Why adoption of some Technologies is faster? An Explanation through Sequential Coherence

Shanta R Yapa
Faculty of Management and Finance
University of Colombo, Sri Lanka
shantayapa@gmail.com

R Senathiraja
Faculty of Management and Finance
University of Colombo, Sri Lanka

Jurgen Poesche
Department of Industrial Engineering and Management
Aalto University, Finland

Ilkka Kauranen
Department of Industrial Engineering and Management
Aalto University, Finland

Abstract

Technology adoption is a concern of business practitioners, policy makers and academics. Slow or low adoption can deprive stakeholders from intended benefits. Existing theories concerning technology adoption mostly focus on factors within a single organization. In this concept paper, we argue that sequential coherence which addresses knowledge flows that cross borders between organizations can provide enhanced insights in understanding technology adoption. Sequential coherence takes into consideration factors of both the transferor organization and the recipient organization. We propose a novel conceptual model of technology adoption based on sequential coherence. It takes into consideration the perceived usefulness and perceived ease of using technology. We have coined the model CUE (Coherence, Usefulness and Ease of use) of technology adoption. The CUE model can be used by practitioners, policy makers and academics.

Key words: Technology adoption, knowledge transfer, sequential coherence, knowledge flow, usefulness of technology, ease of use, CUE model

Introduction

Regular changes in technologies create opportunities to business organizations and also pose serious threats (Lai, 2016). How fast a new technology is diffused and adopted is a concern of an organization creating new technology. An organization cannot benefit from a new technology if utilization is low (Aubert et al, 2008). Failed attempts of introducing new technologies not only lead to financial loses but also result in dissatisfaction among stakeholders including employees (Venkatesh, 2000). Differences in adoption may create a digital divide within an industry sector. As an example, Ayinla and Adamu (2018) emphasize that there exists a digital divide in large and SME construction firms in adopting building information modelling technology.

Technology adoption and knowledge flows are interconnected (Bossink, 2018). In the case of a potential organization to adopt a new technology, cross border knowledge transfer must take place. Rational behaviour of managers demands a reasonable understanding of the new technology when making the decision of the possible adoption of this technology. Knowing the determinants that can influence the adoption decision of users is important for making decisions in designing and developing products (Mathieson, 1991). Transferring the required knowledge as to how the technology can be used at organizational level is very important to ensure successful adoption of technologies (Kyratsis et al., 2012). Researchers use many theories in understanding technology adoption (Taherdoost, 2018; Lai, 2017). However, extant theories mostly have an internal focus and fail to pay attention to cross border knowledge flows (Taherdoost, 2018; Bossink,2018).

We argue that in studying the success of technology adoption, the efforts taken by the supply side should also be considered in addition to paying attention to the demand side (Yapa et al, 2019). Even in a case of a new technology where there is no human involvement from the supplier such as downloading from the internet or self -studying by the recipient using a video, the way it is presented matters. In such a context, the analysis should necessarily go beyond the boundaries of a focal firm. Sequential coherence goes beyond the boundaries and examines the boundary conditions from both sides, namely the transferor of knowledge and transferee (Yapa et al, 2019). This approach will enable answering questions such as “Why adoption of the same technology from one supplier is easy but difficult with others?” and “Why does the capability of organizations to teach other organizations vary, and often to a great extent?” Extant theories fall short of answering these questions.

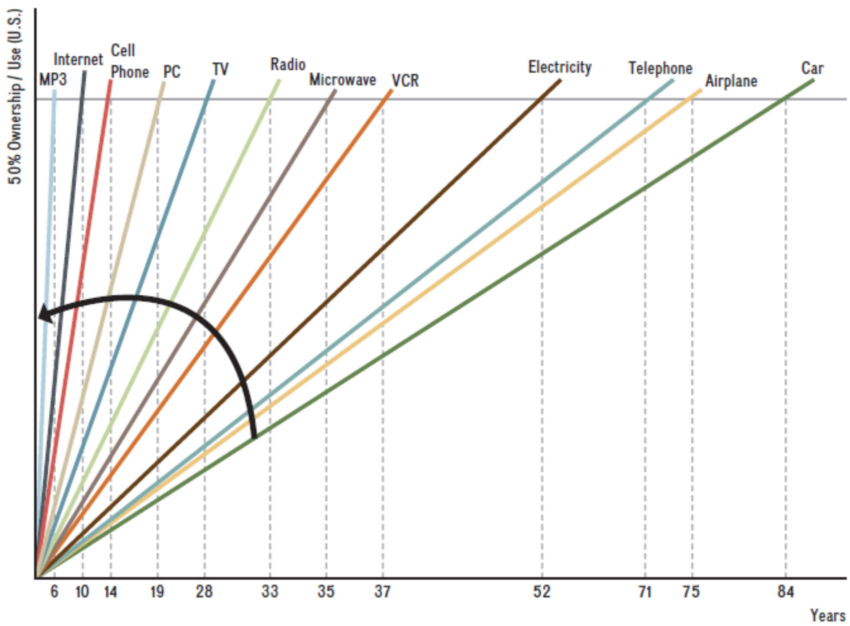

Figure 1: Accelerating Speed of Technological Change
Source: Rotheramel, 2017

Of the wide array of newest technologies introduced in the latest years, how many of them have we really adopted? Cloud computing, robotic process automation, big data, business intelligence, machine learning and deep learning are examples of newest technologies. Is it the cost of adoption which prevents organizations from using them? Is it the lack of knowledge of the new technology or the inability to access the new technology? Or is it something we are not even paying attention to? As shown in Figure 1, adoption of new technologies happens now at a faster rate than it did in the past. Therefore, business organizations must necessarily re-examine their strategies. Whether it is the adoption of 5G technology by mobile operators, minimal-invasive surgical procedures by medical doctors, utilizing block chains in the state sector or utilizing drip irrigation by farmers, technology adoption is a concern of all stakeholders. A common question that business practitioners, policy makers, and academics need to answer is “Why do people accept new technologies? (Taherdoost, 2018)”. Finding an answer to this question will enable them to more accurately predict user responses to new technologies (Dillon and Morris, 1996).

Methodology

We conducted a systematic literature review on technology adoption by reviewing over 300 peer reviewed journal articles appeared in Web of Science and Google Scholar databases using keywords such as technology adoption, knowledge transfer, sequential coherence, knowledge flow, usefulness of technology, ease of use, etc. 52 articles from these two sources and over 20 articles from other leading journals were thoroughly reviewed. Many scholars have pointed out the necessity of introducing new factors that can influence and explain technology adoption (Wisdom et al, 2014). Having identified a theoretical and empirical gap where extant literature predominantly focuses on internal factors of organizations, this concept paper attempts to introduce and justify a conceptual model by incorporating sequential coherence as a novel determinant which has a focus beyond the organizational boundaries. The authors identified sequential coherence as a novel variable through a qualitative inquiry conducted using five technology companies in Sri Lanka. We believe that it has the potential of explaining how aspects of technology transfer. We first give a brief description on existing theories on technology adoption. Next, we describe a new concept coined with sequential coherence and a novel theoretical framework incorporating the same. Then we provide a justification to use the new model in understanding technology adoption.

Literature review

In the technology adoption process, members of an organization will compare the advantages and disadvantages of the new technology using their previous knowledge (Kyratsis et al, 2012). Rogers (2003) describes three types of knowledge used in this process namely; (1) awareness knowledge that covers the existence of the technology and its key properties, (2) how-to knowledge that addresses the information which is necessary to use the technology properly, and (3) principle knowledge that deals with the functioning principles to understand how the technology works. Introduction of technology to an organization is a multi-staged and sequential process and there is no single point of introduction according to the theory of technology assimilation (Conboy and Morgan, 2012).

Nonaka and Takeuchi (1995) refer to knowledge as the justified true belief that builds capacity for organizations for effective action. Being complementary to each other, both tacit knowledge and explicit knowledge are essential in knowledge creation. Explicit knowledge loses its value quickly in the absence of tacit knowledge, and knowledge is created through the interaction between tacit and explicit knowledge (Nonaka, 2000). Nonaka and Takeuchi (1995) suggest that fundamental building blocks of knowledge creation comprises of four types of knowledge conversions between explicit and tacit forms. They are socialization, externalization, combination and internalization. An adopter's ability to understand, replicate or exploit new knowledge can be severely constrained unless a comprehensive knowledge transfer takes place (Zahra and George, 2002). Although, information and explicit knowledge can be transferred to others relatively easily, the associated transfer of tacit knowledge requires intimate human interaction (Roux et al, 2006).

Roux et al (2006) consider that knowledge transfer efforts that do not end with adoption are failures. Cohen and Levinthal (1990) emphasize that prior learning related to an object makes learning more efficient. As individuals prefer to adopt learning patterns that relate to previously accumulated knowledge, it is a challenge to acquire knowledge in realities from other fields (Roux et al, 2006). The more we know about something, the harder it is to learn to do it differently which Miller and Morris (1999) describe as trained incapacity. Path of selective exposure (Rogers, 1995) and proactive inhibition (Lyndon, 1989) also describe a similar phenomenon. Hall and Khan (2003) emphasize that the cumulative skills of an organization and the manner in which skills are acquired are important determinants of technology diffusion.

Nguyen (2009) describes three drivers of technology: the need for improving efficiency, business expansion, and meeting customer and industry standards. Nguyen et al (2015) describe these drivers as part of the innovation decision process in which managers compare advantages and disadvantages of adopting a new technology. Whether it is technology diffusion or technology adoption, knowledge transfer from upstream players to downstream players is important. Similarly, upstream transfer of knowledge plays a vital role in RandD, innovations and sustainability. Knowledge sharing is important for supplier innovations (Pihlajamaa et al, 2019).

There are many models and frameworks to explain user acceptance of new technologies (Taherdoost, 2018). Porter and Donthu (2006) emphasize two research paradigms of technology adoption. The system specific paradigm focuses on how different attributes of a technology affect an individual's perception on that technology. The technology acceptance model is a popular theoretical framework under this paradigm (Cebeci et al, 2020). The other paradigm focuses on the latent personality dimensions in explaining the use and acceptance of a technology. The technology readiness index (Parasuraman, 2000) is one of the frameworks under this paradigm. Both system specific dimensions and personality dimensions are important when adopting new technologies (Godoe and Johansen, 2012).

Goodhue et al (1995) introduced the task and technology fit model where they argue that a good fit between task and technology will increase the probability of technology adoption. Task and technology fit is attained by ensuring efficiency, effectiveness and quality. The theory of reasoned action (Fishbein and Ajzen, 1975) explains how an individual's attitudes, beliefs and behaviour influence adoption intentions. Ajzen (1991) introduced the theory of planned behaviour by adding perceived control behaviour as a determinant to the theory of reasonable action as shown in Figure 2.

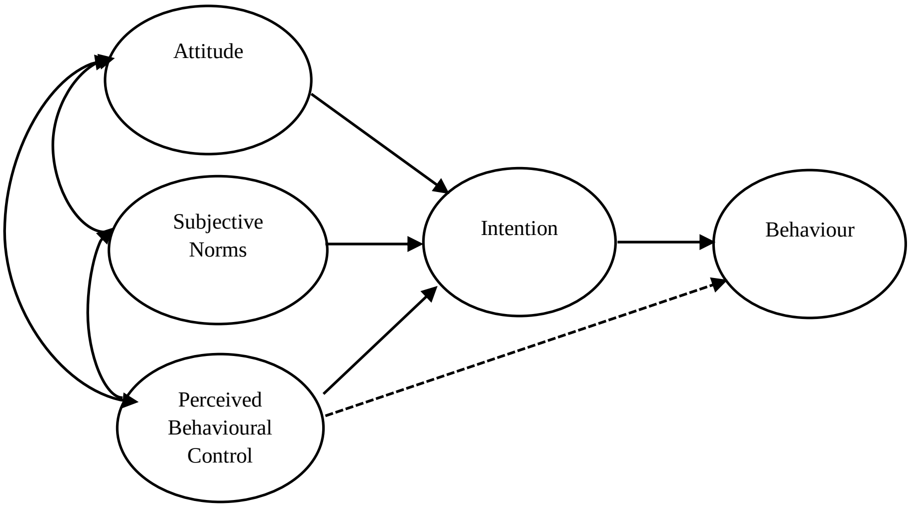

Figure 2: The theory of planned behaviour (Ajzen, 1991) adapted from Lai (2017)

Taylor and Todd (1995) introduced the Decomposed Theory of Planned Behaviour where the determinants of technology adoption are attitudes and subjective norms which cover views of the society and perceived behaviour controls. As an adaptation of the Theory of Reasoned Action, Davis (1986) introduced the Technology Acceptance Model (TAM) which is the most extensively used theoretical framework of technology adoption (Bolen, 2020; Cebeci et al, 2020). Venkatesh and Davis (2000) introduced TAM 2 which can explain voluntary adoption and mandatory adoption better. Perceived usefulness and perceived ease of use are the key determinants of technology adoption in the TAM framework.

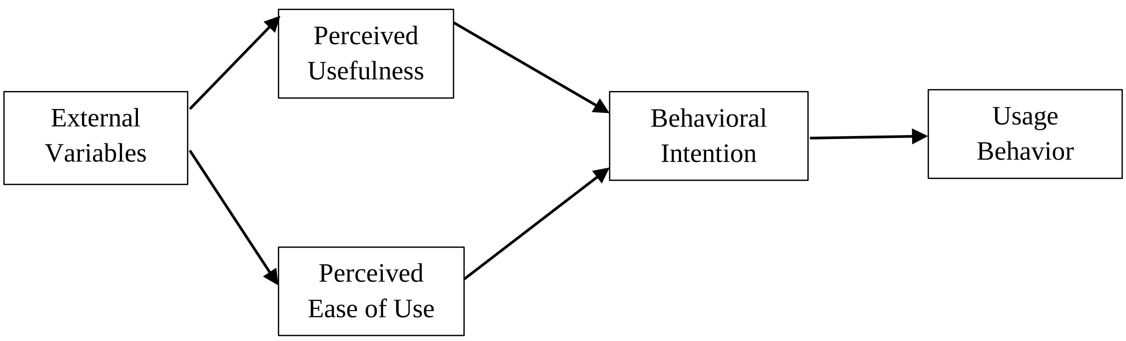

Figure 3: Improved technology Acceptance Model (Venkatesh and Davis, 1996)

Taking performance expectancy, effort expectancy, social influence and facilitating conditions into consideration as the determinants, Venkatesh et al (2003) introduced the Unified Theory of Acceptance and Use of Technology (UTAUT). Figure 4 shows multiple theories available in understanding technology adoption.

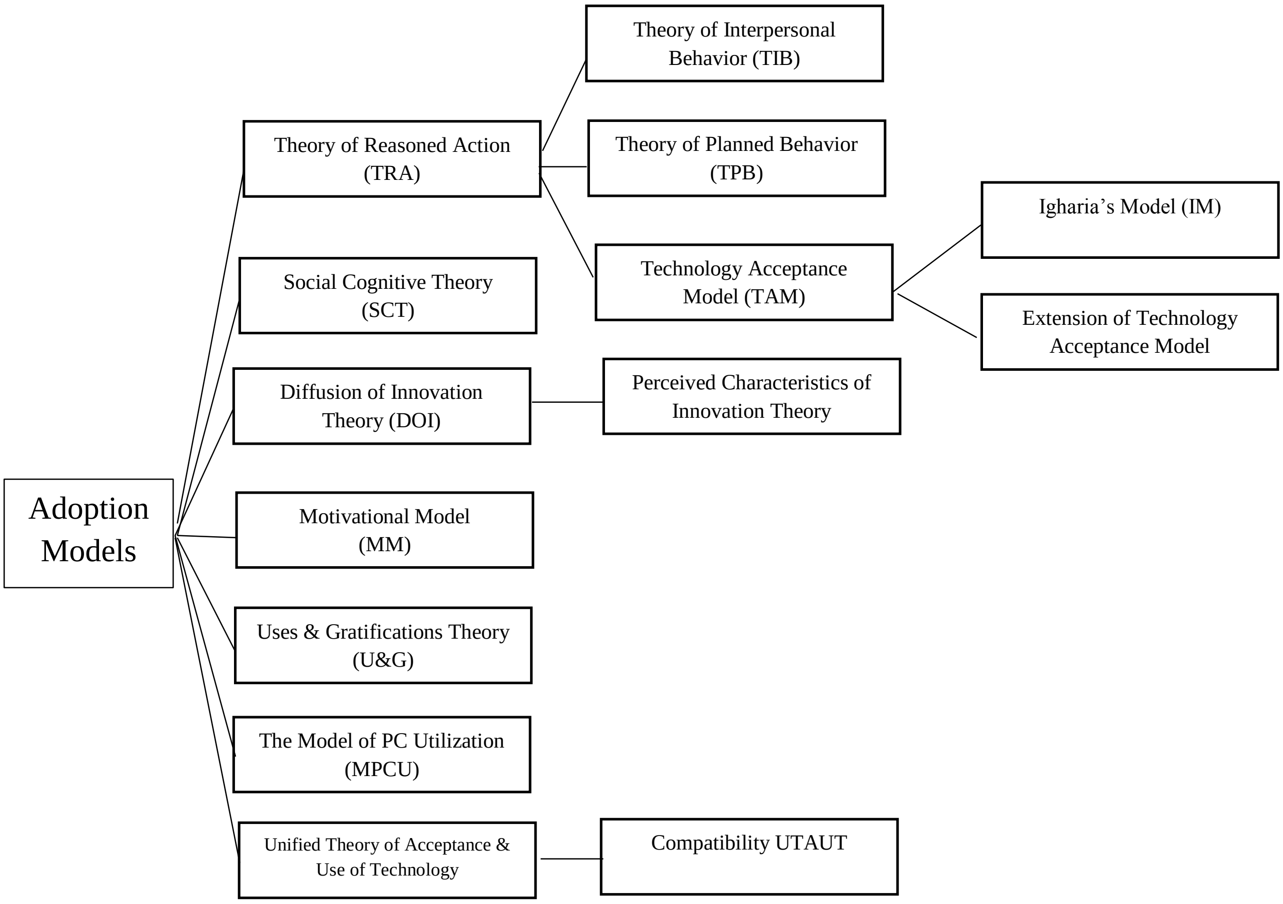

Figure 4: An overview of technology adoption models (Source: Taherdoost, 2018)

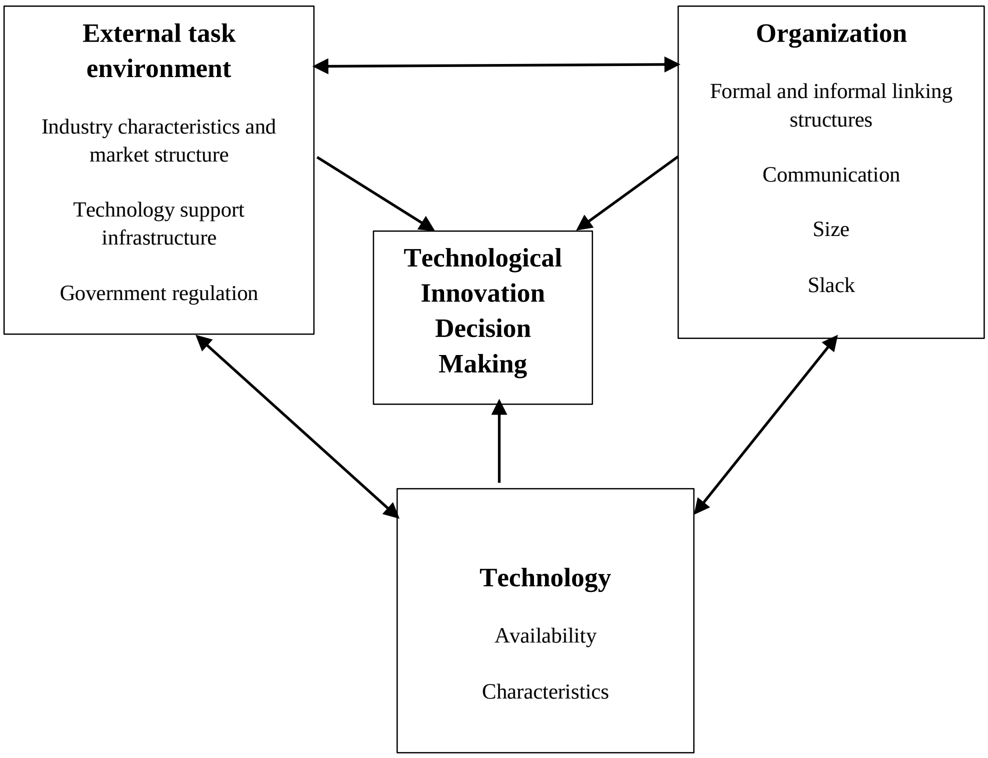

Figure 5: Technology, organization, and environment (TOE) framework (Tornatzky and Fleischer, 1990)

Taking three aspects from the context of an organization into consideration namely technological, organizational and environmental contexts, Tonartzky and Fleischer (1990) introduced the TOE framework shown in Figure 5 to understand technology adoption. The TOE framework has a sound theoretical background and consistent empirical support (Ahuja et al, 2020; Oliveira and Martins, 2011). It enhances the ability of Roger's Innovation Diffusion Theory to explain intra-firm innovation diffusion (Hsu et al, 2006).

Analyzing inter-organizational system characteristics that can influence organizations to adopt technology, Iacovou et al (1995) introduced the model shown in Figure 6. In this model, trading partner power is considered as one dimension of the external environmental context of the TOE model.

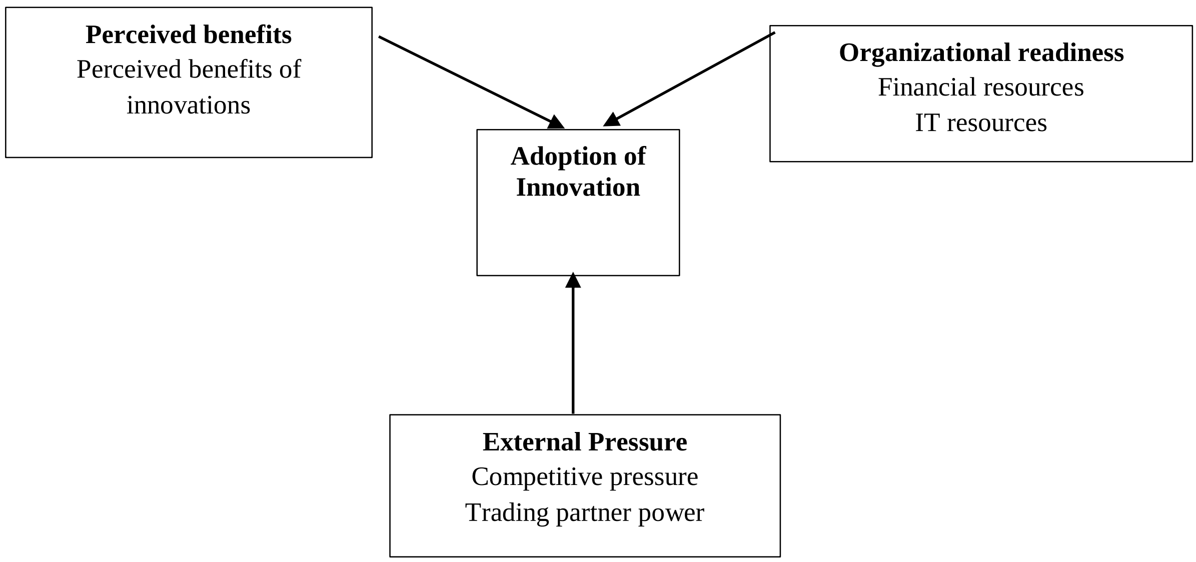

Figure 6: Model by Iacovou et al. (1995)

Based on the work of Cooper and Zmud (1990), Gallivan (2001) introduced a six-staged technology adoption model shown in Table 1.

Table 1: Innovation assimilation stages (Galivan , 2001) adopted from Weibl and Hess, 2018

Stages	Description
Initiation	A match is identified between an innovation and its intended application in the organization.
Adoption	The decision is made to invest resources to accommodate the implementation effort.
Adaption	The innovation is developed, installed and maintained, and organizational members are trained both in the new procedures and in the innovation.
Acceptance	Organizational members are committed in using the innovation.
Routinization	Usage of the innovation is encouraged as a normal activity in the organization.

Given below is the summary of selected models on technology adoption in Table 2.

Table 2: Summary of selected models on technology adoption

Model	Determinants	Authors/Year
Theory of Task-technology fit (TTF)	Task characteristics and technology characteristics	Goodhue, and Thompson, 1995
Theory of Reasoned Actions	Attitudes, subjective norms	Ajzen 1985, Ajzen 1991, Fishbein and Azjen, 1975
Theory of Planned Behavior	Attitudes, subjective norms, perceived behavioral control	Ajzen, 1985, 1991
Decomposed Theory of Planned Behavior	Attitudes, subjective norms, perceived behavioral control	Taylor and Todd, 1995
Technology Acceptance Model (TAM)	Perceived usefulness, perceived ease of use	Davis, 1986: Davis, 1989
Diffusion of Innovation Theory	Understanding, persuasion, decision, implementation, and confirmation as different stages	Rogers, 1995
Expectation – Confirmation Model	Perceived usefulness, customer satisfaction, repeat purchase decision	Bhattacharjee, 2001
Unified Theory of Acceptance and Use of Technology (UTAUT)	Performance expectancy, effort expectancy, social influence and facilitation conditions	Venkatesh et al., 2003
TOE framework	Technology context, organizational context and environmental context	Tornatzky and Fleischer, 1990

There is considerable overlap of determinants across the different models. Almost all the models mentioned above have an emphasis on a focal organization and thus demonstrate an inward looking approach. Although, in the TOE model (Tornatzky and Fleischer, 1990), the environmental factors are considered, it does not address the attributes of technology providers. Wisdom et al (2014) studied 20 technology adoption models and identified external influencers as a determinant of adoption in two theories. However, these external influencers also do not address any attributes of technology providers. As technology transfer happens from one organization to another or from one individual to another along and across the value chains, it is important to have a focus going beyond a single organization's boundaries. We argue that an approach going beyond a single organization can provide more insights as to how technology transfer takes place. On the other hand, however much we pay attention to other commonly used determinants, failing to understand how cross-border technology transfer happens can bring the adoption process to a standstill.

Instead looking at technology adoption as an endeavor of one entity, be it an individual, organization or a community, we suggest assessing it as an endeavor of two or more entities namely the provider and recipient. In a value chain, this may happen starting from upstream players to downstream players ending with final consumers. This can fall under B2B, B2C and

P2P. Raux et al (2006) emphasize the importance of user involvement in knowledge creation. A consequence of not paying attention beyond the boundaries of the organization may be that the organization does not get a true picture of the progress. Hall and Khan (2003) emphasize that although buying is a demand side decision, the benefits and costs of the technology can be influenced by the supply side decisions. Sometimes, getting users to adopt a new technology is difficult even if the benefits are well-proven (Panuwatwanich and Peansupap, 2013). We argue that in technology adoption, carefully balanced attention should be given to both the technology provider and recipient of the technology as neglecting one of these two sides will result in a distorted understanding and possibly detrimental consequences. Understanding technology adoption as an inter-organizational interaction brings new insights to the domain.

Verkijika et al (2018) using the extended unified theory of acceptance and use of technology (UTAUT2) model identified social influence, facilitating conditions, hedonic motivations, perceived risk and trust as significant predictors of behavioural intention to adopt technology. Toma et al (2018) emphasize that access to information and trust on the sources of information have an impact on technology adoption. Alalwan et al (2019) suggest that behavioural intentions in technology adoption are significantly influenced by performance expectancy, hedonic motivation, price value and perceived risk.

Choi and Ji (2015) conducted a study on the use of autonomous vehicles and concluded that perceived usefulness and trust are important determinants of technology adoption intentions. Okcu et al (2019) studied intentions to use big data tools by a Turkish airline and found that perceived usefulness and the perceived ease of use are important determinants in technology adoption. Bhatiasevi and Naglis (2018) observed that compatibility, technological readiness, top management support and competitive pressure are determinants influencing technology adoption. According to Yadegaridehkordi et al, (2019) perceived usefulness and perceived ease of use influence the intention to adopt new technologies. Bossink (2018) emphasizes the importance of knowledge flows in technology adoption.

Table 3: Summary of determinants of technology adoption used in selected empirical studies

Author(s)/Year	**Determinants**
Yadegaridehkordi et al, 2019	Perceived usefulness, perceived ease of use
Bolen, 2020	Perceived usefulness, aesthetics, individual mobility
Burke et al, 2018	Accessibility, Perceived usefulness
Al-Somali & Baghabra, 2019	Accessibility of the technology, perceived vulnerabilities, individual characteristics and social image
Verkijika, 2018	Social influence, facilitating conditions, hedonic motivations, perceived risk and perceived trust
Kumar et al., 2018	Method of information transfer, characteristics of the technology, recipient characteristics, economic factors, and socio demographic and institutional factors

Alalwan et al, 2018	Performance expectancy, effort expectancy, hedonic motivation, price value and perceived risk
Alkhater et al, 2018	Quality of service and trust
Korwatanasakul, 2020	Cooperation of related parties, Social acceptance, ease of use and perceived usefulness
Kijsanayotin et al, 2009	Performance expectancy, effort expectancy, social influence and voluntariness
Toma et al, 2018	Access to technical information, trust, perceived usefulness
Buabeng-Andoh, 2012	Personal, institutional and technological factors

Sequential Coherence

Sequential coherence refers to the reciprocal result of the pushing effects induced by individuals of a teaching firm and the pulling effects induced by individuals of a learning firm that enables knowledge to flow across the boundaries of firms (Yapa et al, 2019). Sequential coherence can be measured through the ability and willingness to teach by the teacher firm participants and the ability and readiness to learn by the participants of the student firm.

As the name suggests, sequential coherence connects knowledge flows among the organizations in the value chain sequentially. This binding enables back and forth knowledge exchange among individuals and groups. There is higher resistance to knowledge flows between organizations if the knowledge is complex. Complex knowledge can create preventive resistance even between organizations that are close to each other (Sorenson et al, 2016). Sequential coherence can help in overcoming such resistance, especially in the case of complex knowledge. Sequential coherence focuses on cross-border knowledge transfer. Knowledge management should be continuous and dynamic and not one dimensional (Lin, 2019). The approach in sequential coherence is to look at knowledge flows from both the supply side and demand side. The focus of sequential coherence goes beyond the boundaries of a single organization. This is a key difference between sequential coherence and existing technology adoption approaches we have studied. Sequential coherence helps managers to easily identify where knowledge does not flow smoothly, and accordingly to take corrective actions. Knowledge flows pertaining to technology adoption can take place from the manufacturer to the end user through various intermediate parties. Such knowledge flows can take place among existing users or among potential users or even between these two groups. All parties in such interactions can have an influence on each other. In order to better understand technology adoption, we propose a new conceptual model shown in Figure 6. The new model combines sequential coherence with two other determinants, namely perceived usefulness and perceived ease of use which are widely used in existing models of technology adoption such as the TAM model.

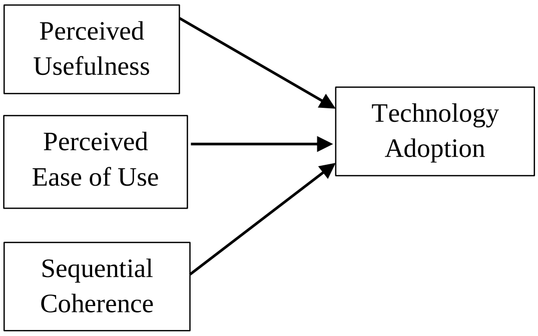

Figure 6: The proposed CUE (Coherence, Usefulness and Ease of use) model of technology adoption with sequential coherence as a determinant

Compared to existing models, the difference in the CUE (Coherence, Usefulness and Ease of use) model of technology adoption with sequential coherence as a determinant is that it demands the manager's attention beyond the organizational boundaries. Why a technology is not adopted even with a high perceived benefits and high level of ease of use can now be better understood with the proposed model. If the technology provider has not deployed the right resources including employees who have the ability and willingness to teach, the diffusion will not take place even if the recipient organization is willing and able to adopt. Similarly, however much the technology provider has the willingness and the ability to teach, if there is no pulling effect from the recipient organization as demonstrated by willingness and ability of student firm employees, the effort will not succeed.

Crossing the chasm (Moore 1991) in the case of high-tech products may not be such a challenge if managers can pay attention to knowledge flows by means of using the lense of sequential coherence. Why a particular group, be it early adopters or early majority, hesitates adopting a new technology can be examined through cross border knowledge flows as explained in sequential coherence for corrective actions. Existing theories with an inward looking approach can be reinforced by adding sequential coherence as a determinant of technology adoption. In this regard, sequential coherence can increase the understanding of why some technologies are adopted faster than others by looking at how cross-border knowledge is facilitated by each party.

Discussion and Conclusion

In the literature review, we studied a large number of models which researchers have used in understanding technology adoption. It is evident that the focus of the existing models is on a single organization. As an enhancement to the existing models, we suggest that the focus should be shifted to including multiple organizations. This can mean two or more organizations in a single value chain or multiple value chains with a larger number of organizations. Studying how cross border knowledge flows take place is crucial when ensuring that technology adoption happens along the value chain up to the end users. Alipranti et al (2015) emphasize that the presence of vertical relations can accelerate the adoption of a new technology. It is not enough that the recipient organization is geared to adopt the new technology. In addition, the organizations through which the technology is provided should also be geared to diffuse the technology. Mechanisms of technology diffusion also need to be geared to yielding optimum results. Any mismatch in terms of the ability and willingness to either diffuse or adopt can affect the process resulting in adoption rates below expectations. The knowledge transfer is not a one- time activity. Knowledge transfer may happen in both ways from the supplier to the recipient and vice versa. In view of the complex nature of technologies, it is important to use more than one theoretical model in understanding technology adoption (Oliveira and Martins, 2011). Zahra and George (2002) emphasize the importance of comprehensive knowledge transfer to ensure the adopter's ability to explore new knowledge. The need of intimate human interaction in knowledge transfer is stressed by Roux et al (2006). We argue that inclusion of sequential coherence as a novel determinant to existing models of technology adoption can bridge a theoretical and empirical gap.

Sequential coherence goes beyond the boundaries of a focal firm as it examines the boundary conditions from both sides, namely the teaching firm from the supply side and the student firm from the demand side (Yapa et al, 2019). Theory of sequential coherence prompts us to understand that enhancing knowledge flows is a joint effort by all participants in the value chain in contrast to the traditional approach where this task is seen as the responsibility of the focal firm only. Sequential coherence can assist managers to identify weak links in the value chain where knowledge transfer does not happen smoothly. Accordingly, the managers can take corrective actions. Roux et al (2006) emphasize the importance of identifying the push effects induced by technology and the pull effects induced by the market. Enhancing these effects can facilitate technology diffusion. Such enhancement can be achieved by deeper involvement of the end-users in the knowledge creation process by improving the credibility of the technology suppliers and by supporting managers in their quest for gathering and assimilating knowledge of the technology for their strategy formation. These actions contribute to pushing knowledge across the divide and cross the boundaries of firms. Roux et al (2006) list the following as strategies that enhance the effect of market pull: Uncovering and articulating the "real information" that is needed, getting involved in upstream activities and improving information seeking and filtering abilities. We argue that sequential coherence measured by the pushing efforts of the teacher firm employees and the pulling efforts of the student firm employees is a fundamental determinant in the above explained diffusion processes.

Understanding the determinants of technology adoption is crucial in designing, planning and implementing technology-based initiatives by policy makers. Knowing the challenges and constraints in technology adoption is essential for business organizations in developing and introducing new products and processes. We argue that two-way knowledge transfer between the supplier and potential user is crucial in technology adoption intentions. Forman and Zeebroeck (2019) argue that similar prior knowledge bases support knowledge flows between different locations. Sequential coherence can bring new insights into analyzing knowledge flows with regard to technology adoption.

Sepazgosar et al (2019) describe three stages of vendor and customer engagement in the adoption of modern technologies. In the first stage, the ability of the new technology to solve some existing problem is communicated to the buyers. In the second stage, detailed knowledge is shared through discussions, demonstrations and other materials. In the third stage, specific knowledge required in comparing alternative solutions and in the use of the new technology is addressed. It is evident that knowledge sharing is essential in all three stages, and hence, sequential coherence can offer better insights on technology adoption. We suggest incorporating sequential coherence as a determinant in technology adoption models so that it can provide a better understanding of why some technologies are adopted faster than others. The CUE model suggested in this article will be useful to business practitioners, policy makers and academics.

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