QUALITATIVE STUDY OF REINTEGRATION OF SLOVAK RESEARCHERS BASED ON CLUSTERING METHOD

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Abstract: *When it comes to a topic of reintegration of researchers from abroad back to Slovakia, there are often some stereotypes used in society. Research performed among them showed broader results that we have studied with help of clustering method to be able to learn more than aggregate statistical numbers. In this paper, we present details about the methodology, results from the clustering analysis and discuss results from it.*

Keywords: reintegration, Slovak researchers, return strategy, motivational factors

JEL Classification: C43, J61

1. INTRODUCTION

Situation concerning reintegration of Slovak researchers working abroad back to Slovakia is not ideal. Many perspective people go abroad, either during or after their university studies. On the one hand, the fact is positive because these people gain invaluable experience and knowledge abroad. On the other hand, only few of them return to Slovakia. Financial rewards, research conditions, motivation for work, these are perhaps the most significant factors holding Slovak researchers abroad.

The problem, however, is not black and white. As one Slovak scientist working in Germany said: "Give me a one third of my current salary and within a month, I will come back home." This particular case illustrates that the salary is not the most important thing for them. The words "come back home" indicate that the scientist does not feel in Germany as at home and that they still consider Slovakia as their home. And there are other people realising that their potential can be realised to the benefit of the country [1].

Topic of reintegration shall be studied deeper. To understand the attitude of Slovak scientists, why their ambition is not to come to work back to Slovakia, a research has been carried out. It contained a survey among scientists [2], results of which have been further analyzed. In this paper, we describe the process details and we draw conclusions from the analysis.

Some studies were focused on mobility of researchers [3-5], however the reintegration of scientists is very often land-specific.

2. RESEARCH APPROACH AND METHODOLOGY

The survey has been conducted in the last quarter of 2013 by Netmarketer. It consisted of five areas of questions. The first area covers the profile of the researcher and therefore individual details from this area will be further referred as *indicators*. Answers in the remaining four areas contained opinions of the respondents - they will be referred as *views*.

Scientific researcher's profile in the area 1 includes the basic characteristics of the researchers, the research stay and type of research. The indicators considered for analysis have been:

1. Male/female
2. Age
3. Resident address in Slovakia
4. Research stay is running / is completed
5. Intended duration of stay
6. Real duration of stay

The area 2 focused on the original reasons for going abroad. The questionnaire named possible reasons for departing for a research stay abroad and asked to provide scores to them on how much they are important to the respondent - on a scale of 1 ("irrelevant") to 6 ("extremely important"). The reasons are:

1. Quality research program
2. Research, where I worked / work is not offered by any home university
3. Helpful approach of researchers
4. Career opportunities in the future
5. Interesting extracurricular activities
6. Higher quality of life
7. Learning about new cultures
8. Relationship with a partner coming from abroad
9. Scholarship, salary
10. Improving language skills
11. Obtaining contacts
12. Quality of working environment (eg. technical equipment, library, access to technical literature)
13. I felt a need to get to know something new, unknown
14. There has been a suitable opportunity, so I did not think of other reasons
15. I was sent from domestic workplace

The area 3 investigated how the respondents' expectations from their stay abroad were met, concerning the conditions that the research institution provided them - on a scale of 1 ("not met at all") to 6 ("fully met").

1. Technological support at the workplace (beneficial research environment, including the relevant facilities, esp. for remote collaboration over research networks)

2. Education system (specialized training within the career development of researchers)
3. Access to necessary information
4. Financial support (suitable financing/wage conditions with adequate social security)
5. Knowledge of research colleagues
6. Opportunities for further development in the field
7. Opportunities to participate at scientific conferences
8. Opportunities to work on various projects
9. Cooperation with industry
10. Employability at the institution where the research stay is conducted

The area 4 verified importance of possible factors for moving their research activities from abroad to Slovakia:
1. Pleasant working environment
2. High-level quality technological equipment for carrying out research
3. Experts for cooperation in research
4. Sufficiently large financial grant to carry out research
5. Long-term job security
6. Social security
7. High social prestige of the research institution in Slovakia
8. International prestige of the research institution
9. Salary
10. Perceiving of researchers (and teachers) by public with high-level prestige
11. Changes in managing the state education system
12. High professional prestige for people with international experience
13. Family or other personal reasons
14. Interest in participating in the development of science and research in Slovakia
15. Opportunity to use your mother tongue
16. Pride of Slovak origin
17. Opportunities to find engagement in the field of studies
18. Maintaining contact with home institution

The area 5 studies importance of factors for remaining at work for foreign institution(s) abroad:
1. Quality research program
2. Research, where I worked / work is not offered by any home university
3. Helpful approach of researchers
4. Career opportunities in the future
5. Social prestige and respect
6. Interesting extracurricular activities
7. Higher quality of life
8. Learning about new cultures
9. Gaining independence (eg. from parents)
10. Relationship with a partner coming from abroad
11. Scholarship, salary
12. Improving language skills
13. Obtaining contacts
14. Quality of working environment (eg. technical equipment, libraries, etc..)
15. I have no interest in returning to the original environment

16. I have not yet learned everything, what I came to research stay for

The target group of the survey was scientific researchers of Slovak origin working in foreign scientific research institutions whose research stay abroad lasts or lasted at least one year. For data collection, the representative sampling technique has been chosen. The advantage of representative samples is that when analyzing their data, it is possible to generalize obtained results to the whole population. More specifically, random selection has been used in combination with an intentional technique, because there was no actual database of scientific researchers working in scientific research institutions in target countries available - although considerable efforts were made to obtain such a database through official contacts with universities and other research and scientific institutions as well as on a personal basis.

Based on the indicative value of the basic set of 341 respondents, the sample size of 181 respondents (researchers abroad) has been calculated at the desired 95% confidence interval and a maximum admissible error of 5%. Since there were 92 respondents taking part in the survey, the maximum admissible error (sampling error) rose to 8.74%.

Data were collected through an electronic questionnaire via Internet.

3. INTRODUCTION OF CLUSTERING METHOD IN PROCESSING OF RESULTS

Survey has been processed by means of statistical methods for quantitative evaluation. More specifically, statistical values of average, deviation and percentage were produced, and statistical tests and other statistical methods associated with the likely accuracy of the resulting statistical review and admissible error were used.

The methods were applied to the whole sample of responses. For example, the arithmetic average of responses to a question provided information about what is "average" opinion of scientists working abroad. If the answers to a question were more or less homogeneous, plausible conclusions of such an average number can be drawn. However, if the values of the responses covered large part of the value range, no representative conclusions can be made.

As a solution to this problem, it seemed appropriate to us to use a clustering method where the set of respondents is divided into subsets that may have likely more homogeneous opinion, i.e. their responses are less different from the average in the subset.

A natural question is on what basis are the respondents to be divided into groups. As mentioned earlier, we have indicators and views of respondents. Some indicators have only two options (e.g. indicator 1.1 Sex), and thus a division into two parts according to the options is straightforward. Other indicators have a range of values, e.g. 1.5 Planned length of stay with values ranging from 1 to 11. Dividing responses according to 1.5, could be realized in various ways, for example, into three groups: 1-2 years (short-term stay), 3-6 years (medium-term) and 7 years or more (long-term). Individual process of dividing depends on the indicator.

Table 1 Correlation matrix for question areas 2 and 3

	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	2.11	2.12	2.13	2.14	2.15	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10
1.1	0.07	0.22	0.21	0.14	0.09	0.07	0.13	0.28	0.08	0.05	0.04	0.02	0.05	0.02	0.45	-0.02	-0.09	0.09	0.04	0.14	-0.02	0.00	-0.03	0.16	-0.21
1.2	0.02	-0.24	-0.30	-0.01	-0.35	-0.19	-0.33	-0.05	-0.23	-0.21	-0.15	0.18	-0.09	-0.02	-0.11	0.09	0.22	0.09	-0.01	0.14	0.07	0.10	0.11	-0.06	0.23
1.3	0.08	-0.06	0.07	0.14	-0.08	-0.09	-0.09	0.13	-0.23	-0.08	0.12	0.08	0.11	0.08	-0.13	0.19	0.17	0.17	0.00	0.17	0.11	0.03	0.06	0.18	0.02
1.4	-0.01	0.02	-0.09	-0.09	-0.08	-0.17	-0.17	-0.26	-0.01	0.14	0.00	-0.08	0.04	-0.06	0.14	-0.20	-0.17	-0.20	-0.02	0.02	-0.14	0.01	-0.22	-0.41	-0.16
1.5	0.11	0.05	-0.14	0.01	-0.06	0.14	0.07	0.09	-0.07	-0.24	-0.13	0.03	-0.15	-0.08	-0.26	0.15	0.10	0.23	0.10	0.10	0.16	0.25	0.17	0.18	0.31
1.6	0.10	-0.20	-0.43	0.02	-0.28	-0.12	-0.24	0.02	-0.08	-0.17	-0.15	0.09	0.01	-0.04	-0.25	0.07	0.11	0.13	-0.16	-0.05	0.10	0.19	0.05	-0.12	0.22

Table 2 Correlation matrix for question area 4

	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	4.10	4.11	4.12	4.13	4.14	4.15	4.16	4.17	4.18
1.1	-0.01	0.18	0.33	0.22	0.04	0.20	-0.11	0.05	0.21	0.12	0.11	-0.02	0.20	0.04	0.20	0.11	0.18	0.22
1.2	-0.15	0.19	0.03	0.15	0.38	0.25	0.14	0.23	0.08	0.24	0.02	-0.03	-0.10	0.16	-0.16	-0.08	0.08	-0.02
1.3	-0.06	0.06	0.03	0.07	0.15	-0.06	0.17	0.12	0.00	0.15	-0.01	0.01	-0.09	-0.01	-0.23	-0.01	0.11	-0.01
1.4	0.07	-0.12	-0.10	-0.04	-0.01	0.04	-0.11	-0.07	0.01	0.05	-0.09	0.01	0.14	-0.01	-0.12	-0.09	0.09	0.09
1.5	-0.11	0.08	0.02	0.07	0.22	0.07	-0.04	0.03	0.02	0.04	-0.19	-0.07	-0.33	-0.07	-0.08	-0.05	-0.07	-0.32
1.6	-0.27	-0.05	-0.25	-0.05	0.02	-0.14	0.13	-0.04	0.04	-0.09	-0.20	-0.08	-0.21	0.03	-0.18	0.04	-0.22	-0.32

Table 3 Correlation matrix for question area 5

	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	5.10	5.11	5.12	5.13	5.14	5.15	5.16
1.1	0.10	0.09	0.15	0.14	0.01	-0.06	0.00	-0.05	0.17	0.16	0.02	0.12	0.19	0.13	0.13	0.31
1.2	0.21	-0.08	-0.01	0.11	0.17	-0.25	0.12	-0.19	-0.19	-0.35	0.05	-0.31	-0.15	0.26	0.08	-0.42
1.3	0.03	0.10	0.12	0.03	-0.05	-0.15	0.02	-0.09	-0.20	-0.18	-0.05	-0.34	0.06	-0.04	0.09	-0.17
1.4	-0.10	0.11	-0.11	-0.12	-0.18	0.16	-0.14	-0.19	0.00	-0.11	-0.03	0.04	0.14	0.01	-0.27	-0.07
1.5	0.26	-0.01	-0.03	0.02	0.08	0.00	0.19	0.10	-0.16	0.07	-0.03	-0.30	-0.32	0.00	0.08	-0.29
1.6	0.17	-0.06	-0.11	-0.08	-0.04	-0.19	0.14	-0.07	-0.17	-0.12	-0.05	-0.26	-0.20	-0.01	-0.03	-0.38

Another natural problem is what pairs of indicator-view are to be studied. There are 6 indicators and 59 views. If we wanted to cover each pair, we would analyze 354 pairs. But it would be ineffective work, since many pairs indicator-view are very little related.

The degree of how two statistics sets are related to each other can be expressed in different ways. The basic statistical method is correlation. The number expresses how much the two statistical variables are related on the same set of respondents. Therefore, we calculated the correlation matrix that is shown in tables 1-3.

Correlation is a number between -1 and 1. The greater absolute value it has, the stronger is the relationship between the statistical variables. Depending on how big are the values in the table, we have set a minimum correlation threshold for choosing pairs of variables for further analysis and in the matrix, we highlighted fields with absolute values greater than the selected minimum. The threshold of 0.3 is met or overcome in 19 values (see table).

For wider coverage, we could reduce the threshold and take into account more fields. Question arises, however, what correlation values will still provide us with interesting information.

Each field describes one indicator-view pair and for all the selected pairs, we applied the clustering method, described in detail in the next section.

4. CLUSTERING METHOD

Example of the clustering procedure is presented on a pair of indicator-view 1.4 - 3.9. Statistical correlation of the vari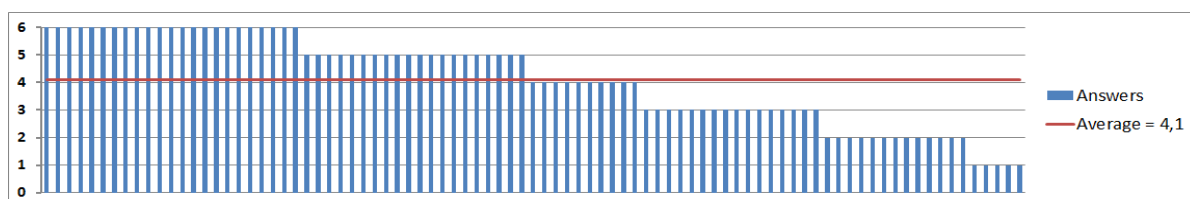ables is -0.41. The indicator 1.4 indicates whether the respondent's stay abroad is still running or the person has returned back. The view 3.9 expresses fulfillment of respondent's expectations upon arrival to foreign institution with regard to cooperation with industry. The figure 1 shows the answers of respondents.

The question has been answered by 87 respondents. Responses were sorted according to their values. Red line marks average value of 4.1.

A primary conclusion can therefore speak about a slightly positive fulfillment of expectations. Knowing the value, a question arises whether and how much were the responses homogeneous. It is visible from the chart already that not only replies with the value of 4 (10 times) or value different from the average by approx. 1 (36) are available, but there is also a large number of responses that differ from the average by approx. 2 or more (41), with the maximum of 3.1. It is proven also by standard deviation of 1.6, so the responses to this question are rather inhomogeneous.

The next question, however, is that when the answers are not homogeneous, whether they depend on other factors in any way. If we do not find any link, a too large standard deviation rather suggests that no major conclusion can be drawn from the answers.

The indicator 1.4 has only two possible states, and therefore it divides the responses into two groups: from respondents whose stay is still going on (G) and those who have their stay completed (C).

Figure 1 Answers for question 3.9 with average indicated by horizontal line

Figure 2 Regrouped answers for question 3.9 with averages over different subsets

Answers in the chart below have been first sorted by state of the stay (G / C) and then by response values.

The bottom axis indicates whether the respondent's stay is going on (G) or is completed (C).

We can see that the structure of responses in the two groups of respondents differs. In the group G, the positive fulfillment of expectations regarding the cooperation with industry still dominates. Compared to the overall average of 4.1, the average of responses in that group is slightly more: 4.43. On the other hand, in the group C, the expectations are not met: providing that 3.5 is the middle point of the possible answers 1 to 6, the average of this group is equal to 2.74, which is clearly in the negative part of the response range. We can thus formulate a conclusion that respondents whose stay is still going on, have their expectations from cooperation with industry more fulfilled than those who have already completed their stay and returned home.

5. POSSIBLE EXTENSION OF THE METHODOLOGY

In this work, we focused on clustering respondents based on the indicators. Grouping of respondents may be, however, based on selected views from them. That opens up far more possibilities, in our particular case, it is by 59 views as many as 3,481 additional potential pairs.

Examination of all possible options does not seem to be effective. It is thus appropriate to determine in the beginning either specific pairs of views, where we are interested in correlation, or subsets of views where we want to explore all combinations of them. In any case, a specific goal of examination shall be set, dependent on the goal of the analysis, and to adapt the extension of methodology to it.

For purposes of our analysis, results of pairs indicator-view were sufficient, so we did not pay any further attention to the extended methodology.

6. ANALYTICAL RESULTS

By analysis of 17 pairs with the greatest correlation, we have got the following results. The following table shows the analysed relationships, and for each of them, its overall average value without clustering, the distribution of clusters and the average values in them.

Table 4 Summarized results of the clustering method. For each pair indicator-view the corresponding clusters are listed with averaged values over the clusters.

Relationship	Average	Cluster 1 Average in cluster 1	Cluster 2 Average in cluster 2	Cluster 3 Average in cluster 3
2.3 - 1.6	4.422	0-1 year 5.5	2-10 years 4.51	11 and more years 3.47
2.5 - 1.2	2.44	less than 35 years 2.77	over 35 years 2	
2.7 - 1.2	3.07	less than 35 years 3.38	over 35 years 2.66	
2.15 - 1.1	1.614	men 1.36	women 2.8	
3.9 - 1.4	4.1	unfinished 4.43	finished 2.76	
3.10 - 1.5	3.99	0-1 year 3.38	2-7 years 3.68	8 and more years 4.85
4.3 - 1.1	4.74	men 4.48	women 5.8	
4.5 - 1.2	4.73	less than 30 years 2.75	30 - 40 years 4.75	more than 40 years 5.34
4.13 - 1.5	5.2	0-1 year 5	2-4 years 5.09	5 and more years 3.93
4.18 - 1.5	2.64	0-4 year 2.95	5 and more years 2.1	
4.18 - 1.6	2.63	0-2 year 3.47	3 and more years 2.23	
5.10 - 1.2	2.98	less than 40 years 3.31	over 40 years 2.06	
5.12 - 1.2	3.23	less than 40 years 3.51	over 40 years 2.65	
5.12 - 1.5	3.25	0-1 year 5	2-4 years 2.84	5 and more years 2.68
5.13 - 1.5	4.05	0-1 year 5.29	2-4 years 3.76	5 and more years 3.53
5.16 - 1.2	2.92	less than 35 years 3.57	over 35 years 1.89	
5.16 - 1.6	2.92	0-1 year 3.88	2-9 years 3.17	10 and more years 1.58

The above table can be explained by the statements in the following table:

Table 5 Rephrasing of numerical results from the previous table.

No.	Relationship	Statement
1	2.3 - 1.6	The longer is the researcher abroad, the less important is the **helpful approach of scientists** for him.
2	2.5 - 1.2	Younger researchers see **interesting extracurricular activities** as more important reason for leaving abroad than senior researchers.
3	2.7 - 1.2	Younger regard **learning about new cultures** as more significant reason for leaving than senior researchers.
4	2.15 - 1.1	Women consider **sending from domestic workplace** as more significant reason for leaving abroad than men.
5	3.9 - 1.4	Those who have completed their stay abroad, are less satisfied with **cooperation with industry** than those whose stay is still going on.
6	3.10 - 1.5	Those planning a longer stay abroad, consider **employability at the institution where the research stay is conducted** as more important than those who are there for shorter time.
7	4.3 - 1.1	Women regard the existence of **experts for cooperation** as more important for their return home than men.
8	4.5 - 1.2	The older the researcher, the more is the **long-term job security** important for him.
9	4.13 - 1.5	Those originally planning a shorter stay, consider **family or other personal reasons** as more important to return home, than those who are abroad for longer.
10	4.18 - 1.5	Those planning a shorter stay, view **maintaining contact with home institution** as more important than those who are planning a longer stay.
11	4.18 - 1.6	Those who have stayed abroad shorter time so far, consider **maintaining contact with home institution** as more important.
12	5.10 - 1.2	For younger participants is the **relationship with a partner coming from abroad** more important.
13	5.12 - 1.2	For younger participants is the reason of **improving their language skills** more important than for older.
14	5.12 - 1.5	For those planning a shorter stay abroad is the reason of **improving their language skills** more important than for those who have gone for longer.
15	5.13 - 1.5	Those planning a shorter stay abroad see the reason to **obtain contacts** as less important than those who have gone for longer.
16	5.16 - 1.2	Younger researchers regard the reason of unmet own expectations as more important for staying abroad (I have not yet learned everything, what I came to research stay for) than the elder ones.
17	5.16 - 1.6	Those who stay abroad for less see the reason of unmet own expectations as more important for staying abroad (I have not yet learned everything, what I came to research stay for) than those who stay there longer.

7. RESULTS ANALYSIS

In this section, we try to justify some of the interesting results without doing deeper research. As the most value bringing (i.e. logically the least expected) results, we consider the statements 5, 7, 8 and 9.

The statement 5 showing lower satisfaction of researchers returned after their stay abroad with **cooperation with industry on their stay abroad** is very interesting. Slovak researchers when going on a research stay abroad expect better cooperation with industry than in Slovakia. This expectation is quite natural since the cooperation between academia and industry in Slovakia generally is not very intensive. Therefore in the first years of their research stay, they are enthusiastic and their positive evaluation of cooperation with industry comes rather from the expectations than from real experiences. Also, in the first years, they may have a little chance to work with industry. On the other hand, the researchers which already came back do have their real experiences with cooperation with industry abroad. The average value 2.76 is negative and this is an important indicator of disillusion they have. In fact, their real experiences with academia-industry cooperation have disappointed them. This may be an important observation when creating a strategy for successful reintegration of Slovak researchers.

The statement 7 indicating women's interest in having **experts for cooperation** after returning home is an interesting conclusion. We have no explanation for it at this moment and it could be a suitable question for further research.

In the statement 8 (older researchers look for more **long-term job security**), there may be the factor of age:

older people may have their families and therefore they seek more stable positions not depending on short-term funding.

The statement 9 (people planning a shorter stay, consider **family or other personal reasons** as more important to return home) seems to be quite obvious. It is likely that researchers with some family or other personal links to home land would plan rather shorter stays because of them.

Lower, however still interesting value, have the statements 12-15. As for the relationship with a partner from another culture (12), this phenomenon is rather more typical for younger members of our culture, often without strong bonds to their family or friends from home, so it seems obvious that they give it higher importance than older generations who are more likely to have the stable relationship or family issue solved.

Improvement of language skills (13) is clearly more important for younger researchers abroad: they are in the beginning of their careers and they take the language skills improvement as an important part in their preparation for future. At the same time, older researchers, presumably with more experience from stays abroad have their language skills developed to more satisfactory level and take other challenges in life.

The same topic in the next statement (14) can be justified by the fact that researchers planning a short stay are more aware of the short nature of their planned stay and potential scarcity of opportunities to improve their language skills, while the researchers intending to stay abroad longer expect that the length of their stay will

naturally contribute to the language skills improvement without a need to worry about it beforehand.

Statement 15 can be explained by deeper interest of researchers willing to spend longer time abroad in the quality of their stay, including close research relationships with good contacts for their future performance.

The rest of statements seem to be quite obvious logically and need no further search of explanations. Although they do not bring any additional information, their presence is also important: they prove the methodology to be correct, since it is able to display also logically expected results.

The major benefit from the analysis is that all the conclusions will be used in further synthesis of recommendations for institutions to motivate Slovak researchers to come back home and facilitate the process. Whether they are obvious or not, they inspire us about defining specific recommendations for different social groups among researchers based on gender, age or length of stay abroad.

8. CONCLUSION

In the paper, we described the way how we coped with the conclusions of a survey on the reintegration of the Slovak scientific researchers abroad that, by using basic statistical methods, did not provide sufficient information to us. We used a method for clustering according to some indicators from the respondents' profile and we tried to find out differences in answers based on the created groups. It helped us to get some dependencies between indicators of respondents' groups and their views what has enriched the original results from the survey.

The clustering analysis showed us some new as well as some obvious and expectable conclusions. For the non-obvious, we drew some hypotheses that would require further research for confirming them. The obvious ones confirmed that the used methodology is correct for our purpose. All of them will contribute to definition of better and more appropriate measures for institutions to facilitate the comeback of researchers home from abroad.

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