

# ENABLERS AND BARRIERS OF TECHNOLOGY TRANSFER IN ROMANIAN ORGANIZATIONS IN THE CONTEXT OF THE KNOWLEDGE-BASED ECONOMY: A FACTOR ANALYSIS

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## Abstract

The research presented in this paper aimed to analyze the influence that certain factors (barriers and enablers) have on the processes of technology transfer carried out in research organizations and in the productive sector in Romania, in the context of the knowledge-based economy. It was carried out using a questionnaire-based survey answered by both researchers and employees from other organizations in Romania (industry companies, employers' associations and producers from various fields of activity, NGOs). Factor analysis of the technology transfer enablers highlighted three latent factors: the environment of the technology transfer processes, the synergy effects of the technology transfer processes and the financing. Factorial analysis of barriers also revealed three latent factors: improper focus, difficulties in financing and sophistication and level of knowledge involved.

**Keywords:** technology transfer, enablers; barriers; factor analysis

## 1. INTRODUCTION

The knowledge-based economy is a type of economy in which the success of organizations is based on their ability to quickly incorporate into their own products and services the results of research and development. The implementation of innovation requires the acquisition of new technologies, using the technology transfer technique. The sector that is primarily called upon to respond with an offer corresponding to this continuous and accelerated upward growth is the research-development and innovation sector. Each country perceives its own system of research - development and innovation as a generator of knowledge, results, new or improved processes that through technological transfer processes are capitalized by the economic environment. Technology transfer processes thus become part of the general knowledge transfer processes.

The effectiveness of technology transfer processes is conditioned by several factors that the literature divides into barriers (Mazurkiewicz and Poteralska, 2017; Ciocoiu et al., 2020) and enablers. The purpose of this article

ENABLERS AND BARRIERS OF TECHNOLOGY TRANSFER IN ROMANIAN ORGANIZATIONS IN THE  
CONTEXT OF THE KNOWLEDGE-BASED ECONOMY: A FACTOR ANALYSIS

is to analyze the influence that certain factors (barriers and enablers) have on the technology transfer processes carried out in research organizations and in the productive sector in Romania. The article has, from the perspective of the research purpose, the following objectives:

- Identifying the barriers and enablers relevant for the technology transfer processes within the Romanian organizations.
- Carrying out a factor analysis (FA) to reveal which are the main influencing factors that appear in the technology transfer processes.
- Contextualizing the influence of factors in the relationship between the national research-development and innovation system and the productive sector.

The factorial analysis of the enablers and barriers of the technological transfer processes is the first research of this type carried out for the organizations in the field of research - development and innovation and in the productive sector in Romania.

## 2. LITERATURE REVIEW

In the literature, the issue of technology transfer but also of barriers and enablers has been the subject of several previous researches. Technology transfer processes were considered as a source of competitive advantage for organizations that benefited from the results of these processes (Mansfield, 1975). Also, in Romania, studies conducted mainly on SMEs in certain regions of the country have revealed the propensity of companies to obtain competitive advantage based on differentiation (Popa, Simion, Ștefan and Albu, 2019).

Malik (2002) describes the positive and negative factors that influence the technology transfer process. Waroonkun and Stewart (2008) starts from the premise that the transfer process is influenced by the political and social environment. Mojaveri et al. (2011) considered that there are four main groups of barriers that may arise in terms of technology transfer: technical, attitudinal, cultural, and market barriers. Gilsing et al. (2011) conducted a research on the differences that exist between various industries regarding the mechanisms used mainly for technology transfer and the barriers specific to each industry. Research using a questionnaire-based survey involving representatives of entities involved in technology transfer processes found that industries use specific technology transfer mechanisms but face a number of common barriers.

Khabiri, Rast and Senin (2012) proposed a model that represents an extension of Malik's model by taking into account the legal environment that influences technology transfer. Bozeman, Rimes and Youtie (2014) start from the premise that the efficiency of the process is a fundamental factor that determines the success of technology transfer. The efficiency of the technology transfer process is a first condition that is especially required by the beneficiary organizations of the technology transfer processes.

Kalnins and Jarohnovich (2015) describe the formal and informal elements of technology transfer. Nijboer (2015) conducted an analysis of the barriers specific to technology transfer in the field of brain-computer interfaces. His study revealed that there are three specific barriers to technology transfer in this area: the need to create a usable technology, the small size of the potential user group of new technology in the field and the need to include potential users in the design process.

Mazurkiewicz and Poteralska (2017) structured the main barriers of technology transfer into: technical, organizational-economic and system barriers. Arenas and Gonzales (2018) performed an analysis of technology transfer models identifying quantitative and qualitative models. MacNeil et al.(2019) conducted a research to identify policy and regulatory barriers and enablers of adoption of health technologies in Canada.

So far, no FA have been performed regarding the barriers and enablers of technology transfer in Romanian organizations. This missing element of the technology transfer analysis at national level is covered by the research results presented in this paper.

### 3. RESEARCH METHODOLOGY

The analysis of the current situation of the technology transfer process in Romania was focused on the identification of the favorable factors of this process (enablers), but also of the barriers, respectively of the elements that prevent / hinder its development in optimal parameters.

To determine the intensity with which each of the enablers / barriers is perceived, a questionnaire-based survey was carried out. An online questionnaire was sent to both researchers and employees from other organizations in Romania (industry companies, employers' associations and producers from various fields of activity, NGOs) involved into the technology transfer process. Between April and May 2020, 103 valid answers were received, almost two third of them (66.01%) representing entities that transfers the technology, 27.18% - entities that assimilates the technology, while 2.91% - entities regulating the technology transfer process and 3.88% Where involved in different ways in technology transfer.

The questionnaire included 19 questions designed to capture different aspects off technology transfer process in Romania, from which in this paper only those related to factors enabling and those hindering this process (see table 1 and table 2) were analyzed. Respondents were informed on the purpose of the research, their answers are anonymous and data collected will be used only in scientific purposes.

In addition to the analysis of each specific element, relevant information can be obtained by grouping and analyzing them in the form of major areas / factors. In this sense, both for the elements that favor the technology transfer processes and for those that make them difficult, through the factor analysis, a smaller number of factors was identified under which to group the specific elements identified in the previous stage.

Given that the items that make up the two scales were formulated during this research, to determine the latent structure of the two scales and how to group the variables into factors, we opted for exploratory factor analysis, Principal Axis Factoring - as a method of factor extraction and Promax - as a method of rotation.

Although the number of cases analyzed is only 103, the minimum criteria for performing FA are met, both in terms of the number of cases and the ratio between it and that of the variables involved in EFA. At the same time, the other conditions (Hair, et al., 2014; Tabacknick & Fidell, 2007) necessary to meet the AFE were verified, including the values of the Barlett and Kaiser - Meyer - Olkin (KMO) test.

In order to determine the number of factors extracted for each scale, as a basic criterion, the eigenvalues were taken into account, taking into account all factors whose values were greater than 1. In order to refine the final solutions, in addition to this criterion, the scree plot graphs, the percentages of the extracted common variance, but also the conceptual significance of the extracted factors were also studied.

### 4. RESEARCH RESULTS

#### 4.1. *Descriptive statistics*

The most important facilitators of the technology transfer processes are considered by the respondents, according to the data presented in Table 1, the European financing of the research and development system and of the technology transfer processes ( $M = 4.359$ ;  $SD = 0.969$ ) and the national public financing of the research and development system and technology transfer processes ( $M = 4.359$ ;  $SD = 0.969$ ). The financing of the research and development field and implicitly of the technology transfer processes is felt by the respondents especially as a potential facilitator since in Romania the financing of the research and development system is one of the lowest in Europe (and in some years even the lowest in Europe). On the other hand, the consideration of national and European funding as the main facilitators of technology transfer processes shows that organizations involved in technology transfer processes either do not have the resources allocated for this purpose (in the case of innovative SMEs) or, if they have resources, do not want to allocates them to these processes in Romania.

ENABLERS AND BARRIERS OF TECHNOLOGY TRANSFER IN ROMANIAN ORGANIZATIONS IN THE CONTEXT OF THE KNOWLEDGE-BASED ECONOMY: A FACTOR ANALYSIS

TABLE 1 -ENABLERS OF TECHNOLOGY TRANSFER PROCESSES

| Enablers  | Mean  | SD    | Var(X) |
|---|-------|-------|--------|
| European funding of the research and development system and technology transfer processes                                       | 4.359 | 0.969 | 0.938  |
| National public funding of the research and development system and technology transfer processes                                | 4.359 | 0.969 | 0.958  |
| The rate of renewal / modernization of products / services / works on the market on which the organization operates             | 3.757 | 1.150 | 1.323  |
| Share of applied research and technological development activities in all research and development activities at national level | 3.641 | 1.170 | 1.370  |
| Number of entities specialized in technology transfer existing at national level  | 3.612 | 1.096 | 1.201  |
| The positive impact of the technological transfer processes previously carried out on the activity of the organization          | 3.602 | 1.123 | 1.262  |
| Intellectual property law   | 3.583 | 1.125 | 1.265  |
| Number of international technology transfer entities  | 3.456 | 1.144 | 1.309  |
| Previous relationships between entities involved in technology transfer processes   | 3.427 | 1.072 | 1.149  |
| Involvement of the organization's competitors in similar technology transfer processes  | 3.282 | 1.183 | 1.400  |

Source: own calculations with SPSS 27.0 (IBM Corp., 2020)

The financing as a facilitator precedes, according to the opinions expressed by the respondents, both the rate of renewal / modernization of products / services / works on the market on which the organization operates and the share of applied research and technological development in all research and development activities nationwide. Romanian organizations seem less connected to the pace of renewal / modernization of products / services / works globally and do not perceive their own sustainability as dependent on the ability to synchronize with this rate. The number of entities involved in technology transfer and the positive impact of technology transfer processes previously carried out on the organization's activity are facilitators with a relatively close importance to the pace of renewal / modernization of products / services / works or the share of applied research and technological development.

TABLE 2 -BARRIERS OF TECHNOLOGY TRANSFER PROCESSES

| Barriers  | Mean  | SD    | Var(X) |
|---|-------|-------|--------|
| Focusing the evaluation system of the entities from the research and development system mainly on the results of research - development and less on their technological transfer to industry                      | 4.068 | 0.963 | .927   |
| Focusing the evaluation system of research projects mainly on the results of research - development and less on their technological transfer to industry  | 3.990 | 1.034 | 1.069  |
| Focusing organizations in the field of research and development and innovation mainly on the dissemination of research results before patenting without having a correspondent in the demand of industry partners | 3.874 | 1.177 | 1.386  |
| Lack of financial resources at the level of Romanian enterprises, especially at the level of SMEs   | 3.786 | 1.063 | 1.130  |
| Difficulties in accessing financing for technology transfer (equity, loans, venture capital funds, etc.)  | 3.767 | 1.040 | 1.082  |
| Reluctance / lack of interest of companies regarding the transfer of research results in industry   | 3.728 | 1.238 | 1.533  |
| Lack of promotion of research results that could be the subject of technology transfer  | 3.641 | 0.917 | .840   |
| The asymmetry between the expectations of the partners involved in the technology transfer process  | 3.544 | 1.083 | 1.172  |
| Reduced applicability of research and development results   | 3.476 | 1.136 | 1.291  |
| The low commercial potential of the results of applied research and technological development   | 3.320 | 1.173 | 1.377  |
| The high level of tacit knowledge involved in technology transfer processes   | 3.165 | 1.030 | 1.061  |
| The degree of sophistication of new technologies  | 3.117 | 1.096 | 1.202  |

Source: own calculations with SPSS 27.0 (IBM Corp., 2020)

The least important facilitators, according to the respondents, are the previous relationships between the entities involved in the technology transfer processes ( $M = 3.427$ ;  $SD = 1.072$ ) and the involvement of the organization's competitors in similar technology transfer processes ( $M = 3.282$ ;  $SD = 1.183$ ). The large number of responses from public organizations explains why competitive pressure is not felt as a key facilitator of technology transfer processes. Other facilitators of technology transfer processes are the fiscal facilities for technology transfer and the number of researchers involved in technology transfer activities.

The focus of the evaluation system of the entities from the research and development system mainly on the results of research and development and less on their technological transfer to industry ( $M = 3.282$ ;  $SD = 1.183$ ) is, according to the data in Table 2, the main barrier of the technology transfer processes. If such an assessment were the exclusive expression of the opinions of the private respondents, it could be considered as relatively normal. Surprisingly, this barrier is the first in the opinion of respondents, even if they come mostly from research institutes and universities. Therefore, this barrier is followed in the preferences of the respondents by two other relatively similar ones: focusing the evaluation system of research projects mainly on the results of research - development and less on their technological transfer to industry; focus of the organizations in the field of research and development and innovation, especially on the dissemination of research results.

Other barriers whose intensity is less felt compared to the first three are those related to the lack of resources to finance technology transfer processes, the disinterest of some of the key actors involved in these processes and possible asymmetries between the expectations of these actors. Respondents do not seem to feel that the high level of tacit knowledge involved in technology transfer processes and the sophistication of new technologies are an obstacle. Other barriers mentioned by respondents are:

- bureaucracy;
- demotivating researchers for lack of involvement in technology transfer;
- inconsistency of the legislative framework;
- non-existence of specialized departments in technology transfer in enterprises;
- lack of interest of researchers for assimilation in production;
- poor training of enterprise staff.

#### 4.2. Factor analysis

Following the methodology described above, FA of the 10 variables that measure the extent to which respondents feel various elements as facilitators of the technology transfer process highlighted the existence of three latent factors that encompass 62.11% of their common variance. As can be seen in Table 3, all three extracted factors explain a considerable part of the common variance (between 8.08% - factor 3 and 35.31% - factor 1), have loadings higher than 0.6 and a good internal consistency (with values of the Cronbach Alpha coefficient higher than 0.8), which suggests that the extracted factors represent an adequate solution of AFE.

TABLE 3 ENABLERS - PATTERN MATRIX

| Variables              | Factors      |              |              |
|------------------------|--------------|--------------|--------------|
|                        | 1            | 2            | 3            |
| Extracted variance (%) | 35.306       | 18.730       | 8.078        |
| Cronbach Alpha         | 0.853        | 0.816        | 0.816        |
| @17.Enblers_g          | <b>0.810</b> | 0.053        | -0.021       |
| @17.Enblers_h          | <b>0.767</b> | -0.019       | -0.047       |
| @17.Enblers_i          | <b>0.719</b> | -0.033       | 0.102        |
| @17.Enblers_j          | <b>0.701</b> | -0.073       | -0.012       |
| @17.Enblers_f          | <b>0.690</b> | 0.067        | 0.002        |
| @17.Enblers_c          | -0.112       | <b>0.867</b> | 0.038        |
| @17.Enblers_d          | 0.136        | <b>0.804</b> | -0.041       |
| @17.Enblers_b          | 0.071        | -0.058       | <b>0.843</b> |
| @17.Enblers_a          | -0.053       | 0.070        | <b>0.824</b> |

Source: own calculations with SPSS 27.0 (IBM Corp., 2020)

ENABLERS AND BARRIERS OF TECHNOLOGY TRANSFER IN ROMANIAN ORGANIZATIONS IN THE CONTEXT OF THE KNOWLEDGE-BASED ECONOMY: A FACTOR ANALYSIS

Factor 1 is the *Environment* of technology transfer processes. Under this factor were grouped five variables that measure respondents' perception of the contribution that previous relationships between entities involved in technology transfer processes, the positive impact of technology transfer processes, the involvement of competitors in similar processes and renewal rate of products / services have as facilitators of this trial. This factor includes the largest proportion of the common variance of the observed variables (35.306%).

Factor 2 is represented by the *Synergy Effect*. Under this factor, two variables were grouped that measure the respondents' perception regarding the contribution of the number of entities specialized in technology transfer existing at national and international level have as and enablers of this process. This factor encompasses 18.730% of the common variance of the observed variables.

Factor 3 is *Financing*. Under this factor, two variables were grouped that measure respondents' perception of the contribution that European funding of the research and development system and technology transfer processes and the national public funding of the research and development system and technology transfer processes have as enablers. Surprisingly, this factor encompasses the smallest proportion of the common variance of the observed variables (8.078). The following table contains elements of descriptive statistics of the three extracted factors.

TABLE 4 - FACILITATING FACTORS OF THE TECHNOLOGY TRANSFER PROCESS

|                | Mean  | SD    | (1)     | (2)   |
|----------------|-------|-------|---------|-------|
| Environment    | 3.530 | 0.898 |         |       |
| Sinergy effect | 3.534 | 1.030 | 0.365** |       |
| Financing      | 4.359 | 0.895 | -0.138  | 0.191 |

Source: own calculations with SPSS 27.0 (IBM Corp., 2020)

As can be seen, financing is perceived by respondents as the strongest facilitator of the technology transfer process (M = 4.359, DS = 0.895), the other two factors being perceived with a much lower intensity and almost equal to each other. There is a correlation between the first factor and the second, which has an important theoretical significance, since the relationship between the environment of the transfer processes and the synergy effect of the number of entities specialized in technology transfer existing at national and international level is an obvious one. The relatively small sample size affects the statistical significance of the link observed between the first two factors considered in the FA for enablers.

The 11 variables that measure the intensity with which respondents feel various elements as barriers to the technology transfer process were subjected to FA, highlighting three latent factors that encompass 58.96% of their common variance.

TABLE 5 BARRIERS - PATTERN MATRIX

| Variables              | Factors      |              |              |
|------------------------|--------------|--------------|--------------|
|                        | 1            | 2            | 3            |
| Extracted variance (%) | 33.805       | 14.265       | 10.891       |
| Cronbach Alpha         | 0.824        | 0.774        | 0.794        |
| @18.Barriers_h         | <b>0.987</b> | -0.091       | 0.004        |
| @18.Barriers_g         | <b>0.858</b> | 0.022        | -0.054       |
| @18.Barriers_i         | <b>0.762</b> | 0.028        | 0.017        |
| @18.Barriers_a         | <b>0.407</b> | 0.043        | 0.145        |
| @18.Barriers_d         | 0.020        | <b>0.872</b> | -0.060       |
| @18.Barriers_e         | 0.085        | <b>0.748</b> | -0.008       |
| @18.Barriers_c         | -0.008       | <b>0.683</b> | 0.015        |
| @18.Barriers_b         | -0.116       | <b>0.454</b> | 0.119        |
| @18.Barriers_l         | -0.005       | 0.000        | <b>0.919</b> |
| @18.Barriers_k         | 0.064        | 0.044        | <b>0.691</b> |

Source: own calculations with SPSS 27.0 (IBM Corp., 2020)

Factor 1 is *Improper focus*. Under this factor were grouped four other variables that measure respondents' perception of the contribution that the negative impact of the focus of the evaluation system of the entities from the research and development and the research projects mainly on research results and less on their technology transfer to industry, the focus of organizations in the field of research and development and innovation mainly on the dissemination of research results before patenting without having a correspondent in the demand of industry partners, reluctance / lack of interest of companies regarding the transfer of research results in industry are barriers to this process.

Factor 2 is *Difficulties in financing*. Under this factor were grouped four variables that measure respondents' perception of the contribution that the negative impact of difficulties in accessing financing for technology transfer (equity, loans, venture capital funds, etc.), lack of financial resources at the level of Romanian enterprises, especially at the level of SMEs, the lack of promotion of research and development results and the reduced applicability of research and development results.

Factor 3 is represented by *Sophistication and level of knowledge Involved*. Under this factor were grouped two variables that measure respondents' perception of the contribution that the negative impact of the high level of tacit knowledge involved in technology transfer processes and the degree of sophistication of new technologies have as barriers to this process.

As can be seen in Table 5, all three extracted factors explain a considerable part of the common variance (between 10.89% - factor 3 and 33.80% - factor 1), with two exceptions, they have loadings higher than 0.6 and good internal consistency (with Cronbach Alpha values greater than 0.7), suggesting that the three factors extracted represent an appropriate solution for the barriers to the technology transfer process.

Table 6 contains elements of descriptive statistics of the three extracted factors.

TABLE 6 - BARRIERS TO THE TECHNOLOGY TRANSFER PROCESS

|   | Mean  | SD    | (1)     | (2)     |
|---|-------|-------|---------|---------|
| <i>Improper focus</i>                                 | 3.915 | 0.896 |         |         |
| <i>Difficulties in financing</i>                      | 3.667 | 0.805 | 0.304** |         |
| <i>Sophistication and level of knowledge Involved</i> | 3.141 | 0.969 | 0.275** | 0.273** |

Source: own calculations with SPSS 27.0 (IBM Corp., 2020)

As can be seen, the focus is perceived by respondents as the most important barrier of the technology transfer process (M = 3.915, DS = 0.896), the other two factors being perceived with a lower intensity. There is a correlation between the first factor and the second, which has an important theoretical significance, since the relationship between the improper focusing of the research and development system and difficulties in financing is obvious. Significant are, at least from a theoretical point of view, the correlations between improper focus and the sophistication and the level of knowledge. Inadequate focus of the research and development system in relation to the objective needs of technology transfer processes leads to potential barriers to the level of knowledge that this type of process involves.

## 5. CONCLUSIONS

As so far no analysis has been performed on the barriers and facilitators of technology transfer in Romanian organizations, the analysis of the current situation of the technology transfer process also took into account the identification of factors favoring this process (enablers), but also barriers, respectively to the elements that prevent / hinder its development in the optimal parameters. Also, the intensity with which each of the enablers / barriers is perceived by each category of stakeholders involved in the technology transfer process was determined.

European funding for the research, development and innovation system and national public funding for the research, development and innovation system are considered by respondents to be the most important facilitators of technology transfer processes. Funding as a facilitator precedes both the rate of renewal / modernization of products / services / works on the market on which the organization operates and the share

of applied research and technological development activities in all research-development and innovation activities.

The factor analysis of the variables that measure the extent to which respondents feel various elements as facilitators of the technology transfer process highlighted the existence of three latent factors that encompass most of their common variance. These are the environment of technology transfer processes, the synergy effect of the number of entities involved in technology transfer processes and financing. Funding as a factor that conditions the success of technology transfer processes has been directly revealed by other previous research (Mock, 1974).

Regarding barriers, factor analysis highlighted three latent factors that encompass most of their common variance: improper focus, difficulties in financing and sophistication and level of knowledge involved. Difficulties in financing, as a factor, groups a series of variables, among which are in addition to the actual financing difficulties, the lack of promotion of development research results or their reduced applicability. From this point of view of the barriers related to the market, the conducted research confirms some of the elements highlighted by Mojaveri et al. (2011).

The research has three categories of implications: managerial (for the management of the national research-development system), technical-scientific and commercial for the organizations in the national system-research-development and innovation that are involved in technology transfer processes. For the management of the national research-development system, the knowledge of the barriers and enablers of the technological transfer creates the possibility to modify the content and structure of the national research-development programs and the legislation in the field so that the effect of certain barriers is not felt at the same intensity. For the organizations involved in the technology transfer processes, the technical-scientific and commercial implications are related to the fact that the research carried out provides the premises for the recalibration of guidelines in the field of applied research and technological development.

The research conducted had two important limitations. The first limit is the one regarding the size and structure of the sample in which not all the categories of actors involved in the technological transfer processes in Romania are represented uniformly. The second limit comes from the assumed purpose of the research to study the technological transfer on the relationship between the national research-development system and the productive sector. Therefore, future research will take into account a broader representation of the entities involved in technology transfer processes carried out in Romania. Another future direction of research is to study the barriers and facilitators of technology transfer processes that take place between local and multinational companies in Romania.

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