THE CHARACTERISTICS OF INNOVATION AND THE TECHNOLOGICAL DIFFUSION

Raul Florentin DRENȚA
Technical University of Cluj-Napoca
62A Dr. Victor Babeș St., 430083 Baia Mare, Romania
drenta.raul@gmail.com

Gabriela LOBONȚIU
Technical University of Cluj-Napoca
62A Dr. Victor Babeș St., 430083 Baia Mare, Romania
gabriela.lobontiu@cunbm.utcluj.ro

Abstract. *This paper demonstrates that the importance of each of the characteristics of innovation in the process of adoption of a new technology is different. We have done a hierarchy of these criteria elaborated by Rogers (2003), according to their importance as it is perceived by the Romanian adopters which have implemented projects of technological development. The five characteristics surveyed are (Rogers, 2003): (1) Relative advantage of the innovation; (2) Compatibility; (3) Complexity; (4) Trialability; (5) Observability. The purpose of this paper is to demonstrate the fact that, for a certain innovation, the general characteristics play a different role in the process of adoption or rejection of the technology. The conducted research is a descriptive one (by the nature of the analytical methods used), and it allows the outlining of some clear characteristics on the common perception of the characteristics underlying technology diffusion process. Specifically, the following objectives were targeted: (1) an AHP analysis regarding the importance that the characteristics of a particular technology show when it comes to the adoption process; (2) identification of potential differences on the general perception depending on the region of residence of the companies. The main method of investigation used to obtain the necessary data for the AHP analysis was the telephone interview. This was based on a predefined questionnaire, and it only pursued some key aspects needed to run the analysis. The results suggest the fact that the relative advantage is the strongest predictor of the diffusion rate of a particular technology. Also, there are clear differences between the observed units if we take into consideration the regions of provenance. These differences are present in both the rate of consent and the hierarchy of the criteria analyzed by the AHP method. The research brings a significant contribution in the area of the diffusion of technology, by the realized ranking itself, which can be exploited by the suppliers of new products on the market with the purpose of improving the diffusion rate. At the same time, based on our results, people can outline industrial marketing strategies, which come to meet the consumers' needs, according to the importance perceived by them.*

Keywords: *technology diffusion; technology adoption; characteristics of innovations; diffusion of innovation; AHP.*

Introduction

The process of diffusion of innovation is directly linked to four main factors: the characteristics of the innovation, the communication channels, the social system and the time factor. It has been established that certain new technologies follow different diffusion patterns in different countries. This fact is clear when we compare the developed economies with those in the process of development, the latter scoring lower diffusion rates (World Bank, 2008).

Rogers (2003), in his work, *Diffusion of Innovations*, states that the innovation spreads into society in the graphic form of an S-curved line. This is how we explain the fact that early adopters select the new technology, being followed by the majority of the system, until the new technology becomes common. Rogers (2003) suggests a five factor framework in order to explain the attributes of innovation. Based on these, the adoption speed of a specific technology can be predicted. He states that the relative advantage of technology, compatibility, trialability and observability are positively associated with the adoption, while the complexity is in a negative relationship with it, but empirically connected with each other by all the five dimensions. This paper aims to realize a ranking of these characteristics, based on the grade of importance that these have for the adopters.

Various studies which have applied and replicated the characteristics of innovation (Kitchen & Panopoulos, 2010; Lee, 2004; Zolkepli & Kamarulzaman, 2015), have modified them (Agarwal & Prasad, 1997), or even extended them (Moore & Benbasat, 1991, Kearns, 1992), offer an empirical support for the present research. Nevertheless, Peres, Muller and Mahajan (2010) underlines the fact that only few researchers have approached the subject of the diffusion of technology at a group level or at a state level and the way in which it differs when we speak of the adoption of a new technology. In order to meet these deficiencies, we structured our sample in such a manner that it can generate valid conclusions at the level of Romania, but also at the level of development regions.

The importance of knowing the reasons which make people adopt new technologies is also supported by other researchers, like Big and Lobonțiu (2008), Koc (2007), Petrovan, Ungureanu, Lobonțiu and Ravai-Nagy (2014) or Sun (2016). Furthermore, we need to know the process of adoption at a group level and its particular characteristics (Desmarchelier & Fang, 2016). The understanding of the reasons situated at the basis of the adoption of a new technology supplies clues about the way in which a new innovation must be introduced into the market.

When we study the diffusion of the technology, a recurrent question emerges. What makes people adopt a certain technology, rather than another one? If it is not only about the personal characteristics of the adopter, which are the other factors and what is their role? Research questions are essential because they offer a wide vision which can be explored by various methods.

We must know all these aspects due to the fact that, as Fisher and Wesolkowski (1999) observe, if the experience of the user with another innovation leads to a big discrepancy to their usual routine or their expectations, he will no longer be open to embracing the change. This resistance to new technologies leads to high opportunity

costs. They emerge due to the decrease in the efficiency, the increase in the number of errors and the waste of organizational resources.

The diffusion of technology

The diffusion of innovation is a theory which tries to find the answers to the questions "How?", "Why?" and "At what pace?" are the innovative ideas and new technologies disseminated. Bibliographical research have shown that the person who has popularized the most the theory of the diffusion of innovation was Everett Rogers, a Science of Communication teacher at the University of Ohio, by his book *The Diffusion of Innovation*, published in its first edition in 1962.

Everett Rogers (2003) considers that the diffusion is the process by which an innovation is communicated in time, by means of specific channels, among the members of a social system. In the opinion of the foregoing author, the diffusion is a special communication model in which the messages are centered on new ideas. He also defines communication as a process in which the participants create and share information with the purpose of acquiring mutual agreement.

The process of adoption can be summed up as being "*the process through which an individual (or other decision-making unit) passes from first knowledge of an innovation, to the formation of an attitude toward the innovation, to a decision to adopt or reject, to implementation and use of the new idea, and to confirmation of this decision*" (Rogers, 2003). Our research is focused only on the third stage. We are trying to identify the weight of each of the characteristics of innovation in the process of making the decision of adopting a new technology.

The first main element of the diffusion, dealt with in this paper, innovation- represents an idea, an object or a practice model which is perceived as a novelty by an individual or an entity (Rogers, 2003). Generally speaking, innovation represents a novelty, a change, and in the context of this paper represents a novelty for an individual or a company and it is directly dependent on the perception that set individual or set company has towards novelty. Thus, there is the possibility that an innovation to existing on the market for a long time without an individual having any connection to it or without him adopting it, case in which the novelty represents an innovation to set individual at the moment of adoption. Therefore, the novelty component of an innovation is not enough to define it, but, in Rogers's opinion, the defining elements of innovation are a novelty, persuasion and the decision of adoption.

The characteristics of innovation

This research analyses the characteristics of innovation from the perspective of the role that they play in the adoption of a new technology by the companies. The characteristics of innovation are the elements which have a significant impact on the decision-maker and determine the adoption of a new technology. The power of prediction of this variable is strong (Labby & Kinnear, 1985). The innovations which are more likely to be adopted by the users are the ones that are perceived as having a bigger relative advantage, a better compatibility and observability, with a higher rate

of trialability, but at the same time present a low complexity. In the context of this research, the characteristics of innovation make reference to the attributes of the technologies adopted by the companies from the analyzed sample.

The relative advantage

The relative advantage represents the grade up to which an idea is considered to be better than the precedent one. The rate of the relative advantage can be quantified by means of economic indicators, without them being, nevertheless, the only defining factors of the present attribute. The other factors are the social prestige, convention and the satisfaction it generates (Rogers, 2003). The relative advantage is given by the nature of the innovation itself. Previous studies (Kitchen & Panopoulos, 2003; Ho & Wu, 2011) have discovered that the relative advantage is one of the strongest predictors of the decision of adoption.

Compatibility

The compatibility represents the rate at which an innovation is perceived as being consistent with the values, experiences and needs of the potential adoptive entity of the innovation. There is a link of direct proportionality between the adoption of a new technology and the values of the social system in which it will be adopted. The social culture is an element of major importance in the adoption of an innovation; there are many cases in which it is necessary that the values of the members of the system and of the system itself be changed first in order to be able to successfully implement an innovation. Compatibility helps give meaning to a new idea so that it can be considered to be more familiar (Rogers, 2003). The compatibility perceived, together with the previous experience of the adopters, determines them to use the innovation correctly (Garcia & Calantone, 2002; Kitchen & Panopoulos, 2010; Rogers, 2003).

Trialability

Trialability represents the extent up to which an innovation can be tested, on a limited basis. Generally speaking, the innovations which can be applied at a small scale before being applied at a large scale are adopted faster than those which do not offer this possibility (Rogers, 2003). To personally test an innovation is an instrument by which an individual can give it purpose and find out how it works. In the case of an innovation, which can be designed in such a way as to be easily tested, it will have a high rate of adoption (Venkatesh, Morris, Davis & Davis, 2003).

Observability

The observability refers to the extent up to which the results of an innovation are visible for other individuals or other entities. The more visible the results of an innovation are, the higher the probability of it being adopted by more members of a social system. The visibility of the results makes a good discussion subject between the members of the social system and the trust that the opinion of a friend, neighbor or an

existing user of the innovation offers represents a determinant factor in the adoption of an innovation by another person (Rogers, 2003).

Complexity

Complexity represents the extent up to which an innovation is perceived as being difficult or hard to understand in order to be used. Any new idea can be classified by complexity - simplicity. Some innovations are clear to their potential adopters, others are not (Rogers, 2003). Complexity cannot be as important as the relative advantage or the compatibility for many innovations, but for some new ideas, complexity is a very important barrier against their adoption (Davis, 1989; Rogers, 2003).

Methodology of research

Having information regarding the degree of importance of the characteristics of innovation that the adopters allocate leads to a decrease in the degree of uncertainty. Thus, we are allowed to predict the behaviour with a higher precision by the regularity and fixing of the behaviour in a system.

The study realized by us has a descriptive character (by the nature of the methods of analysis used) which help researchers observe and identify work models in the relationship between individual variables and dependent variables. The independent variables are given by the 5 characteristics of innovation while the dependent variable is represented by the adoption of a new technology. Therefore, we assume that the characteristics of innovation play the part of a mediator in the relationship between the need of new technologies and the decision of adoption. The main purpose and the novelty that our study brings lies in differentiating between the weights of the characteristics of innovation in the process of making the decision of adoption. The present study set out from the following hypothesis:

The characteristics of innovation (relative advantage, compatibility, observability, trialability and complexity) influence in a different way the behaviour of adoption of a new technology by the industrial consumers.

The main research method used in order to obtain the necessary data for the analysis was the telephonic interview. This was based on a predefined questionnaire in which only the key aspects necessary for the realization of the analysis were pursued. Thus, the conversation time was successfully reduced to 5 minutes/ respondent. There was a pilot test among the targeted population. We considered it necessary to do this test in order to be able to generate a higher response rate. The potential problematic areas of the initial questionnaire were anticipated and eliminated.

We opted for this method holding into account the specific advantages (Bălan, 2006): (i) low cost; (ii) the imperative nature of the telephone; (iii) speed; (iv) cooperation; (v) the final response rate; (vi) obtaining responses to sensitive questions.

The respondents were selected by restricted sampling based on the reasoning from the document made available to the public by the Ministry of European Funds “Contracts

General Basic Information" which includes financing projects from POS POR in the years 2009 – 2013 for all key actions and major intervention domains.

On the first phase we selected only DIM 4 key action 3 and, out of a total of 1,726 projects, we made an analysis which showed the fact that a number of 254 projects targeted the acquisition of productive technologies and, therefore, correspond to the criteria of selection of the unities of observation. Out of these, we excluded the production systems with their headquarters in the Maramureș County, N-W development area. This decision was taken on the basis of spatial proximity of the company to the place where the research takes place (Baia Mare), therefore facing the possibility of realizing semi-structured interviews with the representatives of these companies with low traveling costs. A number of 82 companies were contacted with the help of contact data made available by MFE. Out of these, 41 companies gave their consent for the interview, hence the achievement of a response rate of 50%.

We must understand from the very beginning the limitations of this research. They come from the socio-psychological paradigm on which the whole study of the technological acceptance is based. The unit of analysis, in this paradigm, is the action between a subject (the interviewed person) and an object (the adopted technology). For the present study, the social and cultural side was completely ignored. We only took into account the studied independent variables (the characteristics of innovation) which sit at the basis of set action (the adoption of the technology). Also, only the subjects that were known to us for having adopted new technologies were investigated. The addition of new variables would make the examination of the way in which people make decisions even more difficult.

Results

For the manipulation and analysis of the data we used BPMSG AHP Online System and the AHP template (Analythical Hierarchy Process) made by Goepel (2013). This method was elaborated by SAATY, in 1980, and it represents a technique structured for the solving of complex decisional problems, which is based on mathematical results.

The ranking was done for the five characteristics of innovation which influence the adoption of a particular technology (independent variable). A number of 35 rankings were analyzed on the occasion of the conducted research. The AHP scale used in the analysis, with reference to the intensity of the importance, is presented in Table 1.

Table 1. AHP Used Scale

Intensity		Definition	Explanation
1		Equal importance	The two evaluated criteria contribute equally to attaining the objective
3		Moderate importance	One of the criteria is slightly privileged compared to the other one.
5	Strong importance	One of the criteria is strongly privileged compared to the other one	
7	Very strong	Very high demonstrated importance of one criteria over the	

	importance	other one
9	Extreme importance	Absolute importance of one element compared to the other
Values 2, 4, 6 and 8 are intermediate values which can be used in order to represent judgment shades in completing the five basic evaluations.		

The results of the study are presented in Figure 1.

	Level 1	Global priorities
Relative Advantage	0.4551	45.5%
Compatibility	0.2246	22.5%
Trialability	0.0758	7.6%
Observability	0.0868	8.7%
Complexity	0.1557	15.8%

Figure 1. Result of the study (capture BPMSG AHP Online System)

The values of the consistency coefficient for this study is 0.5% or 0.05 lower than 0.1, for all analyzed cases, which denotes the fact that the decisional matrix has been done correctly.

The consolidated results are presented in Figure 2.

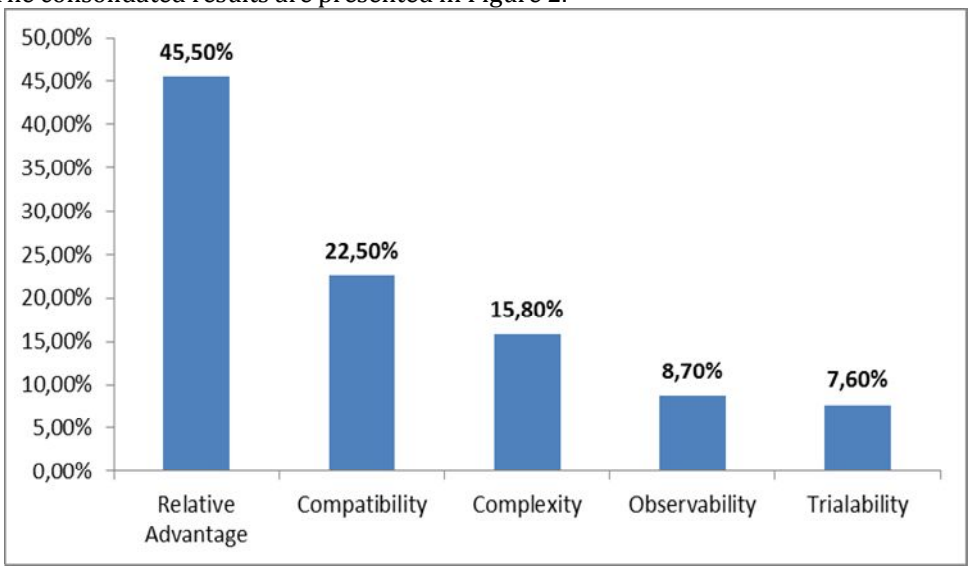

Figure. 2. Results of the AHP analysis done at the whole sample level

The consent rate of the group is 67.3%. This determined us to also investigate, using the same method, the opinion of the subjects from the provenience region.

For this action, 3 samples of research were created. A sample made up of 10 respondents coming from the N-W region, the second made up from a number of 9 respondents with headquarters in the N-E region, and the last sample, with a total population of 17 respondents, which have their headquarters in other development areas of Romania.

The matrix of the comparisons between technologies for the N-W respondents is rendered in Figure 3.

		Relative Advantage	Compatibility	Complexity	Trialability	Observability
		1	2	3	4	5
Relative Advantage	1		2 1/4	4 1/2	4 2/7	2
Compatibility	2	4/9		2	2 2/5	1 3/7
Complexity	3	2/9	1/2		1 3/7	3/4
Observability	4	1/4	3/7	5/7		1
Trialability	5	1/2	5/7	1 1/3	1	

Figure 3. Matrix of the N-W comparisons

The results of the analysis present a consistency coefficient of 1.5% (0.015) which indicated the correctitude of the construction from a methodological point of view. The rate of consent is 56.5%.

The matrix of the comparisons between technologies for the N-E respondents is rendered in Figure 4.

		Relative Advantage	Compatibility	Complexity	Trialability	Observability
		1	2	3	4	5
Relative Advantage	1		3 3/4	2 3/7	7 1/2	6 2/3
Compatibility	2	1/4		5/7	4 1/2	3 2/5
Complexity	3	2/5	1 2/5		4 2/9	2 8/9
Observability	4	1/7	2/9	1/4		2/3
Trialability	5	1/7	2/7	1/3	1 1/2	

Figure 4. Matrix of the N-E comparisons

The results of the analysis present a consistency coefficient of 1.6% (0.016) which indicates the correctitude of the construction from a methodological point of view. The rate of consent is 83.0%.

The matrix of the comparisons between technologies for the respondents from the rest of the regions is rendered in Figure 5.

		Relative Advantage	Compatibility	Complexity	Trialability	Observability
		1	2	3	4	5
Relative Advantage	1		2	2 4/5	5	6
Compatibility	2	1/2		1 1/2	3 4/9	3 2/5
Complexity	3	1/3	2/3		2 1/2	2 1/2
Observability	4	1/5	2/7	2/5		1 1/3
Trialability	5	1/6	2/7	2/5	3/4	

Figure 5. Matrix of comparisons for the rest of the development regions

General conclusions of the study and discussions

Based on the AHP conducted analysis and the objectives of this study, the following conclusions can be drawn:
1. With a rate of consent of 67.3%, we can state that the main characteristics of innovation influence in a different manner the process of adoption, when we speak about the diffusion of a particular technology for the present sample. Therefore, we succeeded in demonstrating the scientific hypothesis from which with set out. The rate of importance that the characteristics have in the decision of adoption is:
- the relative advantage of the technology- 45.5%
- compatibility- 22.5%
- the complexity of the technology- 15.8%
- observability- 8.7%
- trialability- 7.6%

Thus, we are confirmed the results of other similar research in the field, like those of Kitchen and Panopoulos (2010), or those of Ho and Wu (2011). Compliant to the obtained results, we can state that the relative advantage is the strongest predictor of the diffusion rate of a particular technology.

2. With a rate of consent of 56.5%, we can state that the importance that the characteristics of innovation have, for the companies from the N-W region, when we speak about the diffusion of a particular technology for the present sample is:
- the relative advantage of the technology – 42.3%
- compatibility – 21.2%
- observability – 15.2%
- complexity of the technology – 11.3%
- trialability - 10.0%

With a grade of consent of 83.0% we can state that the importance that the characteristics of innovation, for the companies form the N-E region, when we speak about the diffusion of a particular technology for the present sample is:
- the relative advantage of the technology – 49.3%
- complexity of the technology – 21.0%

- compatibility – 18.0%
- observability – 6.7%
- trialability – 4.9%

Analysing the results obtained for the N-E region, we can observe that the result are in contradiction with Davis's (1989) statements, and the complexity of the technology seems to have a higher influence rate over the process of making the decision of adoption.

4. There are clear differences between the observed units if we take into consideration the regions of provenance. These differences are present in both the rate of consent and the hierarchy of the criteria analyzed by the AHP method. These results, correlated to the conclusions of the studies conducted by Desmarchelier and Fang (2016), entitle us to believe that, in Romania, the process of diffusion of the technology is highly influenced by different cultural factors which are present territorially, at a group level.

As a consequence of these differences between the results, we consider it necessary that we increase the number of participants in the research and the conducting of individual studies at a group level in all the development regions of Romania. Also, we need to take into consideration Yaacob and Yusoff's (2014) suggestions, who recommends a revision of the characteristics of innovation.

From what we know so far, it is the first time when a hierarchy of the importance that each of the specific characteristic of innovation has for the decision-maker is made. Our contribution to the specialized literature dealing with this subject comes to fill the conducted research in the domain. Thus, we can lower the grade of incertitude faced by a company witch wishes to launch innovative products on the market, if it takes into consideration, from the projecting step, the importance of the characteristics of innovation for each segment of the targeted market.

Summarizing the foregoing conclusions, we can state that, for the decision-maker, the general characteristics of innovation weight differently.

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