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# SUCCESS FACTORS IN THE PROCESSES OF COMMERCIALIZATION OF KNOWLEDGE — RELATIONAL AND COMMUNICATIONAL ASPECT

# SUCCESS FACTORS IN THE PROCESSES OF COMMERCIALIZATION OF KNOWLEDGE — RELATIONAL AND COMMUNICATIONAL ASPECT

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## Summary

The aim of the article is to identify the ways of communication that increase the chances of researchers being at different stages of a scientific career to collaborate with companies. Inefficient communication and the closeness of research units to the environment are considered to be the greatest barriers to the development of R&D cooperation between science and industry[1]. Lack of knowledge results in the formation of negative stereotypes on both young and senior researchers. The former are considered incompetent, while the latter — too little interested in cooperation with companies or holding high financial expectations. However, according to the research outcomes companies prefer to invest their resources in studies carried out by experienced and acclaimed scientists[2]. The higher status has a researcher, the greater variety of contacts with industry he possess[3]. Thanks to contacts developed throughout their scientific career senior researchers usually cooperate with business more frequently[4]. In turn, young scientists are more open to undertaking new forms of cooperation. However, in some cases they have to reduce their engagement as they are overloaded by teaching duties[5].

Considering presented evidence, I assumed that the way of sharing the research findings, that resulted in establishing cooperation with industry, varied at different stages of scientific career. In order to verify this assumption, I used logit regression. The first model constructed examines how different ways of communication affect the likelihood of cooperation with companies in the case of postdoctoral researchers, and the second model - in the case of more experienced researchers, i.e. associate professors and professors. In addition, there is a set of variables that are controlled in each of the models (such as: a type of scientific unit that employed a researcher, a field of science that a researcher represented and a type of research that she/he carried out). I performed the analyses on data obtained from 1960 scientists who participated in a nationwide survey conducted by CAWI and realized by National Information Processing Institute in 2013.

The results indicate that associate professors and professors are more likely to cooperate with industry if they establish direct contacts with companies and take part in conferences and symposia in which entrepreneurs participate. Scientists with a doctoral degree have a wider range of communication tools that positively affecting the possibility of their engagement in cooperation with industry; apart from the aforementioned methods it also includes sending offers and publishing in professional or industry press. It is worth to mention that researchers' activity in the field of scientific publications influences their chances of cooperation negatively.

**Keywords: communication, R&D cooperation, scientist, postdoctoral researchers, associate professors, professors, logit regression**

## Introduction

The development of the concept of entrepreneurial science and the entrepreneurial scientist points to the change in the mission of scientific units in the research dimension. In the double helix model proposed by Henry Etzkowitz and Loet Leydersdorff, the task of scientific units is to take up research representing value for the industry and contributing this way to economic development[6]. This means that scientists are expected to be active in the area of transfer of knowledge to the economy and conducting research works supporting innovation.

Thanks to cooperation with entrepreneurs scientists gain access to practical knowledge, which they can later use for educational purposes. What's more, contacts with the industrial sector make it easier for them to find sponsors and raise funds for research[7]. At the same time for companies cooperation with the scientific sector means the possibility of gaining academic knowledge, which they can use in the process of production and thanks to this achieve a whole series of benefits such as: raising competitiveness, boosting growth, lowering costs, improving image, as well as the development of human capital and organization's learning ability[8].

The significance of the exchange of knowledge and cooperation of representatives of the sectors of science and industry was emphasized in the "Europe 2020" strategy, which assumes intelligent growth as one of priorities[9]. Stimulating the cooperation between the scientific environment and industry has a major significance for Poland. Formulating the recommendations getting Poland closer to the achievement of the goals of “Europe 2020” strategy, the European Commission pointed to the exceptionally low level of innovativeness of Polish economy, compared to other countries of the European Union[10].

In light of the above facts it seems to be justified to start research on interactions between science and industry and interactions aimed at commercialization of scientific knowledge. The goal of the article is to identify the methods of communication which raise the chances of scientists at various stages of their careers for cooperation with the business sector. Methods of dissemination of research results by two groups of scientists: young ones with doctor's degrees and more experienced ones holding the title of habilitated doctor, or professor will be subject to analysis.

## Communication and cooperation with the enterprise sector in light of literature research

What is often highlighted as a barrier in the development of cooperation between science and industry is the lack, or inefficiency of communication. The authors of research conducted both in Poland and abroad point to this problem[11]. Without faith in the benefits arising from cooperation and knowledge concerning what a potential partner has to offer and what his requirements are, it is hard to expect an open approach to the research-development resources coming from outside of own organization. At the same time, both national and foreign entrepreneurs know very little about the activity of scientific units. In a nation-wide survey over 50% of enterprises concluded that they had never received an offer of cooperation from a scientific unit and only every 50th of them receive such offers often[12]. Unsatisfactory results in this respect are also recorded in case of regional surveys conducted in Poland. Even in Mazovia, which belongs to the most developed regions in Poland, only just over 15% of entrepreneurs admitted that they encountered at least one campaign promoting the offer of universities from the territory of the voivodeship. This means that a vast majority has had no contact with any promotional activities conducted by these organizations. As a result, 88% of the surveyed declared that they had no knowledge about the offer of universities from the Mazovian voivodeship[13]. At the same time entrepreneurs from Wielkopolska emphasized that the barriers in communication that they encounter when they try to establish cooperation, concern not only the area of promotion of scientific units, but also problems with reaching their scientific employees due to lack of prepared procedures and organizational structures responsible for facilitating such contact[14].

The fact that scientific units are closed to the environment leads to a situation in which negative stereotypes about both research units and scientists themselves in the company sector are strengthened. It happens that what is regarded as the cause of passivity of scientific units in the area of informational-promotional activity is the fact that they are not taking actions worth exposure. Moreover, scientific-research units are regarded as focused mainly on theoretical activity and uninterested in solving business problems. There are also views that these entities are unable to offer to companies cooperation on a satisfactory content-related and technological level[15].

At the same time scientists are regarded as detached from life and less competent than companies' employees specialized in particular areas. The latter opinion concerns mainly young scientific employees. At the same time older scientists are regarded as not interested much in cooperation with companies and as people with excessive financial expectations[16]. Despite the accusations directed against more experiences scientific employees, Alfonso Gambardella and Ashish Arora have notices that entrepreneurs generally prefer cooperation with professors who enjoy high renown and recognition in the environment[17]. Taking into consideration the fact that they often invest serious amounts of money in conducted research-development works, it comes as no surprise that they are not interested in financing research conducted by scientific employees with less experience. They don't want to take the risk that a given scientist won't be competent enough to solve their research problem. This way, young scientific employees, who don't have any significant achievements, may find it harder to start cooperation with companies.

The significance of a scientist's status in the context of commercialization has been discussed by Pablo D'Este and Parimal Patel[18]. These authors — in line with earlier conclusions made by A. Gambardell and A. Aror — predicted that scientists with well-founded position would be more willing to take actions aimed at commercialization of knowledge, as they would derive benefits from the position they have reached in course of their scientific work. At the same time young scientists are more focused on preparing publications, especially if cooperation with the industrial sector is not recognized by the academic community, which they belong to, as a basis for promotion. The results of their research have confirmed that the status of a scientist has a significant and positive impact on the diversity of his interactions with the industry. However, the results of the research have also shown that the younger a scientist, the higher the likelihood that he would engage in various interactions with the industry than an old researcher.

At the same time, in a research conducted earlier, Réjean Landry, Nabil Amara and Mathieu Ouimet concluded that it is more experienced scientists who more often take up activity in the area of transfer of knowledge[19]. It is necessary to remark here that they measured scientist's experience as the number of years since the time he received his doctor's degree. What is supposed to make it easier for older scientists to cooperate with the industry is the network of contacts with business worked out at earlier stages of career.

Conclusions from the research conducted by Rada Młodych Naukowców (Young Scientists' Council) in Polish scientific environment don't bring us closer to formulating an unambiguous conclusion about the experience of a scientific employee and his engagement in cooperation either. Even though young researchers are open to starting new forms of cooperation, but as the authors of the report emphasize, their ability to establish cooperation is often limited by overburdening with didactic duties and high dependence on the superiors[20].

In light of the above-mentioned facts, there is no doubt that what plays the biggest role in the establishment of cooperation between science and industry aimed at commercialization of scientific knowledge are not so much the ties between organizations, but relations between people. A special role in this process can be attributed to the scientist, who has the capacity to initiate contact with a potential business partner and who constitutes the key reason for the fact that an entrepreneur undertakes such a move[21].

Due to the fact that the status of a scientist influences his activity in the area of transfer of knowledge to business, it was assumed that it also has an impact on the sphere of communication As a result, the following hypothesis was formulated:

The method of dissemination of research results, which leads to the establishment of cooperation with the sector of companies, differs at every stage of scientists' career.

In order to verify the above hypothesis, further course of deliberations was determined by two research questions:

1) How do young researchers cooperating with the enterprise sector disseminate the results of research?
2) How do experienced researchers cooperating with the enterprise sector disseminate the results of research?

Answering the above questions was possible thanks to carrying out the research described below.

## Research method

Quantitative data used for analyses come from a nation-wide survey carried out by National Information Processing Institute in the middle of 2013. The survey was carried out using the CAWI method (*Computer Assisted Web Interview*). Invitations were sent to scientists' email addresses obtained from the system serving the operation of financing streams (OSF). Eventually, 1960 questionnaires were submitted and the response rate reached almost 4%.

The collected empirical material was used to create two models of logistic regression: one for young scientists, that is, researchers with doctor's degree and the second one for experienced scientists, that is, habilitated doctors and professors. Dependent measure in both cases is dichotomous in character and assumes value 1, when a scientist takes up cooperation with business, or value 0 when he doesn't establish such cooperation. Also, a series of dependent measures which refer to the scientists' tools used to disseminate their research results in the enterprise sector have been defined:

- Scientific publications,
- branch/specialist press,
- conferences/symposia in which companies participate,
- sending offers to entities potentially interested in it,
- non-specialist press, radio and television,
- Internet websites,
- direct contact with entrepreneurs.

Additionaly, the following were included in models as explanatory variables:

- type of scientific unit represented by a scientist (categories: university, research institute, an institute of the Polish Academy of Sciences),
- main area of science in which a scientist conducts R&D works (categories: technical-engineering sciences, humanities and social-economic sciences, exact sciences, natural sciences, medical sciences, as well as sciences about health, agriculture and forestry),
- the fact that a scientist undertakes primary research,
- the fact that a scientist undertakes industrial studies
- the fact that a scientist undertakes development work.

The model of logistic regression makes it possible to calculate the likelihood of appearance of the analyzed event, that is, establishing cooperation with a company, by measuring the strength of influence of each of the independent variables on the growth of the so-called logit. Here logit can be expressed with the following equation: $\ln(\frac{p}{1-p})$ where p means the likelihood expected for success, that is, the likelihood that the dependent variable assumes the distinguished value (1) under condition that independent variables achieve particular values. Due to the fact that interpretation of the logit is not very intuitive, in this article the so-called odds ratio has been applied. Odds here are defined as the proportion of the likelihood of occurence of a given event to the likelihood of its non-occurence. The odds ratio is defined as a relative possibility of occurence of the analyzed event, that is, how many times a chance for the establishment of cooperation could grow under condition that explanatory variables achieve particular values. The value of the odds ratio at the level higher than 1 points to a positive relations between the dependent variable and independent variable, value below 1 should be interpreted as a relation of negative character.

All of the explanatory variables introduced to the models are measured on nominal scales and assume two, or more categories. In case of each of the variables one of the categories is chosen as the so-called reference category, which is used as a point of reference for estimating in the model the level and direction of the influence of other categories of these variables. This way the reference category constitutes only the basis of interpretation of the remaining categories of a given independent variable and a model ration isn't estimated for it. When all explanatory variables assume referential values, a referential group is formed. The chance of occurrence of the investigated event in this group will be equal to the value of the odds ratio calculated for the offset.

Both for the young and the experienced scientists building the model of logistic regression had two stages. The first step involved including all the above-mentioned explanatory variables in the model. Next, assuming the critical level of significance $\alpha$=0,05 variables recognized as statistically insignificant were removed from the model. This way an alternative model was created. For both models the so-called measures of adjustment, which show the quality of achieved estimations. Value of the coefficients R-square Negelkerke's, Cox-Snell's and McFadden's make it possible to assess the credibility of the model taking into consideration the proposed set of variables, in comparison to the base model including only the constant. These statistics assume value from the range [0;1] and are interpreted analogous to the coefficients of determination in the classic model of regression. In order to describe the adjustment of the model to the data, Akaike (AIC) and Schwarz (BIC), as well as Deviance coefficient were used. The lower the values of these indicators, the better the model is adjusted to the data.

For the model, which was eventually chosen and interpreter, the estimations of parameters (*ß*), standard errors of the estimate (*SE*), values of Wald's test statistics, which is the basis for the assessment of the significance of estimation and the level of significance which concerns it (*p-value*). Additionally, charts showing the values of the odds ratio, defining the strength of influence of each of the independent variables on the chance of occurence of cooperation with companies (*exp(ß)*) have been prepared. It is necessary to emphasize here that the presented values of regression coefficients serve only the purpose of assessing the influence of each of these variables separately. At the same time, there is no justification for comparing these values with each other and creating on their basis a ranking of independent variables, according to their strength of influence.

## Description of the research sample

After elimination of not fully filled out questionnaires, statistical analyses were eventually conducted on the basis of data obtained from 1845 respondents. The sample was dominated by researchers with doctor's degree (see table 1). In the subsample of experienced scientists there were more habilitated doctors than professors. The domination of doctors in the whole sample and lower numbers of habilitated doctors and professors complies with the distribution of scientists at the mentioned stages of career in the whole population.

Table 1. **Distribution of the sample according to the basic characteristics of scientists (N=1845)**

| Share of scientists according to: | all | young scientists | experienced scientists |
|---|---|---|---|
| • degree/scientific title | 100% | 100% | 100% |
| doctor | 68% | 100% | 0% |
| habilitated doctor | 20% | 0% | 61% |
| professor | 12% | 0% | 39% |
| • type of scientific unit | 100% | 100% | 100% |
| university | 77% | 78% | 76% |
| scientific institute | 12% | 13% | 10% |
| institute of Polish Academy of Sciences | 11% | 9% | 14% |
| • areas of science | 100% | 100% | 100% |
| engineering and technical sciences | 30% | 32% | 28% |
| humanities and social-economic sciences | 22% | 25% | 14% |
| exact sciences | 15% | 13% | 19% |
| natural sciences | 13% | 12% | 16% |
| medical sciences and sciences about health | 11% | 12% | 10% |
| agricultural sciences and forestry | 9% | 6% | 13% |
| • kind of conducted research* | | | |
| primary research | 67% | 67% | 68% |
| applied research | 60% | 60% | 59% |
| industrial research | 19% | 20% | 18% |
| • undertaking cooperation with companies | 100% | 100% | 100% |
| współpracuje | 66% | 64% | 70% |
| doesn't cooperate | 34% | 36% | 30% |

* Values don't add up to 100, as the respondents can choose more than one kind of conducted research.

Source: Own materials.

What also complies with reality is the distribution of the sample according to the share of representatives of various types of scientific units. Over 3/4 of the surveyed are employed in universities. In the group of young scientists a slightly higher percentage of scientific employees of research institutes and in the group of experienced scientists a higher percentage of scientists employed in the institutes of Polish Academy of Sciences was recorded.

Every third of the surveyed was dealing with engineering or technical sciences. The second biggest group of scientists in the sample were representatives of humanities and social-economic sciences. In the group of young scientists there was a higher percentage of representatives of these sciences than in the group of experienced scientific employees. The second-biggest group among the latter were the representatives of exact sciences. Both in the whole sample and both subsamples natural sciences were represented by a lower number of scientists. The smallest group was formed by scientists conducting research-development works in the area of medical sciences and sciences concerning health, agriculture and forestry.

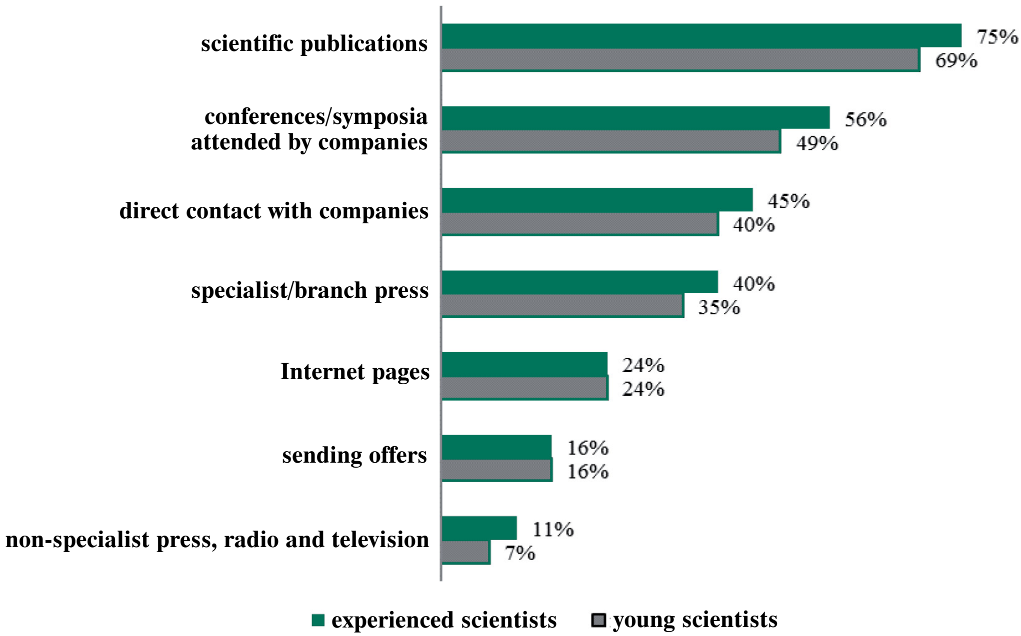
Asked about the kind of conducted research most scientists, regardless of the stage of their career, pointed to primary research, fewer pointed to applied research. Industrial research enjoyed the lowest popularity.

It is worth adding here that the sample was dominated by scientists undertaking cooperation with entrepreneurs. Experienced scientists displayed slightly higher activity in this areas than young scientific employees.

## Research results

Asked how they disseminate the results of their R&D works, most respondents — both in the group of experienced and young scientists pointed to preparation of scientific publications (see picture 1). Less often, in order to popularize own achievements, scientists participate in conferenced and symposia attended by entrepreneurs. Less than a half declare that they establish direct contacts with companies. The next way of disseminating results, in terms of popularity, is preparing articles for specialist/branch press. In both surveyed groups only every fourth scientist publishes his work on the Internet. Among the least popular ways of communication with companies are: sending offers, publications in non-specialist press, as well as appearances in radio, or television.

Picture 1. The popularity of various ways of disseminating research results in the group of experienced and young scientists (N=1845)




Source: Own materials.

Construction of the model has been carried out according to the procedure described in the section about methodology. After the creation of the first model of logit regression ($DN_1$ model) for the experienced scientists, explanatory variables which turned out to be statistically insignificant, that is: articles in specialist/branch press, Internet websites, sending offers, non-specialist press, radio and television and type of scientific unit (see table 2) were removed. As a result, the second model of logit regression for experienced scientists ($DN_2$ model) was created. Values of the measures of adjustment show good diagnostic properties of both models. The values of the likelihood ratio for the estimated models differ substantially from the base model including just one constant. This justifies taking chosen variables into consideration in the model. The values of Negelkerke's R-square coefficient, which normalize the values of Cox-Snell's R-square, point to good adjustment of the models to the data. McFadden's statistics also achieved a satisfactory level in both cases. However, the values of Akaike's (AIC) and Schwarz's (BIC) information criteria point to better adjustment of the data to the $DN_2$ model. For this reason this model has been chosen as the final one in case of experienced scientists and is subject to interpretation below.

Table 2. **Construction of the models for experienced scientists (DN model) and young scientists (MN model): estimations of parameters (*ß*) and standard error of the estimate (*SE*)**

| Variables | $DN_1$ model | | $DN_2$ model | | $MN_1$ model | | $MN_2$ model | |
|---|---|---|---|---|---|---|---|---|
| scientific publications | –0,60 | * | –0,60 | * | –1,04 | *** | –1,02 | *** |
| | (0,29) | | (0,28) | | (0,20) | | (0,19) | |
| conferences/symposia attended by companies | 0,817 | ** | 0,85 | *** | 0,76 | *** | 0,76 | *** |
| | (0,26) | | (0,25) | | (0,19) | | (0,18) | |
| direct contact with companies | 2,18 | *** | 2,22 | *** | 2,25 | *** | 2,25 | *** |
| | (0,30) | | (0,30) | | (0,22) | | (0,22) | |
| specialist/branch press | 0,14 | | | | 0,50 | * | 0,49 | * |
| | (0,28) | | | | (0,20) | | (0,20) | |
| Internet websites | –0,11 | | | | 0,30 | | | |
| | (0,32) | | | | (0,22) | | | |
| sending offers | 0,41 | | | | 1,32 | *** | 1,31 | *** |
| | (0,44) | | | | (0,34) | | (0,34) | |
| non-specialist press, radio and television | –0,09 | | | | –0,42 | | | |
| | (0,39) | | | | (0,36) | | | |
| university (vs research institute) | –0,08 | | | | 0,06 | | | |
| | (0,43) | | | | (0,29) | | | |
| institute of the Polish Academy of Sciences | –0,28 | | | | –0,15 | | | |
| (vs research institute) | (0,49) | | | | (0,36) | | | |
| engineering and technical sciences (vs exact sciences) | 1,31 | ** | 1,32 | ** | 0,61 | * | 0,64 | * |
| | (0,42) | | (0,41) | | (0,29) | | (0,28) | |
| humanities and social-economic sciences | | | | | | | | |
| (vs exact sciences) | 0,12 | | 0,15 | | –0,10 | | –0,04 | |
| | (0,38) | | (0,37) | | (0,25) | | (0,24) | |
| natural sciences (vs exact sciences) | –0,28 | | –0,25 | | –0,14 | | –0,14 | |
| | (0,36) | | (0,35) | | (0,28) | | (0,28) | |
| medical sciences and sciences about health | –0,16 | | –0,11 | | –0,93 | ** | –0,93 | ** |
| (vs exact sciences) | (0,41) | | (0,40) | | (0,30) | | (0,29) | |
| agricultural sciences and forestry (vs exact sciences) | 0,87 | * | 0,88 | * | 0,05 | | 0,05 | |
| | (0,44) | | (0,43) | | (0,38) | | (0,38) | |
| primary research | 0,18 | | | | –0,59 | ** | –0,59 | ** |
| | (0,33) | | | | (0,20) | | (0,20) | |
| applied research | 1,30 | *** | 1,27 | *** | 0,70 | *** | 0,72 | *** |
| | (0,27) | | (0,25) | | (0,17) | | (0,17) | |
| industrial research | 1,26 | * | 1,34 | * | 1,96 | *** | 2,01 | *** |
| | (0,57) | | (0,56) | | (0,43) | | (0,43) | |
| constant | –0,91 | | –0,87 | ** | –0,09 | | –0,08 | |
| | (0,57) | | (0,29) | | (0,40) | | (0,29) | |

Cont. table 2

| Variables | $DN_1$ model | $DN_2$ model | $MN_1$ model | $MN_2$ model |
|---|---|---|---|---|
| Aldrich-Nelson R-sq. | 0,31 | 0,30 | 0,33 | 0,33 |
| McFadden R-sq. | 0,36 | 0,36 | 0,38 | 0,38 |
| Cox-Snell R-sq. | 0,36 | 0,35 | 0,39 | 0,39 |
| Nagelkerke R-sq. | 0,51 | 0,50 | 0,54 | 0,54 |
| phi | 1,00 | 1,00 | 1,00 | 1,00 |
| Likelihood-ratio | 261,95 | 259,77 | 625,33 | 621,74 |
| p | 0,00 | 0,00 | 0,00 | 0,00 |
| Log-likelihood | –232,91 | –234,00 | –504,11 | –505,90 |
| Deviance | 465,82 | 468,00 | 1008,22 | 1011,81 |
| AIC | 501,82 | 490,00 | 1044,22 | 1039,81 |
| BIC | 580,81 | 538,28 | 1136,58 | 1111,64 |
| N | 595 | 595 | 1250 | 1250 |

* $p<0,05$; ** $p<0,01$; *** $p<0,001$

Source: Own materials.

Analogous to young scientists the first model of logit regression ($MN_1$ model) was constructed, next, statistically insignificant explanatory variables — Internet websites, non-specialist press, radio and television, as well as the type of scientific unit (see table 2) — were removed. This way the second logit regression model for young scientists ($MN_2$ model) was created. The values of the measures of adjustment point to good diagnostic characteristics of the created models. The values of the likelihood ratio for both models substantially differ from the base model, which includes only a constant. This justifies considering a chosen set of explanatory variables in the model. Negelkerke's R-square values, which normalize the values of Cox-Snell's R-square coefficient, show good adjustment of the models to the data. McFadden statistics also achieved satisfactory values in both cases. However, the values of Akaike's (AIC) and Schwarz's information criteria point to better adjustment to the $MN_2$ model data. This is why this model has been chosen and interpreted as final in case of young scientists.

Table 3 includes the results of estimations of the final model of logistic regression, which was chosen for the diagnosis in the group of experienced scientists of the relations between starting cooperation and the undertaken ways of disseminating the results of R&D works in the company sector. On picture 2 the estimations of the likelihood ratios in this model are presented.

Table 3. **Final model of logit regression constructed for the experienced scientists**

| Variables | Estimation of parameter (ß) | Standard error of estimate (*SE*) | Value of Wald's test statistics | Significance (*p-value*) |
|---|---|---|---|---|
| scientific publications | –0,60 | 0,28 | –2,15 | **0,03** |
| conferences/symposia attended by companies | 0,85 | 0,25 | 3,35 | **0,00** |
| direct contact with companies | 2,22 | 0,30 | 7,46 | **0,00** |
| engineering and technical sciences (vs exact sciences) | 1,32 | 0,41 | 3,23 | **0,00** |
| humanities and social-economic sciences (vs exact sciences) | 0,15 | 0,37 | 0,40 | 0,69 |
| natural sciences (vs exact sciences) | –0,25 | 0,35 | –0,71 | 0,48 |
| medical sciences and sciences about health (vs exact sciences) | –0,11 | 0,40 | –0,29 | 0,78 |
| agricultural sciences and forestry (vs exact sciences) | 0,88 | 0,43 | 2,05 | **0,04** |
| applied research | 1,27 | 0,25 | 5,13 | **0,00** |
| industrial research | 1,34 | 0,56 | 2,41 | **0,02** |
| constant | –0,87 | 0,29 | –3,02 | **0,00** |

Statistically significant results are highlighted by bold font.

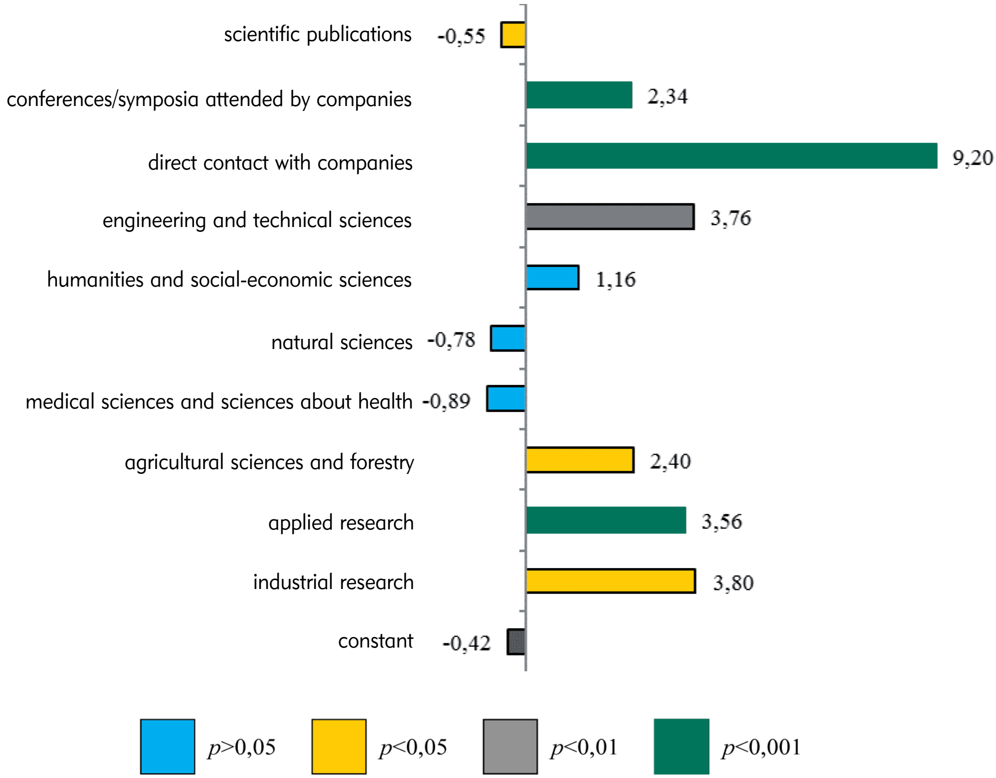
Source: Own materials.

Variables describing the following methods of dissemination of the results of research-development works have a statistically significant impact on the experienced scientists' chance to establish cooperation with companies:

- scientific publications - activity in this area reduces the chance for cooperation with companies by an average of 45% in case of controlled influence of the remaining variables[22];
- conferences/symposia attended by companies — participation in such events on average more than doubles a scientist's chance for cooperation with companies;
- direct contact with companies — establishing such contact raises the chance for cooperation with companies nine-fold on average.

The achieved results, in case of experienced scientific employees, point to lack of relationship between cooperation with companies and such explanatory variables referring to communicational activity as: specialist/branch press, Internet websites, sending offers and non-specialist press, radio and television.

Picture 2. **Estimation of the likelihood ratio in the final logit regression model constructed for experienced scientists (N=595)**




Source: Own materials.

Among variables describing an experienced scientist and the R&D works conducted by him, the following variables have a statistically significant influence on the Chance to establish cooperation with the company sector:

- area of science for which exact sciences were a referential category — significant influence was achieved for engineering, technical, agricultural sciences and forestry:
  - when a scientist conducts research in the area of engineering and technical sciences, he has on average an almost four times higher chance for cooperation with companies than a scientific employee dealing with exact sciences;
  - when a scientists conducts research in the area of agricultural sciences and forestry, he has on average an almost twice higher chance to cooperate with companies than a scientific employee dealing with exact sciences;

- applied research — conducting this kind of research makes it on average almost four times more likely for a scientific employee to establish cooperation with companies; industrial research — activity in this area makes it on average almost four times more likely for a scientist to cooperate with companies.

At the same time such explanatory variables as type of scientific unit employing an experienced scientist and the fact that he undertakes primary research don't influence establishing cooperation.

The value of the odds ratio calculated for the offset (0,42) quantifies the likelihood of establishment of cooperation in the referential group of experienced scientists. This group consists of scientists who don't undertake any of the methods of dissemination of research results included in the model, represent exact sciences and don't conduct applied, or industrial research.

In table 4 the results of estimation of the final model of logistic regression for group of young scientists which was chosen for the diagnosis of the relationship between establishing cooperation with companies and disseminating the results of research-development works among them. On picture 3 the estimations of odds ratios in the above-mentioned models are presented.

Table 4. **Final model of logit regression for the young scientists**

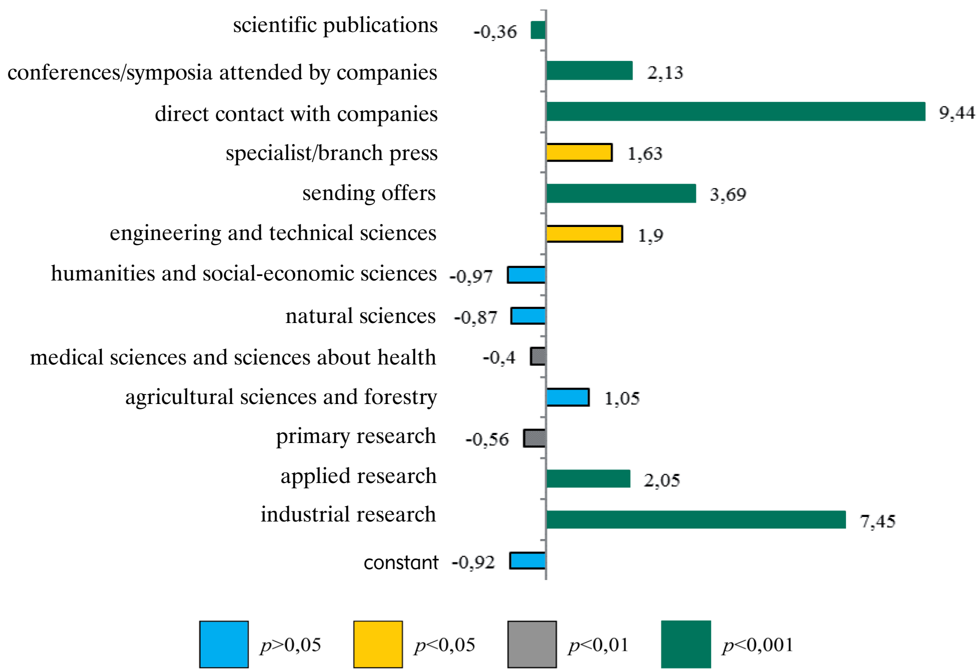
| Variables | Estimation of parameter (ß) | Standard error of estimate (*SE*) | Value of Wald's test statistics | Significance (*p-value*) |
|---|---|---|---|---|
| scientific publications | –1,02 | 0,19 | –5,27 | **0,00** |
| conferences/symposia attended by companies | 0,76 | 0,18 | 4,14 | **0,00** |
| direct contact with companies | 2,25 | 0,22 | 10,34 | **0,00** |
| specialist/branch press | 0,49 | 0,20 | 2,51 | **0,01** |
| sending offers | 1,31 | 0,34 | 3,88 | **0,00** |
| engineering and technical sciences (vs exact sciences) | 0,65 | 0,28 | 2,28 | **0,02** |
| humanities and social-economic sciences (vs exact sciences) | –0,04 | 0,24 | –0,15 | 0,88 |
| natural sciences (vs exact sciences) | –0,14 | 0,28 | –0,49 | 0,62 |
| medical sciences and sciences about health (vs exact sciences) | –0,93 | 0,29 | –3,18 | **0,00** |
| agricultural sciences and forestry (vs exact sciences) | 0,05 | 0,38 | 0,13 | 0,90 |
| primary research | –0,59 | 0,20 | –2,93 | **0,00** |
| applied research | 0,72 | 0,17 | 4,12 | **0,00** |
| industrial research | 2,01 | 0,43 | 4,69 | **0,00** |
| constant | –0,08 | 0,29 | –0,28 | 0,78 |

Statistically significant results are highlighted by bold font.
Source: Own materials.

Variables describing the following methods of dissemination of the results of R&D works have a statistically significant impact on the chances of young scientists for cooperation with companies:

- scientific publications — preparing such publications contributes to reducing the chance for cooperation with companies by an average of 64% in case of controlled influence of the remaining variables[23] ;
- conferences/symposia attended by companies — participation in such events on average more than doubles the chance of a scientific employee to cooperate with the company sector;
- direct contact with companies — establishing such contact increases the chance for cooperation with companies nine-fold on average;
- specialist/branch press — publications in this kind of press on average almost doubles the chance for cooperation with companies;
- sending offers — on average, preparing offers raises the chance for establishing cooperation almost four-fold.

Picture 3. **Estimation of the odds ratios in the final model of logit regression constructed for young scientists (N=1250)**




Source: Own materials.

At the same time, among variables describing a young scientist and the research-development works he conducts, the following have a significant impact on the chance to start cooperation with companies:

- area of science for which exact sciences were a referential category - a significant influence was observed in case of engineering and technical sciences, as well as of medical sciences and sciences about health:
  - o when a scientific employee conducts research in the area of engineering and technical sciences, he has an almost twice higher chance for cooperation with companies than a scientist representing exact sciences;
  - o when a scientific employee conducts research in the area of medical sciences, he has on average a 60% lower chance to cooperate with companies the a scientist representing exact sciences;
- primary research —- conducting this kind of research makes it on average 44% less likely for a scientific employee to cooperate with companies;
- applied research — undertaking this kind of research on average more than doubles the chances of a scientist to cooperate with the company sector;
- industrial research — activity in this field raises the chance of a scientist for cooperation with companies more than seven times.

It is worth adding here that in case of young scientific employees a relationship between establishing cooperation and such explanatory variables as: Internet websites, non-specialist press, radio and television, as well as type of scientific unit represented by a scientist hasn't been observed.

## Conclusions and discussion

Ways of disseminating the results of R&D works raising the chances of experienced and young scientists to start cooperation with enterprises have been put together in table 5. According to the presented information, young scientific employees have at their disposal a twice bigger range of communication tools, which have a positive impact on establishing cooperation with companies. This way, the achieved results make it possible to accept the hypothesis on differences in the area of efficient ways of dissemination of research results existing between scientists at various stages of scientific career.

Table 5. **List of efficient ways of communication with companies in the groups of experienced and young scientists**

| Experienced scientists | Young scientists |
|---|---|
| • direct contacts with companies<br>• publications in branch/specialist press attended by entrepreneurs | • direct contacts with companies<br>• sending offers<br>• participation in conferences/symposia attended by entrepreneurs<br>• publications in branch/specialist press |

Source: Own materials.

For the experiences scientists a way to raise the chance for cooperation are direct contacts with entrepreneurs. Direct communication takes place on the level of personal contacts between the representatives of the sectors of science and business. In comparison to formal channels of communication, direct contacts favour the creation of stronger ties between the sides and more frequent communication[24]. Informal interactions in form of exchange of information constitute a catalyst of future agreements concluded on the formal level. For this reason, when you are a scientist, you have to pay special attention to maintaining relations and repeatability of interactions, as previously established personal contacts, joint work, or graduating from the same university may become a basis for undertaking joint R&D projects[25]. The significance of informal relations for the choice of a partner from the R&D sector was highlighted by entrepreneurs from Wielkopolska region. They declared that in such situation they resort to own contacts (also non-professional), or refer to the social capital of their associates[26]. Diana Nadine Boehm and Teresa Hogan add that relations — and in particular their quality — play a major role when more than one scientific institution is able to provide a company with similar research results[27].

What is closely related to the method of communication discussed above is the second of the efficient tools used by experienced scientists to disseminate the results of research-development works, namely conferences and symposia attended by entrepreneurs. Participation in such events gives an opportunity to a scientific employee to establish new, or refresh old contacts, which in the future may lead to joint research projects.

Both mentioned ways of disseminating the results of R&D works belong to the arsenal of efficient means of communication with the representatives of the enterprise sector, which young scientists have at their disposal. Moreover, in their case it will be justifiable to send offers, or prepare articles for branch or specialist press. Preparing an offer especially for a particular company a scientists has a chance to individualize his message and present the benefits that a particular company could derive from cooperation. At the same time the efficiency of publications in specialist and branch press may result from the fact that it is a clear signal sent by a scientist to a company and that he  pays attention to the practical dimension of the conducted research and that he is potentially interested in its commercial utilization.

Both in the group of young and experienced scientists, due to the character of influence on cooperation, scientific publications turned out to be a noteworthy means of communication In earlier research their relationship with cooperation with business was ambiguous.  For example, according to Rudi Bekkers an Isabel Maria Bodas Freitas, carrying out projects in cooperation with the industry not only provides financial assets for research, but also has a positive impact on the number of scientific publications[28]. At the same time in the research conducted by Magnus Gulbrandsena and Jens-Christiana Smeby no relationship between financing of research by the industry and scientific publications was observed[29]. The results of this research show that regardless of the stage of career, scientists who focus on preparing scientific publications have smaller chances for establishing cooperation. At the same time this method of communication is most popular among scientific employees. High activity in this field is closely related to the criteria of parametric assessment of scientific units and promoting scientific employees. The superiors' pressure on gaining points for scientific publications results in lower engagement of scientific employees in other, important areas of scientific activity, including establishing contacts with companies. In light of these facts, the question which comes up is whether in times of striving to  develop cooperation between science and business and raising the innovativeness of the national economy, it is justifiable to attach such great importance to publishing activity.

As the conducted analysis shows, scientists comparably rarely — regardless of the stage of career — resort to quite an easy and cheap method of disseminating the results of their research, namely, publishing results on Internet websites. Low engagement in this activity goes against the concept of *open science*, which has recently been promoted. However, it turns out that publishing research results on Internet websites doesn't influence establishing contacts with companies. Perhaps, this is caused by the fact that the information is too general and the entrepreneurs expect the scientists to present something valuable for them[30].

Similarly, what doesn't influence cooperation is disseminating research results in non-specialist press, or through scientists' appearance in radio, or television. However, this doesn't mean that you should abandon these means of communication, as they can certainly be helpful in building the personal brand of a scientific employee, raising his recognisability, or prestige. However, these methods can be classified as image-building tools, which don't influence establishing contact with companies directly.

The analysis of a scientist's characteristics and the research he conducts provides results complying with intuition. In this context it is necessary to mention above all the fact that scientific employees representing engineering and technical sciences and those conducting applied and industrial research have greater chances for establishing cooperation with companies. What also comes as no surprise is the fact that younger scientists have lower chances for cooperation due to their involvement in primary research. At the same time, lower chances for establishing cooperation at the early stage of scientific career in case of the representatives of medical sciences and sciences about health can be explained with the fact that the educational path in these areas is longer. What may be regarded as surprising is the fact that there are higher chances for cooperation in case of agricultural sciences and forestry. This may be traced back to close relationship between these sciences and the manufacturing activity, however, this effect requires verification in further research.

It is also worth pointing out that in light of the obtained results all scientific employees have equal chanced for cooperation with business regardless of the place of their employment. This means that scientists can't justify their passivity with regard to cooperation with companies with the fact that they work at a university, or in an institute of Polish Academy of Sciences.

Taking the achieved results into consideration, it seems to be justified to further explore the subject of influence of the scientists' communicational activities, including scientists at various stages of career, on cooperation with business. In particular, what may be very interesting is a more insightful analysis of various means of communication at lower level of their aggregation than was the case in this research, also by taking into consideration new communication tools, which are getting more and more common, due to popularization of Web 2.0 solutions.

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