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ICT as an Enabler for Innovation Adoption

A study in the Dutch installation sector within the building industry

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Abstract

In this paper we investigate how two online services (a portal and a digital library) may influence the adoption of an innovation. It is known from prior surveys that the installation services branch of the Dutch building industry has a relatively slow adoption rate for innovations. We examine if these two online services can influence the attitude towards the adoption of innovations. From the academic literature we have derived a list of factors that influence the attitude towards adoption by individuals. We limited this project to a number of factors that are commonly referred to as technological factors. Using an online digital library and a custom-built portal, we conducted a field experiment with a post-test only control group design for one particular innovative product (a gas-analysis device); the test was performed using a survey. Our main finding is that the portal has a significant and positive effect towards the adoption of the innovation by an individual. We did not find a significant impact for the use of the digital library. On the basis of this experiment, we propose that online services that offer a high degree of interaction amongst their users are more likely to induce an increase in the willingness of an individual to adopt an innovation.

Keywords: innovation, adoption, portal, digital library, field experiment.

1. Introduction

A number of studies have described the lag between a technological breakthrough and its adoption (Mansfield, 1968; Schumpeter, 1934; Schumpeter, 1950). Schumpeter and Mansfield attributed the long time to adoption to the uncertain nature of innovations. Later, several authors (Bhattacharya, Chatterjee, & Samuelson, 1986; Jensen, 1982; McCardle, 1985) proposed that the delay of acceptation arises because companies want to gather extra

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information about a technological breakthrough to get insight into its profitability (Doraszelski, 2004). Recent research (Newman & Dale, 2008) has stated that the problem of the lag between innovation and adoption is still present. The lag was also found in an industry-specific study (Ooij, Putte, & Zwinkels, 2005) for the Dutch installation sector within the building industry.

The Dutch installation sector is characterized by a relatively large number of small companies. The average age of employees is higher than average for the Dutch labour force. The Dutch institute for Study and Promotion of Research in the building services (ISSO) has found that the adoption of innovations within this particular industry is very slow.

If we accept the proposition that the lag occurs because potential adopters need to gather additional information, then we can consider ways to reduce the lag by facilitating access to this additional information. Here, information and communication technology (ICT) could be useful as it facilitates the exchange of information and can be deployed to large groups of users at relatively low cost using the Internet. The World-Wide-Web in particular has become a building block for all sorts of online information exchanges, from chat boxes, reference sites such as Wikipedia, to company intranet sites. In this paper, we thus propose to use the communication and information sharing facilities of the World-Wide-Web to speed-up the innovation adoption process for the Dutch installation sector. In particular, we want to investigate the following hypothesis: “The opinion of individuals regarding the adoption of an innovation is positively influenced by ICT products that inform about the innovation.”

1.1. Relevance

A review of the academic literature on the adoption of innovations has not revealed any previous studies that investigate the influence of ICT products on the adoption process. This review has unearthed a number of factors that have been found to influence the adoption process. In this study, we link these factors to particular ICT products and investigate if these ICT products can influence the factors, which in turn influence the adoption process. We will therefore gain an initial insight in the potential of ICT products to positively influence the adoption process.

For the building industry, the relevance is clear; the ISSO has found the Dutch installation sector to be slow adopters of innovations. In the face of an ageing work force and a shortage of skilled workers, innovations can provide at least a partial solution if they increase productivity.

1.2. Methodology

The methodology for this project consists of three parts: literature review, field experiment, and analysis of the results.

We reviewed the academic literature on innovation, adoption of innovation, factors that influence the adoption process, ICT products, and the impact of digital products on the factors that influence the adoption process.

To examine the influence of ICT products on the adoption process of innovations we have conducted a field experiment. For this experiment we defined two experimental groups and a control group. The members of all groups received information about an innovation which is relevant for the installation sector within the building industry. The innovation that was used for this experiment was an innovative flue gas analysis computer. We subjected the two experimental groups to an intervention (stimulus); the control group did not receive an intervention. The use of a control group is included to eliminate outside influences that are

beyond the control of the researchers. The intervention was designed to trigger the participants in the experimental groups to find more information about the new technology using a particular ICT product. The installers were randomly selected from the customer database of a supplier of innovative measurement tools.

At the end of the field experiment all collected data were analysed. Goal of the analysis was to determine if there were differences between the attitude of the control group and experimental groups to the innovation. The differences between the groups were analysed using the independent samples t-test. The independent samples t-test is designed to discover differences between groups.

1.3. Structure of paper

The remainder of this paper is structured along the following lines. Section two explores the theoretical background of the major topics in this thesis: innovation and IT products. In the next section we describe the design of the experiment. The data that was gathered during the experiment is analyzed in section 4. Finally, we formulate our conclusions and an outlook for future research.

2. Theoretical background

2.1. Adoption of Innovation

Several research papers (Cohen & Levinthal, 1990; Dewar & Dutton, 1986; Dodgson, 1991; Dosi, 1982; Fischer, 2001; Garcia & Calantone, 2002; McDermott & O'Connor, 2002; Pedersen & Dalum, 2004; Rowe & Boise, 1974) discuss the definition of innovation from different perspectives. In this research we follow the definition of Rogers, who defined an innovation simply as “an idea, practise or object that is perceived as new by an individual or other unit of adoption” (Rogers, 1995).

Adoption of innovations concerns the decision of an individual or organization whether to use an innovation or not (Rogers, 1995). We can thus identify two types of organizational adoption decisions: made by an organization and made by an individual within an organization (Frambach & Schillewaert, 2002). These two types of adoption are separate concepts of adoption, but organizational adoption can only be realized when individuals within the organization make the decision to make use of the innovation (Russel & Hoag, 2004). In this paper we focus on the adoption of technology by individuals within organizations.

We classify the factors influencing the adoption of innovations into organizational (internal), external, and technological factors, as proposed by (Tornatzky, Fleischer, & Chakrabarti, 1990):

The Technology Acceptance Model (TAM, (Davis, 1986)) is one of the most cited models on innovation adoption. TAM is a specific adaptation of the theory of reasoned action (Ajzen, 1991) to the study of IT usage (Dishaw & Strong, 1999). According to TAM, perceived ease of use and perceived usefulness influence individuals whether to use an innovation or not. Perceived ease of use has been shown to be important in innovation diffusion in general (Rogers, 1995).

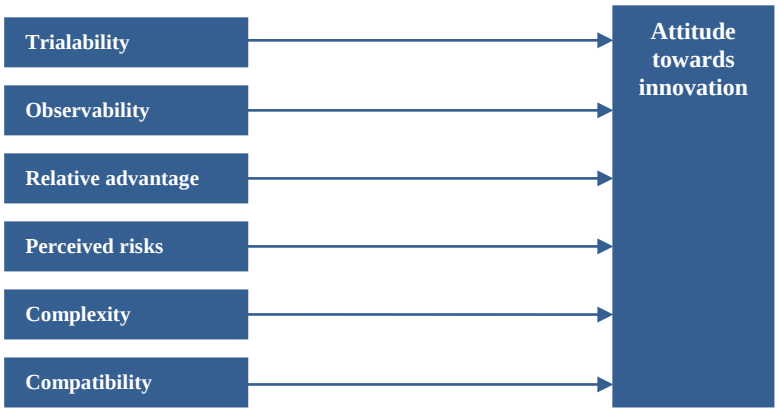
The model of (Rogers, 1995) which describes the diffusion of innovations (DOI) is frequently used to explain user adoption of innovations. The model defines the following technology based attributes of an innovation to explain the rate of its adoption: relative advantage, compatibility, complexity, trialability, and observability. All but one of these factors have a

positive impact on the rate of adoption; the exception is complexity, which has a negative impact on the rate of adoption.

A study of (Ostlund, 1974) operationalized the attributes of Rogers and it confirmed the expectations of Rogers. Ostlund added perceived risk, which is conceptualized to be negatively related to adoption (Bauer, 1960), to the attributes of Rogers.

In this paper we are interested in the potential to influence the individual's adoption decision of innovations through the use of ICT products. These products are unlikely to directly influence organizational and external factors. For example, the size and structure of a company cannot be changed by visiting a portal or digital library. The technological factors are more appropriate to be influenced by ICT products. Most of the technological factors are related to the attitude of an individual towards an innovation. Influencing an individual using ICT could change his or her attitude towards the innovation. Figure 1 gives a schematic view of the factors that influence the adoption decision of an individual.

Figure 1: Schematic view of the factors that influence the adoption decision of an individual



2.2. ICT products

A variety of Internet-based products, e.g. websites, portals, digital libraries, and e-learning platforms, have been developed for the installation sector within the building industry. The two products we consider in this paper are a portal and digital library.

2.2.1. Portal

The basis of a portal is to aggregate information from multiple sources, to publish this information to a variety of users, and to support the user to gain access to other sites with protecting the user from the chaos of the internet (Tatnall, 2005). A major difference between a traditional web site and a portal is that a portal is designed according to the users' need (Benbya, Passiante, & Belbaly, 2004). A research of (Lara et al., 2004) advocated that, in a prototypical case, 'a portal collects and presents relevant data for the community and users can publish information to the community'. Portals give users the possibility to locate interesting information based on their personal preferences (Lara et al., 2004).

A study of (Tatnall, 2005) discussed the benefits of using a portal. Usage of a portal delivers new partnerships which gives the opportunity to win new businesses and buyers. Another benefit is that portals help to build communities and regional relationships through services like chat rooms and message boards which stimulate interaction. This is a relevant property for this project as we have seen that interaction enhances the adoption and diffusion process

(Zaltman, Duncan, & Holbek, 1973). Portals also enable businesses adopt an e-business structure to share ideas with other businesses and achieve management support.

2.2.2. Digital library

(Marchionini & Maurer, 1995) defined a traditional library as an organized set of resources, which includes human services as well as the entire spectrum of media. Most of the digital libraries implemented virtual collections in their library. A virtual collection is a more easily explorable set of resources about a certain subject that prevents new users to be intimidated by the search interface or search results (Geisler, Giersch, McArthur, & McClelland, 2002). Other benefits of virtual collections are a more productive use of time and guidance of users to related work. A study of (Koohang & Harman, 2005) elaborated the benefits that are documented in research: accessibility and use of information, improved searching abilities, sharing and collaboration, and minimizing the digital divide (Arms, 2000). (Marchionini & Maurer, 1995) reported additional benefits such as reusing and sharing of resources, improvement of productivity, and an active community of learning and innovation.

2.3. Discussion

In this section, we have discussed the relevant academic literature in the fields of innovation, innovation adoption, and ICT. From the Technology Adaption Model (TAM) and the Diffusion of Innovation (DOI) model we conclude that the attitude of an individual within an organization is influenced by a number of adoption factors. As we are interested in the attitude towards adoption of an innovation of an individual within an organization, we want to investigate whether this attitude of an individual can be (positively) influenced by the application of ICT focused on these adoption factors.

Table 1 gives an overview of the expected influences, based on the literature review, of the ICT products on the factors that are affecting the adoption process. The discussed factors can be seen as the connection between the ICT products and the stimulation of the adoption process.

Table 1 Overview of expected influence of ICT products on the adoption process

Factor	Portal	Digital Library
Relative advantage	+	+
Complexity	+	+
Observability	+	
Trialability	+	
Compatibility	+	+
Perceived Risks	+	+

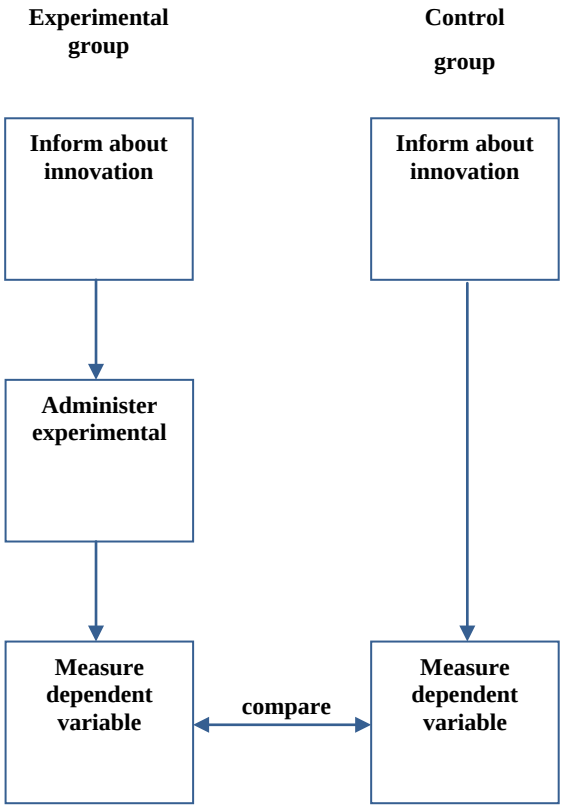
3. Experiment

3.1. Experimental setup

The design for the experiment is a post-test only control group design. At the start of the experiment a group of installers is informed about an innovation in the traditional way (e.g.

brochure, exhibition, symposia) by the supplier. The composition of the groups is a reflection of the Dutch installation sector within the building industry. We compiled a list of installers from the customer database of the supplier; this list was supplemented from the ISSO's internal database with a selection of installers that were known to perform gas measurements. This is achieved by selecting the installers participating in the experiment randomly from the list (Babbie, 2007). After informing the installers, the total group was divided into three subgroups: one control group and two experimental groups. As displayed in Figure 2 the two experimental groups received a stimulus; the control group did not receive an intervention.

Figure 2: Schematic overview of experiment (based on Babbie (2007))



The control group ensures that differences in key variables resulting from the stimulus in the experimental groups are measurable. The stimulus informed the members of the experimental groups that there is an ICT product available on the Internet related to the new technology. Finally, all groups were subjected to a survey to examine their attitude towards the innovation.

3.2. Hypotheses

We define the following hypotheses:

H1 The opinion of individuals regarding the adoption (measured by the factors trialability, relative advantage, complexity, compatibility, perceived risks, and observability) of an innovation is positively influenced after visiting a portal that informs about the innovation.

H2 The opinion of individuals regarding the adoption (measured by the factors relative advantage, complexity, compatibility, and perceived risks) of an innovation is positively influenced after visiting a digital library that informs about the innovation.

3.3. Innovation

The innovation used in the experiment is a new high-tech gas analysis device (figure 3). These gas analysis computers are a highly effective, real-world entry-level solution for measurements at oil and gas-fuelled systems.

Figure 3: The gas analyser Eurolyzer ST

3.4. ICT Products

3.4.1. Portal

We developed a portal specifically for this experiment. Using the characteristics that were described in the academic literature, we designed this portal to have a positive effect on the adoption process. As we have seen that aggregated information is a key component of a good portal, we have included relevant information about gas analysis, e.g. general information, need for gas analysis, news items (to offer recent information), links to other information, and a glossary. The portal was personalized to the needs of installers. Several industry experts verified the design of the portal before the start of the experiment.

3.4.2. Digital library

The digital library that was used for the experiment consists of a number of virtual collections for the Dutch building industry. We used three existing virtual collections: ISSO-digitaal (technical publications), BRIS Warenhuis (legislation), and a library of technical publications (the organisation providing this library requested not to be identified in publications). During the experiment all relevant publications and legislation concerning gas analysis were available to the experimental group.

3.5. Measurement

The post-test survey was based on the factors we extracted from the academic literature on the adoption of innovations. We included a number of questions (or *items*) for each factor to establish the attitude of the respondent. These variables were measured using multi-item indicators. Most of them were measured by using a five-point Likert-scale ranging from "strongly disagree" to "strongly agree".

The relative advantage was measured by five items that assessed the perceived benefits of the gas analysis device. For example, the gas analysis device offers more precise measurements than the current measurement tools. Compatibility was tested by two items that elaborated if the gas analysis device is compatible with the values and beliefs of a firm. Observability was measured by stating that the benefits of the gas analysis device will be directly visible. The measurement of the complexity was assessed by three items that determined the complexity of the gas analysis device. Three items were used to measure the perceived risks of the gas analysis device. The items evaluated the perceived risks that are present when buying the gas analysis device. Finally, trialability was assessed by one item that determined the need to evaluate the gas analysis device before buying it. We used a list of items from a prior survey (Premkumar & Roberts, 1999) as the starting point for the items used to measure relative advantage, compatibility, and complexity.

To assess the consistency of the responses for each factor, we computed Cronbach's alpha (α). This measure indicates the consistency of the responses within a factor: a value of 0.6 or higher is considered adequate (Churchill, 1979). The results are displayed in table 2: all of the α-values are above 0.6 which makes them adequate. The items for observability and trialability could not be assessed by Cronbach's alpha because both variables exist of a single item.

Table 2 Reliability properties of the measurement items

Variable	Number of items	α-value
Compatibility	2	0.7
Complexity	3	0.8
Observability	1	-
Perceived risks	3	0.6
Relative advantage	4	0.8
Trialability	1	-

3.6. Demographics of respondents

A total of 576 installers were approached via postal mail to participate in the experiment. A total of 107 respondents participated in the experiment and completed the survey. The age of the respondents is relatively old. Only a small part (18) of the respondents is younger than 30 years. This is consistent with a study (Tillaart et al., 2006) of the trends and developments in the installation sector within the building industry: the group of installers older than 55 years is growing while the group younger than 25 years is shrinking. The size of the companies (mostly small and medium sized organizations) of the respondents is also consistent with the findings of that study.

The experimental groups and the control group had the same proportions as the total group of respondents. This means that the experimental groups and the control group are also an adequate reflection of the Dutch installation sector within the building industry.

4. Data analysis

The experiment was designed to discover differences between the control group and the experimental groups that visited either the portal or the digital library. We will therefore compare the responses from both experimental groups with the responses from the control group. To test the hypotheses that the experimental groups differ from the control group, we use the independent samples *t*-test (Blumberg, Cooper, & Schindler, 2008) for the means of the responses. As usual, the null hypothesis is that there is no difference in the means of the experimental group and the control group ($\mu_e = \mu_c$); the alternative hypothesis is that there is a difference in the means of the two groups ($\mu_e \neq \mu_c$).

4.1.1. Experimental group: Portal

The t-test starts with a test to examine if the populations of the experimental group and control group have equal variances. For all the statements that were analyzed the results of this test were not significant. This means that equal variances are assumed between the groups. The results of the t-test are displayed in Table 3. The table lists the statements, the difference between the means for the experimental and control group, and the p-value; for clarity, we have explicitly indicated if the means are different at the 0.05 and 0.01 level of statistical significance.

Table 3 Results of the t-test of the experimental group that visited the portal versus the control group

Factor	Question	$\mu_c - \mu_e$	p-value	Sig. at 5%	Sig. at 1%
Relative advantage	The Eurolyzer ST will improve my measurements	-0.4	0.141		
	Application of the Eurolyzer ST will help me to reduce costs	-0.6	0.024	+	
	The Eurolyzer ST gives me the possibility to do all my required measurements	-0.7	0.008	+	+
	The Eurolyzer ST offers benefits in comparison to my current measurement tools	-0.6	0.014	+	
Complexity	The skills required to use the Eurolyzer ST are too complex for our employees	0.7	0.019	+	
	The Eurolyzer ST is a complex product	0.6	0.037	+	
	I think that it is difficult to work with the Eurolyzer ST	0.4	0.157		
Compatibility	The Eurolyzer ST can be easily integrated in our organization	0	0.906		
	Application of the Eurolyzer ST is compatible with our values and beliefs	-0.1	0.634		
Observability	The benefits of application of the Eurolyzer ST will directly be visible	-0.7	0.007	+	+
Perceived risks	Application of the Eurolyzer ST is a risky investment	0.8	0.006	+	+
	The investment for using the Eurolyzer ST is too high	0.6	0.023	+	

	There will be aversion within our organization when the Eurolyzer ST is used	0.2	0.446	
Trialability	Before buying the Eurolyzer ST I would like to trial the product for a period	0.6	0.025	+

Wherever there is a significant difference, the influence of the ICT product on the factors is positive, i.e., the ICT product improves the attitude towards adoption of the innovation.

Three of the four items related to the factor of relative advantage show a significant difference at the 0.05 level; for all four items, the means for the experimental group are higher than the means for the control group. From this, we conclude that this factor is significantly different for this experimental group. In terms of complexity, the experimental group has a lower mean for the three items and for two out of three items the difference is significant at 0.05 level. Observability and trialability were tested using a single item; the difference in means for both items are significant. For the compatibility factor we find no significant differences. The factor of perceived risks has two of the three items with a statistically significant difference in the means for the two groups. The means are lower for the experimental group, i.e. the experimental group is in less agreement with the statements that label the innovation as risky.

Table 4 summarizes our conclusions from this analysis for each factor. The third column shows if we consider the hypothesis to be supported by the experiment.

Table 4 Overview of hypotheses (portal)

Hypothesis		**Support**
1.1	The opinion of individuals regarding the trialability of an innovation is positively influenced after visiting a portal that informs about the innovation	+
1.2	The opinion of individuals regarding the relative advantage of an innovation is positively influenced after visiting a portal that informs about the innovation	+
1.3	The opinion of individuals regarding the complexity of an innovation is positively influenced after visiting a portal that informs about the innovation	+
1.4	The opinion of individuals regarding the compatibility of an innovation is positively influenced after visiting a portal that informs about the innovation	-
1.5	The opinion of individuals regarding the perceived risks of an innovation is positively influenced after visiting a portal that informs about the innovation	+
1.6	The opinion of individuals regarding the observability of an innovation is positively influenced after visiting a portal that informs about the innovation	+

4.1.2. Experimental group: Digital library

The results of the statistical analysis are in Table 5.

Table 5 Results of the t-test of the experimental group that visited the digital library versus the control group

Factor	**Question**	$\mu_c - \mu_e$	**p-value**	**Sig. at 5%**	**Sig. at 1%**
Relative advantage	The Eurolyzer ST will improve my measurements	-0.2	0.544		
	Application of the Eurolyzer ST will help me to reduce costs	-0.2	0.311		

	The Eurolyzer ST gives me the possibility to do all my required measurements	-0.2	0.477	
	The Eurolyzer ST offers benefits in comparison to my current measurement tools	-0.4	0.179	
Complexity	The skills required to use the Eurolyzer ST are too complex for our employees	0.3	0.206	
	The Eurolyzer ST is a complex product	0.3	0.315	
	I think that it is difficult to work with the Eurolyzer ST	0.2	0.563	
Compatibility	The Eurolyzer ST can be easily integrated in our organization	-0.1	0.728	
	Application of the Eurolyzer ST is compatible with our values and beliefs	-0.3	0.202	
Perceived risks	Application of the Eurolyzer ST is a risky investment	0.6	0.044	+
	The investment for using the Eurolyzer ST is too high	0.6	0.018	+
	There will be aversion within our organization when the Eurolyzer ST is used	0.4	0.156	

As we can see from table 5, there are just two items that show a statistically significant difference between the experimental group that used the digital library and the control group. Two out of three items that related to perceived risk exhibit a significantly lower mean for the experimental group, which means that the experimental group evaluates the investment into the innovation as less risky.

Table 6 gives an overview of the hypotheses that were made. The third column shows whether we consider the hypothesis to be supported by the experiment.

Table 6 Overview of hypotheses

Hypothesis		**Support**
2.1	The opinion of individuals regarding the relative advantage of an innovation is positively influenced after visiting a digital library that informs about the innovation	-
2.2	The opinion of individuals regarding complexity of an innovation is positively influenced after visiting a digital library that informs about the innovation	-
2.3	The opinion of individuals regarding the compatibility of an innovation is positively influenced after visiting a digital library that informs about the innovation	-
2.4	The opinion of individuals regarding the perceived risks of an innovation is positively influenced after visiting a digital library that informs about the innovation	+

5. Conclusions

The goal of this project was to find an answer on the question if there are web based ICT products that can stimulate the adoption of innovations in the Dutch installation sector within the building industry. We reviewed the academic literature to identify the factors that influence the attitude towards the adoption of an innovation. We then designed and conducted an experiment to test our hypotheses that ICT can make a positive contribution towards the attitude of the (rather conservative) Dutch installation sector. Using a post-test only control group design, we executed the experiment with two specific ICT products: a custom-built Internet portal and an online digital library.

The response to the stimulus was positive: two-thirds of the installers that received the stimulus (a link to either the portal or the digital library) actually used the ICT product. This indicates the potential for ICT products to promote the adoption of innovations. The experimental group that used the portal showed a significant and positive change of attitude with regard to relative advantage, complexity, observability, trialability, and perceived risks of the innovation. The second experimental group, which was given an online digital library with information regarding the innovation, showed less change in attitude in comparison to the control group. Only the perception of risk was significantly lower than the perception of the control group.

Overall, we conclude that ICT products such as portals can have a significant and positive effect on the attitude towards adoption of innovations at the individual level. From the difference in response to the two different stimuli, we hypothesize that ICT products that offer a richer, more interactive environment that facilitate information exchange among the users are more suitable than a less interactive environment such as a digital library.

This project was based on a single innovation within a particular industry in a single country. Thus, we can not yet claim more general results, i.e. for other innovations, industries or economic regions. Also, the effort required to create the online environments used for the experiment means that we have been able to test just two instances of such ICT products.

The focus of the field experiment was on the technological factors which influences the adoption process of innovations. External and organizational factors did not feature in the experiment. This means that the possible influences of these factors were not examined during the research.

Both types of limitations (the scope of the experiment and the focus on the technological factors) could prove fertile starting points for further research. Additionally, the hypothesis that the interactive elements of the portal gave it an advantage over the more passive digital library warrants further investigation.

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