THE PERSONAL FACTORS IN SCIENTIFIC COLLABORATION: VIEWS HELD BY SLOVENIAN RESEARCHERS

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ABSTRACT *Scientific collaboration (SC) has become a widespread feature of modern research work. While many social network studies address various aspects of SC, little attention has so far been given to the specific factors that motivate researchers to engage in SC at the individual level. In our article, we focus on the types and practices of SC that researchers in Slovenia engage in. We consider this topic by adopting a quantitative and qualitative methodological approach. The former was conducted through a web survey among active researchers, and the latter through in-depth interviews with a selected group of top researchers, i.e. intellectual leaders. Results show the extent of individual SC depends on the perceptions of researchers of the benefits of SC. Qualitative interviews additionally provide broader reflections on certain policy mechanisms that could better motivate Slovenian scientists to scientifically collaborate in the international arena.*
KEYWORDS: *scientific collaboration; research cooperation; personal factors; scientific disciplines*

INTRODUCTION

In contemporary science, scientific collaboration (SC) is becoming an ever more complex and necessary phenomenon that can take many forms. Although

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the term SC[2] is hard to define clearly (Hara et al. 2003) and its borders therefore remain "very fuzzy or ill-defined" (Katz et al. 1997, p. 8), there is a general societal consensus about its growing importance. SC is shaped by the social norms of various research practices and the different structures of scientific knowledge that exist across the scientific community. For practical purposes, we refer to Sonnenwald's definition of SC as "human behavior among two or more scientists that facilitates the sharing of meaning and completion of tasks with respect to a mutually shared superordinate goal and which takes place in social contexts" (Sonnenwald 2007, p. 645). We could say that, regardless of the level and type of analysis, the concept of SC is understood as a process based on knowledge-sharing and one that facilitates the achievement of common goals.

SC can be observed from different perspectives and this diversity contributes to the abundance of various terminologies, research approaches and methodologies (Katz et al. 1997, Shrum et al. 2008, Shrum et al. 1998). Further, a range of indicators for measuring SC has also been used. Co-authorship publications are usually regarded as the most prominent indicator (Katz et al. 1997, Glaenzel et al. 2004). However, many other instances of SC are not "consummated" by way of co-authorship publications and thereby remain undetected by bibliometric approaches (informal interactions at a distance, exchanges of students and researchers, hosted visits etc.) (Melin et al. 1996, Laudel 2002).

The wider question of what SC is and how it can be investigated leads us to consider which factors can influence and promote SC. Such an interplay of factors occurs at the micro level (individual scientists), meso level (research groups, departments, institutions) and macro level (institutional sectors, in particular collaborative agreements between university and industry, countries or regions) (Franceschet et al. 2010, Melin 2000). National and transnational R&D policy decisions have a big impact on SC at the macro level (Katz et al. 1997, Sonnenwald 2007, Maglaughlin et al. 2005). The various institutional mechanisms for funding and encouraging various types of SC, such as mobility programs, common international use of large research facilities etc., could be seen as the most important macro external factors affecting SC (Langfeldt et al. 2012, Toral et al. 2011).

Regarding the R&D science policy context in Slovenia, our previous analyses of SC have shown that different types of SC are still not properly supported with appropriate policy mechanisms. We have detected many deficiencies (Mali et al. 2010, Mali et al. 2012, Kronegger et al. 2012a, Mali 2013). A considerable

2 In many cases, the term "collaboration" is used intuitively and interchangeably with other similar terms such as "co-operation" and "co-ordination" (Hara et al. 2003). In this paper, we will use the term scientific collaboration (SC).

disadvantage of Slovenian R&D policy during the whole transitional period was that, while its strategic documents acknowledged the need to promote interdisciplinary publications co-authored with researchers from abroad or inter-sectoral publications, these measures were only normatively declared. Namely, they were not put into practice, as in many other EU member states (Tijssen 2004).

While "macro" R&D policy factors might play an important role in promoting SC, "micro" factors are even more important. In the case of micro factors, the basic question is how strongly researchers themselves are motivated to cultivate rich and productive forms of SC. However, researchers' individual motivations and practices are never completely independent of the wider policy frameworks that determine the extent and possibilities of SC. This wider policy and institutional framework at the macro level consciously or unconsciously influences the "micro-decision" (Tijssen 2004, p. 629) of researchers to build collaboration networks. But the converse also applies – the most successful R&D policy measures for SC are usually accepted if they motivate scientists at the individual level (Parker et al. 2016).

In our contribution, most attention is given to micro-decision factors, which chiefly refer to the perceptions, incentives, and personal strategies for SC from the perspective of individual scientists. These factors depend on "individual choices" (Wagner et al. 2005, p. 189) and help us understand which rational choices individual scientists make to encourage collaborative research activities.

As we empirically study this complex topic, we take the differences between scientific disciplines into account. Our assumption is that SC is especially interesting as a subject of study when researchers are separated by disciplinary boundaries. First of all, we tried to ascertain any differences between "office disciplines" and "laboratory disciplines" with regard to Slovenian researchers' propensity to collaborate. In the empirical part of our research, we combine different methodological approaches in order to obtain a more complete and informative picture of this intricate topic. The article is divided into four main sections. First, a brief theoretical overview of the factors influencing SC is presented. This is followed by the research background that also describes the research questions for the quantitative part of the study and the methodologies used in the empirical research. The third section is devoted to the analysis and a discussion of the results. The final section presents the conclusions with some recommendations for R&D policy in Slovenia.

THEORETICAL FRAMEWORK: FACTORS AFFECTING SCIENTIFIC COLLABORATION

Since SC can take various forms in practice, and as Katz and Martin write, may range "...from the very substantial to the almost negligible" (Katz et al. 1997, p. 3), we can think of numerous factors that influence SC. Such collaboration usually entails a high degree of uncertainty, and trial and error is an integral part of the processes within SC (Sonnenwald 2007). Given the diversity of this phenomenon, the theoretical concepts explaining it are not always very clearly articulated. The categories and criteria employed in previous social network and bibliometric studies intended to classify the types and factors of SC have neither been universally defined nor are mutually exclusive. They largely depend on the studied research problem and the specific sociocultural context.

Generally speaking, scientists may collaborate with each other due to complementary factors. Despite some criticism, SC is usually perceived as beneficial.[3] Some STS scholars classify the reasons for collaborating into seven general categories: scientific, political, socioeconomic, structural, social, personal, and resource accessibility. Of course, these categories often overlap and their borders are fuzzy (Klenk et al. 2010). Scientific reasons can include access to expertise, encouragement of cross-fertilisation across disciplines, etc. (Autio et al. 1996, Grey et al. 2001, Bozeman et al. 2016). It is generally agreed that scientists benefit from collaboration in terms of both scientific productivity and scientific impact. Jonathan Adams analyzed the data on research articles and reviews from the Thomson Reuters Web of Science between 1981 and 2012 (covering 25 million papers) and found that the best science in terms of impact comes from international collaboration (Adams 2013).

The list of various categories of factors that affect SC shows the primary drivers of most SC are scientists themselves. For example, the personal factors of SC pertain to expertise, social networks, trust, personal compatibility, and common professional traits (Maglaughlin et al. 2005). This list is, of course, far from exhaustive and authors dealing with this issue rarely use the same typology. The relative importance they attribute to various typologies usually depends on their theoretical perspective and the level at which they perform the analysis (Hara et al. 2003, Katz et al. 1997, Toral et al. 2011, Melin 2000, Presser 1980).

3 Some scholars have also pointed out the potential negative effects of SC (Cassuto 2016, Wray 2006). According to this view, the first concern is that collaborative research seems to threaten the motivation of scientists. This, in turn, may have adverse effects on what sorts of things scientists can effectively investigate.

Nevertheless, most STS scholars distinguish two types of motivation that drive individual scientists to engage in SC. On one hand, individual scientists have expectations about the direct benefits of SC that motivate them to collaborate (e.g., producing research of higher quality, conducting research more quickly than without cooperation). On the other hand, there are also expectations about the indirect benefits of SC (e.g., enhancing one's reputation, gaining access to further research funds) (Katz et al. 1997, Beaver et al. 1978). Sometimes these personal motivations that encourage SC are explained in terms of either the resource-based view or more specifically in terms of costs and benefits (Ponomariov et al. 2016).

One of the strongest individual motives for SC connected with the resource-based view is the desire to obtain access to the expertise and competencies of others which provide complementarities in the research process. For example, two investigators – say, one particularly skilled in experimental design, the other in data analysis – should be able to produce a better scientific result than either one working alone (Bozeman et al. 2013, Bermeo Andrade et al. 2009). In modern science, the lone scientist is no longer able to tackle most larger scientific projects. No individual scientist would have been able to sequence the human genome – this required massive manpower and diverse expertise. Sergio Toral and co-authors write that "researchers consider it more exciting working with people and groups that have different skills and viewpoints" (Toral et al. 2011, p. 21). Some scholars dealing with social network analyses connect this aspect with scientists' ability to obtain human capital (Bozeman et al. 2015, Bozeman et al. 2016, Bozeman et al. 2001, Bozeman et al. 2004, Clark et al. 2012). Human capital is understood here as the sum of skills, knowledge and social relations needed for individuals to participate effectively in the modern system of science. It improves the ability of scientists to compete for future grants because their ability to secure grants is strongly linked to their reputation and capacities as researchers.

Another important purpose of collaboration is to increase popularity, visibility and recognition (Wuchty et al. 2007, Hoekman et al. 2010, Gazni et al. 2011). Such scientists see the benefit of SC in terms of publications written by multiple authors that tend to have a higher impact on their recognition inside and outside the scientific community (Boyer-Kassem et al. 2015). Many bibliometric analyses show that scientific articles stemming from international collaborations are, on average, cited more frequently than scientific articles produced within national collaborative projects (Adams 2013, Endersby 1996). As we can see, a purely epistemic account of SC is hard to defend and the incorporation of social aspects makes SC explanations more powerful (Holgate 2012). This is true especially for international SC.

The training of young scientists is another important internal factor for SC (Whitley 2000, Kronegger et al. 2011). Young scientists' interest in collaboration is usually reflected in their striving to be mentored by a good mentor or research group during the process of their professional training. This is further expanded by the mentor introducing the young researcher into their own professional network of research contacts and collaborators, thereby providing them with greater prospects for future research and career development.

The issue of SC initiated through mentorship has attracted quite a lot of interest in classical studies in the sociology of science. In those studies, the relationship between juniors and their mentors has been imagined as a craft activity, learned by experience through "on the job" training and academic "apprenticeships." Here, it is very important that mentors teach their young colleagues personal craft skills (Whitley 2000, Campbell 2003). The well-known phenomenon of the Mathew effect in science functions on the grounds of the relationship between the mentor and the junior researcher. According to many interpretations, the Matthew effect (summarized in the phrase "the rich get richer and the poor get poorer" [Merton 1973, p. 125]) should produce a negative effect in science. Eminent scientists who have the role of mentors should be particularly favoured because in both collaborations and multiple discoveries disproportionate credit would be given to them. But, as already noted by Robert Merton, the author of the Matthew effect, this situation would primarily play a positive role in science. It leads to social selection processes that result in a concentration of resources and talent in science. For example, SC between a mentor and Ph.D. students is essential for helping to create the intellectual and social capital of these PhDs for their later scientific career. Moreover, many empirical analyses that deal with the implications of the Mathew effect confirmed that, for the publication productivity of PhDs in their later scientific career, in the earlier phase of doctoral training it was very important to work with highly reputable scientists acting as their mentors (Zuckermann 1977, Simonton 1997). Finally, scientists' interest in SC encompasses not only productivity, visibility, mentorship and an extension of skills, but also the faster "spillover" of new scientific knowledge into society at large.

Some of the factors that most frequently influence collaboration strategies are access to otherwise unavailable equipment and resources, increasing science specialization and, finally, the pleasure of working with other research colleagues (Bozeman et al.2004, Haslam et al. 2009).

Ultimately, the set of factors that enables collaboration to continue to run smoothly and successfully is strongly connected to the personality of the collaborators, namely personal compatibility, style of work, respecting deadlines and trust the assigned tasks will be done well (Hara et al. 2003).

This can typically only be adequately judged in the longer term and is often the reason that specific collaboration is discontinued or does not lead to a new collaboration effort with the same collaborators.

This overview of the motives stimulating scientists to collaborate is of course incomplete. However, while most of the former are analyzed in the qualitative analysis, only some of those selected are included in the quantitative analysis.

BACKGROUND FOR THE EMPIRICAL ANALYSIS: RESEARCH QUESTIONS AND METHODOLOGIES

In our empirical investigation, we explore the views of Slovenian researchers about their positive and negative experiences with SC, and the factors influencing their decisions about whether to join and actively participate in research collaboration networks. This was achieved by a limited questionnaire analysis and more extensively by a qualitative approach. Our first research question to be addressed by the quantitative approach concerned the perception of the benefits of collaboration. More specifically, the research question was: Are those scientists who perceive SC benefits to be high more willing to collaborate? The second research question was whether there are differences between "office disciplines" and "laboratory disciplines" with regard to the propensity to collaborate.

In differentiating between office and laboratory disciplines, we relied on evidence from previous studies in the sociology of science (Ziman 2000, Whitley 2000). According to these studies, the scientific disciplines which depend on a crucial institutional and organizational framework in order to conduct their scientific activities may be classified as laboratory disciplines. These usually require special research infrastructures and large research groups. Here, we can talk about the existence of a type of "collaborative imperative" (Bozeman et al. 2016, p. 1718). In the case of office disciplines, research can be conducted in the office and by only a few researchers.

Methodology and data

Our empirical analysis employed not only a standardized quantitative survey among researchers from the selected scientific disciplines, but also in-depth qualitative interviews among a small group of "intellectual leaders"[4] in the Slovenian scientific community. We included the results of 18 interviews with top scientists from selected scientific disciplines within a broader interpretative framework, assuming they could provide better in-depth reflection on the up- and downsides of internal (scientific) as well as external (policy) mechanisms that encourage SC.

The quantitative approach was conducted by a web survey (the Computer-Assisted Self Interviewing technique was used) on a large sample of scientists (researchers were selected from those registered in the Slovenian current research database [SICRIS]).

The data were collected over two different time periods within a larger study in which many different research questions were addressed. The survey consisted of around 50 survey questions and only a few are analyzed in this paper. Moreover, the researchers from nine very different scientific disciplines (physics, mathematics, biotechnology, sociology, economics, materials, neurobiology, plant production and historiography) were selected to cover as wide a field of scientific activity as possible. Therefore, different scientific disciplines were selected in both time periods.

The questionnaire was sent out to a total of 2,469 researchers. In the first period of the survey (in 2010) the questionnaire was sent out to all researchers from physics, mathematics, biotechnology and sociology (a total of 662 researchers). After two reminders, the response rate was 52%. In the second period (2015) the same questionnaire was sent out to all researchers from economics, materials, neurobiology, plant production and historiography (a total of 1,807 researchers). This time, two reminders were sent and the response rate was 31%. An analysis of the data from the first survey period was recently published by Iglič et al. (2017).

At the end of both surveys 893 responses had been received, although not all respondents had completed all questionnaire segments. Regarding the classification into office and laboratory disciplines, 44% of respondents were from office disciplines and 56% from laboratory disciplines. Regarding gender, the respondents were about evenly matched in both groups of scientific disciplines (52% male and 48% female). For more details of the respondents' distribution by gender and discipline, see Table 1.

4 The group of "intellectual leaders" in the Slovenian scientific community consisted of scientists who had obtained excellent scientific results and in the past or currently held leading (management) positions at their institutions.

Table 1 *Survey respondents by sex and discipline*

	Male	Female	Total (100%)	Type of scientific discipline
Time period: 2010	**209**	**127**	**336 (38%)**	
Mathematics	64	20	84 (9%)	office
Sociology	42	50	92 (10%)	office
Physics	89	17	106 (12%)	laboratory
Biotechnology	14	40	54 (6%)	laboratory
Time period: 2015	**255**	**302**	**557 (62%)**	
Economics	62	94	156 (17%)	office
Historiography	28	34	62 (7%)	office
Materials	85	72	157 (18%)	laboratory
Neurobiology	32	45	77 (9%)	laboratory
Plant production	48	57	105 (12%)	laboratory
Grand total (%)	**464 (52%)**	**429 (48%)**	**893 (100%)**	

The qualitative part was conducted through in-depth interviews with selected representatives from each of the nine scientific disciplines included in the quantitative survey. Eighteen in-depth interviews were conducted. The interviewees were chosen according to two criteria: at the time of interview they were playing an active expert role in Slovenian R&D policy institutions, and they had demonstrated scientific excellence in terms of research results. In other words, our interviewees had to show some kind of intellectual leadership in their research area. This qualitative approach provided us with a wide spectrum of contextual information. The interviews were audio-recorded and transcribed. After gathering this extensive material, we used matrix mapping for the analysis. This method helped sort the material according to key issues and summarize the respondents' perceptions.

Measuring the perceived importance of scientific collaboration and the time spent on collaboration

Our main interest in the quantitative empirical part of the research was to investigate whether the perception of the benefits of SC affects the amount of actual SC (the first research question). As noted in the theoretical part of our discussion, researchers' decisions to join networks are connected with their expectations about the direct and indirect benefits of such collaborations.

Birnholtz (2007) conceptualized and operationalized propensity for collaboration. To measure this concept, he proposed five indicators which were all included in our survey (all survey questions were translated into Slovene). Since two indicators (*"I plan to engage in collaborative research in the future,"* and *"Collaboration is necessary in my field"*) were not sufficiently correlated with other indicators, they were not included in the analysis. Therefore, the following indicators were used in the research to measure the perceived benefits of SC:

- *"Researchers who collaborate with other researchers are more successful than those who do not."*
- *"Collaboration with other researchers can benefit my career."*
- *"Collaboration can help me tackle research problems."*

For each indicator, the participants indicated their level of agreement on a five-point ordinal scale (from "strongly disagree" to "strongly agree"). Cronbach alpha values are 0.80 for the first point in time and 0.78 for the second, showing a good level of reliability of measurement.

In general, the respondents agreed or strongly agreed with all the measured potential benefits of SC (Table 2).

Table 2 *The perceived benefits of SC of the surveyed group of researchers*

	Strongly disagree	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly agree**	**n**	**Average**	**Standard deviation**
	percentages							
Time period: 2010								
Researchers who collaborate with other researchers are more successful than those who do not	1	1	8	40	51	324	4.38	0.74
Collaboration with other researchers can benefit my career	0	2	4	39	55	318	4.48	0.65
Collaboration can help me tackle research problems	0	1	7	38	55	322	4.47	0.65

Time period: 2015								
Researchers who collaborate with other researchers are more successful than those who do not	1	0	3	30	65	530	4.58	0.67
Collaboration with other researchers can benefit my career	0	1	4	37	58	531	4.52	0.63
Collaboration can help me tackle research problems	0	0	2	39	58	531	4.54	0.58

Considering the Likert scale (sum of the three variables), on average, the researchers interviewed in 2015 perceived the importance of SC as being more important than those interviewed in 2010 ($p < 0.05$) (Table 3).

Table 3 *Perception of the importance of SC (Likert scale)*

Time period	**n**	**Average**	**Standard deviation**	**Mean difference**	**Welch's -test**		
					t	***df***	***p***
2010	**316**	**4.45**	**0.58**	0.10	2.54	634.6	0.01
2015	**528**	**4.55**	**0.53**				

In order to measure the extent of the actual amount of work done in collaboration, the respondents were asked "What share of your research work over the last 12 months was spent in collaboration with different types of co-workers?" To answer this, they had to distribute the total amount of time, expressed in percentages, among different categories of co-workers, where the first category was "individual work." Based on the percentage shares assigned to each category, the variable expressing work time spent on collaboration was calculated as . On average, the researchers who were interviewed in 2010 spent 58% (with a standard deviation of 23.9%) of their working time in collaboration with others, while those researchers interviewed in 2015 spent 4% (with a standard deviation of 25.0%) less of their working time collaborating with others. The difference is small, although statistically significant ($p<0.03$, see Table 4).

Table 4 *The share of time (in %) spent on collaboration*

Time period	n	Average	Standard deviation	Mean difference	Welch's -test		
					t	*df*	*p*
2010	**292**	**58**	**23.9**	-4	-2.16	621.77	0.03
2015	**532**	**54**	**25.0**				

To study how the perceived importance of SC affects the share of research time spent on collaboration, Multiple Group Structural Equation Modelling (SEM) (Ullman et al. 2003) was applied. To estimate the parameters, the DWLS (Diagonally Weighted Least Squares) estimator was used. The latter was employed since it provides more accurate parameter estimates when the variables are measured using ordinal scales and when their distribution is not normal (Mindrila 2010). The analysis was completed using the lavaan R package (Rossell et al. 2016).

EMPIRICAL FINDINGS AND DISCUSSION

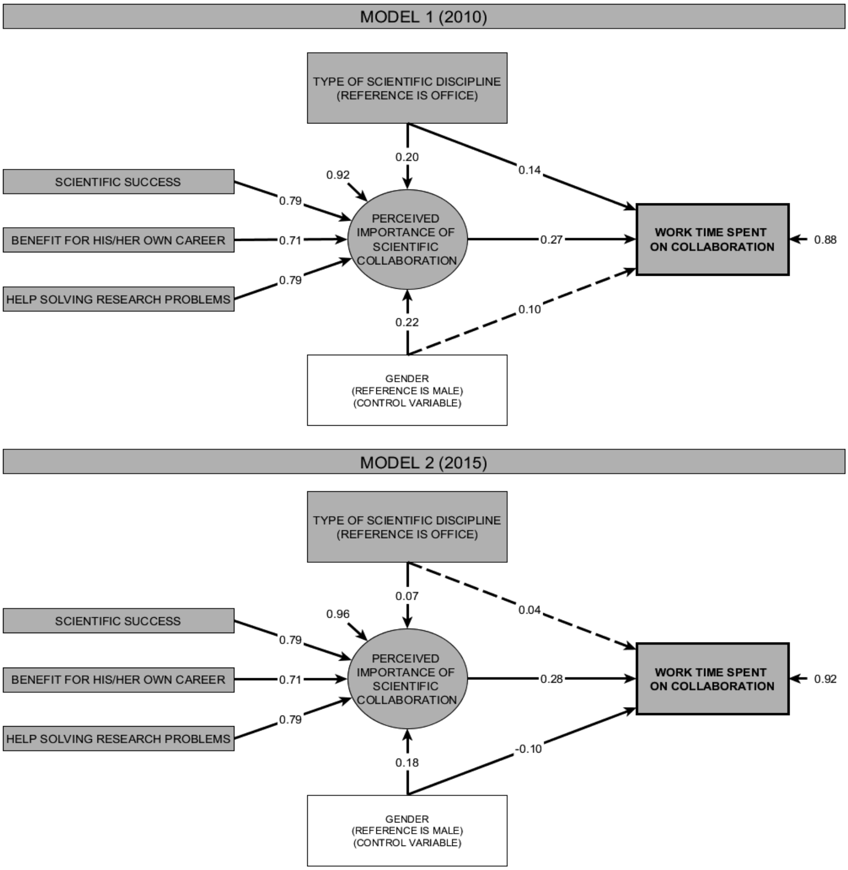
We first present the structural equation model used to study the impact of some of the personal factors on SC. As noted in the theoretical part of our discussion, national and transnational R&D policy decisions have a big impact on SC at the macro level. Second, in the qualitative part of our study, we focus on the micro-decision factors that relate to the personal strategies of individual scientists.

Impact of the perceived importance of sc and the type of scientific discipline on the time spent on collaboration

To study the impact of the perceived importance of SC and the type of scientific discipline (office vs. laboratory) on time spent on collaboration, we used multiple group SEM (groups were defined by the two data-collection time periods). Besides these variables, gender (0 – male, 1 – female) was included as a control variable, assuming that it affects both the importance of SC and the estimated time of work spent on collaboration. Weak invariance between the two groups of researchers is confirmed (χ^2=12.46, df=2, p=0.54), meaning the factor loadings can be considered as being equal across the two groups of researchers.

Model 1 (data collected in 2010): Both the type of a scientific discipline (laboratory or office) and the gender affect the perceived importance of SC. Those from the laboratory category of scientific disciplines consider, on average, SC as being more important than those from the office category. Females also consider SC as more important than males. A stronger impact (according to the standardized values of the regression coefficients) on the perceived importance of SC is shown by gender, followed by the type of scientific discipline. The model explains 8% of the variability in the perceived importance of SC.

Figure 1 *The SEM model with standardised regression coefficients and factor loadings*



The dashed lines are for non-statistically significant effects at $p<0.05$. $\chi^2=16.9$, $df=14$, $p=0.26$; $CFI=0.99$, $TLI=0.99$, $RMSEA=0.02$.

The impact of the perceived importance of SC affects the share of research work done in collaboration with other scientists ($p < 0.01$). Not surprisingly, those who consider SC as more important report a higher share of research time spent collaborating with others. However, the category of scientific discipline ($p < 0.05$) also affects the share of time spent on collaboration, but the value of the standardized coefficient is lower (0.14) than the one corresponding to the importance of SC (0.20). Researchers from the laboratory category of disciplines report spending more work time spent collaborating with others. The value of the regression coefficient of gender is not statistically significant ($p = 0.13$) and hence one cannot say that gender affects the actual share of work spent on collaboration. The model explains 12% of variability in the share of time spent collaborating.

Model 2 (data collected in 2015): Even though females perceive SC as more important than males on average ($p < 0.05$), they spend less working time collaborating than males ($p < 0.05$). There are statistically significant differences in the perceived importance of SC between the office and laboratory scientific disciplines ($p < 0.05$) than was the case in Model 1, but the value of the standardized regression coefficient is lower (0.07 vs. 0.20). Yet, the difference in the actual time spent collaborating (between the office and laboratory types of scientific disciplines) is not statistically significant ($p = 0.39$). There is a positive impact of the perceived importance of SC on the time of work spent on collaboration. The model explains 8% of variability in the estimated share of time spent collaborating and 3.5% of variability in the estimated actual time of work spent on collaboration.

How Slovenian intellectual leaders view the advantages and disadvantages of scientific collaboration

In order to shed light on the whole (macro and micro) context of SC, we decided to complement our quantitative analysis with qualitative interviews conducted with a small number of top Slovenian researchers. Our assumption was that this would be an important source for a deeper study of the wider dimensions of SC in Slovenia.

Concerning the perceived benefits of SC, the 19 intellectual leaders in Slovenia who were interviewed in some sense confirmed the results of our survey analysis. Namely, all of them stated they prefer to work with colleagues with whom they are close in terms of the working environment and common research topics. Further, they were all predominantly involved in international R&D projects, meaning they are aware of the importance of the internationalization of science in small countries.

Concerning the factors they perceive as most problematic for SC, the intellectual leaders especially stress the various kinds of difficulties in establishing co-operation with professional colleagues from different disciplines. In this regard, it is sometimes more difficult to harmonize the elements of a common research interest (differences in methodologies and subjects can be large even within a single discipline) than to find the proper "'personal chemistry." Given the division between laboratory and office disciplines, it is interesting that it was an interviewee from sociology who very strongly emphasized the problem of extreme specialization in his discipline: "*I feel there is great deal of fragmentation within my discipline, which is not based on subject differentiation, but is instead interest-driven, with small islands of power protecting their own territory and resources. This hinders efforts at inter-institutional and also interdisciplinary collaboration. Further, it makes it more difficult to establish communication with a more developed, international environment."* The interviewee from the field of economics assessed that, because her discipline is more applied, there is also less problem with SC between disciplines: "*Because our research is more applied, it is also more widely based on various kinds of interdisciplinary co-operation*".

Concerning R&D policy support for inter-sectoral SC, which in the theoretical part of this paper we defined as the so-called macro factor, most of the Slovenian intellectual leaders were extremely critical. Especially those from the "laboratory" disciplines mentioned the lack of adequate policy mechanisms for increasing inter-sectoral collaboration. The interviewee from the field of biotechnology assessed that the policy of the Slovenian Research Agency (for example, the R&D evaluation methodology it uses) is unsuitable for promoting strong cooperation between R&D teams from the academic and the business-enterprise sectors. A similar opinion was expressed by the representatives of other laboratory disciplines.

Given that all our interviewees belong to the elite group of Slovenian scientists and they have been very active in various international R&D networks throughout their careers, it is not surprising that they strongly emphasize the need for Slovenian science to become more internationalized. The interviewed biotechnologist said that international collaboration is a "must." He noted that Slovenian researchers must be more ambitious in applying for EU projects, especially by assuming the role of project coordinators. "*We do not need further fragmentation of our already scarce R&D efforts in mutual competition for EU R&D projects.*" The historiographer criticized the parochial orientation of his discipline: "*Better international collaboration would require a more rational structuring of the Slovenian capacities, the merging of different groups, to be able to compete abroad. The ethnocentricity of Slovenian historiographic* *research often narrows the possibilities for wider international collaboration."* In presenting the opinions of Slovenia's intellectual leaders, we should emphasize one additional remark. All interviewees expressed the view that, in order to join EU projects, as a rule it is extremely important to have some prior informal connections (getting in touch with the authors of a scientific paper, meeting at a conference, etc.) with the proposed future collaborators.

Concerning the factors that influence researchers' decisions to collaborate, the key factor identified as essential by representatives of the Slovenian scientific elite is the ability to produce better research outcomes in the first place. Namely, as most of them agree, the first benefit (i.e. achieving the best research results), logically leads to the second-most important benefit: the possibility that, based on good scientific results, they can increase their appeal as potential collaborators in the international arena. Or, as the physicist said: "*The internationalization of Slovenian science, which is based on collaboration with excellent scientific centers abroad, has many positive effects. In the natural-technical sciences in Slovenia, about 20 years ago an important 'leap' occurred if we measure the quality of scientific results with publications in the most prestigious international scientific journals. In the old times, Slovenian natural scientists had not published one single article in journals such as Nature and Science. Since the mid-1990s, the situation has changed dramatically."*

All interviewees also pointed out the critical importance of possessing and developing a good network of personal contacts, especially in "mentorship networks." Many mentioned how important it is to help young researchers enter their networks which, for these young researchers, is a prerequisite for successful collaboration throughout their later researcher careers. In this regard, the interviewee from historiography criticized the restriction that excludes retired researchers from further participation in research projects and programs, which means losing their valuable networks. This support can be seen as helping young researchers join already established networks of senior researchers and develop their own connections. The sociologist pointed to another problem connected with the "transition" processes in research networks which originates from the current employment crisis facing young researchers in Slovenia. Namely, if young researchers have no prospect of obtaining a permanent research position and are treated as a burden or unnecessary expenditure, the intergenerational process of building collaboration will be interrupted and the contacts will be lost.

Also quite expected were our interviewees' opinions about the role of trust in initiating and forming new types of collaboration. They are aware that SC requires a degree of warranted (not naive) trust and trustworthy behaviour, which is expected to be based on the ethical values of honesty and fairness. Without this, any kind of research activity quickly becomes riddled with defensive ploys. Accordingly, many interviewees mentioned that collaboration can follow less predictable patterns, and that previous contacts and informal connections are often a prerequisite for more formal collaboration, when collaborators have already determined each other's expertise, trust, reliability, and other individual factors. Another element continuously repeated as crucial for establishing successful collaboration was having common research problems, needs and goals.

CONCLUSION

In our contribution, we started with the assumption that SC is a complex phenomenon that can take many forms. Since SC can take place in different formats, the personal factors affecting SC are also numerous and diverse. The focus of our empirical interest was whether the expectations of Slovenian scientists regarding the direct or indirect benefits of SC significantly affect the share of research time they spend on SC. Our analysis included mainly expectations regarding some type of benefit from SC. By predominantly focusing on scientific success, scientific career, and solving scientific problems, we concentrated only on some of the most important factors which motivate scientists to collaborate. Perhaps this restriction is too narrow and a more general set of direct and indirect benefits is the most significant limitation of our contribution. As we mentioned in the theoretical part, it is impossible to present all the motives that drive scientists to become engaged in SC. Nevertheless, the results of our analysis point out very clearly that individual expectations about the benefits of collaboration play a prominent role in scientists' pragmatic R&D strategies. In other words, scientists operate – to use the terminology of Max Weber – as "rational actors" in their decisions to invest time in various forms of SC. It was also not surprising that our empirical analysis confirmed that scientists from the laboratory category of disciplines, on average, tend to collaborate more than scientists from the office category. Various reasons explain why Slovenian researchers socialized in laboratory disciplines are more inclined to adopt the "cognitive culture" of SC. In our contribution, we explained these differences derive not only from internal cognitive, but also from external social factors. These cognitive/social differences between the two categories of disciplines regarding participation in SC were further highlighted in our in-depth interviews with the intellectual leaders of Slovenian science. The latter provided broader reflections on the role of macro R&D policy factors which might be important for initiating and promoting the collaboration of Slovenian scientists in the international arena. Their strong criticism of R&D policy mechanisms regarding various types of SC additionally support the view that in Slovenia the micro-decision factors, which mostly relate to active researchers' personal collaboration strategies, are basically the most important. Thus, as we can see, Slovenia still lacks adequate R&D policy mechanisms (financing, evaluation, etc.) that would reorient the majority of scientists towards the establishment and development of collaborative structures in the international (and not local) environment.

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