

ČOREJOVÁ Tatiana¹
PODPEROVÁ Angela²

Diffusion and adoption models at firm level

Diffusion of innovations, TOE framework, inter-firm diffusion, intra-firm diffusion.

Abstract

This paper investigates the issue of diffusion research focused on diffusion and adoption models at firm level. Diffusion theories are aimed at exploring issues as how, why and with what intensity there are new knowledge, innovations, skills and technological changes spread. The purpose of this article is to analyse diffusion processes and describe inter-firm and intra-firm diffusion and differences between them. In this article there is a theoretical review of IT adoption models at the firm level stated, and factors that influence IT adoption and diffusion in each of them. Most empirical studies are derived from the DOI theory and the TOE framework, but to achieve better understanding of the IT adoption phenomenon, it is important to combine more than one theoretical models.

DIFÚZNE A ADAPTAČNÉ MODELY NA PODNIKOVEJ ÚROVNI

Streszczenie

Príspevok je zameraný na prístupy vo výskume difúzie zameranej na difúzne a adaptačné modely na podnikovej úrovni. Difúzne teórie sa zameriavajú na skúmanie ako, prečo a s akou intenzitou sú nové poznatky, inovácie, zručnosti a technologické zmeny rozširované. Účelom príspevku je analyzovať difúzne procesy a popísať medzifiremnú a vnútrofiremnú difúziu a rozdiely medzi nimi. Je tu uvedený teoretický prehľad modelov prijímania IT na firemnej úrovni a faktory, ktoré ovplyvňujú prijatie a difúziu IT v nich. Väčšina empirických štúdií je založená na teórii DOI a rámci TOE, ale pre lepšie porozumenie javom spojeným s prijatím IT je nutné kombinovať rôzne teoretické prístupy.

1. INTRODUCTION

Technology diffuses slowly both across and within countries resulting in significant lags between the time of invention and the time when a technology is initially used in a country. Even when a technology has arrived in a country, it takes years and decades before it has diffused to the point of having impact on productivity. This leads us to study why technology diffuses slowly, and what explains cross-country differences in its speed of diffusion. The effects of innovation on economic development were first systematically studied by Schumpeter (1934), who stated that innovative activities by firms often require costly and time-consuming processes in order to gain competitive advantages. According to Schumpeter, competition is primarily a process of the creation and diffusion of new knowledge within the economic system under conditions of rivalry.

2. DIFFUSION PROCESSES

Empirical studies on technology adoption consider adoption units (e.g. countries, cities, or firms) as independent. There is a link between country's technology adoption patterns and the country's characteristics. But this empirical approach ignores the possibility of cross-country interactions in the adoption process. Adopting a new idea requires acquiring knowledge which often comes from interactions with other entities. It seems more likely to be knowledge transmitted between agents in countries that are close than between agents located far apart. The adoption intensity of a new technology in a country increases when nearby countries have a high adoption level. Innovations requiring an individual-optional innovation-decision are generally adopted more rapidly than innovations that are adopted by an organization. The more persons are involved in making an innovation-decision, the slower the rate of adoption is. [1]

2.1 Inter-firm and intra-firm diffusion

In last few years, research has made great progress in understanding and modelling the factors that lead to the first adoption of IT, so called *inter-firm diffusion*. It is the time profile of number of firms using the technology. If we are

¹Prof. Ing. Tatiana Čorejová, PhD., rector of the University of Žilina, Univerzitná 8215/1, 010 26, Žilina. Tel.: +421-41-513 51 01, Fax: +421-41-513 50 56, E-mail: rektor@uniza.sk.

² Ing. Angela Podperová, University of Žilina, Faculty of Operation and Economics of Transport and Communications, Univerzitná 8215/1, 010 26, Žilina. Tel.: +421-41-513 31 44, E-mail: angela.podperova@fpedas.uniza.sk.

interested in the benefits generated by a certain technology within an economy, it is important to understand factors that determine the extent of IT use by adopting firms, after first adoption, which is called *intra-firm* diffusion. It is the extent of IT use or level of IT adoption by individual firms (Battisti et al. 2004, Hollenstein 2004, Teo and Pian 2003, Teo and Pian 2004). Battisti (2000) empirically shows that in explaining the overall level of use of new technologies in an industry, both factors are important. Their relative importance differs over the diffusion time profile. Battisti and Stoneman (2003) have shown that the inter-firm effect is more important in the early stages and that the intra-firm effect is more relevant in the latter stages of the whole diffusion process. [2, 6]

A diffusion literature has tended to separately model inter and intra-firm diffusion, developing distinct models. Exceptions are works of Battisti (2000) and Battisti and Stoneman (2003, 2005) which can be considered early attempts to bring together the two analyses by proposing a two-step approach (linking the decision to adopt and the decision to extensively use a new technology). Most of the limited intra-firm literature builds upon the work of Mansfield (1963, 1968) based upon the epidemic learning process. Stoneman and Battisti (1997) have shown that this approach provides only a partial explanation of the intra-firm process. One way forward is to attempt to bring over from the analysis of inter-firm diffusion some of the recent advances. To classify the inter-firm literature, there is a fundamental distinction between equilibrium and disequilibrium approaches. The classic disequilibrium approach is the Mansfield epidemic model, which identifies diffusion as “*a process of adjustment to a fixed end point*”. Karshenas and Stoneman (1993) classify the inter-firm equilibrium models into three approaches. Their idea is that “*at a point in time diffusion extends only to the point where it is profitable to adopt the new technology. Over time the cost of adoption, or the size of returns, or the distribution of returns change and the diffusion path is then mapped out.*” In the three different approaches there are three main drivers of profitability [9]:

- Rank effects – firms have different characteristics and thus different returns.
- Stock effects – a firm’s adoption impacts (negatively) upon the profitability of further adoption by others.
- Order effects – returns are determined by positions in the order of adoption. A firm’s adoption reduces the returns to all other non-adopters as they are moved down the order.

A firm’s decision to adopt an innovation may be motivated by three different mechanisms:

- Rationalism – assumes that innovation adoption by firms aims at closing competitive gaps and provides market leadership.
- Bandwagon pressure – is a mechanism by which organizations adopt an innovation to imitate either direct competitors or companies from other strategic groups.
- Forced choice – assumes that firms may be forced to adopt an innovation by institutional agents, customers or suppliers. [8]

3. DIFFUSION THEORY MODELS USED AT A FIRM LEVEL

Various models have been developed to model innovation diffusion. Among them, there are two models, the external and internal influence models, which have received strong empirical support. *The external influence* model assumes that adoption is driven by information from a source external to the social system and adoption is related to the number of individuals in the social system that have yet to adopt the innovation. *The internal influence* model assumes that adoption is driven by communication within social system and that the expected number of adopters is related to the number of actors that have already adopted as well as the number of potential adopters. [8]

There are many theories used in diffusion research concerning technology adoption. The most used theories are the technology acceptance model (TAM – Davis, 1989), theory of planned behaviour (TPB – Ajzen, 1985), unified theory of acceptance and use of technology (UTAUT – Venkatesh et al. 2003), diffusion of innovations (DOI – Rogers, 1995) and the TOE framework (Tornatzky and Fleischer, 1990). One of the most commonly employed models is the Technology Acceptance Model, which explains and predicts an individual’s acceptance behaviour toward a new technology. While this theory is useful for understanding individual’s acceptance, it is not suited for investigation of organizational-level acceptance. The adoption decision on a firm level is generated as a strategic firm-level initiative.

From these theories only DOI and TOE framework explain adoption process at a firm level. Besides these two models there is also *Institutional theory* and *Iacovou et al. model* which can help to better understand this issue.

3.1 Diffusion of innovations

Roger’s diffusion of innovation theory can be used to study individual acceptance of a new technology, but it can be also used to explore the adoption on a firm level. Based on this theory, innovation is influenced by independent variables, namely: *individual characteristics of the organization, internal characteristics of organizational structure* and *external characteristics of the organization* (see Fig.1).

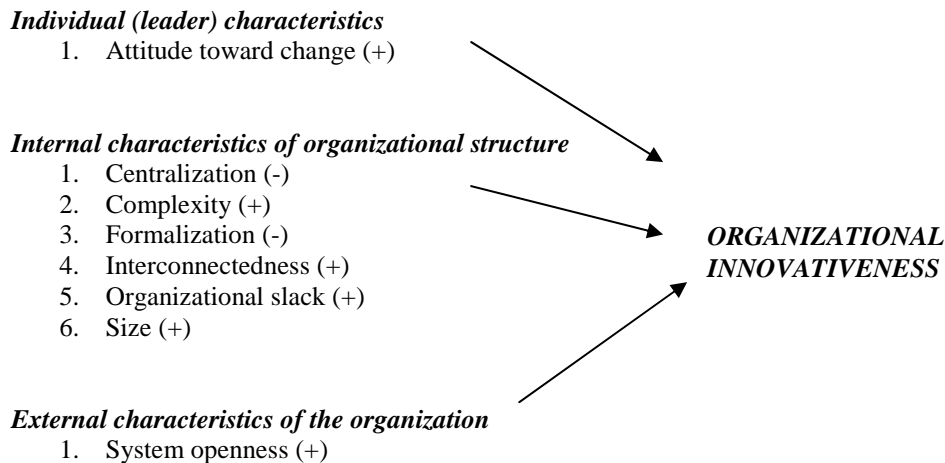


Fig. 1. Variables related to organizational innovativeness (source: Rogers, 2003)

Based on Diffusion of innovations theory, organization's attitude toward change is positively related to its innovativeness. *Centralization* is the "degree to which power and control in a system are concentrated in the hands of a relatively few individuals". Usually the more power is concentrated in an organization, the less innovative the organization is, so centralization has been found to be negatively associated with innovativeness.

Complexity is the "degree to which an organization's members possess a relatively high level of knowledge and enterprise". Complexity is usually measured by the members' range of occupational specialties and their degree of professionalism expressed by formal training. High degree of complexity encourages members of the organization to grasp the value of innovation, but it can complicate the achievement of consensus about its implementation.

Formalization is the "degree to which an organization emphasizes its members' following rules and procedures". The high degree of formalization inhibits the consideration of innovations by organization members but encourages the implementation of innovations.

Interconnectedness is "is the degree to which the units in a social system are linked by interpersonal networks". New ideas flow more easily among members of the organization if it has a higher degree of network interconnectedness. This variable is positively related to organization's innovativeness.

Organizational slack is the "degree to which uncommitted resources are available to an organization". This variable is positively related to organizational innovativeness, especially in cases when an innovation is higher in cost.

The finding that larger *size* is related to organizational innovativeness might seem surprising, given the conventional business wisdom that smaller companies can be more flexible. Nevertheless, the size-to-innovativeness relationship holds across a large number of investigations. (Rogers, 2003) [4]

Low centralization, high complexity, and low formalization facilitate initiation in the innovation process, but they make it difficult to implement an innovation (Zaltman et al., 1973). Generalization is: "Each of the organizational structure variables may be related to innovation in one direction during the initiation phases of the innovation process, and in the opposite direction during the implementation phases". [4]

3.2 TOE framework

Research based on the Innovation Diffusion Theory assumes that the adoption decision is undertaken to improve operational efficiency (Teo et al., 2003). However, the organizational decision to adopt new technology may be also influenced by the environment of the organization – customers, suppliers, other trading partners, competitors, and government regulations that provide barriers and incentives to technology adoption. [5]

The TOE framework (technology, organization, environment) was developed in 1990 by Tornatzky and Fleischer. It is very similar to Roger's diffusion model, but it takes into account also the aspect of external business environment, which can better explain adoption of innovations. Internal and external characteristics of the organization from DOI theory are identical to the technology and organization context of the TOE framework. TOE aims at describing three aspects of an enterprise's context that influence the process by which it adopts and implements a technological innovation: *technological context, organizational context and environmental context* (see Fig. 2).

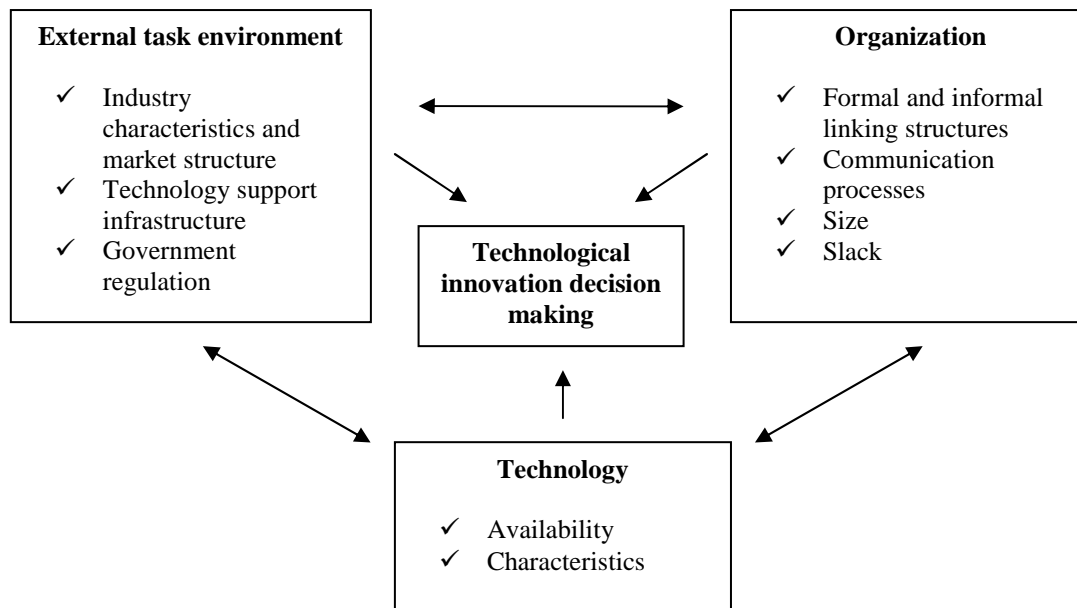


Fig. 2. Technology, organization, and environment framework (source: Tomatzky, Fischer, 1990)

Technological context describes both – the internal and external technologies relevant to the firm. It takes into account available technologies important for the organization that could be useful for increasing productivity including existing processes and equipment (Starbuck, 1976), as well as the set of available technologies external to the firm (Thompson 1967, Khandwalla 1970, Hage 1980).

Organizational context is defined in terms of resources available to support the acceptance of the innovation. It refers to descriptive measures such as organization's size, scope, managerial structure, and the quality and availability of the firm's human resources.

Environmental context represents the setting in which the organization conducts business. It covers industry, competitors and dealings with government. [3, 5]

The TOE framework provides a useful analytical framework that can be used for studying the adoption of different IT innovations. The TOE framework has a solid theoretical basis, consistent empirical support, and the potential of application to IS innovation domains. The TOE framework makes Roger's innovation diffusion theory better able to explain intra-firm innovation diffusion (Hsu et al., 2006). To better understand IT adoption decision, some authors used TOE framework with combination with other theories, especially DOI, Iacovou et al. model and Institutional theory.

3.3 Institutional theory

Institutional theory has its economic roots in what is now known as "old institutionalism". The "old institutionalism" was developed by Selznick (1949). He looked at the organization as a structure of rational action, and as an adaptive organic system which is affected by environmental pressures. As an organization takes on a character of its own, it becomes institutionalized, becoming stable and integrated within its social environment.

The institutional theory emphasizes that institutional environments are crucial in shaping organizational structure and actions (Scott and Christensen 1995, Scott 2001). According to this theory, organizational decisions are not driven only by rational goals of efficiency, but also by social and cultural factors and concerns for legitimacy. Institutions operate at multiple levels, transported by cultures, structures, and routines. According to this theory, firms become more similar due to isomorphic pressures and pressures for legitimacy (Dimaggio and Powell 1983). It means that firms in the same field tend to become homologous over time, because they are motivated by competitive and customer pressures to copy industry leaders. For example, organization is more likely to be inducted to adopt and use e-commerce by external isomorphic pressures from competitors, trading partners, customers and government rather than making a purely internally driven decision. The institutional theory adds to the environmental context of the TOE external pressures, which include pressure from competitors and trading partners. [3]

3.4 Iacovou et al. model

Another model used to study the adoption of innovations at firm level is model developed by Iacovou et al. (1995). It was used to explain the adoption of interorganizational systems. The model is based on three factors: *perceived benefits of innovation*, *enterprise readiness* and *external pressure* (see Fig. 3).

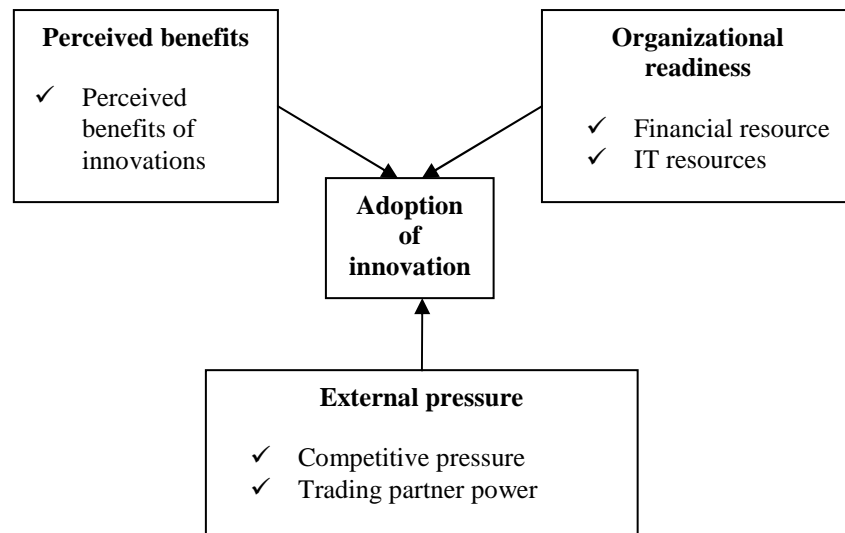


Fig. 3. Iacovou et al. model (source: Oliveira, Martins, 2011)

The factor *perceived benefits* is in the model TOE missing, while the *readiness of the organization* is a combination the technology and organization context of the TOE framework. Hence, IT resources is similar to technology context and financial resources is similar to organizational context. The external pressure in the Iacovou et al. Model adds the trading partners to the external task environment context of the TOE.

4. CONCLUSIONS

There are few reviews in the literature about the comparison of IT adoption models at the individual level, and there are even fewer at the firm level. This article analyses the most used theories and models – Diffusion of technology, TOE framework, Institutional theory and Iacovou et al. model. The DOI found that individual characteristics, internal characteristics of organizational structure, and external characteristics of the organization are important antecedents to organizational innovativeness. The TOE framework identifies three aspects of an enterprise's context that influence the process by which it adopts and implements a technological innovation: technological context, organizational context, and environmental context. The institutional theory postulates that mimetic, coercive, and normative institutional pressures existing in an institutionalized environment may influence the organization's predisposition toward it innovation. The analysis of these models takes into account existing literature and empirical researches.

5. REFERENCES

- [1] Comin, D., Dmitriev, M., Rossi-Hansberg, E.: The spatial diffusion of technology. *Working paper Princeton University*, 2011. Available at: <<http://www.princeton.edu/~erossi/SDT.pdf>>
- [2] Oliveira, T., Martins, M.F.: Determinants of Information Technology Diffusion: a Study at the Firm Level for Portugal. In: *The Electronic Journal Information Systems Evaluation* [online], 2008 Volume 11 Issue 1, pp. 27 – 34. Available at: <www.ejise.com>
- [3] Oliveira, T., Martins, M.F.: Literature review of information technology adoption models at firm level. In: *The Electronic Journal Information Systems Evaluation* [online], 2011, Vol. 14, Issue 1. Available at: <www.ejise.com>
- [4] Rogers, E. M.: *Diffusion of innovations*. Free Press, New York, 2003. ISBN-13: 978-0743222099. ISBN-10: 0743222091.
- [5] Lippert, S.K., Govindarajulu, Ch.: Technological, organizational, and environmental antecedents to web services adoption. In: *Communications of the IIMA*, 2006, Vol. 6, Issue 1, pages 146-158.
- [6] Battisti G., Stoneman, P.: The intra-firm diffusion of new process technologies. In: *International Journal of Industrial Organization*, 2005, Vol. 23, Issues 1-2, pages 1-22.
- [7] Schumpeter, J.A.: *The Theory of Economic Development*, Harvard University Press, Cambridge, 1934.
- [8] Hsin-Yu, S.: Contagion effects of electronic commerce diffusion: Perspective from network analysis of industrial structure. In: *Technological Forecasting & Social Change*, 2008, Vol. 75, Issue 1, pages 78-90. Available at <www.sciencedirect.com>
- [9] Battisti, G., Canepa, A., Stoneman P.: Profitability, externalities and policy in the inter and intra firm adoption of new technology: The example of e-business activities in the UK. *Paper presented at the 8th conference of the European network on industrial policy (EUNIP)*, Birmingham, 2004.

This paper was supported by project VEGA 1/0421/12 Modelling of knowledge diffusion in firm value chains