfer. The results also allow decision makers for forward-looking allocation of ICT competencies.

Originality/value – The study presents a valid model that comprises the antecedents, moderators (three specific types of ICT competencies), and consequences of knowledge transfer for innovation competitive advantage of healthcare organizations.

Keywords Knowledge stickiness, Knowledge ambiguity, Information communication technology competency, Knowledge transfer, Innovation competitive advantage, Healthcare organization, Health care, Innovation, Taiwan

Paper type Research paper



1. Introduction

Medical knowledge is an essential component of medical competency (Verhoeven *et al.*, 2002). As increasing competitiveness, medical knowledge has emerged as the most strategically significant resource for healthcare organizations. Healthcare organizations are increasingly aware of the change in the competitive environment

from an emphasis on tangible assets to an intangible knowledge-based competition. Riusala and Smale (2007) argue that organizations can attribute their existence to their superiority over the external market mechanism in terms of internalizing intangible assets through transferring and leveraging knowledge. Therefore, knowledge and knowledge transfer has increasingly become a key source of competitive advantage.

The use of knowledge requires an understanding of knowledge transfer (Ansell, 2007). However, past research has shown that two main barriers of knowledge transfer are knowledge stickiness and knowledge ambiguity. Knowledge stickiness, or the inability or unwillingness to transfer knowledge, is one factor that keeps knowledge from flowing and has been cited as the major reason for knowledge transfer failure (Gupta and Govindarajan, 2000; Szulanski *et al.*, 2004). Simonin (1999a, b) also indicates that knowledge ambiguity plays a key inhibiting role in the process of knowledge transfer.

In addition, knowledge transfer in healthcare organizations relies on many factors such as people, organizational structure, culture, process and strategy, and information communication technology (ICT) (Ives *et al.*, 2003; Spender and Grant, 1996) to overcome knowledge barriers. However, medical service delivery is fundamentally a collaborative process where healthcare providers work together to achieve outcomes in terms of access, quality, and cost that they would find difficulty to accomplish on their own. ICT has the potential to increase the access to and the quality of healthcare delivery while simultaneously lowering cost, especially in knowledge transfer. Therefore, this study makes the following contributions. First, although Meera *et al.* (2004) and other scholars understand that ICT in healthcare organizations can be regarded as a powerful means to catalyze the formation of the knowledge society, this understanding has not been formalized in terms of a theoretical construct. Therefore, it is essential to develop a formal conceptualization of ICT competencies in the context of healthcare. Second, prior research has not identified the specific competencies of ICT that can foster knowledge transfer inside hospitals. We contribute to the healthcare literature by identifying three specific types of ICT competencies. Third, the degree to which ICT competencies can mitigate or moderate the effect of knowledge barriers in knowledge transfer has not been examined. This study extends previous research by examining the moderating effects of ICT competencies on the relationship between knowledge barriers and knowledge transfer. Fourth, the study presents a valid model that comprises the antecedents, moderators, and consequences of knowledge transfer for innovation competitive advantage.

2. Theoretical background and research hypotheses

2.1 Knowledge transfer

A theory of knowledge transfer was first proposed by Findlay in 1978 and has since been variously labeled as knowledge sharing, knowledge flow, and knowledge acquisition (Renzl, 2008; van Wijk *et al.*, 2008). Several studies view the transfer of knowledge as the transmission of a message from a source to the recipient in a given context. This message is then absorbed by, and changes the behavior of the recipient (Szulanski *et al.*, 2004). Davenport and Prusak (1999) indicate that knowledge transfer involves two actions: transmission (sending or presenting knowledge to a potential recipient) and absorption by a person or a group. Thus, if knowledge has not been transmitted or absorbed, it has not been transferred. Dixon (2000) claimed that the existence of knowledge transfer is part of the organization of knowledge that is applicable to another

part of the organization and members through a variety of knowledge sharing tools and procedures. These tools and procedures can be a knowledge database, a best practice workshop, science and technology, a cross-functional team, e-mail and community software. Knowledge transfer is also defined by Kumar and Ganesh (2009) as activities of exchanging explicit or tacit knowledge between two agents, during which one agent receives and applies the knowledge provided by the other agent. The agents could be an individual, team/department, or an organization (Joshi *et al.*, 2007). As such, knowledge transfer in organizations is the process through which one agent is affected by the experience of another.

Polanyi in 1962 introduced a widely accepted classification of knowledge as explicit knowledge and tacit knowledge. Explicit knowledge could be codified and communicated in human scientific or linguistic symbols, while tacit knowledge is very difficult to articulate but may be communicated through direct human interactions. As tacit knowledge is gained through experience, it may be extremely hard to codify and transfer from one individual or organization to another. According to Nonaka (1994, p. 16), tacit knowledge is “deeply rooted in action, commitment, and involvement in a specific context.” Reed and DeFillippi (1990) suggest that tacit knowledge is developed through learning by doing which supports Polanyi’s (1966, p. 4) argument that “We can know more than we can tell.” However, given how difficult it is to capture tacit knowledge, the databases have been used to collect more generic or explicit information and knowledge and to seek help from others who may be experts in a particular area. However, personnel may hoard, rather than share, his/her tacit knowledge because it is valuable. As a result, the contributions of tacit knowledge cannot be easily measured and accordingly compensated.

Similar to organizational knowledge, medical knowledge can be classified as either explicit or tacit. Explicit medical knowledge has attained a greater prominence recently, while experience and skill-rich tacit knowledge is seen as ineffective and is rarely appreciated, captured, and utilized (Cheah and Abidi, 2001). Tacit knowledge, often referred to as “the art of medicine”, constitutes an important part of diagnostic reasoning. Medical practitioners apply a broad range of experiential knowledge and strategies seldom mentioned in textbooks.

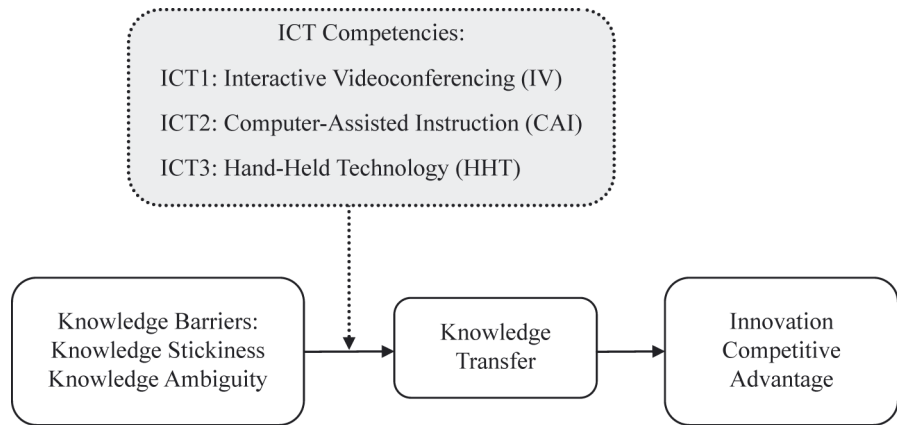
This study proposes a research model that comprises antecedents (e.g. knowledge barriers defined in terms of knowledge stickiness and knowledge ambiguity), ICT competencies, knowledge transfer, and consequences of knowledge transfer as shown in Figure 1.

2.2 Antecedents of knowledge transfer

2.2.1 Knowledge stickiness.

The notion of sticky knowledge comes from “sticky information,” as introduced by von Hippel (1994) to describe information that is difficult to transfer. von Hippel (1994) defines stickiness as the incremental expenditure required to transfer specific information in a form usable to the information seeker. Szulanski (1996) proposes “knowledge stickiness”, to refer to the difficulties encountered within the knowledge transfer process. Stickiness can be attributed to such factors as the information itself (Tece, 1998), the way it is encoded, and the characteristics of information seekers or providers, such as their skills and familiarities with a particular type of knowledge. Szulanski *et al.* (2004) also found that stickiness can come from organizational context, such as formal organizational structure and

Figure 1.
Conceptual framework



systems, sources of coordination and expertise that influence the number of attempts to transfer knowledge and the fate of those attempts. Szulanski (1996) further clarified that knowledge stickiness can be seen as a transfer barrier because transferring knowledge can be costly, time consuming, and may not always be successful. Szulanski *et al.* (2004) also proposed that stickiness could hinder the transfer of knowledge from the sender to the receiver. Many scholars and practitioners suggested that knowledge stickiness that cause transfer difficulties and incremental costs may exist in the knowledge transfer process (Gupta and Govindarajan, 2000; Jensen and Szulanski, 2004). Thus, we propose:

H1. Knowledge stickiness is negatively related to knowledge transfer within the firm.

2.2.2 Knowledge ambiguity. Knowledge ambiguity is an extension of Lippman and Rumelt's (1982) concept of causal ambiguity, which is the basic ambiguity concerning the nature of the causal connections between actions and results. Simonin (1999a, b) argues that ambiguity consists of tacitness, complexity, and specificity. Reed and DeFillippi (1990) define tacitness as the implicit and non-codifiable accumulation of skills resulting from learning by doing. Complexity results because of the interdependent skills and assets, arises from large numbers of technologies, and an organization's routines, along with individual and team-based experience. Specificity, as transaction-specific skills and assets, is utilized in production processes and the provision of services for particular customers. Based on previous intra-firm (Zander and Kogut, 1995; Minbaeva, 2007), and inter-firm (Simonin, 1999a, b, 2004) knowledge transfer studies, we propose that knowledge ambiguity has a negative relationship with knowledge transfer. It follows that:

H2. Knowledge ambiguity is negatively related to knowledge transfer within the firm.

2.3 Information and communication technology

Information and communication technologies (ICT) are broadly viewed as technologies used to convey, manipulate, and store data by electronic means. They include e-mail,

SMS text messaging, video chat, online social media, and all different computing devices (e.g. laptop, handheld computers, PDA, and smart phones). Open communication and information exchange appears to be a key component of knowledge management, and ICT plays a key role in enabling this exchange and enhancing the management practices of any organization (Reich, 2007).

ICT helps in the promotion of effective resource management and planning, the efficiency in processing of transactions, and access to more reliable information. Rao (2001) summarized the advantages of using ICT in healthcare organizations:

- sharing information with other health professionals;
- internal and external communication between health professionals and bodies;
- reporting on disease surveillance;
- reduction of the costs of patient transfers; and
- provision of quality healthcare across distances.

Many companies recognize that the knowledge which resides in their organizations may be leveraged for competitive advantage; however, they do not exploit its full potential for a variety of reasons (Paswan and Wittmann, 2009). Alavi and Leidner (2001), and Sargeant (2009), concluded that ICT in healthcare organizations not only improves organizational performance, but also accelerates knowledge transfer by enabling rapid access to search and retrieve information, as well as supporting collaboration and communication among organizational members. Many researchers and practitioners suggest that one of the organizational factors as an important mechanism in knowledge transfer is ICT systems (Sher and Lee, 2004; Sargeant, 2009). Therefore, we can recognize how the integration of ICT systems in business intelligence areas such as portals, data mining, workforce search, customer relation management and e-learning, could increase the transfer of organizational knowledge.

Indeed, according to Hauschild *et al.* (2001, p. 74), “many executives think that knowledge management begins and ends with building sophisticated information technology systems.” ICT is regarded as a powerful means of catalyzing the formation of knowledge societies in rural parts of the developing world (Meera *et al.* 2004). Bolisani and Scarso (1999) studied the cases of ICT applications implemented in Italy and they argued that ICT could accomplish all sorts of knowledge transfer tasks, including the transfer of tacit knowledge. Blumentritt and Johnson (1999) argue that IT is not only able to transfer knowledge directly, but can also assist the transfer process. They believe that ICT transfers information that the receiver in turn decodes into knowledge. Roberts (2000) predicts that advanced ICT may provide enough contexts to be as equally rich as face-to-face contact, leading to the “death of distance.” We may thus reasonably infer that ICT can facilitate various task, including transfer of tacit knowledge.

In addition, some scholars propose that knowledge stickiness or knowledge ambiguity is not a problem, since they are solvable through electronically mediated channels (Amiri, 2007; Sargeant, 2009). Johannessen (2008) proposes in the short run that ICT helps firms or people find and communicate with a knowledge source; in the long run, ICT contributes to the development of trust, commitment, and feelings of possession, which are embedded in reliable social networks that can further enhance knowledge transfer. Coakes *et al.* (2004), as wells as authors such as Davenport and

Prusak (1999), claim that the knowledge combines experience, values, contextual information, and insight to create a framework to evaluate and absorb new experience and information. Alavi and Leidner (2001) indicate the potential of using ICT to systematize, facilitate, and expedite cross-border knowledge transfer. ICT enables information and knowledge transfer.

2.3.1 Moderating effects of ICT competencies. Tippins and Sohi (2003) conceptualize IT competency as the extent to which a firm is knowledgeable about and effectively utilizes IT to manage information. Included in this conceptualization is the assumption that firms also possess IT objects. Based on Tippins and Sohi (2003), we thus define ICT competencies in three dimensions: ICT operations, ICT knowledge, and ICT objects. ICT operations can be considered the method, skills, and process that required for completing a focal task and are conceptualized as the extent to which the hospital utilizes ICT to manage clinical information. ICT objects act as “enablers” and are largely responsible for the current increases in information production and dissemination. ICT objects represent information and communication based hardware, software, and support personnel. ICT knowledge has been described as contextually based know-how. That is, given certain circumstances, the correct sequence of actions and administration of appropriate decision rules can lead to predictable outcomes. ICT knowledge is conceptualized as the extent to which the hospital possesses a body of technical knowledge about objects. In this study, ICT objects represent interactive videoconferencing (ICT1-IV), computer-assisted instruction (ICT2-CAI), and hand-held technology (ICT3-HHT) as Sargeant (2009) classifies ICT in healthcare organizations, from simple to complex, into three major groupings:

- (1) *ICT1: interactive videoconferencing (IV).* Interactive videoconferencing incorporates computer technology to provide interactive, “real-time” transmission of audio and video, the transmission of files, graphics, and so forth. Interactive videoconferencing is extensively used for formal medical education. It synchronously connects learners, instructors, and course materials and effectively provides traditional programs for physicians and other health professionals at distributed sites and supports their interactions (Misra, 2004). Interactive videoconferencing connects sites for grand rounds and other sessions traditionally hosted by a medical center, and allow peripheral sites to present clinical materials during these rounds (Sclater *et al.*, 2004). Electronic diagnostic images (e.g. computerized tomography, angiograms) and video-clips or live videoconferencing of the patient can be transmitted, adding value to the programs (Klein *et al.*, 2005).
- (2) *ICT2: computer-assisted instruction (CAI).* Computer-assisted instruction refers to the use of computer technology to provide instruction and enhance its design, while web-based learning incorporates these features through the internet (McKimm *et al.*, 2003). Computer technology and software enable computer-assisted instruction and web-based learning, computer conferencing, and the access and transmission of large databases, files and images. They can be an effective learning tool for knowledge and skills and are easily and cheaply distributed.

Multi-media CAI with internet connectivity facilitates access to sophisticated learning resources. Examples include an undergraduate program that teaches

how to conduct eye and ear examinations by using computer-assisted interactive learning and virtual reality (Grundman *et al.*, 2000). Web-based programs enable interpersonal interaction and collaborative learning among learners or learners and instructors, either synchronously or asynchronously. These capabilities are especially important for rural and isolated healthcare providers. Other web-based multi-media programs link learners, resources, and instructors through the internet (Fordis *et al.*, 2005). In addition to facilitating formal learning, the internet provides access to medical information, journals, libraries and databases, for all levels of medical education and lifelong learning.

- (3) *ICT3: hand-held technology (HHT)*. Hand-held technologies can be used alone or linked to the internet to provide “just in time” information. Since their introduction in the early 1990s, the use of hand-held computers or personal digital assistants (PDAs) has steadily increased. Generally, hand-held technologies link the learner/practitioner directly to the information resource. They are most frequently used to access clinical and evidence-based information at the point of care, providing immediate access to journals, databases, and calculators for clinical procedures (Fischer *et al.*, 2003). Another application is in undergraduate and postgraduate education to record and monitor learners’ clinical experiences, data collection, logbooks, and evaluation. More recently, cellular telephone technology provides hand-held capacity to perform many electronic and communication activities, such as the capture and transmission of digital images, e-mail access, internet searches, and information storage.

Therefore, we hypothesize the moderating effect between knowledge stickiness and the three competencies of ICT on knowledge transfer as follows:

- H3*. Higher levels of (a) ICT1-Interactive Videoconferencing, (b) ICT2-Computer-assisted Instruction, (c) ICT3-Hand-held Technology competencies will mitigate the negative relationship between knowledge stickiness and knowledge transfer.

The moderating effect between knowledge ambiguity and the three competencies of ICT on knowledge transfer can be hypothesized as follows:

- H4*. Higher levels of (a) ICT1-Interactive Videoconferencing (b) ICT2-Computer-assisted Instruction (c) ICT3- Hand-held Technology competencies will mitigate the negative relationship between knowledge ambiguity and knowledge transfer.

2.4 Consequences of knowledge transfer

2.4.1 Innovation competitive advantage. Knowledge is viewed as a resource with a significant potential for a firm’s competitive advantage (McCann and Buckner, 2004). Grant (1996) claims knowledge transfer is a key route for organizations to share and create knowledge, which can foster competitive advantage (Desouza and Evaristo, 2003). Past studies suggest that the success of any knowledge transfer may also be affected by the introduction of new and improved ways of doing things at work, which is commonly referred to as “innovation” (Bandyopadhyay and Pathak, 2007; Liu and Liu, 2008). It may be suggested that the adaptation of existing knowledge, which serves as the base for building new knowledge or reconfiguring existing knowledge,

will result in innovation. Therefore, the purpose of knowledge transfer is to improve the capacity of organizations to act by enhancing their core values. If the new knowledge cannot change organizational behavior or develop new patterns of behavior, even if there is communication and the act or process of absorption, it may not create a value that is truly useful to the organization. In other words, the purpose of knowledge transfer is the knowledge or personal experience through a variety of transfer mechanism extended to each member of the organization to improve the ability of members to enhance organizational performance, thereby improving the organization's competitive advantage.

The ability to seek and maintain knowledge transfer capability facilitates a higher level of innovation (Strach and Everett, 2006). Furthermore, when a recipient internalizes knowledge through sufficient understanding and adoption (absorption), knowledge can be effectively recreated and used (Cummings and Teng, 2003). Knowledge transfer facilitates innovation through problem definition, alternative generation and evaluation, and the ultimate choice of transferred knowledge (Brockman and Morgan, 2003). In other words, higher levels of innovation and performance are achievable once an organization increases its knowledge internalization. In addition, innovation performance would also affect the competitive advantages of firms. Thus, we propose:

H5. Knowledge transfer is positively related to innovation competitive advantage.

3. Research method

The purpose of this study is to investigate why and how two knowledge barriers (knowledge stickiness and knowledge ambiguity) hinder knowledge transfer inside hospitals and hospitals should possess what kind of ICT competencies to mitigate the negative effects of knowledge barriers in knowledge transfer, thus enhancing innovation competitive advantage. Hierarchical regression analysis was used to test the hypotheses and analyze the data. Both the main effects and moderating effects were examined.

3.1 Sample and data collection

Since small clinics lack the resources needed to develop and maintain ICTs in Taiwan, our study focuses on medium and large hospitals. According to Taiwan's Department of Health, medium and large hospitals include a medical center, a regional teaching hospital, a regional hospital, a district teaching hospital, and a district hospital.

A total of 160 questionnaires, along with a cover letter describing the study's purpose as well as our intended use and management of their data, were distributed to hospitals and 112 responses were obtained, representing a response rate of 70 percent. All responses are key informants in their hospitals. All informants are in the upper middle management of their hospitals – 62 percent of them carried title of director, vice president, superintendent, or senior physician, indicative of their responsibilities of providing information on the complex activities involved in ICTs. To enhance the response rate, respondents were offered a copy of the results for completing the survey. Among the 112 responses, 33 percent of hospitals were classified as academic medical centers. 34 percent were classified as metropolitan teaching hospitals, 9.8 percent were classified as metropolitan hospitals, 12.5 percent were classified as local community teaching hospitals, and 10.7 percent were classified as local community hospitals. 62 percent of the hospitals were classified as large and 38 percent were classified as medium sized.

3.2 Measures of constructs

The survey questions used to measure the research constructs were derived from existing literature. Knowledge transfer items were adapted from Nonaka and Takeuchi (1995), Alavi and Leidner (2001), and Dixon (2000), using seven questions. Four questions are chosen to identify the codified knowledge transfer and the other three questions are related to individualized knowledge transfer. Knowledge stickiness is described as a knowledge barrier to cause knowledge transfer difficulties and incremental costs in the knowledge transfer process and was measured via five questions adapted from Szulanski *et al.* (2004), along with Li and Hsieh (2009). Knowledge ambiguity was measured via twelve questions adapted from Simonin (1999a, b.), using three dimensions to measure knowledge ambiguity: tacitness, specificity, and complexity. ICT competencies were adapted from Tippins and Sohi (2003), measuring ICT competencies by possessing ICT knowledge, ICT operations, and ICT objects. The classification of ICT objects was assessed using scale questions adapted from Sargeant (2009) using 13 questions for interactive videoconferencing (ICT1), computer-assisted instruction (ICT2), and hand-held technology (ICT3) respectively. Innovation competitive advantage was measured via Chen *et al.* (2009), Paswan and Wittmann (2009), and Li and Hsieh (2009), using eight questions. We use a seven point Likert scale: 1 = “strongly disagree”; 2 = “mostly disagree”; 3 = “disagree”; 4 = “average”; 5 = “agree”; 6 = “mostly agree”; 7 = “strongly agree”.

3.3 Reliability and validity

Construct reliability was assessed using Cronbach’s alpha. In Table I, alpha values ranged from 0.787 (knowledge transfer) to 0.980 (ICT3). Nunnally and Bernstein (1994) recommended Cronbach’s alpha above 0.7 as the appropriate reliability level. All our constructs possess adequate reliability of 0.7 or above. To assess convergent validity, Fornell and Larcker (1981) proposed examining the item reliability of each construct, the composite reliability of each construct, the average variance extract (AVE) of each construct. Item reliability was assessed through a principal component analysis with varimax rotation for the constructs recommended by Straub (1989). Hair *et al.* (1999) suggest the factor loadings of all individual items exceed 0.5. Fornell and Larcker (1981) suggest CR value be over 0.6 and AVE value be greater than 0.5 in each dimension. The constructs in the survey demonstrate adequate convergent validity in Table I. With reference to Fornell and Larcker’s (1981) work, we tested the discriminant validity of the constructs by examining if the square root of the AVE of each construct was greater than the highest correlation between the latent variable involving the focal

Factor	Composite reliability	AVE	Reliability alpha
ICT1	0.959	0.583	0.952
ICT2	0.972	0.733	0.968
ICT3	0.983	0.814	0.980
KT	0.844	0.684	0.787
ICA	0.956	0.731	0.947
KS	0.689	0.566	0.790
KA	0.758	0.635	0.822

Table I.
Reliability alpha,
composite reliability, and
AVE

constructs (shown above the diagonal in Table II). Results indicate adequate discriminant validity.

4. Analyses and results

We used hierarchical regression analysis to test hypotheses and analyze the data. Specifically, we included only knowledge stickiness and knowledge ambiguity in model1, producing its *R*-square of 0.118 (in Tables III-V). Next, we added ICT1, ICT2, and ICT3 into model 1 to construct model 2, a direct effect model. *R*-square increased

	KS	KA	KT	ICT1	ICT2	ICT3	ICA
KS	0.752						
KA	-0.126	0.797					
KT	-0.207*	-0.268**	0.827				
ICT1	-0.187*	-0.196*	0.332**	0.764			
ICT2	-0.232**	-0.248**	0.387**	0.331**	0.856		
ICT3	-0.173*	-0.182*	0.321**	0.321**	0.357**	0.902	
ICA	-0.183*	-0.292**	0.497**	0.388**	0.406**	0.341**	0.858

Table II.
The square root of AVE and relative coefficient of each dimension

Notes: * $p < 0.05$ ** $p < 0.01$; The diagonal is the squared root of AVE and the others are correlation coefficients

Table III.
The moderation effect of knowledge barriers and ICT1 on knowledge transfer

	Step 1	Knowledge transfer Step 2	Step 3
Knowledge stickiness	-0.244**		
Knowledge ambiguity	-0.343**		
ICT1		0.359***	
Interaction between knowledge stickiness and ICT1			0.259**
Interaction between knowledge ambiguity and ICT1			0.198**
<i>F</i> value	12.798**	14.964***	14.544***
<i>R</i> ²	0.118	0.240	0.326
Adj <i>R</i> ²	0.108	0.224	0.300
ΔR^2		0.122***	0.086***

Table IV.
The moderation effect of knowledge barriers and ICT2 on knowledge transfer

	Step 1	Knowledge transfer Step 2	Step 3
Knowledge stickiness	-0.244**		
Knowledge ambiguity	-0.343**		
ICT2		0.426***	
Interaction between knowledge stickiness and ICT2			0.306**
Interaction between knowledge ambiguity and ICT2			0.212**
<i>F</i> value	12.798**	19.204***	14.899***
<i>R</i> ²	0.118	0.288	0.322
Adj <i>R</i> ²	0.108	0.273	0.301
ΔR^2		0.170***	0.034***

significantly (ICT1 of 0.240, ICT2 of 0.288, and ICT3 of 0.242, $p < 0.001$). Last, we added all moderating effects to model 2 to construct model 3, a moderating effect model. R -square increased significantly (ICT1 of 0.326, ICT2 of 0.322, and ICT3 of 0.257, $p < 0.001$). The significant change in R -square demonstrates the robustness of including the moderating effects in the model 3. We estimated variance inflation factors (VIF) for each model to examine collinearity and found that they were below harmful levels (Mason and Perreault, 1991).

4.1 Direct effect and moderating effect of ICT competencies

As Tables III-V show, knowledge stickiness ($b = -0.244$ $p < 0.01$) and knowledge ambiguity ($b = -0.343$ $p < 0.01$) have negative impacts on knowledge transfer. These results support $H1$ and $H2$. Higher levels of knowledge transfer result in higher levels of innovation competitive advantage ($b = 0.534$ $p < 0.001$). $H5$ is supported.

In Table III, the results indicate that ICT1 mitigates the negative relationship between knowledge stickiness and knowledge transfer (ICT1 of $b = 0.259$ $p < 0.01$) and ICT1 mitigates the negative relationship between knowledge ambiguity and knowledge transfer (ICT1 of $b = 0.198$ $p < 0.01$). $H3a$ and $H4a$ are supported. Also, in Table IV, ICT2 mitigates the negative relationship between knowledge stickiness and knowledge transfer (ICT2 of $b = 0.306$ $p < 0.01$) and ICT2 mitigates the negative relationship between knowledge ambiguity and knowledge transfer (ICT2 of $b = 0.212$ $p < 0.01$). $H3b$ and $H4b$ are supported. In contrast to our expectation in $H3c$ and $H4c$, ICT3 is not significant (in Table V) either in knowledge stickiness ($b = 0.153$ $p > 0.05$) or knowledge ambiguity ($b = 0.125$ $p > 0.05$). The moderating effects between knowledge barriers (knowledge stickiness and knowledge ambiguity) and the three competencies of ICT result in a different level of mitigating effects. Among three ICT competencies, ICT2 has the largest mitigating effect on the negative impact of knowledge stickiness and knowledge ambiguity on knowledge transfer. ICT1 and ICT3 placed second and third.

4.2 Findings

The results show that both knowledge stickiness and knowledge ambiguity are significantly and negatively related to knowledge transfer. Higher level of knowledge transfer can lead to the firm's innovation competitive advantage. Furthermore, both ICT1 and ICT2 not only create direct and positive effects on knowledge transfer but also reduce the negative relationship between knowledge stickiness and knowledge

	Step 1	Knowledge transfer Step 2	Step 3
Knowledge stickiness	-0.244**		
Knowledge ambiguity	-0.343**		
ICT3		0.362***	
Interaction between knowledge stickiness and ICT3			0.153
Interaction between knowledge ambiguity and ICT3			0.125
F value	12.798**	15.154***	10.819***
R^2	0.118	0.242	0.257
Adj R^2	0.108	0.226	0.233
ΔR^2		0.162***	0.015***

Table V.
The moderation effect of
knowledge barriers and
ICT3 on knowledge
transfer

transfer. In other words, the effect of knowledge stickiness on knowledge transfer is weaker under high level of ICT1 or ICT2 than under low level of ICT1 or ICT2. In contrast, the effect of knowledge stickiness on knowledge transfer is stronger under low level of ICT1 or ICT2 than high level of ICT1 or ICT2. Meanwhile, both ICT1 and ICT2 not only create direct and positive effects on knowledge transfer but also reduce the negative relationship between knowledge ambiguity and knowledge transfer. In other words, the effect of knowledge ambiguity on knowledge transfer is weaker under high level of ICT1 or ICT2 than under low level of ICT1 or ICT2. In contrast, the effect of knowledge ambiguity on knowledge transfer is stronger under low level of ICT1 or ICT2 than high level of ICT1 or ICT2.

5. Discussions

The model in Figure 1 includes both moderating effects (i.e. ICT competencies) and mediating effects (i.e. knowledge transfer). Therefore, we followed the three-step regression procedure that Baron and Kenny (1986) recommended in examining the mediating effect of knowledge transfer between knowledge stickiness and knowledge ambiguity and innovation competitive advantage. As the results show, knowledge stickiness and knowledge ambiguity have significant effects on knowledge transfer. In addition, knowledge stickiness has a significant effect on innovation competitive advantage. When knowledge transfer is included, it reveals a significant effect on innovation competitive advantage. The inclusion of knowledge transfer leads to a slight decrease in the effect size of knowledge stickiness but remains significant, suggesting partial mediation. It means that the knowledge stickiness has a direct effect (through knowledge transfer) on innovation competitive advantage. However, the effect of knowledge ambiguity on innovation competitive advantage is not significant, suggesting full mediation. It means that knowledge ambiguity influence innovation competitive advantage through knowledge transfer. Overall, the model fit is superior when knowledge transfer is included, suggesting mediating effects of knowledge transfer.

5.1 Theoretical implications

There are several theoretical implications of this study. First, our study contributes to the healthcare literature on ICT competencies in knowledge transfer by developing a formal construct that capture the characteristics of ICT. Specifically, we identify three types of ICT competencies (ICT1: Interactive videoconferencing, ICT2: computer-assisted instruction, and ICT3: hand-held technology) that can foster knowledge transfer in healthcare organizations. Second, our results provide some indication of the importance of different types of ICT competencies (ICT2 > ICT1 > ICT3) in moderating the relationship between knowledge barriers and knowledge transfer. This provides important insights as to which type of ICT is more effective in mitigating the negative effects knowledge stickiness and knowledge ambiguity. Third, we show that knowledge transfer has a positive relationship with innovation competitive advantage. Knowledge transfer has mediating effects between knowledge barriers and innovation competitive advantage. Fourth, our study establishes a model for healthcare organizations that comprises the antecedents (knowledge stickiness and knowledge ambiguity), moderators (ICT1, ICT2, and ICT3), and consequences of knowledge transfer in innovation competitive advantage.

5.2 Practical implications

On the basis of our research, we identified three specific ICT competencies that healthcare professionals and practitioners should implement for ICTs to occur. The first ICT, interactive videoconferencing, synchronously links users with their instructors and any other necessary resources to support their learning and interaction. A disadvantage of interactive videoconferencing is that it currently cannot save a record of the interaction. The second ICT, computer-assisted instruction, in addition to synchronously and asynchronously linking users with their instructors and any other necessary resources, can search the internet and support links to a large-scale database. The most important advantage is that computer-assisted instruction is supported by multimedia, which can link users to more complicated teaching resources through multimedia computer-assisted instruction. For example, the “interactive patient” program evaluates performance in history taking, physical examination, diagnosis and treatment, and it also assesses knowledge and skill matched to the learner’s level. Moreover, it enables interpersonal interaction and collaborative learning between users or users and instructors, either synchronously or asynchronously, and it is easier to provide this information to more people, and make the teaching process easier to offer to a larger number of people. Thus, ICT2 is better than ICT1 in mitigating knowledge barriers. As for the third ICT, hand-held technologies, the major difference from the former two ICTs is that users can access it at any time or place, and they link the users and instructors directly to the information resource, so they can access the information at their leisure. Hand-held technologies also possess the advantages that interactive videoconferencing and computer-assisted instruction possess.

The results also show that knowledge stickiness and knowledge ambiguity are significantly and negatively related to knowledge transfer in healthcare organizations. Knowledge stickiness and knowledge ambiguity are barriers to the knowledge transfer process and no firms can afford to ignore. Therefore, it demands immediate attentions to find ways to mitigate the negative effect of knowledge stickiness and knowledge ambiguity on knowledge transfer since the higher levels of knowledge transfer will result in higher levels of innovation competitive advantage. For healthcare professionals, the study indicates that ICT competencies do enhance knowledge transfer within the firm and that the three competencies of ICT that can mitigate the negative impact of knowledge stickiness and knowledge ambiguity on knowledge transfer. Computer-assisted instruction has the largest mitigating effect on the negative impact of knowledge stickiness and knowledge ambiguity on knowledge transfer. Interactive videoconferencing has the smallest mitigating effect. Hand-held technology does not have an obvious impact as expected. The results allow for forward-looking allocation of ICT competencies and present an interesting avenue for future research.

This study suggests that healthcare organizations should have a clear understanding of the attributes of their field knowledge (i.e. stickiness and ambiguity) and build their ICT competencies in terms of ICT operations, ICT knowledge, and ICT objects. In practice, healthcare organizations should select the appropriate ICT technologies, establish relevant ICT departments, train or recruit personnel related to their ICT technical needs, be mindful of future ICT developments, budget in advance for updates as the technology advances, own the software and

hardware when necessary, and build customized health-oriented applications to better meet the special needs of patients. To support knowledge transfer, healthcare organizations should gradually establish ICTs as the main knowledge management platform to efficiently transfer knowledge. If this is done, all the participants in the learning experience will be able to efficiently communicate with the other participants, and it will be quicker and easier to disseminate knowledge, and improve the innovative capacity of users, thereby enhancing the hospital's innovation competitive advantage.

5.3 Limitations and future research directions

There are three key limitations in this study. First, we view knowledge transfer inside hospitals from the perspective of knowledge barriers (knowledge stickiness and knowledge ambiguity) and excluded from consideration other factors, such as organizational structure, culture, and strategic goals, policies, people – their personality, attitude, and behavior which can also affect knowledge transfer. Second, we collected data from physicians at various hospitals. Future research can benefit from collecting data from multiple sources (e.g. pharmacists, nurses, hospital staffs). Third, our model focuses on intra-firm characteristics that enhance knowledge transfer. However, ICT also occurs at the inter-firm interface, making it necessary to examine the role of inter-firm factors in fostering this knowledge transfer. Future research should identify and evaluate more ICT competencies that foster knowledge transfer for healthcare organizations; and study how these competencies moderate the direct effects of knowledge barriers in knowledge transfer.

References

- Alavi, M. and Leidner, D.E. (2001), "Review: knowledge management and knowledge management systems: conceptual foundations and research issues", *MIS Quarterly*, Vol. 25 No. 1, pp. 107-36.
- Amiri, A. (2007), "Dare to share: protecting sensitive knowledge with data sanitization", *Decision Support Systems*, Vol. 43 No. 1, pp. 181-91.
- Ansell, C. (2007), "Fostering innovation and collaboration", *Medical Device Technology*, Vol. 18 No. 1, pp. 52-3.
- Bandyopadhyay, S. and Pathak, P. (2007), "Knowledge sharing and cooperation in outsourcing projects – a game theoretic analysis", *Decision Support Systems*, Vol. 43 No. 2, pp. 349-58.
- Baron, R.M. and Kenny, D.A. (1986), "The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations", *Journal of Personality and Social Psychology*, Vol. 51 No. 6, pp. 1173-82.
- Blumentritt, R. and Johnson, R. (1999), "Towards a strategy for knowledge management", *Technology Analysis and Strategic Management*, Vol. 11 No. 3, pp. 287-300.
- Bolisani, E. and Scarso, E. (1999), "Information technology management: a knowledge-based perspective", *Technovation*, Vol. 19 No. 4, pp. 209-17.
- Brockman, B.K. and Morgan, R.M. (2003), "The role of existing knowledge in new product innovativeness and performance", *Decision Sciences*, Vol. 34 No. 2, pp. 385-419.
- Cheah, Y.-N. and Abidi, S.S.R. (2001), "The role of information technology in the explication and crystallization of tacit healthcare knowledge", *Health Informatics Journal*, Vol. 7 Nos 3/4, pp. 158-67.

- Chen, Y.S., Lin, M.J. and Chang, C.H. (2009), "The positive effects of relationship learning and absorptive capacity on innovation performance and competitive advantage in industrial markets", *Industrial Marketing Management*, Vol. 38 No. 2, pp. 152-8.
- Coakes, E., Bradburn, A. and Sugden, G. (2004), "Managing and leveraging knowledge for organisational advantage", *Knowledge Management Research & Practice*, Vol. 2 No. 2, pp. 118-28.
- Cummings, J. and Teng, B.S. (2003), "Transferring R&D knowledge: the key factors affecting knowledge transfer success", *Journal of Engineering and Technology Management*, Vol. 20, pp. 39-68.
- Davenport, T.H. and Prusak, L. (1999), *Working Knowledge: How Organizations Manage What They Know*, Harvard Business School Press, Boston, MA.
- Desouza, K. and Evaristo, R. (2003), "Global knowledge management strategies", *European Management Journal*, Vol. 21 No. 1, pp. 62-7.
- Dixon, N.M. (2000), *Common Knowledge: How Companies Thrive by Sharing What They Know*, Harvard Business School Press, Boston, MA.
- Fischer, S., Stewart, T.E., Mehta, S., Wax, R. and Lapinsky, S.E. (2003), "Handheld computing in medicine", *Journal of the American Medical Informatics Association*, Vol. 10 No. 2, pp. 139-46.
- Fordis, M., King, J.E., Ballantyne, C.M., Jones, P.H., Schneider, K.H. and Spann, S.J. (2005), "Comparison of the instructional efficacy of internet-based CME with live interactive CME workshops: a randomized controlled trial", *JAMA*, Vol. 294 No. 9, pp. 1043-51.
- Fornell, C. and Larcker, D. (1981), "Evaluating structural equation models with unobservable variables and measurement error", *Journal of Marketing Research*, Vol. 18 No. 3, pp. 39-50.
- Grant, R.M. (1996), "Toward a knowledge-based theory of the firm", *Strategic Management Journal*, Vol. 17, Winter, pp. 109-22.
- Grundman, J.A., Wigton, R.S. and Nickol, D.A. (2000), "A controlled trial of an interactive, web based virtual reality program for teaching physical diagnosis skills to medical students", *Academic Medicine*, Vol. 75, Suppl. 10, pp. 47-9.
- Gupta, A.K. and Govindarajan, V. (2000), "Knowledge flows within multinational corporations", *Strategic Management Journal*, Vol. 21 No. 4, pp. 473-96.
- Hair, J., Anderson, R., Tatham, R. and Black, W. (1999), *Multivariate Data Analysis*, Macmillan, New York, NY.
- Hauschild, S., Licht, T. and Stein, W. (2001), "Creating a knowledge culture", *The McKinsey Quarterly*, No. 1, pp. 74-81.
- Ives, W., Torrey, B. and Gordon, C. (2003), "Knowledge transfer: transfer is human behavior", in Morey, C., Maybury, M. and Thuraisingham, B. (Eds), *Knowledge Management: Classic and Contemporary Works*, MIT Press, Cambridge, MA.
- Jensen, R.J. and Szulanski, G. (2004), "Stickiness and the adaptation of organizational practices in cross-border knowledge transfers", *Journal of International Business Studies*, Vol. 35 No. 6, pp. 508-23.
- Johannessen, J.A. (2008), "Organizational innovation as part of knowledge management", *International Journal of Information Management*, Vol. 28 No. 5, pp. 403-12.
- Joshi, K.D., Sarker, S. and Sarker, S. (2007), "Knowledge transfer within information systems development teams: examining the role of knowledge source attributes", *Decision Support Systems*, Vol. 43 No. 2, pp. 322-35.
- Klein, D., Davis, P. and Hickey, L. (2005), "Videoconferences for rural physicians' continuing health education", *Journal of Telemed Telecare*, Vol. 11, Suppl. 1, pp. 97-9.

- Kumar, J. and Ganesh, L. (2009), "Research on knowledge transfer in organizations: a morphology", *Journal of Knowledge Management*, Vol. 13 No. 4, pp. 161-74.
- Li, C.Y. and Hsieh, C.T. (2009), "The impact of knowledge stickiness on knowledge transfer implementation, internalization, and satisfaction for multinational corporations", *International Journal of Information Management*, Vol. 29 No. 6, pp. 425-35.
- Lippman, S.A. and Rumelt, R.P. (1982), "Uncertain imitability: an analysis of interfirm differences in efficiency under competition", *Bell Journal of Economics*, Vol. 13 No. 2, pp. 418-38.
- Liu, M.S. and Liu, N.C. (2008), "Sources of knowledge acquisition and patterns of knowledge-sharing behaviors – an empirical study of Taiwanese high-tech firms", *International Journal of Information Management*, Vol. 28 No. 5, pp. 423-32.
- McCann, J.E. III and Buckner, M. (2004), "Strategically integrating knowledge management initiatives", *Journal of Knowledge Management*, Vol. 8 No. 1, pp. 47-63.
- McKimm, J., Jollie, C. and Cantillon, P. (2003), "ABC of learning and teaching: web based learning", *BMJ*, No. 326, pp. 870-3.
- Mason, C.H. and Perreault, W.D. (1991), "Collinearity, power, and interpretation of multiple regression analysis", *Journal of Marketing Research*, Vol. 28 No. 3, pp. 268-80.
- Meera, S.N., Jhamtani, A. and Rao, D. (2004), "Information and communication technology in agricultural development: a comparative analysis of three projects from India", Agricultural Research and Extension Network, Network Paper No. 135.
- Minbaeva, D. (2007), "Knowledge transfer in multinationals", *Management International Review*, Vol. 47 No. 4, pp. 567-93.
- Misra, U.K. (2004), "Telemedicine for distance education in neurology: preliminary experience in India", *Journal of Telemed Telecare*, Vol. 10 No. 6, pp. 363-5.
- Nonaka, I. (1994), "A dynamic theory of organizational knowledge creation", *Organization Science*, Vol. 5 No. 1, pp. 14-37.
- Nonaka, I. and Takeuchi, H. (1995), *The Knowledge-Creating Company*, Oxford University Press, New York, NY.
- Nunnally, J.C. and Bernstein, I.H. (1994), *Psychometric Therapy*, McGraw-Hill, New York, NY.
- Paswan, A.K. and Wittmann, C.M. (2009), "Knowledge management and franchise systems", *Industrial Marketing Management*, Vol. 38 No. 2, pp. 173-80.
- Polanyi, M. (1966), *The Tacit Dimension*, Routledge & Kegan Paul, London.
- Rao, P.M. (2001), "The ICT revolution, internationalization of technological activity, and the emerging economies: implications for global marketing", *International Business Review*, Vol. 10 No. 5, pp. 571-96.
- Reed, R. and DeFillippi, R.J. (1990), "Causal ambiguity, barriers to imitation, and sustainable competitive advantage", *Academy of Management Review*, Vol. 15 No. 1, pp. 88-102.
- Reich, B.H. (2007), "Managing knowledge and learning in IT projects: a conceptual framework and guidelines for practice", *Project Management Journal*, Vol. 38 No. 2, pp. 5-17.
- Renzl, B. (2008), "Trust in management and knowledge sharing: the mediating effects of fear and knowledge documentation", *Omega*, Vol. 36 No. 2, pp. 206-20.
- Riusala, K. and Smale, A. (2007), "Predicting stickiness factors in the international transfer of knowledge through expatriates", *International Studies of Management and Organization*, Vol. 37 No. 3, pp. 16-44.

- Roberts, J. (2000), "From know-how to show-how? Questioning the role of information and communication technologies in knowledge transfer", *Technology Analysis & Strategic Management*, Vol. 12 No. 4, pp. 429-43.
- Sargeant, J.M. (2009), "Medical education for rural areas: opportunities and challenges for information and communications technologies", *Journal of Postgraduate Medicine*, Vol. 51 No. 4, pp. 301-7.
- Sclater, K., Alagiakrishnan, K. and Sclater, A. (2004), "An investigation of videoconferenced geriatric medicine grand rounds in Alberta", *Journal of Telemed Telecare*, Vol. 10 No. 2, pp. 104-7.
- Sher, J. and Lee, C. (2004), "Information technology as a facilitator for enhancing dynamic capabilities through knowledge management", *Information & Management*, Vol. 41 No. 8, pp. 933-45.
- Simonin, B.L. (1999a), "Ambiguity and the process of knowledge transfer in strategic alliances", *Strategic Management Journal*, Vol. 20 No. 7, pp. 595-623.
- Simonin, B.L. (1999b), "Transfer of marketing know-how in international strategic alliances: an empirical investigation of the role and antecedents of knowledge ambiguity", *Journal of International Business Studies*, Vol. 30 No. 3, pp. 463-90.
- Simonin, B.L. (2004), "An empirical investigation of the process of knowledge transfer in international strategic alliances", *Journal of International Business Studies*, Vol. 35 No. 5, pp. 407-27.
- Spender, J.C. and Grant, R.M. (1996), "Knowledge and the firm: overview", *Strategic Management Journal*, Vol. 17, Winter, pp. 5-9.
- Strach, P. and Everett, A.M. (2006), "Knowledge transfer within Japanese multinationals: building a theory", *Journal of Knowledge Management*, Vol. 10 No. 1, pp. 55-68.
- Straub, D.W. (1989), "Validating instruments in MIS research", *MIS Quarterly*, Vol. 13 No. 2, pp. 147-69.
- Szulanski, G. (1996), "Exploring internal stickiness, impediments to the transfer of best practices within the organization", *Strategic Management Journal*, Vol. 17, winter, pp. 27-44.
- Szulanski, G., Cappetta, R. and Jensen, R.J. (2004), "When and how trustworthiness matters: knowledge transfer and the moderating effect of causal ambiguity", *Organization Science*, Vol. 15 No. 5, pp. 600-13.
- Teece, D.J. (1998), "Research directions for knowledge management", *California Management Review*, Vol. 40 No. 3, pp. 89-292.
- Tippins, M.J. and Sohi, R.S. (2003), "IT competency and firm performance: is organizational learning a missing link?", *Strategic Management Journal*, Vol. 24 No. 6, pp. 745-61.
- van Wijk, R., Jansen, J. and Lyles, M. (2008), "Inter- and intra-organizational knowledge transfer: a meta-analytic review and assessment of its antecedents and consequences", *Journal of Management Studies*, Vol. 45 No. 4, pp. 830-53.
- Verhoeven, B.H., Verwijnen, G.M., Scherpbier, A.T.T. and van der Vleuten, C.P.M. (2002), "Growth of medical knowledge", *Medical Education*, Vol. 36 No. 8, pp. 711-7.
- von Hippel, E. (1994), "Sticky information and the locus of problem solving: implications for innovation", *Journal of Management Science*, Vol. 40 No. 4, pp. 429-39.
- Zander, U. and Kogut, B. (1995), "Knowledge and the speed of the transfer and imitation of organizational capabilities: an empirical test", *Organization Science*, Vol. 6 No. 1, pp. 76-92.

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Further reading

Hunt, S.D. and Morgan, R.M. (1995), "The comparative advantage theory of competition", *Journal of Marketing*, Vol. 59 No. 2, pp. 1-15.

Lee, S.M. and Hong, S. (2002), "An enterprise-wide knowledge management system infrastructure", *Industrial Management & Data Systems*, Vol. 102 No. 1, pp. 17-25.

Sargeant, J., Allen, M., O'Brien, B. and MacDougall, E. (2003), "Videoconferenced grand rounds: needs assessment for community specialists", *Journal of Continuous Education Health Profession*, Vol. 23 No. 2, pp. 116-23.

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