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Beyond the Myths about the Natural and Social Sciences: A Sociological View

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Contents

Katarina Prpić

The unbridgeable gap between the natural and social sciences?

The famous thesis about the unbridgeable gap between two cultures – of the natural sciences and the humanities, to which Snow (1959) also later added the culture of (some) social scientists (Van Dijck, 2003), is a symbol of the great ontological and methodological divide that only few question (Fuchs, 1996). The division was most strongly expressed in the so-called Science Wars of the 1990s which have been extensively discussed (thematic issue of *Science Studies*, 1/1996; Segerstråle, 2000). Even though the Science Wars refer to the acrimonious disputes between researchers of science and some parts of the natural science community, they are only a more recent symbol of the gap articulated by Snow a long time before. However, this is not the place for a wider discussion on the genesis, protagonists and reasons for the verbal conflicts; the reader can obtain information on the issue elsewhere, and also in Croatian publications (Matić, 2001).

The polemic among scientists led to the public expression of opinions of engaged natural scientists who claimed that some circles in the social sciences and humanities simply did not understand the way the natural sciences functioned (Bauer, 1996), not to mention the comments in the widely-known book by Gross and Levitt (1994) *Higher Superstition*. Another type of relation that the natural scientists have towards the social sciences and humanities is the evaluation of other scientific fields according to the criteria of their own cognitive practice. Such an attitude was succinctly expressed by one of our respondents who said that the objectivity of physics has always been "the model for all sciences". Some sociologists of science hold that the hard, natural sciences, which enjoy a higher intellectual and social status, have been attempting to conduct a rather aggressive intellectual colonisation of the soft, lower-status, sciences. And the higher status is shown here in greater public acknowledgment, prestige and funding (Fuchs, 1996).

Some also claim that the natural sciences have in general been a paragon for social scientists, from Comte to Merton and on (Fuller, 1999). Although there are some grounds for this thesis, it is at the same time also rather dubious because of the widespread (self)awareness among the social scientists of the peculiar nature of their fields compared to the natural sciences (Andersen, 2001). In short, the social sciences embrace the non-critical application of the natural science model, but also the uncritical denial of any cognitive similarity between the two areas that is not acceptable to natural scientists. The latter position is frequently stated when research evaluations, promotion criteria or other topics important to science policies are discussed.

Thus, a severe lack of mutual understanding and communication can be seen in scientists from both areas. This is why the argument seems so tempting that two scientific cultures can show mutual indifference, ignorance, suspicion and even open hostility in situations when funding is shrinking, as in the Science Wars (Fuchs, 1996).

Although the widest communities of natural and social sciences are extremely important, they still remain to be encompassed by research. However, the theory of science(s) is more relevant as the starting point of study. Despite talk of the (non)codified sciences, Merton (1973) had no doubt that science was one and unified, "out of one piece", as his critics often reproach him for implying. Within this theoretical framework, there was no interest in wider and deeper comparisons of the epistemic and social dimensions of particular sciences. Kuhn's view of the scientific community gathered around a scientific paradigm, and Price's concept of *invisible colleges* as communication networks in individual sciences have encouraged the spread of sociological and other investigations in the development of scientific fields and specialties (Crane, 1972; Lodahl and Gordon, 1972).

The well-known empirical classification of sciences made on the basis of scientists' assessments of similarity among research fields/disciplines was directly encouraged precisely by Kuhn's distinction between the preparadigmatic (social) and paradigmatic (physical) sciences, and it resulted in a typology of hard and soft, pure and applied, sciences, and the distinction between sciences dealing with living and nonliving systems. These types of sciences differ in terms of the social cohesion of scientists, their teaching, research, expert and administrative work, as well as in terms of their productivity (Biglan, 1973a, 1973b). Kolb also came to a similar typology in his psychometric measurements of students' learning strategies (according to Becher and Trowler, 2001). Nowadays, the distinction used most often in literature and daily communication is the two-member distinction between the hard and soft sciences.

Becher's conception of academic cultures is a synthesis of previous theoretical taxonomies (Pantin and Kuhn) and the above-mentioned empirical studies. Considering their epistemic characteristics, Becher adopted the typology of hard-soft and pure-applied fields, but also introduced two social, cultural dimensions. The convergence-divergence of disciplinary communities indicates the (non)existence of uniform standards, intellectual control and a stable elite, while the urban-rural dimension shows the smaller or greater density of researchers with regard to a lesser or greater restriction of topics and research problems. Becher founded his typology on a great number of interviews with scientists from 12 scientific fields. He also developed an anthropological approach which sees disciplinary communities as academic tribes that inhabit a certain academic territory, that have their own goals, typical behaviours, publication patterns, values, traditions and membership controls (Becher, 1994; Becher and Trowler, 2001).

Theories of scientific organisations or fields are the origin of the sociological typologies of science (Whitley, 1984; Fuchs 1992). The heuristic value and advantage of these theories are their primary thesis that links the cognitive and social organisation of science, and thus allows the scientific fields to be observed as scientific organisations where their intellectual products, cognitive style and epistemological orientations are connected to the social structures, mode and organisation of the production of that knowledge. Individual (sub) disciplines can thus be seen as distinct intellectual and social organisations that differ to a certain extent. Typologies of the scientific fields developed by the theory-makers were very complicated at first (Whitley, 1984), and significantly simpler later (Fuchs, 1992), but that is not their greatest weakness.

There are two key, and even interconnected, flaws in these theories (Prpić, 1997). The first is the excessive sociologisation of the cognitive dimension of science, which later annulled the initially assumed possibility that the cognitive organisation of science affects its social organisation. This even excluded the possibility that the type of demanded (applicable) knowledge encouraged by science policies for decades influenced the (re)shaping of the modes of knowledge production (Whitley, 1984). For this reason, it is not hard to agree with the view that the intellectual structure of science will not be sufficiently considered if the cognitive dimension is not taken as an independent source of variance (Leydesdorff, 2007). The other weakness of these theories is the view that science is almost a series of atomised scientific fields, despite the fact that a sociological, and not philosophical, demarcation of science from other forms of cultural production has been offered. Science is the producer of innovations, cognitive novelties, and is characterised by the high level of uncertainty of its tasks and by the mutual dependence of the knowledge producers.[1] In line with this proposition, the scientific fields should have a minimal nucleus of shared cognitive and social characteristics, apart from their peculiar intellectual and social organisation. The reluctance of scientific field theoreticians to produce such a thesis stems from their tacit view that the nucleus would be understood as a set of firm, unified, universal intellectual rules and procedures, with the same social, professional structures in all sciences.

However, both models of science – unitary and atomised – can be replaced by the concept of the complex socio-cognitive structure of science, with a common (relatively loose) nucleus of the basic characteristics of its social and intellectual system, the interdependence of these two systems, and a high level of cognitive and social peculiarity of individual scientific fields. If modified in this direction, the theories of scientific organisations offer a fruitful, and the widest possible hypothetical framework for sociological empirical investigations of science. This hypothetical starting point could be the basis of broader empirical comparisons of scientific fields in thematically different studies, from productivity to the professional ethics of scientists (Prpić, 1997, 2004, 2005). This was precisely the inspiration for this book.[2]

Our goal was to gain as complete an insight into the socio-cognitive specificities of the natural and social sciences as possible, on the basis of comprehensive empirical research. This would allow us to establish whether the sociological theories of science also built the myths on the great divide between these sciences. The aim was not set too ambitiously, since a single study could not provide an answer to that big

[1] Later, Fuchs (2002) restated his thesis from the 1990s, which proposes that sociologically-determined objectivity, understood as a mode of communication in science, is the very demarcation of science on the one hand, and pre-science and pseudo-science on the other.

[2] The book was written within the scope of the scientific project *Social Actors in Science and Technology* (100-1001172-3041) at the Institute for Social Research in Zagreb. The project is funded by the Ministry of Science, Education and Sports of the Republic of Croatia, and is carried out by a research team made up of all of the authors who contributed to the book, headed by the project leader and editor of the book.

question, even if it included several investigations. We wanted to gain as complex an insight as possible into the differences and similarities between natural scientists and social scientists in their career paths and patterns, professional performances and achievements, and scientific productivity, as well as in their perceptions of scientific objectivity and quality.

To achieve this goal, a more complex quantitative and qualitative methodological approach with several research methods had to be applied. The first ever web survey among Croatian scientists was conducted in 2004, covering 480 or 24.7% of natural scientists and social scientists, from whom both quantitative and qualitative data were gathered. In 2007, the first comprehensive bibliometric study of the productivity of all 1,938 doctors of natural and social sciences was carried out. The data on publications and citations over the period of the last ten years was collected from the WoS (*Web of Science*) and Scopus bibliographic and citation database for every PhD holder.

Empirical material collected in the mentioned studies cannot be analytically processed and exhausted in only one publication, regardless of its extensiveness. Basic quantitative (including bibliometric) and qualitative analyses were conducted, in line with the goal and the concept of the book. Sociological papers, which form the backbone of the book, are enriched by an information-science approach to the analysis of the scientific output, the socio-psychological view of scientific quality, and an epistemological overview of objectivity in the social sciences. We believed that besides a complex theoretical and methodological approach, interdisciplinarity was also necessary if any relevant contribution was to be made to understand the presumed gap between the natural and social sciences.

We hope that such a definition of the scientific goal and approach to research will provide insight into the described and theoretically postulated differences between the natural and social sciences. In other words, we hope it will provide an answer to the question about whether these differences are really as deep as the dominant theories and thesis in the sociology of science and scientific knowledge deem them to be. We also hope that this book will encourage even more complex research that will not accept *a priori* the gap between the natural and social sciences as an undoubted, proven and almost fatal rift, but will question and investigate empirically in its various social and cognitive dimensions and layers.

Apart from the cognitive expectations, our book could also have a double social purpose. On one hand, its very questioning of differences establishes a kind of bridge between the self-sufficient scientific communities of the natural and social sciences. If the assumptions about fresh developments in the mode of knowledge production (Gibbons et al., 1997) turn out to be even partly true, such self-sufficiency will no longer be sustainable. Even without this aspect, empirical insight into the specificities of the cognitive and social organisation of the other scientific area can make communication between them easier, which is especially important in articulating scientific policy. On the national level, this type of communication is more realistic in the small Croatian scientific community than in the communities of large countries. Furthermore, the transformation of the scientific system, especially the evaluation system, has not yet been completed. Therefore, it is important for the Croatian natural and social science communities to become better acquainted with one another, thus reducing potential tensions, especially those concerning the criteria for evaluating research and researchers, and, consequently, those connected with research funding.

The organisation of the book itself has been adapted to its thematic content, so it has been divided into two parts dealing with the important aspects of the social and intellectual organisation of the natural and social sciences. While the first part focuses on the most relevant elements of the social organisation of these areas – the professional profile and productivity of the research staff, the second part discusses the cognitive convictions of the members of these two scientific communities. Apart from this difference in content, there is also another methodological distinction between the two parts of the book: whereas the first part contains quantitative analysis, the second part covers theoretical and qualitative empirical works.

The first chapter of the first part of the book entitled the Social and Professional Profile of Natural and Social Scientists compares the most important socio-professional characteristics of the scientific personnel of the two observed areas. The socio-demographic composition and social background of scientists, their professional socialisation, their organisational and scientific context, and their position and role in Croatian and international scientific institutions and communities are the starting points for the sociological analysis and comparison of the two scientific areas. Most importantly, this chapter also brings a description of samples and tests of their representativeness. In her empirical analysis, author Branka Golub compares the findings of the web survey with the results of earlier project team studies. The comparison is based on a set of the sociologically most relevant indicators of the professional profile of Croatian scientists, which has been followed up for decades, from one survey to another.

The second chapter analyses the patterns and factors of the self-reported productivity of two groups of scientists. Since the Croatian surveys also continuously monitor the research productivity of scientists, it was also possible to make comparisons here with previous results obtained on subsamples of natural and social scientists. The editor of the book, Katarina Prpić, and her co-author, Marija Brajdic Vukovic, have not only compared the data on the most important types of respondents' career and five-year publications, but also analysed the observed trends of changes in these types of productivity. Where possible, the authors have compared their findings with the results of foreign studies. This chapter also includes an analysis and comparison of potential productivity factors – socio-demographic, socialisational, qualificational, organisational and gatekeeping predictors of productivity, in the natural just as in the social sciences.

Bibliometric research of the productivity of all doctors of natural and social sciences is presented in the third chapter by Maja Jokić and Adrijana Šuljok. The pioneering nature of the work cannot be overemphasised. Bibliometric analyses conducted so far in Croatia, largely by natural and medical scientists, have been partial in regards to the range of the scientific fields, number of authors and span of time covered, whereas this analysis covered all the WoS (ISI) and Scopus publications of each scientist. This will allow interrelations to be made with other known and available characteristics of authors, and consequently in future sociological analyses and productivity comparisons of sexes, age groups, scientific fields, institutions, most productive authors, etc. It was not possible to reach this analytical level in the first, general overview and data analysis. One of the special values of this work is that it gives the first comprehensive bibliometric analysis of the output of the social sciences.

The second part of the book, dedicated to the cognitive convictions of natural and social scientists, consists of four papers, with two chapters focusing on scientific quality, and the remaining two on scientific objectivity. Within the framework of each of these important topics of science studies, a qualitative empirical analysis is preceded by a theoretical overview. To be more precise, the concept of the book relies on its aspiration to encompass complementary, wider theoretical discussions that cannot be included in the presented empirical research, which are also the first Croatian studies of scientists' perceptions of scientific quality and objectivity – studies that are generally not very frequent. Thus, the theoretical contributions in the book constitute a kind of theoretical (preliminary) framework for subsequent qualitative research.

Sven Hemlin opens the second part of the book with a chapter entitled *What is scientific quality?* His work begins with the concept of scientific quality and its factors, supported by the findings of psychological and sociological research. The paper then presents the results from several of Hemlin's empirical studies, ranging from research on scientists' quality perceptions, to analyses of researchers' assessment behaviour based on documents on peer reviews in the process of appointing Swedish scientists to academic positions or in evaluating grant applications. The final part of the work presents an overview of new, largely sociological views of the changes in the relation between science and society. These new models also bring a new understanding of scientific quality and its evaluation. The chapter provides an overview that offers a hypothetical framework and a classification of categories necessary for the empirical research of scientific quality.

The next chapter, written by the editor of the book and Adrijana Šuljok, brings an empirical comparison of natural and social scientists' perceptions of scientific excellence. The paper analyses qualitative data, open-ended answers by respondents in the web survey in which they defined quality and expressed their opinions on its measurability. Since this was the first study of Croatian scientists' perceptions of research quality, the most suitable methodology was qualitative. Therefore, a combined system of quality categories or of elements of two Nordic studies was drawn up for the needs of the analysis, and it was adapted to the obtained empirical material. It allowed the respondents' answers to be classified and then compared regarding the parts of the research process most often stressed by natural and social scientists in their definitions of quality, and regarding the attributes of excellence they most often ascribe to them.

Franc Mali presents an epistemological view of scientific objectivity in the third chapter of this part of the book. After comparing objectivity in natural and social research, the author concentrates on the social sciences, especially on the significant contribution of classical sociological thought to the basic epistemological principles of the field. Along the lines of the mentioned contribution, Mali indicates that it is heuristically more productive in the social sciences to connect the critical-analytical and hermeneutical approach and draw together quantitative and qualitative methodology. An understanding of the epistemological structure of science is also key to understanding its social organisation. The chapter focuses on the social sciences with a dual goal: to inform the widest scientific public about the scarcely known specificity of objectivity in this scientific area, but also to remind social scientists themselves of its intricate nature.

In the final chapter of the second part of the book, Katarina Prpić sets out a qualitative analysis of natural and social scientists' perceptions of objectivity. The empirical basis of the paper is the respondents' answers to the open-ended questions on scientific objectivity obtained in the web survey. Since the sociological studies of science have not developed a categorial system for the empirical analyses of objectivity, Stephan Fuchs's (1997) classification of definitions of objectivity has been adapted to the empirical material. Respondents' answers were categorised into perceptions that objectivity refer to the scientists' characteristics, to the nature of the research process, and to the relation between knowledge and reality. Apart from the definitions of objectivity provided by natural and social scientists, their opinions on the possibility of achieving objectivity in their research field are also compared.

These studies and analyses, briefly outlined above, will try to find the answer to the following question: do the key professional characteristics, publication practices and cognitive convictions of natural and social scientists corroborate the social and cognitive gap emphasised by analysts of science which, it seems, is also frequently promoted by practising scientists?

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Part I.

The profile and productivity of natural and social scientists

Branka Golub

The social and professional profile of natural and social scientists

1. Social position and socio-professional differentiation of scientists

As its first step, a sociological analysis of one or more individual social segments requires an overview of the general context and of similar analyses that preceded it. Precisely for this reason, any outlining of the social and professional profile of natural and social scientists in Croatian science should be placed within the framework of studies of scientists' social and professional position and their role in general.

This type of research in the sociology of science and the sociology of scientific knowledge has for years been more common in underdeveloped scientific communities (countries such as Venezuela or Croatia, for example) than in the scientific environments that have for decades been setting the main course and content of sociological research of science. This neglect of the social roots and differentiation of scientists has been repeatedly highlighted and evidenced in detail by sociologist Katarina Prpić in her analyses. According to Prpić, the reluctance of sociologists of science to tackle that primarily sociological problem is not in the least incidental. It is grounded in the very theoretical and empirical orientation of the older and more recent disciplinary mainstream. However, following the line of demarcation between the Mertorians and the social constructivists, the former cover some aspects of the social position and role of scientists, despite the fact that the functionalist concept did not find the functionally unimportant factors of scientists' life and work pressing (Merton, 1974; Mitroff et al., 1977; Zuckerman, 1977; Cole and Cole, 1981; Berry, 1981; Allison et al., 1982; J. Cole, 1987), whereas constructivists largely focus on the content of science and usually remain on the microanalytical level (Knorr-Cetina and Mulkay, 1983). In other words, with the exception of occasional and partial investigation of the sociological position and role of scientists, the topic never became a distinct subject or a relevant problem and content feature in the mainstream of social analyses of science in the last century, and neither has it become one today.

On the other hand, we have the example of a peripheral scientific environment, such as the Croatian scientific community, which has been a subject of this type of sociological research for years. Individual segments of the social and professional position and role of scientists and researchers in their social and institutional environment have been monitored and studied, partially at first, and then increasingly more systematically. Unlike the developed scientific communities where good research conditions and a high standard of living have long been a given, the social position of Croatian science and the living and working conditions of scientists and researchers have been inadequate for years. And that has made them intriguing for research. The marginal social position of science and its chronic underfunding were the enduring characteristics of all the different stages of the *socialist development* of Croatian society. A similar situation also continued in the times of turbulent change, as well as during the time of the stabilisation of the new social organisation, that is, in the changed political, legal and institutional environment.

The first studies of this type date back to the 1970s (Koričančić, 1971; Previšić, 1975). The continued investigation of the position and role of Croatian scientists in the 1980s and the intensification and deepening of the studies in the 90s can largely be credited to the efforts of a team of collaborators formed around regular research programmes at the Institute for Social Research (of the University) in Zagreb. The two latest studies were conducted in 2004 – one on a representative sample of Croatian scientists, and the other as a web survey covering all doctors of science in the field of the natural and the social sciences. The findings of these and all earlier studies conducted over a period of almost forty years constitute a respectable tradition in the socio-professional analysis of Croatian scientists. Thus, these analyses have been established as a relevant complex of problems and content worthy of research, at least within the framework of a smaller social entity and within one of the peripheral scientific communities.

The most imposing topics with which the socio-professional background was introduced into the studies of Croatian scientists, and which were theoretically elaborated and empirically founded in this period, were the following:

- assistants' social position (Cifrić et al., 1984);
- determining the basic characteristics of the human potential of science and identifying and classifying three marginal groups in the Croatian science of the 1980s (Prpić, 1984, 1987);

- changes in the social profile of Croatian scientists investigated repeatedly in the 1980s, 1990s and at the start of the new millennium (Golub, 1990; Golub and Šuljok, 2005);
- social and professional characteristics of the scientific and technological potential and actors in the innovation subsystem (Prpić et al., 1992);
- socio-professional determinants of scientific productivity (Prpić, 1990, 1991; Prpić and Brajdić Vuković, 2005);
- professional and social position of young researchers (Prpić, 2000, 2004);
- socio-professional profile of scientific and social elites (Golub, 1997; Krištofić, 1997; Čengić, 1997);
- social and professional determinants of scientists' drain abroad (Prpić, 1989; Golub, 1988, 2000, 2004, 2005);
- scientists' professional ethics (Prpić, 1997);
- interrelation between science and the public (Prpić, 2005).

2. Socio-professional portrait of Croatian scientists

The starting point for conceptualising the previous analyses of the socio-professional characteristics of Croatian scientists was the simple hypothesis that scientific activity, research and the production of new knowledge, just like topics regarding the wider interrelation between science and other social actors or groups, cannot be interpreted, analysed and completely understood without knowledge of the overall life and professional situation of scientists and researchers.

The analyses of the social position and basic professional characteristics of the Croatian scientific potential and the analyses of the changes that occurred in the course of the transformation of Croatian society in the process of transition were based on conceptual and theoretical knowledge and the rare studies of the issue in the world and on the empirical findings of the position and role of Croatian scientists in the social system and the scientific subsystems of earlier years (Prpić, 1984, 1987). The continuity of research on the problem conceptually defined the basic determinants of the socio-professional profile of Croatian scientists. The stages in which the profile was formed were investigated based on chronology and content. The socio-demographic origin was always the starting point, which was then followed by the social origins and collection of data on social origin and the conditions of early socialisation. The next step was the education and preprofessional scientific socialisation as the potential determinants of the future career in science. Scientific education, linked to the qualification structure, and the context of the institution and the field completed the widest framework of the determinants of the social and professional profile of scientists. Together with the elaboration of the components of the social position of scientists in the wider social community, the survey of their family, housing and financial situation provided the basic empirical insight into their life outside science and into their social and financial status.

Based on several studies, and especially those highlighting the changes connected to the transition of Croatian society, the profiling of Croatian scientists can be outlined in the following way.

The latest socio-demographic analysis made in 2004 indicated the still (too) old structure of the total Croatian scientific population and noticed signs of its rising feminisation. In the 1980s it was already noticed that the rejuvenation of the scientific potential was conducted by employing a large share of young women scientists. The trend also continued in the final decade of the last century, so the recent gender structure reflects the gradual recruitment of women: the proportion of women scientists in the generational structures is the greatest in the younger age brackets, successively decreasing towards the older age groups.

The feminisation of Croatian science, which has largely been achieved by rejuvenation, is a consequence of the long marginalisation of the scientific, research and development sectors back in socialist times, but also of its even greater pauperisation in the early 90s. The inadequate social treatment of science and permanent financial neglect had a long-term effect on the composition of the scientific potential. Financially undervalued, but very demanding and including a long initiation period, the scientific profession was becoming increasingly more unattractive as a career or vocation. Persons with lower income expectations were more inclined to opt for a career in science, which facilitated the entry of more young women into science. This type of feminisation of science, connected to the negative social and economic trends, has also been recorded in Russian science (Mirskaya, 1995). However, Russian feminisation was not so much a result of the inflow of women scientists as of the drain of their male colleagues to foreign countries.

Drain processes, hiding under the established terms *brain waste* and *brain drain,* did not bypass the Croatian scientific community either. The drop in, or dispersal of, the scientific personnel in the first half of the 90s can be ascribed to these processes which also contributed to the process of feminisation of Croatian science. The narrowing down of the stratum of the middle generation of scientists, that is, the drop in the number of scientists in their forties, is a consequence of the increased scientists' drain at the time when – in the midst of war and social transformation – the social, professional and even family standard of living of the majority of scientists was deteriorating rapidly.

The starting social position of the generation of scientists caught up in the transition is the base for a comparison of the socio-professional characteristics of Croatian scientists. Based on early socialisation, measured by the level of the father's education and the place of residence while growing up, the starting social position already indicated a tendency for the selection of scientists from higher social strata in the 1970s and 1980s. The movement of the sociological process towards more educated families can be studied also within the scientific population itself. Comparing the indicators of the starting year of transition (1990) with the latest available empirical data (2004) indicates a significant decrease in the share of fathers with elementary education, and a rise in the share of highly educated fathers. Analysing the social background of the young(est) generation of scientists tends to show a share of fathers with a higher level of academic education, especially fathers with a master's or doctoral degree. There are some indications of a closing process of reproduction of scientific personnel, that is, a strengthening of the self-reproduction process in this segment, which was generally slightly more evident in biomedicine and the social sciences and humanities.

The other aspect of the greater narrowing of the social origins of the Croatian scientific potential is the loss of new generations in the segment of talented persons from deprived social environments that were not able to nurture the natural potential of their children. The failure to recognise and develop the talents and creativity in the overall child and adolescent population led to the dissipation of human potential. This was a loss to the essential resources of national as well as scientific development. This finding was especially important in the atmosphere of the transformed social structure of overall Croatian society during the transition, which caused a pauperisation of a great portion of the population and caused pronounced social stratification.

Available career pattern indicators, examined in the initial year 1990, and the latest available year of transition, 2004, indicate significant differences in the patterns of scientists' performance in climbing the career ladder in the pre-transition and transition periods, partly thanks to the different patterns of the science policy and partly thanks to the new tendencies of the social environment. Today, there are increasing numbers of excellent university students who enter the world of science directly from university already with preprofessional experience in research and published papers. There are fewer experts formed in other activities and accomplished as experts in their field who take up work in scientific institutions. It is evident that academic degrees and scientific ranks are obtained more comprehensively and earlier, so one can quite soon expect an insignificant number of unqualified and a greater number of younger and middle-aged scientists in the segment of scientists in the highest scientific ranks, although the old(er) age groups still prevail in that segment. Judging by the formal scientific degrees and ranks obtained according to strict procedures, there are more competent scientists today, bringing the Croatian scientific corpus closer to the international (European) criteria. In addition, there are more scientists with a knowledge of foreign languages, and more scientists with some education, training or specialisation acquired abroad. This is a direct consequence of the more accessible channels of international scientific communication, but also of the tendency of creating wide socio-professional networks, more open to Croatian scientists as well.

Professional activity, research and dissemination of knowledge take place within two separate, but functionally intertwined, areas. The first is the socio-organisational environment where the division of science tasks into research, teaching and development is reflected in the types of scientific institutions. The other environment is the scientific fields that make up the socio-cognitive framework of the scientific profession. And while the cognitive differentiation of science reflected in scientific fields is something that reflects the internal dimension and developmental logic of science, and thus the autonomy of science itself, the institutional system is far more liable to the (organisational) interventions of the wider social environment. This is precisely what happened to the scientific institutions in Croatia in the fourteen years of transition, between 1990 and 2004. Particularly great changes took place in the management and organisation of university institutes which were turned into public (state) institutes, and in the former industrial institutes, but also in the research departments in the economy, which were completely disappearing or whose R&D function was eroding due to the economic collapse of the early 1990s.

The changes in the institutional system were reflected in the structure of the personnel in the primarily research, teaching or developmental dimensions of scientific work. However, the most striking changes come down to the trend of increasing competition of the scientific and teaching staff at universities, and a reduction in the segment of institutes and especially research and development, which is almost obsolete today. The rejuvenation of the pool of scientists that followed this path of institutional restructuring showed the best results in the academic sector which has the youngest personnel potential, and much worse results in the institute and development sectors which have the older (oldest) potential.

In the majority of previous analyses, the scientific fields have also proved to be a dividing factor within the scientific profession. There were only few respondents whose characteristics did not vary between these socio-cognitive entities. They attracted and recruited people of different demographic and social profiles, all the way down to identifying the differences in the gender and age structure and socio-spatial and social and educational origin. Scientists profiled by fields also partly differed in terms of education and initial scientific socialisation. Although to a certain extent they showed differences in the rejuvenation of some disciplines, scientific fields manifested much greater diversification of new scientists in terms of their formation and professional socialisation. This is also clear in the differing patterns of professional careers, especially direct entry into the scientific profession, further education abroad and the mode of acquiring scientific competence through the system of scientific degrees and ranks. However, the most striking differences were noticed in productivity.

3. Natural and social scientists

The cognitive differentiation of science, expressed in differing cognitive objects, structures and styles within different scientific fields, was conceived back in the 1970s and 1980s (Bourdieu, 1975; Becher, 1981, 1989; Liebau and Huber, 1985). Even then, researchers drew attention to disciplinary patterns that could be identified in layers, supported by the social organisation of scientific work (Whitley, 1984).

Selecting the natural and the social sciences to address diverse aspects of scientific work, socio-professional characteristics and scientists' achievements should certainly be explained. In doing so, the importance of discoveries in the natural sciences, which become the driving force of overall social and civilisation development, can be descriptively highlighted. On the other hand, the importance of the social sciences that enlighten, interpret and predict the effect of that knowledge and new technologies on humankind and society in general should not be neglected either.

However, positioning the natural and the social sciences on the scale of the *hard* and *soft* sciences, seems far more important. Establishing routine research and its fragmentation in cognitively more restricted sciences leads to protocolisation and different styles of work and research, which can thus affect the initiation, scientific socialisation and overall career pattern of persons focusing on those fields. The cognitively non-restrictive sciences, whose cognitive objects and methods are not that firmly defined, and whose research findings are more open and much more uncertain, may have a completely opposite effect. The findings of the thus confronted natural and social sciences will also be interesting at the level of the analysis of scientific production (productivity), and epistemic concepts (objectivity) and perceptions of scientific quality, while the socio-professional profile of scientists, outlined with the logic and method of a certain type of science, will be the first step along that path.

3.1. Empirical grounds: web survey and sample of doctors of the natural and social sciences

The sociological view of the socio-cognitive peculiarities of the natural and the social sciences, which is the topic of this book, will be based (just like our topic of the social and professional differences/similarities of natural and social scientists) on the results of a web survey conducted in 2004. Since this chapter, more than any other in the book, focuses on the very *producers* and promoters of knowledge within the two selected fields, thus focusing on persons whose references, characteristics and attitudes are analysed, it seems logical to briefly present those actors.

The survey covered all the 1,131 doctors of the natural sciences and all the 809 doctors of the social sciences listed in the *Registry of*

Scientists and Researchers at the Ministry of Science, Education and Sports of the Republic of Croatia in June 2004.[1] On average, one quarter of the respondents answered the survey, or, to be more precise, 477 scientists or 24.7% of the surveyed scientists. Natural scientists responded to the survey in greater numbers – 27.4% (310), whereas the social scientists' response rate was lower – 20.6% (167). This fact seemed to have influenced the greater representativeness of answers provided by natural scientists, although such answers could not be considered truly representative.

Sociological studies based on web surveys have only recently appeared, but they can no longer be ignored in scientific research (Solomon, 2001), despite the fact that they are limited in scope. Thus, the experiences regarding the usual response rates are rather limited in this type of research. For example, Kaiser (2002) reports a 39% response rate for Norwegian scientists, while Iranian researcher Heydar Janalizadeh Choobbasti puts the response rate of British academics (Royal Society members) at around 19% in his doctoral thesis.

The most similar mode of reaching respondents is mail surveys which have been used quite often precisely on scientific populations. Comparing experiences, the response rates have differed greatly, ranging from 25% (Markusova et al., 1996) or 33% (Eastwood et al., 1996), and 50% (Hemlin and Gustafsson, 1996), to the extremely high response rate of 78% (Kyvik, 1989) or 89% (Hagstrom, 1974). Our experiences with mail surveys conducted in 1984, 1990 and 2004 showed the willingness of the Croatian scientific population to respond to the mail survey, most similar to Hemlin and Gustafsson's surveys in scope, recording a response rate of slightly less than 50%. The response rate of natural and social scientists to the 2004 web survey was half that figure.

[1] It seems methodologically fair to point out that the database of Croatian scientists at the Ministry of Science, Education and Sports was rather disordered and incomplete in 2004. Our experience indicates two pieces of evidence of such a state. Firstly, the Institute for Social Research in Zagreb conducted other research on a sample of one in five Croatian scientists the same year. The out-of-datedness of the Registry and non-transparent records were noticeable even then. Judging from the reactions of scientists to the questionnaire survey, (some) former scientists who had gone abroad or who had found employment in other walks of life were also listed. There were also retired and dead scientists on the lists, and junior researchers were registered according to two different principles (some were on the list with other scientists, other were listed separately). Secondly, the Ministry's website contained a notice dated 4 March 2005 announcing the upcoming compilation of a new database, or Scientists' Registry, into which all the data from the existing list would be transferred in the first phase. The need to update the list used in the two mentioned studies the year before confirms the inaccuracy of the records at the time.

In order to present the restricted representativeness of such a sample reached via the internet, limited by the (un)willingness of scientists to respond to the survey, but also by the deficiencies of their records, we examined the differences between some available socio-professional characteristics of the overall population of doctors of the natural and social sciences and the realised sample.

A chi-square test determined that natural scientists in the sample differed from their population in only one of the four controlled variables (gender, age, type of scientific institution, scientific fields), while social scientists differed in all the variables. The gender and age structure of the sample of natural scientists deviated insignificantly from the gender and age structure of natural scientists. Furthermore, the institutional distribution of natural scientists in the sample and the corresponding population did not show any significant differences. Thus, while representativeness in terms of selected socio-professional characteristics exists on the level of the overall area of the natural sciences, it is lost at the level of individual fields. The investigated deviation (unrepresentativeness) of the natural scientists was determined precisely at the level of scientific fields. As the first table (1) shows, more biologists, geographers and geologists answered the survey, while mathematicians, chemists and physicists responded to a lesser extent. A similar analysis by field of social sciences showed that sociologists, psychologists and politologists completed the survey disproportionately more than they were represented in the sample, while legal scientists, economists and educationists responded to a lesser degree. Only the response rate of IT scientists was proportional. Furthermore, considering the statistically significant deviations of the social scientists, it can be said that women and younger scientists and scientists working at institutes completed the survey disproportionately more frequently, while men, older scientists and scientists working in higher education and institutes such as industrial institutes, health care institutions, R&D units of other institutions, but also the Croatian Academy of Sciences and Arts, and the National Meteorological and Hydrological Service, completed it disproportionately less frequently.

4. Social and socialisational elements of disciplinary differences among scientists

Certain aspects of the social and professional position and role of scientists, mentioned in the introduction were investigated more partially and occasionally than systematically. The certain neglect of the social roots and mutual differentiation of scientists, which can partly be justified by the concepts and views of the constructors and leaders of the major directions of modern sociology, does not imply that no such investigations took place. The findings of H. Zuckerman, for example, show that 82% of Nobel Prize winners who grew up in the USA (71 of them) come from families of a higher social and financial status. Their fathers were most often members of different vocations – high school teachers, priests, college professors, medical doctors, engineers, lawyers, managers or business owners (the fathers of 54% of laureates belonged to the former, and 28% to the latter group) – a significantly more elite social background than that of American doctors of science of approximately the same age (47.8% of their fathers were members of the professions, managers and business owners), not to mention the population of employed men (Zuckerman, 1977).

In his doctoral dissertation, Xie (1989) studied the social context and potential influences in the process of educating American scientists. He focused particularly on the demographic and social characteristics and the social background of scientists in various scientific fields and disciplines (physics, mathematics/statistics, biology, social sciences). According to his findings, the disciplinary differences found in the recruitment of scientists of different social backgrounds are eliminated or become insignificant at the level of scientists who had completed 16 years of education. Social deprivation, which was the disturbing factor in regular education and in acquiring the preconditions for their future careers in science, was cancelled or lost in levelling out the average values in different scientific fields by the persons who managed to complete the process and achieve the preconditions of academic education despite an adverse social background.

By the same token of investigating the social background and gender differentiation of scientists as the possible origins of the deviations from the norm of universalism in science (the Mertonian tradition) and on a random sample of 788 Danish scientists (618 from the social sciences, 83 from information sciences and 87 from the natural sciences and medicine), Andersen (2001) also came to the conclusion that social selection worked much more strongly through the process of education, and even before the decision on one's scientific career is made. Differences found later among scientists in the process of building their careers in science that can be linked to gender and preprofessional social differentiation were not grounded on empirical evidence in a way that they should be interpreted through a pattern of deviation from the universalism norm or as (gender or social) discrimination.

Bormann and Enders (2004) went one step further in an analysis of the advanced scientific career of German doctors of science in six disciplinary fields – biology, electrical engineering, German language, mathematics, sociology, business studies (economics). The control group was made up of university-educated researchers without a doctoral degree. The breakdown of results on the influence of the social background and gender on education and career success by discipline was statistically largely insignificant, and many of the links were weak. However, in the context of gender and social inequality, these two authors highlighted two points.

First, the results of the influence of the individual characteristics of social background in *obtaining* a doctoral degree did not indicate any exclusive academic self-reproduction. The majority of doctors of science came from families without university education. On the other hand, the analysis showed that doctors of science were selected in four out of six scientific disciplines considering (1) social background and (2) gender compared to the control group of university-educated respondents. (1) Doctors of science in electrical engineering, German language, mathematics and business studies (economics) more frequently came from parents with higher education and secondary education than the persons from the control group. (2) Doctors of science in the fields of biology, German language, mathematics and sociology were more frequently men than the respondents who had only a university degree in the same disciplines. Bormann and Enders allow that the results may reflect also the gender differences in opportunities for scientific success, as well as the improper procedures in education. In support, they quote studies written in German (Allmendinger et al., 1999; Bochow, Joas, 1987) which showed the difficulties that women face when being granted the status of young scientists in a male-dominated environment. According to Krűger (1999), many women do not ascribe their educational success to their capacities, but to some fortunate set of circumstances. A Spies and Schute study (1999) points out that women are much more pessimistic in estimating their own potential and opportunities for success than men, while Bischof-Kőhler (2002) reports in an empirical study the widely underestimated female sensitivity to minor mistakes, and its effect on women's more modest educational and business success.

Second, the findings of the studies on the influence of gender and social background on career success *after obtaining a doctoral degree* indicated the far greater influence of gender. Ten, fifteen or twenty years after obtaining a doctoral degree, the influence of social background on the career was hardly noticeable any more. It seems that, according to the authors, the "need for inequality" was largely met in the process of selection in the course of education. However, an analysis of later success in their career indicated the significant influence of gender on two out of the three criteria. Furthermore, certain differences were noticed in the employment of women and men doctors of science at faculties and in science. In terms of expressed career achievements within and outside the sectors of higher education and research, statistical analyses showed that gender, alongside other potential influences on the career, was the source of differences in biology and in business studies (economics). Considering the third criterion of analysis – income – male doctors of science had better pay per hour than their female colleagues in all disciplines. The greatest differences between genders were manifest in business studies (economics).

Bormann and Enders conclude their analyses aware of the insufficient knowledge of the mechanisms that produce inequality, which prevents them from directly interpreting the mechanisms as violations of equality. The complex picture of interrelations between social selection and self-selection in producing inequalities among scientists presupposes the elimination of uncontrolled lateral influences, that is, the achievement of experimental (unambiguous) results.

5. Socio-demographic characteristics of doctors in the natural and the social sciences

Narrowing down the issue of disciplinary differences in the socio-professional profiling of scientists to two scientific areas, the social and natural sciences, and to the population of scientists with a doctoral degree, will necessarily show an empirical deviation from *case analysis*. What was seen as the inability to reach far-reaching conclusions due to the methodological limitations in the previous example of analysis of disciplinary differences in the socio-demographic selection of German doctors of science will apply to the Croatian case as well, especially bearing in mind the limitations of the sampling procedure. However, this does not mean that a *possible* analysis does not have to be conducted.

The socio-demographic breakdown of the overall population of Croatian scientists, and the socio-demographic breakdown of all scientists by scientific fields, can be read from the results of parallel research done in 2004, and changes in the biological substratum in the socio-democratic structure can be identified in research conducted in 1990 and in some earlier studies[2] (Golub, Šuljok, 2005).

(1) Changes in the gender structure of Croatian scientists in the identified fourteen-year period were manifest in the increased share of female researchers in the overall scientific potential by a significant 11.7 structural points. More precisely, in 1990, the proportion of women came to 34.2%, and in 2004 it grew to as much as 45.9%. However, there is also a background to such an increase in the transition period.

Rejuvenation of the pool of scientists, identified back in the 1980s, largely took place in the process of the increased hiring of young female researchers. According to the Registry of Scientific Workers and Researchers at the Republic Committee for Science, Technology and IT (on 30 June 1985), there were 31.5% women in the total scientific potential, but only 17.9% of them in the oldest age group of scientists. Their share grows in the younger age groups. For example, there were as many as 43.2% of female researchers among scientists under the age of 30.

Our findings from 2004 show that the trend continued in the last decade of the previous century, when the share of the youngest women researchers (under 30) in the generational gender structure came to 56.9%, while the share of women researchers between 30 and 40 years of age was even greater, standing at 58.3%. The share of women above that age limit dropped below the average share of women in the overall scientific population, amounting to 43.9% for female scientists in their forties, 43.0% in their fifties and only 25.0% in their sixties. The process of rejuvenation of the scientific potential by hiring an increas-

[2] The 1990 and 2004 studies covered the complete scientific population – scientists and researchers working at universities (faculties), institutes and R&D units in economics and the public sector registered at the Ministry of Science, Education and Sports of the Republic of Croatia with identical or very similar batteries of questions. The final samples of 8.6%, 921 respondents in 1990 and 915 respondents in 2004, were only partly representative of the overall population of scientists, taking into account the mail survey and the non-responses that accompany this method. However, they were representative in terms of gender in both studies, i.e. at both points of time.

ingly greater number of young women is more than obvious.[3] Their predominance in the younger age groups can be identified from scientific (under)qualification, which shows that female holders of a master's degree accounted for a greater share (53.7%), and female doctors of science were underrepresented (42.9%).

According to the latest available data, women outnumber their male colleagues today in the social sciences and humanities (58.7%) and in the natural sciences (54.4%). As the young population (female scientists under 35), they were also already more numerous in biomedicine (67.7%) in 1998, but today their total number (although relatively greater than the proportion of women in overall Croatian science) has remained below half (47.3%) compared to their colleagues in biomedicine.

These findings suggest that the process of feminisation has taken place in some scientific areas over the last ten, and sometimes even twenty, years, but we cannot even talk of scientific fields since there are no conditions for detailed analysis. It is noticeable that feminisation has advanced the most in the social sciences, humanities and natural sciences (Table II, appendix). Biomedicine had also already been caught up in this process in the 1980s (51.9%),[4] so it even witnessed a slight masculinisation in the period of transition, despite a still above-average share of women in the field (47.3%). The biotechnical (39.2%) and technical fields (23.4%) were the slowest in giving in to the process, so these sciences, especially the technical sciences, have traditionally remained more male than female occupations.

Returning after this general overview to the object of our study – the population of doctors of the natural and the social sciences – we should first point out that the list of the Registry of Scientists and Researchers at the Ministry of Science, Education and Sports in 2004 contained 517 female doctors and 614 male doctors of the natural sciences, and 306 female doctors and 501 doctors of the social sciences. The proportion of female doctors in the natural and the social sciences

[3] Sociological analyses of contemporary society generally show that the (more) balanced representation of genders in individual disciplines does not necessarily imply a (more) equal social treatment and position of women in society. Furthermore, increased employment of women in certain economic and social activities as a rule correlates with the social and economic marginalisation of those activities.

[4] The data were obtained by investigating the characteristics of the personnel potential of science in 1983. The study was conducted by the Institute for Social Research of the University of Zagreb.

in a ratio of 46%:38% also shows the significantly greater (qualification) competence of women in the natural than in the social sciences. If we support this with the data on the age structure of doctorate holders in the two scientific areas, then the greater contingents of social scientists in the older age brackets (see Table I, appendix) only support the conclusion on the lower qualifications of female scientists in the social sciences, considering that the qualifications are achieved in time.

(2) The dominant characteristic of Croatian scientists, which also goes back decades, their (too) high average age, has not been set off to this day, not even by the rejuvenation process that has gained momentum over the last ten years or so. Comparing the extreme age strata, it is revealed that the oldest scientists, over sixty years of age (13.7%), are still more prevalent in the overall scientific potential than the youngest scientists under thirty years of age (7.1%) who are only entering the scientific system. Moreover, their share increased compared to the fist year of the transition when the oldest scientific population accounted for 8.8% of human resources. Scientists in their thirties witnessed a standstill in the relevant period of fourteen years (1990: 26.5%; 2004: 27.9%), and only scientists in their fifties (1990: 24.8%; 2004: 27.8%) recorded a slight rise. However, the intellectually and scientifically (most) potent forty-year-olds (aged 40 to 49) became/remained the *truncated* generation, with the age stratum dropping by a whole 7 structural points (1990: 30.5%; 2004: 23.5%). Since a large share of scientists in their fifties and sixties (41.5%) will complete their active careers or they will be drawing them to a close in the next ten years, a narrow stratum of leading producers of new knowledge,[5] today's forty-year-olds (23.5%), will not be a sufficient bridge to transfer the accumulated knowledge and experience to new generations who will be entering the professional world of science. It is precisely the slump in the generation of forty-year-olds that is the weak spot of the human potential of Croatian science today.

In terms of the age division of scientists by fields (Table II), the contingent of the youngest scientists (under 29) proved to be the strongest in the technical sciences (11.6%), thirty-year-olds are extremely strong in biotechnology (43.2%), forty-year-olds (28.2%) and fifty-year-olds (34.0%) are most prevalent in medicine compared to other disciplines, while sixty-year-olds and even older scientists are most frequently engaged in natural (15.2%) and even medical sciences (14.7%). Having

[5] Cole, 1979; Kyvik, 1988.

in mind the fifty-percent contingent of scientists under the age of 40, biotechnical sciences have become the scientific field with the youngest average scientific potential, thanks to the strong segment of thirty-year-olds and a significant segment of younger scientists. The medical sciences, with 62.7% of scientists over 50 years of age, however, are the opposite – this is the field with the oldest human potential in Croatian science.

The age distribution of doctors of science in the natural and the social sciences, as already mentioned regarding their breakdown by gender, has shown greater efficiency in the process of rejuvenation with competent staff (with scientific qualifications) in the natural than in the social sciences (Table I, appendix). Thus, the youngest contingent of doctors of science in the natural sciences (aged 30 to 39), according to the data provided by the competent ministry for 2004, reaches 9.2%, and in the social sciences 5.5%. The stratum of forty-year-olds (40–49) was also stronger in the natural (27.8%) than in the social sciences (25.7%). Quite the reverse, the strata of older doctors of science, fifty-year-olds, sixty-year-olds and older scientists were more prevalent in the social than in the natural sciences.

Since the gender and age breakdown of doctors of science from the sample obtained in the web survey was selectively representative of the scientific fields – it was representative for the natural sciences, and selected for the social sciences – the textual overview of the basic demographic variables of gender and age was limited to this official information on the population. Their unreliability (described in the section on sampling) should also be kept in mind.

Table 1 shows the gender and age differentiation of doctors of science who responded to our web survey. Since the representativeness of the sample was selectively weighed in the way described above, the results of testing the significance of the differences between the gender and age distribution of respondents from the natural and the social sciences should be taken with reserve. According to the level of chi-square significance, the differences were not statistically significant, and natural and social scientists should not differ by basic demographic variables. However, since women doctors of the social sciences and younger social scientists answered the web survey in greater numbers, the data have to be taken with some reserve. With the same qualification, we also report the finding that doctors of the natural sciences and doctors of the social sciences were of roughly the same age (50 or 51) *on aver-*

age. The youngest doctors in both scientific fields were twenty-nine-year-olds, while the oldest were seventy-year-olds (statutory age limit for regular employment).

Table 1. Gender and age structure of doctors of the natural and the social sciences (web survey)

	Natural sciences (310)		Social sciences (167)
GENDER			
Female	48.7		53.6
Male	51.3		46.4
Total	100.0		100.0
Chi-square		1.042	
Degrees of freedom		1	
Chi-square significance		0.307	
AGE			
under 39	20.8		13.8
40 – 49	26.6		32.9
50 – 59	31.8		35.9
60 and older	20.8		17.4
Total	100.0		100.0
Average age	50		51
Standard deviation	9.94		9.63
Youngest person	29		29
Oldest person	70		71
T-value		–0.632	
Degrees of freedom		473	
T-test significance		0.528	

6. Socialisational and educational characteristics of doctors of the natural and the social sciences

The early socialisational context of growing up connected with the educational level of parents and the socio-spatial environment has for several decades been the subject of especially in the period of transition, between 1990 and 2004 (Golub; Šuljok, 2005).

The earliest analyses conducted in the 1970s and 1980s showed the tendency of social selection of scientists. The wider basis of the selection, or the shift of the social origin to the more urban and educated segments of society, was already noticeable in the reproduction of the

Croatian highly-educated population that did not originate from all socio-professional strata, but was socially selected. The scientific profession, as a primarily intellectual activity, has been becoming socially less accessible to talented persons in society, regardless of the socio-economic stratum.

The changes in the social basis of scientists' origin have become sociologically transparent lately in two of its characteristics: the type of settlement the surveyed scientists mostly lived in before completing their elementary education, and the father's education.

The statistically significant differences in socio-spatial origin, identified by comparing the data from 1990 and 2004, indicating the greater domination of persons socialised in urban environments, only showed that the pre-transition processes of selection gained even more ground. Medium and large Croatian cities such as Osijek, Split and Rijeka, together with the city of Zagreb, recorded a nine-structural-point increase in the prevalence of scientists from urban environments compared to the rural, peripheral or small-town locations (60.5% in 1990, 69.5% in 2004).

The educational status of the family in which the primary socialisation took place showed, even more markedly than the socio-spatial indicator the shift to the more elite social origins of Croatian scientists. In a country whose population even nowadays has only a slim stratum of 7.3% of highly-educated inhabitants, the share of 39.6% of university-educated fathers of today's scientists, including 9.9% holders of master's or doctoral degrees, is more than a significant shift to the pronouncedly elite source groups, especially bearing in mind the time span from the fathers' generations to the generations of today, in which the educational attainment of the population has been growing progressively.

The shift of the socialisation process to more educated families has been observed recently even within the scientists' population. A comparison of indicators from the first year of transition with the data of 2004 shows that the share of 25% of scientists from 1990 whose fathers had only elementary education dropped to only 11.8% in 2004. In contrast, the share of 28.7% of highly-educated scientists' fathers in the 1990 survey increased to 39.6% in a period of fourteen years. If the analysis of social background is limited to the youngest scientists (under 35 years), the share of fathers with academic education grows to even higher values, to 42.2%, and fathers with a master's or doctoral degree in science to even 12.6%! Such figures recorded in this segment allow us to conclude that the process of the self-reproduction of scientists is closed in this segment, and was slightly more evident in biomedicine and the social sciences and humanities (the differences between scientific fields in terms of the fathers' education were determined at the chi-square level of 36.386; df = 20, p = 0.01).

(1) Our studies were the first to examine the educational structure of mothers alongside the educational structure of fathers in the investigation of the indicators of the social origin of doctors of the natural and the social sciences (Table 2). Although no statistically significant differences were found between the natural and social scientists in terms of the education of their mothers and fathers, some differences can nevertheless be noticed. First, fathers were on average more educated than mothers in both strata. Both parents of doctors of the social sciences had only elementary education (28.7% of mothers and 15.0% of fathers) slightly more often than the parents of doctors of the natural sciences (26.9% of mothers and 11.3% of fathers). At the level of two-year postsecondary and university education, both mothers and fathers of natural scientists have a slight advantage. Furthermore, it is interesting that the share of mothers and fathers with a master's or doctoral degree is almost the same in both scientific fields. And mothers are even (!) slightly more represented. This finding could be said to be in accordance with similar findings (Xie, 1989; Andersen, 2001) that support the thesis on *satisfying* the need for or necessity of (gender and social) inequality in the course of the process of education. The share of around 11% of parents with a master's and doctoral degree whose children are today doctors of the natural and the social sciences of all age groups, including seventy-year-olds, has more weight in supporting the thesis on the self-reproduction of the scientific profession than the piece of data on 12.6% of fathers of young scientists (under 35 years of age) who also had formal proof of the highest educational and scientific competence.

(2) Judging from the socio-educational characteristics, scientists present a narrow segment of the Croatian population which has succeeded in bringing together in their socialisation their individual capacities, verified by academic performance, and the positive socialisational effects of the environment outside school, primarily the closest family which substituted the part of the stimulating and developmental roles that the school and the whole society failed to perform.

Table 2. Parents' level of education and university performance of doctors of the natural and the social sciences (web survey)

	Natural sciences (310)		Social sciences (167)
MOTHER'S EDUCATION			
Elementary	26.9		28.7
High school (skilled worker + secondary school)	35.0		37.7
Two-year postsecondary and university	27.2		22.2
Master's, doctoral degree	11.0		11.4
Total	100.0		100.0
Chi-square		1.464	
Degrees of freedom		3	
Chi-square significance		0.691	
FATHER'S EDUCATION			
Elementary	11.3		15.0
High school (skilled worker + secondary school)	39.8		37.7
Two-year postsecondary and university	38.2		36.5
Master's, doctoral degree	10.7		10.8
Total	100.0		100.0
Chi-square		1.342	
Degrees of freedom		3	
Chi-square significance		0.719	
UNDERGRADUATE ACADEMIC PERFORMANCE			
Good	3.6		4.8
Very good	62.3		62.3
Excellent	34.1		32.9
Total	100.0		100.0
Average grade	4.31		4.28
Standard deviation	0.533		0.548
Lowest grade	3		3
Highest grade	5		5
T-value		0.459	
Degrees of freedom		473	
T-test significance		0.646	

The examined differences of the university performance of doctors of the natural and the social sciences did not show any statistical relevance. Their performance at undergraduate examinations ranged from good (3) to excellent (5), and the average grade of natural and social scientists at university can be rounded up to 4.3.

However, a comparison of the undergraduate academic performance of doctors of science from both areas with the undergraduate performance of all scientists, regardless of scientific qualifications and field of work and research, shows some differences. At the level of students with the grade "very good", hardly any differences were found, but they are evident on the level of "good" and "excellent" students. Doctors of science were rarely only "good" students, and they were "excellent" students much more often (Table 3). This becomes more evident when compared to the generation of 1990, since the pool of doctors of science changed only slightly in terms of average age (50.5 years). Hence, the differences between the academic performance of the total population of scientists and doctors of the (natural and social) sciences are declining over time, but are still statistically relevant.

Table 3. Academic success of Croatian scientists (1990 and 2004 samples) and doctors of the natural and the social sciences (2004 web survey)

Undergraduate academic performance sciences	Sample of Croatian scientists 1990 (921)	Sample of Croatian scientists 2004 (915)	Doctors of the natural sciences (310)	Doctors of the social sciences (167)
Good	22.0	10.2	3.6	4.8
Very good	61.8	63.3	62.3	62.3
Excellent	16.1	26.5	34.1	32.9
Total	100.0	100.0	100.0	100.0
Chi-square	160.589	26.367	20.010	7.428
Degrees of freedom	2	2	2	2
Chi-square significance	0.000*	0.000**	0.000***	0.000****

* Significance of differences in samples of scientists (1990) and doctors of the social and natural sciences
** Significance of differences in samples of scientists (2004) and doctors of the social and natural sciences
*** Significance of differences in samples of scientists (2004) and doctors of the natural sciences
**** Significance of differences in samples of scientists (2004) and doctors of the social sciences

7. Working and professional environment

Earlier analyses of the socio-demographic determinants and the socialisational and educational environment as elements of social background did not show greater differences between the preprofessional determinants of the future careers of doctors in the natural and the social sciences. Noting the only partial representativeness of the sample, the findings of the web survey did not select them either by age or by gender. With minor discrepancies, the findings were the same for the educational status of the mother and father and for the undergraduate academic performance.

At the level of the overall scientific population, according to the findings of the earlier studies, scientific fields did to a certain extent define rejuvenation. It was shown that different scientific fields did to a degree attract persons of different social or demographic profiles. However, to a far greater extent the young scientists socialised and developed professionally in different ways depending on their fields. This was evident in the different patterns of professional career, and especially the patterns of scientific productivity. The following analyses show the extent to which the population of doctors of the natural and the social sciences will repeat these findings.

In the working and professional environment, we investigated the variables of scientific competence, patterns of professional advancement (career), institutional context, professional position and roles, focusing on the division of scientific roles, participation in the wider scientific community, networking and scientific achievements.

7.1. Scientific education (competency) in the natural and social sciences

The scientific career, in the sense of development and the final reach of overall scientific achievements, is built on the different patterns of synergic action of a larger number of constituents of a career (Hermanowicz, 2007). Advancement in science is "reinforced" by scientific qualifications. The change in the qualification patterns in the Croatian public can be traced in the data on scientific degrees and scientific ranks. For example, a 1983 study determined that only 39.7% of registered scientists had a doctoral degree that year. Since this study already indicated a shift of samples to strata of higher qualifications compared to the total scientists' population, this finding had to be complemented with available records. According to the three-year older statistics, the share of doctors of science in the Croatian scientific population was even smaller, only 34.8%. At the same time, 42.8% of the scientific potential that was involved directly in the scientific process did not have any scientific degree. This means that almost half of the scientific potential that was engaged in science and research had only university education in the 1980s. Since 54.7% of scientists over fifty years of age still did not have a doctoral degree at that time, it is estimated that a great number of them completed their professional careers in science without the complete formal education.

Significant differences in qualifications recorded from 1990 to 2004 indicate some significant changes that took place in the scientific system. The process of transition witnessed an almost threefold drop in the share of scientists without any scientific degrees in favour of a rising share of doctors of science who make up by far the biggest segment today (Table III, appendix). The acute improvement in the qualifications structure of Croatian scientists is primarily the result of the strict demands for advancement, under the threat of termination of employment unless the researcher's scientific competence rises in a given period. The strict criteria of initiation of the new generations of scientists also go by the token of higher qualifications, despite the fact that they do not have any more significant effect now in the mass of total potential.

(1) Table III (appendix), presenting the determinants of the professional and career patterns of the overall population of Croatian scientists, indicates that five scientific areas (natural, technical, medical, biotechnical sciences and social sciences and humanities) differ in the educational structure of their scientists.[6] At the level of doctors of science, the biggest differences are evident between the technical and medical sciences. While in the technical sciences doctors of science accounted for one half of the scientists' potential (51.3%) in 2004, they reached two thirds in medicine (66.5%). The differences between the natural and the social sciences were not that pronounced: 63.2% of doctors of the natural sciences compared to 59.7% of doctors of the social sciences. The factor that can raise the lower qualification structure of the social sciences is the share of scientists without any scientific qualifications: 14.6% of social scientists and 10.4% of natural scientists did not hold, or have not (yet) obtained, a master's or doctoral degree.

(2) The next step in scientific competence, building on the earlier, formal education achieved in master's or doctoral studies, is scientific ranks. When selecting a scientist to a certain rank, the scientist's published papers (scientific ranks) and lectures (academic ranks) are evalu-

[6] Chi-square = 25.485; df = 8; p = 0.01.

ated, in accordance with set procedures and criteria. Differences between doctors of the natural and the social sciences proved significant in terms of this criterion (Table 4).

Table 4. Components of scientific education (competence) in the natural and the social sciences

	Natural sciences (310)		Social science (167)
SCIENTIFIC RANK			
Without (scientific) rank	14.2		5.5
Research associate	37.7		40.5
Senior research associate	19.9		24.5
Research adviser	28.2		29.5
Total	100.0		100.0
Chi-square		4.129	
Degrees of freedom		1	
Chi-square significance		0.042	
ACTIVE KNOWLEDGE OF FOREIGN LANGUAGES			
No foreign languages	3.6		5.4
One foreign language	48.0		48.9
Two foreign languages	38.0		34.3
Three or four languages	10.4		11.4
Total	100.0		100.0
Average number of languages	1.57		1.55
Standard deviation	0.785		0.856
T-value		0.262	
Degrees of freedom		472	
T-test significance		0.793	
PASSIVE KNOWLEDGE OF FOREIGN LANGUAGES			
No foreign languages	22.1		23.0
One foreign language	34.4		37.6
Two foreign languages	32.8		30.9
Three or four languages	10.7		8.5
Total	100.0		100.0
Average number of languages	1.40		1.28
Standard deviation	1.219		1.029
T-value		1.056	
Degrees of freedom		471	
T-test significance		0.292	

According to the data from the web survey, doctors of the social sciences acquire their first scientific rank more quickly and easily than doctors of the natural sciences. As we know, the very act of obtaining a doctoral degree does not change the position of the assistant, unless other selection criteria for the position of a research associate in a research institute, or for the rank of assistant professor, are met. In the structure of scientific ranks, social scientists had better results even in higher research career grades. Among them, senior research associates (associate professors) and research advisers (full professors) are relatively more numerous. Considering their age, ranging from thirty-year-olds to seventy-year-olds, today's doctors of science went through different stages of strictness in the selection processes in the research career pathway. In the effort to raise the quality of Croatian scientific production to meet global and European criteria, we have been witnessing greater demands in selection procedures in terms of quality and quantity (publishing in refereed and/or international publications). We have also witnessed a greater uniformity of criteria among scientific fields, to the detriment of the scientific fields whose object of study is not universal, but marked by (natural or social) specificities and localities.

The differences noticed in the pattern of the research career pathway in the natural and the social sciences are probably a consequence of the milder criteria in the social sciences. It is a matter of speculation whether the differences will be cancelled out by the scientific policy of harmonising the criteria for advancement in the two fields. However, if the (stricter) criteria of the natural sciences are automatically transferred to the field of the social sciences, irrespective of the specificities of the objects of study (the Croatian social and economic environment), quite the reverse effect is possible – the differences may increase, but to the detriment of the social sciences.

(3) The universal dimension of science and the universality of scientific work itself have imposed the need for linguistic education. In smaller and scientifically peripheral countries like Croatia, this is a fundamental requirement for engagement in science.

Linguistic competence in the field, that is, active and passive knowledge and use of foreign languages by doctors of the natural and the social sciences, does not show any statistically relevant differences. Half of natural and social scientists have achieved almost equal results in basic linguistic competence, that is, active use of one foreign language. With statistically insignificant differences, there are slightly more doctors of the natural sciences proficient in two foreign languages, and more doctors of the social sciences who do not have an active knowledge of any foreign languages. The share of polyglots remains almost the same in both scientific fields.

Not even the passive use of foreign languages, that is, reading and understanding scientific and expert texts without the capacity to speak a foreign language, creates a difference between natural and social scientists. There are only slightly more natural scientists with passive knowledge of several languages, and slightly more social scientists with passive knowledge of only one or no foreign language.

7.2. Professional (career) advancement of natural and social scientists

The basic dimension of career advancement in science, as we have already said, is determined above all by attaining academic degrees (masters and doctoral) and promotion into ranks. For this reason, the career pattern can also be based on the temporal dimension of attaining degrees and ranks.

Table 5 shows the age of natural and social scientists on gaining their doctoral degrees, and the initial age at selection for a specific rank. From all the dimensions of the formal research career pathways, natural and social scientists manifested significant statistical differences only in the age on gaining a doctorate. The median age of the natural scientists on obtaining a doctoral degree was 35.3 years, while social scientists recorded the median age of 38.3. The youngest persons in both fields on earning their doctorate were only 27 years old at the time. The oldest social scientist at the time of obtaining the doctorate was 54, while the oldest natural scientist was even older, 57 year of age. Although the frequency distribution on the age scale is irregular, it is possible to identify the modal and median values that differ by field. Thus, most natural scientists earned their doctoral degrees at the age of thirty-two (32), and then at the age of thirty-four (30), whereas the greatest number of social scientists earned their degrees at the age of thirty-four (14), thirty-five (14), and thirty-eight (13). Furthermore, one half of all natural scientists earned their doctoral degrees at 33.5 years of age, while one half of social scientists did the same at the age of 37.5. A summary by most of the indicators (with the exception of the oldest new doctorate holder) shows that the natural scientists earned their basic precondition for further career much earlier.

Table 5. Patterns of professional (career) promotion by field

	Natural sciences (310)		Social sciences (167)
AGE AT DOCTORATE			
Under 30	18.9		8.2
31 – 35	45.6		30.8
36 – 40	19.6		28.9
41 – 45	9.6		21.4
46 and older	6.3		10.7
Total	100.0		100.0
Average age	35.3		38.3
Standard deviation	5.865		6.025
Youngest person	27		27
Oldest person	57		54
T-value		–5.258	
Degrees of freedom		458	
T-test significance		0.000	
AGE AT ELECTION FOR RESEARCH ASSOCIATE			
Under 30	2.7		4.8
31 – 35	26.1		22.6
36 – 40	35.2		32.3
41 – 45	18.9		20.9
46 – 50	6.3		14.6
51 and older	10.8		4.8
Total	100.0		100.0
Average age	40		40
Standard deviation	6.668		6.354
Youngest person	29		30
Oldest person	57		56
T-value		–0.026	
Degrees of freedom		171	
T-test significance		0.979	
AGE AT ELECTION FOR SENIOR RESEARCH ASSOCIATE			
Under 35	6.9		2.6
36 – 40	15.5		15.8
41 – 45	22.4		26.3
46 – 50	29.3		36.9
51 – 55	17.3		10.5
56 and older	8.6		7.9
Total	100.0		100.0

	Natural sciences (310)		Social sciences (167)
AGE AT ELECTION FOR SENIOR RESEARCH ASSOCIATE			
Average age	46.5		46.6
Standard deviation	7.037		6.188
Youngest person	30		34
Oldest person	62		59
T-value		–0.069	
Degrees of freedom		94	
T-test significance		0.945	
AGE AT APPOINTMENT FOR RESEARCH ADVISER			
Under 40	4.8		0.0
41 – 45	21.7		17.4
46 – 50	38.6		39.1
51 – 55	24.1		26.1
56 and older	10.8		17.4
Total	100.0		100.0
Average age	48.9		50.3
Standard deviation	5.521		4.931
Youngest person	37		42
Oldest person	64		63
T-value		–1.455	
Degrees of freedom		127	
T-test significance		0.148	

The better starting position of the natural scientists, however, did not lead to faster progress up the career ladder. Natural and social scientists did not manifest any statistically significant differences in terms of age on earning their ranks, as shown in Table 5. Having in mind the data from the previous table which indicated that social scientists performed better at all levels of the research career grades, without any difference in the age structures of the natural and social scientists (Table 1), the findings could indicate two different career patterns in the social and the natural sciences. For example, out of the 18.9% of natural scientists who earned their doctorates before the age of thirty, only 2.7% were selected to their first rank (research associate or assistant professor) before the age of thirty. In contrast, of the 8.2% of social scientists who also completed their doctorates before the age of thirty, 4.8% were appointed to their first scientific rank by the age of thirty. In selection to higher ranks, cases of fast promotion take place according to the opposite pattern: by the age of thirty-five, 6.9% of natural scientists and only 2.6% of social scientists have been selected to the rank of senior research associate (associate professor), and by the age of forty, 4.8% of natural scientists was selected to the position of research adviser (full professor), but no social scientists.

Without crossing the line of empirical evidence, we can conclude that, despite the earlier age of obtaining the doctorate, scientific career advancement in the natural sciences is relatively slower (and also harder). Later, natural scientists' careers advance faster than the social scientists' careers. Naturally, this trend, implied from the frequencies, was not statistically significant.

Despite the insignificant difference in earning individual scientific ranks between the fields, an examination of the responses yielded some more interesting information. Scientists become research associates in both fields at the age of 40 on average, senior research associates at 46.5, and research advisers at an average age of 48.9 years in the natural and 50.3 years in the social sciences. Furthermore, the first scientific rank earned at the youngest age was at the age of twenty-nine in the natural sciences, and at the age of thirty in the social sciences. The youngest natural scientist was appointed senior research associate at the age of 30, and the youngest social scientist at the age of 34. The earliest appointment to the highest (professional) rank was made in the natural sciences – at the age of 37 – while in the social sciences it was completed at the age of 42.

7.3. Institutional and organisational context

Scientists' professional activity takes place within two separate, but functionally intertwined, contexts – scientific fields as the socio-cognitive frameworks of the scientific profession on the one hand, and the socio-organisational framework reflecting the division of work in science into research, education and development within the respective types of scientific institutions on the other. While scientific fields reflect the cognitive differentiation of science within different but intertwined fields, and reflect the internal dimension of science itself, the institutional system of scientific activity is more greatly subject to the organisational interventions of the wider social environment. Moreover, contemporary science of the developed world cannot rest on the models of linear impregnation of three types of research with relevant institutions, so the triple helix and endless transition model is applied on the relation between industry, university and the government (Etzkowitz; Leydesdorff, 1998).

Scientific institutions in Croatia witnessed significant reorganisation in the period of transition between 1990 and 2004, but not modernisation. The management and organisation of university institutes underwent particularly significant changes with the change of their status to public institutes under the 1993 Scientific Research Activity Act. Former industrial institutes and R&D departments in the business sector experienced similar changes, with an erosion of their research and development function or their complete disappearance due to the economic collapse in the early 1990s.

(1) The changes in the institutional system naturally also altered the personnel structure in the primarily research, educational or developmental dimension of scientific work. Data from Table 6 thus indicate the increased concentration of the already most numerous scientific personnel at universities by a full ten structural points. On the other hand, the share of scientists working at institutes and other scientific institutions dwindled.

Table 6. Structural changes in the context of institution and field (samples of Croatian scientists from 1990 and 2004)

	1990	2004
SCIENTIFIC INSTITUTION		
Faculty	51.2	61.4
(Public) institute	22.2	16.4
Other institutions	26.6	22.2
Total	100.0	100.0
Chi-square = 39.013; df = 2; p = 0.00		
SCIENTIFIC FIELD		
Natural sciences	16.6	20.0
Technical sciences	31.3	20.7
Biomedical sciences	19.3	28.5
Biotechnical sciences	9.9	8.1
Social sciences and humanities	22.9	22.6
Total	100.0	100.0
Chi-square = 81.919; df = 4; p = 0.00		

Since the R&D sector is presented together with other institutions such as health care institutes, the Croatian Academy of Sciences and Arts (HAZU), the Meteorological and Hydrological Service (DHMZ), the Lexicographic Institute, and similar institutions, due to the shrinking share and for the needs of comparison with the situation in 1990, the reduction in the personnel potential in the segment of other institutions does not seem that dramatic. According to official sources from 1991, industrial institutes employed 1,360 researchers in 1991, while the number dropped to 502 ten years later in 2001.[7] This accounted for a drop in the share of the R&D sector in the structure of total scientific and research potential from 13.3% to only 5.5%. An even greater shrinking of the sector is indicated by the findings that 18.8% of the personnel of the industrial institutes and research units in the business sector in 1990 had declined to only 6.0% of personnel in industrial institutes or R&D units in companies in 2004.

Slovenia, whose institutional structure was less academic and significantly more development-oriented than Croatia's, is a very graphic example. The institutional distribution of R&D in Slovenia is evident from a larger share of companies (20%), a significantly smaller share of universities (43%), a slightly greater representation of public institutes (19%), and a much greater share of other institutions (22%).[8] The share of other institutions in Croatia, without an R&D sector came to only 16.2% in 2004.

On the cognitive level of differentiation of Croatian science, we have to draw attention to the stagnant stratum of the social sciences and humanities, and the increased presence of the natural sciences (by 3.4 structural points) within the overall pool of scientists between 1990 and 2004.

The institutional division of natural and social scientists in 2004 (Table IV, appendix) indicates significant differences by fields: a far greater number of public institutes in the natural sciences (superiority of the Ruđer Bošković institute in terms of personnel), a greater number of faculties in the social sciences, and a higher frequency of other institutions in the natural sciences.

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[7] Source: *Registry of Scientists and Researchers* at the Ministry of Science and Technology of the Republic of Croatia – on 31 December 1991 and June 2001.

[8] According to the data stated in UNESCO's studies of scientific potential of the transition countries of South-Eastern Europe (Prpić, 2002).

The structure of the natural and the social sciences in the institutional context (presented in Table 7) confirms the same significant differences in the distribution of the most qualified scientific potential. Thus, according to the findings of the web survey, of the total number of doctors in the natural and the social sciences, there were 44.2% of natural scientists in public institutes, as compared to 15.6% of social scientists; there were 44.5% of natural scientists at faculties, and as many as 80.8% of social scientists; other institutions employed 11.3% of natural scientists, and only 3.6% of qualified social scientists.

Table 7. Structure of doctors of the natural and the social sciences by institutional context and type of research

	Natural sciences (310)		Social sciences (167)
TYPE OF SCIENTIFIC RESEARCH INSTITUTION			
Public institute	44.2		15.6
Higher-education institution	44.5		80.8
Other institutions*	11.3		3.6
Total	100.0		100.0
Chi-square		58.524	
Degrees of freedom		2	
Chi-square significance		0.000	
TYPE OF RESEARCH			
Basic research	61.4		23.4
Applied and development	15.9		38.3
Mixed-type research	22.7		38.3
Total	100.0		100.0
Chi-square		65.275	
Degrees of freedom		2	
Chi-square significance		0.000	

* Industrial institutes, research/development units within other institutions, HAZU, DHMZ, health care institutions and similar

A comparison of the institutional division of doctors of the natural and the social sciences with the institutional division of the total Croatian scientific potential indicates the following relations. Compared with the average in public institutes (16.4%), the share of doctors of the social sciences is close to the average (15.6%), while the share of doctors of the natural sciences (44.2%) is significantly higher. With the average in higher-education institutions (61.4%), the share of doctors of the natural sciences is underrepresented (44.5%), while doctors of the social sciences are overrepresented (80.8%). Compared with the average in other institutions (22.2%), doctors of science are underrepresented in both fields – slightly less in the natural sciences (11.3%), and significantly more in the social sciences (3.6%). These findings indicate the concentration of the most qualified scientific personnel in the research sector of the natural sciences, and lower-qualified personnel outside the university and research sectors in both fields.

(2) The organisational context of the scientific profession is also determined by the type of research, apart from the mentioned field and institutional patterns. To be more precise, the type of research is an important socio-cognitive framework of the scientific profession that expresses different goals of scientific activity. These goals can be strictly cognitive, but also socially practical or economically profitable. The earlier division to basic research, applied research, and experimental development is rather outdated today and it is mostly connected to the already abandoned division into the pure science that the academic scientist is engaged in, and the applied, commercial science in the business sector. These borders are much more flexible in developed societies, and certain types of research are intertwined. The strict division of work between scientific research institutions has been abandoned, and corporate institutes are also engaged in basic research today. Similarly, universities and scientific institutes also frequently engage in applied research. Whitley (1984) pointed out their increasing relevance back in the 1980s.

Since only a minor number of scientists work on experimental development in Croatian science, they are still (which is usual here) merged with applied research in processing and recording the findings. Table 7 shows doctors of the natural and the social sciences that manifested statistically significant differences according to the research typology modified in this way. Thus, significantly more natural scientists were engaged in basic research (61.4% of natural scientists compared to 23.4% of social scientists), and more social scientists worked on applied research and experimental development (38.3% of social scientists compared to 22.7% of natural scientists). Mixed-type research, which became quite usual in the world a long time ago, was represented in the population of doctors of the social sciences at 38.3%, and in the population of doctors of natural science at 22.7%. If the figures were the other way around, we could perhaps conclude that the one-third share of mixed-type research was an indicator of stimulating scientific activity, but since this concerns the social sciences, it is more probable that it relates to so-called market research which is conducted in parallel to the underfunded research programmes of primary scientific activity due to the lack of funding. Such research was encouraged mostly by scientific policy and its goals, and to a lesser extent by commissions by the potential beneficiaries of scientific results, so it cannot be a true measure of the modernisation of Croatian science.

7.4. Professional position and role of doctors of the natural and social sciences

The professional position and role of scientists are determined by macrosocial conditions, but also by the division of the professional activities on the microlevel of the institution and the macrolevel of the Croatian and international (European) scientific community. Since it was not possible for the first level of the general social and material determinants of the position and role of the scientist to be covered by this study, their professional position was investigated on two other levels. Operationally, the basic characteristics of the professional position of doctors of the natural and the social sciences were investigated with the help of the indicators in the division of research and executive jobs and roles in scientific institutions, the division of collaborative and influential roles in the scientific (Croatian and international) community, and at the level of scientists' networks. Scientific productivity and production, as components of professional roles and status, are dealt with separately in the chapter on scientific production because of their fundamental importance in the overall scientific career.

7.4.1. Patterns of division of research and executive tasks by field

The basic research activity of doctors of the natural and the social sciences was studied in terms of their engagement in local and international projects and through the quantitative and (in one segment) qualitative dimension of their research engagement (Table V, appendix).

(1) Engagement in projects is the basic professional obligation of every scientist in the Croatian scientific system, so the differences in project engagement are not, as can be expected, manifested

by fields.[9] However, differences surface at the level of five-year participation in international projects.[10] The more substantial access of Croatian natural scientists (60.7%) to international research activities and their participation in international research teams on joint projects have a double footing. The more universal object of research in the natural sciences has allowed the greater presence of natural scientists, and at the same time this is a reflection of the longer presence of Croatian natural scientists in the international scientific hubs. In contrast, Croatian social scientists were disadvantaged in the international division of tasks in two ways. They were limited by the specific and locally-determined object of research, and a more significant breakthrough into the international research market is of rather recent date. It is widely known that in the early socialist times, in the 1950s, and even in the early 1960s, scientists largely emigrated, and international collaboration was possible to a limited extent only to natural scientists and scientists of a similar profile, while international cooperation in the social sciences was more an exception than a rule.[11] In later years, when the restrictions and distrust of cooperation with foreigners relaxed, the entrance of the social scientists to the international scientific scene did not take place either. The inertia of scientific cooperation within the country still prevailed, and was tolerated by the scientific system. Institutional encouragement and the pressure from science policy for the Croatian scientific community to open up in all fields of research, including the social sciences, are of recent date, and are connected to the transitional restructuring of the scientific system. Political expectations embodied in demands for international reviews and publishing in international journals have only recently become an instrument in scientific promotion. The finding showing 49.4% of social scientists, with doctoral degrees

[9] Insignificant differences in engagement in domestic projects by field were expressed in chi-square = 2.635; df = 1, p = 0.105.

[10] Insignificant differences in engagement in international (foreign) projects by field were expressed in chi-square = 5.628; df = 1, p = 0.018.

[11] The breaking off of communication with the world in 1946 had a long-lasting impact within the framework of the former socialist system. Even the most accessible mode of international cooperation, publishing in international journals, was established only later, and only in some fields. Yugoslavia, for example, ranked 48th among 172 countries by the number of published works of its scientists in the field of the *natural* and *technical* sciences in internationally renowned scientific/professional journals in 1988. The situation in the social sciences was much worse: it ranked 61st on the list of 143 countries (P. Glavač, in: Mežnarić, 1990: 40).

in their fields, involved in international projects from 1999 to 2004 should be considered in the described context.

(2) At the level of local projects where no differences were noticed between the fields thanks to the mandatory engagement of doctors of science in projects, a difference in the five-year project load was, however, determined.[12] The greatest number of scientists were working on two and even three projects at a time, with natural scientists being in the majority with this level of workload. Social scientists were in the lead with the relatively greater involvement in one project, but also with the greater involvement in a large number of projects. In the observed period, 8.4% of social scientists worked on four projects, 9.0% worked on five projects and as many as 11.4% of social scientists worked on six or more projects. There were around half fewer natural scientists at that level of activity. Expressed in median values, natural scientists worked on 2.7 projects in total in a five-year period, and social scientists on 3.7.

With the greater representation of natural scientists in international research, a borderline significance of differences between fields according the intensity of cooperation and extent of involvement in international projects has been noted.[13] It was reflected in the almost equal proportion of natural and social scientists with one international project (around 29%), but also with a greater stratum of natural scientists with two (18.3%), and three and more international projects (13.1%). The average number of international projects came to 1.2 in the natural sciences, and 0.9 in the social sciences.

(3) The qualitative dimension of information on scientists' project engagement and load refers to the division of research work and the influence in such a division of tasks. The theoretical basis of the needed information at the qualitative level is the concept of the routine and key research roles (Prpić, 2000). They make up one of the most important forms of the division of tasks in science, especially in developing team work. The role of the leader (project, team) implies their key role in the selection of the topic, or object of the research, their key position in the formulation of research objectives, selection of methods and modes of processing findings, in the division of subtopics and sections of the re-

[12] Significance of differences between fields in the number of domestic projects is expressed on the level of t-values = 3.249; df = 469, p = 0.001.

[13] Borderline significance of differences between fields by number of international projects is expressed on the level of t-values = 1.950; df = 469, p = 0.052.

search, and their key role in the finishing of the research – elaboration of results and writing reports. Depending on the size of the teams and the division of tasks in the team, the cooperation and position of the members of the team does not have to necessarily exclude decisive participation in any of the mentioned research tasks. However, the leader's position is, by definition, key. The routine tasks in the research process are usually divided among all members of the team, but the manager does have the key role in their distribution.

The pattern of the key and routine tasks in the research process and the influence of the leader on their distribution did not necessarily include the lack of a key role in the collaborative status for the doctoral population. They key role is something that is (re)defined in the team work of qualified scientists by project segments, from one stage to another, in the course of the whole research process, and the scientist's autonomy is greater than in some other activities. The distribution of the management role in the local[14] and international[15] projects of natural and social scientists did not show any statistically significant differences between the analysed fields. Slightly fewer than one third of doctors of the natural (31.3%) and the social sciences (28.1%) were engaged only as collaborators in local projects in the five-year period from 1999 to 2004. In contrast, the majority of the two-thirds of doctors of the natural and the social sciences performed the leading role in at least one of the projects in the same period. At the same time, the share of persons with leading positions in a great number of projects was two times greater in the population of social scientists. The average number of local projects with leadership roles came to 1.24 for natural scientists, and 1.49 for social scientists. The insignificant differences between the natural and social scientists in the frequency of leadership roles even at the level of international projects lead to the conclusion that scientists' engagement and their international reputation in both fields are balanced, regardless of the wider scientific cooperation of the natural scientists and their longer tradition in cooperation. Eminent persons from the social sciences, despite their scarcity, succeeded in engaging in international scientific cooperation more quickly, and even established a

[14] Statistical insignificance of differences between fields by the number of leading roles in local projects is expressed on the level of t-value = –1.643; df = 334, p = 0.101.

[15] Statistical insignificance of differences between fields by the number of leading roles in international projects is expressed on the level of t-value = 1.726; df = 294, p = 0.085.

reputation as experts in their field who can model and lead research projects.

(4) The frequency of executive and coordinating roles in a scientific institution and its organisational units – departments, divisions, centres, institutes and similar – was investigated in connection with the distribution of the influence and power of natural and social scientists at the microinstitutional level. In total, 36.9% of natural scientists and 43.1% of social scientists performed an executive role at the organisational level or at the helm of an institution, and the differences among them by fields were not statistically relevant.[16]

7.4.2. Patterns of participation and roles in the scientific community by field

Professional and scientific organisations, international associations of scientists, and involvement in the editorial boards of professional and scientific journals and in peer reviews are only a few of the forms of professional integration of scientists into the wider, Croatian and international scientific community. These types of professional association and scientific work form a framework of scientific communication, which defines the standards and rules of professional work and conduct for a certain scientific field or discipline. Considering the doctoral population of the natural and the social sciences, it seemed important to investigate this segment of scientific, professional and social activity in both scientific areas (Table VI, appendix).

(1) One of the positions with the potential power to define standards and influence on the (re)distribution of topics and quality of scientific work is membership in editorial boards of scientific and professional journals. Significant differences were seen between the natural and social scientists' participation in editorial boards at both local[17] and international levels.[18] As many as one half of all the social scientists surveyed participated in editorial boards of a local journal, according to the responses provided by the doctorate holders, while significantly fewer natural scientists performed that role (21.8%). This may be the most prominent case where the non-representativeness of the social sciences was evident through its leaning

[16] Chi-square = 1.762; df = 1; $p = 0.184$.

[17] T-value = –6.801; df = 466; $p = 0.000$.

[18] T-value = –2.429; df = 466; $p = 0.016$.

to the more eminent doctoral structure, while the representativeness of the natural sciences presented more realistic results. Membership of an editorial board of international journals also showed positive correlations with social scientists, but the differences by fields were not particularly expressed: 17% of social scientists compared to 9.2% natural scientists.

The gatekeeping role of the scientist, as a measure of their esteem, can be operatively defined and identified in several ways: as mentorship and membership of an examining committee in master's and doctoral programmes, engagement in editorial work in scientific journals, but also in peer reviews. Within the context of an empirical search for the distinctive components of the professional position and role of a scientist (doctor) of the natural and the social sciences, significant differences appeared in the scope of the role of natural and social scientists as reviewers. As many as 85% of doctors of the social sciences reviewed the work of local peers in the five years between 1999 and 2004, and as many as 43.6% of social scientists reviewed a great number of papers. On average, every doctor of the social sciences reviewed 7.5 papers produced by their Croatian colleagues in the period of five years, whereas every doctor of the natural sciences reviewed only 1.8%.[19] In contrast, the greater activity of natural scientists in international peer reviews is evidence of the greater exposure and international activity of natural scientists. On average, every doctor of the natural sciences reviewed 4.2 papers by their foreign colleagues in the course of five years, and every doctor of the social sciences reviewed half that number of papers, 2.1.[20] To sum up, greater differences by field were seen at the level of reviews of Croatian peers in favour of social scientists, while smaller, but still statistically significant, differences were evident at the level of the review of foreign peers in favour of natural scientists.

(2) The presence of natural and social scientists in the wider scientific community outside their original institution was also practically observed via professional and scientific organisations. Their primary task is to promote scientific knowledge and interest, to advance the profession and scientific field and discipline, determining and protecting professional rights and obligations, and laying down rules of scientific activity and professional behaviour (code of profes-

[19] T-test = −9.481; df = 468; p = 0.000.

[20] T-test = 2.009; df = 468; p = 0.045.

sional conduct and code of ethics). Participation and an active role in Croatian associations proved to be different in the natural sciences than in the social sciences,[21] but it was similar in terms of international organisations[22]. Despite the fact that membership in scientific organisations, with the minimum engagement (payment of membership fee), provides some rather practical benefits – personal visibility and access to a wider circle of colleagues, information on developments in the line of work (field, discipline), discounts for books, journals, etc., as many as 20.7% of doctors of the social sciences were not members of any association, while there were significantly fewer disinterested doctors of the natural sciences (9.4%). The differences between the fields were also seen in the structure of membership. While natural scientists were more inclined to membership in only one association (32.5%), or in a great number of associations (14.3% in four or more associations), social scientists were mostly members of two associations (29.3%) or only one original association (28.6%). On average, natural scientists participated in two Croatian associations, while social scientists took part in 1.6 associations. Furthermore, the active engagement of natural scientists in the executive and operating bodies of professional and scientific associations makes them stand out statistically compared to social scientists. The latter worked in executive and operating structures significantly less (18.8%), and natural scientists significantly more (29.6%).

However, international associations did not distinguish our respondents accordingly. To be more precise, their membership in foreign associations ranged in insignificant differences from average membership in one association in the natural sciences to 1.2 associations in the social sciences. In contrast to the Croatian associations, social scientists were slightly more active in the executive and operating bodies of foreign associations: 10.9% of Croatian scientists and 7.5% of Croatian natural scientists took part in their operation.

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[21] Significance of differences between the social and the natural sciences in membership in local associations was determined on the level of t-value = 3.149; df = 470, p = 0.002. Significance of differences between the social and the natural sciences in membership of executive and operating bodies in local associations was determined on the level of t-value = 2.255; df = 470, p = 0.025.

[22] (In)significance of differences between the social and the natural sciences in membership of international associations was determined on the level of t-value = –1.619; df = 470, p =0.106. (In)significance of differences between the social and the natural sciences in membership of executive and operating bodies in foreign associations was determined on the level of t-value = –1.886; df = 470, p = 0.060.

7.4.3. Patterns of scientists' networks by field

The self-sufficient, loner scientist, working as a one-man-band (to use the pop-culture expression), has almost completely disappeared from contemporary science. It is atypical and almost impossible in the majority of scientific fields and disciplines to survive independently in science and on the project market outside organisational, financial and institutional structures and research, project and group gatherings and associations. Science has changed its internal structure since the times of the giants of science and progenitors of many scientific disciplines, multiplying many times over the areas, disciplines, fields and drawers in which the results of the immeasurable pieces of research are classified. Today, scientists are *double-bound*: they are bound to the results of the research of other scientists, but also to cooperation with others. Team work is one of the most relevant characteristics of the social organisations of science. The web survey of doctors of the natural and the social sciences also collected data on regular cooperation in joint research, both in permanent teams and in flexible research groups. Furthermore, considering our respondents' participation in international projects, the scope of international cooperation and exchange of information with international colleagues were also investigated, even where no firm collaborative connections had been established (Table VII, appendix).

Natural and social scientists differed in the scope of their cooperation, both in the Croatian[23] and international framework,[24] while no statistically significant differences were found at the level of exchange of information.[25] The average number of local collaborators in joint research amounted to 4.6 in the natural sciences and 3.6 in the social sciences. However, the slight differences in average values hide the much greater differences in distribution and range of the circle of collaborators. In response to the question on the number of colleagues with whom they were working on joint research in a permanent research team and in flexible research groups alike, almost one quarter of social scientists (24.1%) said they mostly worked alone! There were much fewer independent natural scientists (6.2%). The modular value of natural scientists that referred to the most frequent form of cooperation was

[23] T-value = 2.078; df = 469; p = 0.038.

[24] Chi-square = 15.533; df = 1; p = 0.000.

[25] Chi-square = 0.042; df = 1; p = 0.838.

found among the highly cooperative natural scientists who, as a rule, cooperated with six or more collaborators (22.1%), while the modular value of social scientists showed a model of cooperation with two collaborators (19.3%). These differences emerge from the very structure of the objects of the two fields, and they partly reflect their different complexity and the depth of analysis, which requires a different approach to research.

The frequency of cooperation at the international level also showed the significant advantage of the natural sciences. Regular cooperation with international colleagues was established by 63.4% of doctors of the natural sciences, and by only 44.6% of doctors of the social sciences. The distribution of information with international colleagues was almost equal in both fields: 72.4% of natural scientists and 71.5% of social scientists conducted regular communication without any firm cooperation.

7.4.4. External signs of acknowledgment or distinctive scientific excellence

An excellent person is created as a result of the personal ambition and capacity to mould oneself in permanent and intense mental and physical effort. The pursuit of one's own vocation and the aspiration to authenticity is a life project that only the best can achieve. Only few meet these anthropological preconditions and are capable of building themselves into a highly-qualified person in one field of human activity.

Scientific excellence and the success of a scientist can be measured in several ways. Practically, acknowledgment by the scientific community and by the wider social public can be expressed in review procedures, citations, recognisability in the international scientific community, awards, etc. Since the valorisation of the scientific work of natural and social scientists on the basis of the production of books and journals is discussed in the chapter on scientific production, and the perceptions of scientific quality in the chapter of that name, we will only touch upon the external signs – the scientific recognisability of our respondents in the international context and their awards. The data presented in the appendix (Table VIII) shows that natural and social scientists did not differ statistically by any of the external measures of scientific excellence.

(1) More than half of the respondents gave a positive answer to the question whether and how often they were invited to go abroad to conduct research or cooperate with foreign colleagues over the course of five years (1999–2004) with paid expenses, or to teach at a foreign university or visit a scientific institution, deliver a lecture at a scientific conference, and so on. The highest-profile scientists in those two fields were those who received the most invitations: 18.9% of natural scientists and 21.5% of social scientists with four or five invitations in five years. This practically means that the segment of around one fifth of the most exposed natural and social scientists was invited to perform a scientific activity abroad with covered expenses at least once a year.

Apart from being a good measure of recognition, invitations from abroad also proved potentially efficient ("dangerous") as a brain drain mechanism. The 2004 study of the overall scientific population indicated that invitations from abroad (with covered expenses) were predictable among the set of variables pertaining to scientific prominence and the potential brain drain (beta-index = 0.102; p = 0.01) (Golub, 2005).

(2) An award for scientific work is the most direct expression of acclaim for a scientist. It is confirmation of the value of their body of scientific work or of an individual achievement (written or material work). Croatia's fundamental award system in science was established by the 1995 Croatian National Science Award Act. The awards are presented by the Republic of Croatia (Parliament) for exceptional achievements in scientific research, for the expansion of scientific knowledge, and for scientific achievements in the application of the results of scientific research. Scientists, researchers and junior researchers can receive a national award (cash prize and certificate) in the form of (1) lifetime achievement award,[26] (2) annual science award[27] and (3) annual award for the popularisation and promotion

[26] The lifetime achievement award is presented to esteemed scientists for their overall scientific work which presents their personal contribution to the expansion of scientific knowledge and the application of results of research and scientific activity (Article 3, Croatian National Science Awards Act).

[27] The annual award is presented for (1) significant scientific achievement (esteemed scientific work or a body of works which significantly contributes to the expansion of scientific knowledge), (2) scientific discovery (internationally recognised scientific work that produces a significant breakthrough in the scientific field), (3) prominent work by a junior researcher, (4) the application of results of scientific work (significant technological achievements manifested in its special quality or distribution) (Article 5, 8, 9, 10 and 11 of the same Act).

of science[28] in all six scientific fields. Furthermore, awards for scientific contributions are also presented by scientific field every year by the Croatian Academy of Arts and Sciences (Josip Juraj Strossmayer Award), and there are also other award systems, such as the Ruđer Bošković award for achievements in natural science, awarded by the Ruđer Bošković Institute.

Natural and social scientists were on a par by this indicator as well. The total number of rewarded scientists hovered around one quarter of the surveyed doctors in both fields (Table VIII, appendix). This piece of information should be compared with the 38.5% of eminent Croatian scientists and 13.2% of all scientists who received awards in 1995 and 1990. Doctors of science ranked somewhere between the scientific elite[29] and the overall scientific population in the award-winner rating, in compliance with the scientific excellence rating, according to which a doctoral degree in science was a springboard for top achievements in science.

An international award can be a measure of excellence in a person's scientific contribution even more than a domestic award. The greatest scientific achievements of Croatian scientists were made by two Nobel Prize winners, natural scientists Lavoslav Ružička and Vladimir Prelog, neither of whom, however, belonged to the Croatian scientific community. International awards for scientific achievements of lower rank were presented to (according to our survey) 6.5% of Croatian doctors of the natural sciences and 4.2% of Croatian doctors of the social sciences. In terms of absolute numbers, this means that there were 15 laureates with one international award, 4 laureates with two awards and one laureate with three awards among 310 natural scientists. Three of the 167 surveyed social scientists won one international award, two won two awards respectively, and one social scientist won three and one won four international awards.

(3) Since our respondents did not show any differences at the level of external signs of scientific excellence measured by international rec-

[28] The annual award for the popularisation and promotion of science is presented for a contribution in the dissemination of scientific knowledge, as manifested in the popular presentation of valuable professional and scientific publications and other forms of presentation (Article 4).

[29] The population of eminent Croatian scientists consisted of scientists listed in the biographical directory *Who is Who in Croatia* (Maletić, 1993), who lived in Croatia and who were (still) active scientists in 1995 at a maximum age of 70.

ognisability and awards by field, we tried to bring together a certain number of variables of the scientific, working and professional environment to identify natural and social scientists with above-average results indirectly or in the segment of extreme values. Following that line of reasoning, attention was focused on the highest achieved ranks, early promotion in their career, exceptional linguistic education (polyglotism), intense project engagement, exposed gatekeeping roles, activity outside institutions in the wider scientific community, and regular international cooperation.

Data from Table 8 indicate the following differentiations by field. Natural scientists achieved better results in terms of early career advancement. Thus, almost two-thirds of natural scientists had acquired their doctoral degrees by the age of 35, and one quarter of them had already been selected to the highest rank by the age of 45. In contrast, social scientists advanced more slowly in their career, but they scored better in the highest ranks in the overall structure of scientific ranks. At the level of above-average linguistic competence, natural and social scientists did not show any differences: one-tenth of the former and one-tenth of the latter could be considered multilingual. A high level of engagement in projects in the five-year period pertained to local projects for social scientists, and to international projects for natural scientists – one-tenth of doctors of the natural sciences performed the leading role in two or even more international projects.

Along the same lines of local and foreign exposure, the division was also seen in high engagement in peer reviews: a great number of Croatian works were reviewed by exposed social scientists, and a great number of international works by exposed natural scientists. And while established social scientists were far more present in editorial boards of both local and international journals, established natural scientists manifested greater activity at the level of management and working bodies of Croatian professional and scientific associations. Finally, regular scientific cooperation is the great trump card and advantage of the natural scientists. Almost two-thirds of doctors of the natural sciences cooperate regularly with foreign colleagues, and, consequently, the indicator cannot be a measure of exposure or extreme achievement in science, but more of an indicator of the readiness of Croatian natural scientists to meet the demands of contemporary science.

Table 8. Patterns (conditions) of scientific eminence by field

Variables of (preconditions of) scientific eminence	Natural sciences (310)	Social sciences (167)	Significance of differences
Highest scientific rank: senior research associate and research adviser	48.1%	**54.0%**	Significant
Early doctorate (under 35 years of age)	**64.5%**	39.0%	Significant
Early election for research adviser (under 45 years)	**26.5%**	17.4%	Significant
Multilingualism (active knowledge of 3 and more foreign languages)	10.4%	11.4%	Insignificant
Five and more domestic projects in five-year period 1999–2004	10.0%	**20.4%**	Significant
Three and more international projects in five-year period 1999–2004	**13.1%**	9.0%	Significant
Leading position in international projects (1999–2004)	**10.8%**	4.2%	Significant
Great number of domestic peer reviews in five-year period (6 and more)	8.5%	**43.6%**	Significant
Great number of international peer reviews in five-year period (6 and more)	**19.3%**	11.3%	Significant
Member of two or more editorial boards of Croatian journals	4.3%	**18.7%**	Significant
Member of editorial board of an international journal	9.2%	**17.0%**	Significant
Member of management/operating bodies of Croatian scientific/professional organisations	**29.6%**	18.8%	Significant
Member of management/ operating bodies of foreign scientific/professional organisations	7.5%	10.9%	Insignificant
Regular cooperation with foreign colleagues	**63.4%**	44.6%	Significant

8. Recapitulation of the differences in the working and professional environments of natural and social scientists

As the earlier part of this chapter focused on the above-average results achieved by natural and social scientists, the recapitulation should certainly identify and underpin the set of variables of the working and professional environment at the level of the average values that showed statistically significant differences between the natural and socials scientists. The following overview will thus ignore all the previously presented indicators of the position and role in the scientific community that did not show any differential characteristics, in order to highlight only the distinctive dimensions of the two fields.

Even a cursory glance at the data in Table 9 reveals two different cognitive and organisational environments pertaining to the natural and social sciences respectively. While the domination of the academic institutional structure is indisputable in the social sciences, the institutional pattern of everyday scientific activity is much more expressed in the natural sciences. If we recall the institutional structure within fields, the frequency of faculties in the natural sciences is on a par with institutes (around 44% in both cases). However, the frequency of faculties in the natural sciences is much lower than the average level of the academic sector in Croatia (61.4%), not to speak of the comparison with the social sciences where academic institutions are especially pronounced (80.8%).

The section on the institutional and organisational context touched upon a certain artificiality and anachronism in the typological division of research into fundamental, applied and developmental research, considering the recent trend of relaxing the strict demarcation among them. Even from that position, the findings obtained from the responses of the Croatian doctors of science indicate significantly different research content and goals realised in the natural and social sciences. While the natural sciences in Croatia were primarily marked by basic research, the social sciences reached a certain balance in practising various types of research, with a more pronounced share of mixed-type research (38.3%).

From the typological point of view, the basic professional activity of an average Croatian natural scientist is far more connected to the institutes than that of the average Croatian social scientist, or even more than that of the average Croatian scientist (Table III, appendix). In their cognitive and research efforts, they are more focused on the content and goals that are primarily achieved within the framework of so-called basic research projects. Their earlier rise in the professional scientific career allowed them to acquire scientific education relatively early – they win their doctoral degree as thirty-year-olds on average (at 35.3 years of age). Their career is not limited to the smaller and locally-determined scientific community, but is focused to a rather great extent on regular cooperation with international colleagues in international and European scientific centres (63.4%). Consequently, they participate extensively in international projects (60.7%), with an average of 1.2 projects in the five-year period between 1999 and 2004. They make ties to the international scientific community also in other forms of cooperation, such as the high rate of international peer reviews, 4.2 papers in five years. The average natural scientist stands out on the Croatian scientific scene with greater scientific cooperation and prominence in scientific and professional associations.

Table 9. Patterns of the working and professional environment at the level of statistical significance ($p \leq 0.05$) by field

Variables of working and professional environment	Natural sciences (310)	Social sciences (167)
Type of scientific research institutions	Public institutes	Faculty
Type of research	Fundamental	Applied, development, mixed-type
Scientific rank	Worse structure	Better structure
Average age at doctorate	**35.3**	38.3
Engagement in international projects in five-year period 1999–2004	**60.7%**	**49.4%**
Average number of domestic projects in five-year period 1999–2004	2.7	3.7
Average number of international projects in five-year period 1999–2004	**1.2**	0.9
Average number of domestic peer reviews in five-year period 1999–2004	1.8	**7.5**
Average number of international peer reviews in five-year period 1999–2004	**4.2**	2.1
Membership in editorial boards of Croatian journals (average number)	0.3	**0.8**
Membership in editorial boards of foreign journals (average number)	0.1	**0.3**
Membership in Croatian scientific, professional organisations (average number)	**2.0**	1.6
Membership in management and operating bodies of Croatian scientific, professional organisations (average number)	**0.4**	0.2
Average number of Croatian collaborators in joint research	**4.6**	3.6
Regular cooperation with foreign colleagues	**63.4%**	44.6%

In contrast, the average Croatian social scientist is most often employed in a higher-education institution (80.8%). Alongside research activity, the average social scientist is primarily focused on teaching and transferring knowledge and acquired research experience to the new generations in the field. The goal and the content of the research are focused on the fundamental determinants of social and economic reality, but also to a far greater extent on the developmental aspect of social and economic relations, and the mixed type of projects that incorporates the fundamental, developmental and applied postulates of the selection of the object and goals of research. The relatively better qualification structure in the social sciences, measured by the scale of ranks, is attained despite the later time of obtaining degrees – the average social scientist wins a doctoral degree almost at the age of forty (at 38.3 years of age). In contrast to the Croatian natural scientist who is more engaged in the international division of work, and is far more present at different levels and in different segments of the world and European scientific scene, the Croatian social scientist had many more professional engagements in Croatia, working on 3.7 projects on average in the observed period of five years (1999–2004), and reviewing as many as 7.5 papers by local authors in the same period. The average social scientist also participated in editorial boards and/or committees of local journals more frequently, and the only segment of the international activities where they scored better than the natural scientist is in the publishing segment, where the social scientist was a member of the editorial board of international journals.

At the end of the final overview of the relevant distinctive components of the working and professional position of the natural and social scientist, let us repeat the analyses of the socio-demographic and socialisational and education variables that did not show any significant differences between the analysed fields. Having in mind the limitations of the methods and conduct of the web survey, it can be underlined in conclusion that the natural and social sciences did not rejuvenate and recruit selectively, but they scientifically socialised and professionally marked their personnel potential in somewhat different ways. The differences in the approach and evaluation of certain aspects of socialisation, but also of the different cognitive, institutional and organisational structure and the preference of different patterns in the selection and approach to scientific topics and social and scientific goals, also resulted in certain differences among natural scientists and social scientists in the manner described above. Far greater differences will be manifested in the sector of scientific productivity, whose determinants were only implied at this level of analysis.

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Appendix – Tables

Table I. Representativeness of the sample of natural and social scientists considering some socio-professional variables (web survey)

	Natural sciences					Social sciences				
	Population			Sample		Population			Sample	
	N	%		N	%	N	%		N	%
GENDER										
Female	517	45.7		150	48.7	306	37.9		89	53.6
Male	614	54.3		158	51.3	501	62.1		77	46.4
Total	1131	100.0		308	100.0	807	100.0		166	100.0
Chi-square			1.118					17.417		
Degrees of freedom			1					1		
Chi-square significance			0.290					0.000		
AGE										
30 – 39 years	104	9.2		64	20.8	44	5.5		23	13.8
40 – 49 years	314	27.8		82	26.6	207	25.7		55	32.9
50 – 59 years	333	29.4		98	31.8	261	32.3		60	35.9
60 and older	380	33.6		64	20.8	295	36.6		29	17.4
Total	1131	100.0		308	100.0	807	100.0		167	100.0
Chi-square			6.938					13.937		
Degrees of freedom			3					3		
Chi-square significance			0.074					0.003		
TYPE OF SCIENTIFIC RESEARCH INSTITUTION										
Public institute	451	39.9		137	44.2	75	9.3		26	15.6
Higher-education institution	553	48.9		138	44.5	704	87.2		135	80.8
Other institutions*	127	11.2		35	11.3	28	3.5		6	3.4
Total	1131	100.0		310	100.0	807	100.0		167	100.0
Chi-square			2.653					7.836		
Degrees of freedom			2					2		
Chi-square significance			0.265					0.020		
SCIENTIFIC FIELDS										
Mathematics	127	11.2		22	7.3					
Chemistry	420	37.2		98	32.5					
Biology	243	21.5		85	28.1					
Physics	232	20.5		57	18.9					
Geo-sciences**	109	9.6		40	13.2					
Psychology						71	8.8		20	12.7
Educational sciences***						129	15.9		21	13.4
Law						128	15.9		15	9.6
Economics						309	38.4		54	34.4
Political sciences						48	5.9		11	7.0
Sociology						66	8.2		25	15.9
Information sciences						56	6.9		11	7.0
Total	1131	100.0		302	100.0	807	100.0		157	100.0
Chi-square			16.649					19.728		
Degrees of freedom			4					6		
Chi-square significance			0.002					0.003		

* Industrial institute, research/development units within other institutions, HAZU, DHMZ, health care institutions and similar

** Geography, geology

*** Pedagogy, disability studies, kinesiology

Table II. Demographic and socialisational and educational characteristics of Croatian scientists by scientific fields (2004 sample)

	Natural sciences (182)	Technical sciences (188)	Medical sciences (258)	Biotechnical sciences (74)	Social sciences and humanities (206)
GENDER					
Female	54.4	23.4	47.3	39.2	58.7
Male	45.6	76.6	52.7	60.8	41.3
Total	100.0	100.0	100.0	100.0	100.0
Chi-square = 58.842; df = 4; p = 0.00					
AGE					
Under 29	8.9	11.6	1.9	6.8	7.8
30 – 39 years	26.3	28.6	21.2	43.2	32.0
40 – 49 years	23.5	20.1	28.2	14.9	23.8
50 – 59 years	26.3	25.9	34.0	24.3	24.8
60 and older	15.1	13.8	14.7	10.8	11.7
Total	100.0	100.0	100.0	100.0	100.0
Average age = 45.8; F-ratio = 4.393; significance of F-ratio = 0.00					
FATHER'S EDUCATION					
Elementary and uncompleted high school	10.4	13.2	8.1	23.0	12.1
Vocational school	12.6	18.0	12.3	13.5	13.1
High school	28.0	19.6	18.5	25.7	19.9
Two-year higher education	13.2	10.6	12.7	14.9	16.5
Faculty, academy, four-year higher education	27.5	28.0	37.7	14.9	27.7
Master's degree, doctoral degree	8.2	10.6	10.8	8.1	10.7
Total	100.0	100.0	100.0	100.0	100.0
Chi-square = 36.386; df = 20; p = 0.01					
ACADEMIC PERFORMANCE AT UNIVERSITY					
Good	6.7	13.2	14.3	8.1	5.8
Very good	65.6	67.2	61.8	75.7	55.3
Excellent	27.8	19.6	23.9	16.2	38.8
Total	100.0	100.0	100.0	100.0	100.0
Average grade = 4.2; F-ratio = 7.312; significance of F-ratio = 0.00					

Table III. Institutional and formal constituents of the professional and career patterns by scientific field (2004 sample)

	Natural sciences (182)	Technical sciences (188)	Medical sciences (258)	Biotechnical sciences (74)	Social sciences and humanities (206)
SCIENTIFIC INSTITUTION					
Public institute	34.3	7.0	9.0	17.6	18.0
Faculty	47.5	79.6	45.1	68.9	74.6
Other institutions	18.2	13.4	45.9	13.5	7.3
Total	100.0	100.0	100.0	100.0	100.0
Chi-square = 182.388; df = 8; p = 0.00					
SCIENTIFIC DEGREE					
No scientific degree	10.4	20.6	6.2	16.2	14.6
Master's degree	26.4	28.0	27.3	21.6	25.7
Doctorate	63.2	51.3	66.5	62.2	59.7
Total	100.0	100.0	100.0	100.0	100.0
Chi-square = 25.485; df = 8; p = 0.01					
SCIENTIFIC RANK					
No rank, associate	18.2	22.9	30.2	9.6	14.6
(Senior) assistant	31.3	34.1	21.8	39.7	31.3
Research associate	20.5	12.3	16.7	24.7	18.7
Senior research associate	10.8	11.2	17.1	9.6	18.7
Research adviser	19.3	19.6	14.3	16.4	16.7
Total	100.0	100.0	100.0	100.0	100.0
Chi-square = 44.641; df = 16; p = 0.00					

Table IV. Career patterns by field (2004 sample)

	Natural sciences (182)	Technical sciences (189)	Medical sciences (260)	Biotechnical sciences (74)	Social sciences and humanities (206)
AGE					
n (907)	179	189	259	74	206
Average age	45.9	45.1	48.1	43.2	44.6
Standard deviation	11.8360	12.2723	10.0982	11.5575	11.3585
Youngest respondent	26	25	26	26	24
Oldest respondent	70	69	67	69	72
F-ratio = 4.393					
Significance of F-ratio = 0.00					
AGE AT MASTER'S DEGREE					
n (236)	47	53	69	16	51
Average age	32.9	31.6	35.5	32.2	32.0
Standard deviation	6.51	5.68	5.68	5.65	5.35
Youngest master's degree winner	25	25	26	27	25
Oldest master's degree winner	57	50	50	50	50
F-ratio = 4.324					
Significance of F-ratio = 0.00					
AGE AT DOCTORATE					
n (552)	114	97	172	46	123
Average age	35.6	39.1	38.9	36.7	38.0
Standard deviation	5.93	6.35	6.56	5.10	6.17
Youngest doctorate holder	27	27	27	28	28
Oldest doctorate holder	55	64	58	50	58
F-ratio = 6.377					
Significance of F-ratio = 0.00					
AGE AT ELECTION TO THE RANK OF RESEARCH ASSOCIATE					
n (148)	35	21	40	17	35
Average age	40.8	40.1	43.3	40.5	41.6
Standard deviation	6.66	7.32	7.50	5.29	6.52
Youngest person	32	30	32	35	30
Oldest person	56	64	59	51	56
F-ratio not significant					
AGE AT ELECTION TO THE RANK OF SENIOR RESEARCH ASSOCIATE					
n (124)	18	20	42	7	37
Average age	45.1	45.8	46.1	42.1	46.1
Standard deviation	6.00	6.46	6.18	3.93	7.25
Youngest person	35	35	35	37	35
Oldest person	56	57	59	49	62
F-ratio not significant					
AGE AT ELECTION TO THE RANK OF RESEARCH ADVISER					
N (145)	33	34	36	12	30
Average age	49.3	49.9	48.5	50.3	49.9
Standard deviation	5.45	5.79	5.53	4.90	6.60
Youngest person	40	39	38	43	40
Oldest person	59	62	59	56	64
F-ratio not significant					

Table V. Structure of doctors of the natural and social sciences by professional (research and leading) activities

Five-year period 1999 – 2004	Natural sciences (310)		Social sciences (167)
ENGAGEMENT IN LOCAL PROJECTS			
No engagement	1.0		3.0
Engaged	99.0		97.0
Total	100.0		100.0
Chi-square		2.635	
Degrees of freedom		1	
Chi-square significance		0.105	
ENGAGEMENT IN INTERNATIONAL PROJECTS			
No engagement	39.3		50.6
Engaged	60.7		49.4
Total	100.0		100.0
Chi-square		5.628	
Degrees of freedom		1	
Chi-square significance		0.018	
NUMBER OF LOCAL PROJECTS			
No projects	1.0		3.0
One project	10.5		12.6
Two projects	42.6		29.9
Three projects	28.3		25.7
Four projects	7.6		8.4
Five projects	4.3		9.0
Six and more projects	5.7		11.4
Total	100.0		100.0
Average number of projects	2.73		3.74
Standard deviation	1.515		5.037
T-value		−3.249	
Degrees of freedom		469	
T-test significance		0.001	
NUMBER OF INTERNATIONAL, FOREIGN PROJECTS			
No projects	39.5		50.9
One project	29.1		29.8
Two projects	18.3		10.3
Three and more projects	13.1		9.0
Total	100.0		100.0
Average number of projects	1.18		0.91
Standard deviation	1.427		1.456
T-value	1.950		
Degrees of freedom		469	
T-test significance		0.052	
NUMBER OF LOCAL PROJECTS WITH LEADING ROLE			
No leadership	31.3		28.1
One project	36.5		34.1
Two projects	23.0		19.8
Three and more projects	9.2		18.0
Total	100.0		100.0

Five-year period 1999 – 2004	Natural sciences (310)		Social sciences (167)
NUMBER OF LOCAL PROJECTS WITH LEADING ROLE			
Average number of projects	1.24		1.49
Standard deviation	1.519		1.563
T-value		−1.643	
Degrees of freedom		334	
T-test significance		0.101	
NUMBER OF INTERNATIONAL, FOREIGN PROJECTS WITH LEADING ROLE			
No leadership	76.1		88.5
One project	13.1		7.3
Two and more projects	10.8		4.2
Total	100.0		100.0
Average number of projects	0.40		0.24
Standard deviation	0.875		1.023
T-value		1.726	
Degrees of freedom		294	
T-test significance		0.085	
EXECUTIVE OR LEADERSHIP ROLE			
No	63.1		56.9
Yes	36.9		43.1
Total	100.0		100.0
Chi-square		1.762	
Degrees of freedom		1	
Chi-square significance		0.184	

Table VI. Participation and roles in scientific community by field

	Natural sciences (310)		Social sciences (167)
MEMBERSHIP IN CROATIAN EDITORIAL BOARDS			
Not a member	78.2		50.9
Member of one editorial board	17.5		30.4
Members of two editorial boards	3.3		13.9
Member of three and more editorial boards	1.0		4.8
Total	100.0		100.0
Average number of memberships	0.27		0.76
Standard deviation	0.569		0.999
T-value		−6.801	
Degrees of freedom		466	
T-test significance		0.000	
MEMBERSHIP IN FOREIGN EDITORIAL BOARDS			
Not a member	90.8		83.0
Member of one editorial board	7.6		11.5
Members of two or more editorial boards	1.6		5.5
Total	100.0		100.0

	Natural sciences (310)		Social sciences (167)
MEMBERSHIP IN FOREIGN EDITORIAL BOARDS			
Average number of memberships	0.12		0.32
Standard deviation	0.430		1.282
T-value		−2.429	
Degrees of freedom		466	
T-test significance		0.016	
DOMESTIC PEER REVIEWS IN FIVE-YEAR PERIOD			
No reviews	49.0		15.0
One review	12.3		4.2
Two reviews	14.3		9.0
Three reviews	6.5		7.2
Four reviews	2.6		9.6
Five reviews	6.8		11.4
Six or more reviews	8.5		43.6
Total	100.0		100.0
Average number of peer reviews	1.85		7.46
Standard deviation	3.250		9.337
T-value		−9.481	
Degrees of freedom		468	
T-test significance		0.000	
FOREIGN PEER REVIEWS IN FIVE-YEAR PERIOD			
No reviews	41.3		56.9
One review	11.0		9.6
Two reviews	10.0		9.6
Three reviews	8.4		4.8
Four reviews	4.2		2.4
Five reviews	5.8		5.4
Six and more reviews	19.3		11.3
Total	100.0		100.0
Average number of peer reviews	4.16		2.13
Standard deviation	12.608		4.203
T-value		2.009	
Degrees of freedom		468	
T-test significance		0.045	
MEMBERSHIP IN CROATIAN ASSOCIATIONS			
Not a member	9.4		20.7
Member of one association	32.5		28.6
Member of two associations	28.2		29.3
Member of three associations	15.6		16.5
Member of four associations	9.1		4.3
Member of five and more associations	5.2		0.6
Total	100.0		100.0
Average number of memberships	2.01		1.60
Standard deviation	1.398		1.300
T-value		3.149	
Degrees of freedom		470	
T-test significance		0.002	

	Natural sciences (310)		Social sciences (167)
MEMBERSHIP IN FOREIGN ASSOCIATIONS			
Not a member	43.5		39.0
Member of one association	31.5		29.3
Member of two associations	18.2		17.1
Member of three or more associations	6.8		14.6
Total	100.0		100.0
Average number of memberships	0.99		1.21
Standard deviation	1.457		1.426
T-value		–1.619	
Degrees of freedom		470	
T-test significance		0.106	
MEMBERSHIP IN EXECUTIVE AND OPERATING BODIES OF CROATIAN ASSOCIATIONS			
Not a member	70.4		81.2
Member of executive and operating bodies of one association	22.8		13.9
Member of executive and operating bodies of two or more associations	6.8		4.9
Total	100.0		100.0
Average number of memberships in executive and operating bodies	0.38		0.24
Standard deviations	0.677		0.554
T-value		2.255	
Degrees of freedom		470	
T-test significance		0.025	
MEMBERSHIP IN EXECUTIVE AND OPERATING BODIES OF FOREIGN ASSOCIATIONS			
Not a member	92.5		89.1
Member of executive and operating bodies of one association	6.5		7.3
Member of executive and operating bodies of two or more associations	1.0		3.6
Total	100.0		100.0
Average number of memberships in executive and operating bodies	0.09		0.16
Standard deviation	0.336		0.533
T-value		–1.886	
Degrees of freedom		470	
T-test significance		0.060	

Table VII. Patterns of scientist's networks by field

	Natural sciences (310)		Social sciences (167)
NUMBER OF CROATIAN COLLABORATORS IN JOINT RESEARCH			
Working alone	6.2		24.1
One collaborator	4.6		6.6
Two collaborators	17.7		19.3
Three collaborators	18.0		13.9
Four collaborators	14.4		11.4
Five collaborators	17.0		9.6
Six and more collaborators	22.1		15.1
Total	100.0		100.0
Average number of Croatian collaborators	4.55		3.5
Standard deviation	3.808		6.247
T-value		2.078	
Degrees of freedom		469	
T-test significance		0.038	
FOREIGN COLLABORATORS			
No regular cooperation	36.6		55.4
Regular cooperation	63.4		44.6
Total	100.0		100.0
Chi-square		15.533	
Degrees of freedom		1	
Chi-square significance		0.000	
EXCHANGE OF INFORMATION WITH FOREIGN COLLEAGUES WITHOUT STRONGER COOPERATION			
Do not communicate regularly	27.6		28.5
Communicate regularly	72.4		71.5
Total	100.0		100.0
Chi-square		0.042	
Degrees of freedom		1	
Chi-square significance		0.838	

Table VIII. Division of visible scientific excellence

	Natural sciences (310)		Social sciences (167)
NUMBER OF INVITATIONS FROM ABROAD			
No invitations	43.0		40.5
One invitation	16.6		11.0
Two invitations	13.7		14.1
Three invitations	7.8		12.9
Four and more invitations	18.9		21.5
Total	100.0		100.0
Average number of invitations	2.1		2.36
Standard deviation	3.311		3.233
T-value		–0.811	
Degrees of freedom		468	
T-test significance		0.418	
AWARDS FOR ACHIEVEMENTS IN SCIENCE			
No awards	76.9		72.3
Awards	23.1		27.7
Total	100.0		100.0
Chi-square		1.259	
Degrees of freedom		1	
Chi-square significance		0.262	

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Self-reported research productivity: patterns and factors

1. Knowledge production – the key to understanding socio-cognitive differences between sciences?

Theoretically, research production and productivity might be the key to understanding the differences between individual sciences and entire scientific areas, especially between the natural and social sciences. In binary and contrastive, and even in bipolar typologies of science, these fields are considered paradigmatic examples of restrictive and non-restrictive, hard and soft, codified and non-codified, exact and non-exact scientific (sub)fields (Pantin, 1968, according to Whitley, 1977; Biglan, 1973a; Merton, 1974; Whitley, 1977; Becher 2001). Despite their conspicuousness, differences in the quantity, type and scope of research publications by natural and social scientists are rarely stressed by the creators of the typologies of scientific fields, and are even more rarely corroborated by the existing evidence on scientific productivity in these scientific areas.

The neglect of the obvious in these, but also in more complex, classifications of science (Whitley, 1984; Fuchs, 1992) is surprising, especially since a specific thesis with a strong empirical stronghold in research production could be derived from their fundamental assumptions. Namely, one could assume that the dominant types and quantity of publications in individual scientific areas and fields stem from the differences in the mode of knowledge production, that is, differences in the intellectual and social organisation of individual sciences. Even if theoreticians, who focus on the deeper epistemic and social aspects of disciplinary differentiation, did not have a need for such a thesis to classify sciences, the creators of the classifications of sciences based on empirical research, such as Becher and Biglan, did not give it enough attention either.

Based on an empirical classification of science with the help of multidimensional scaling founded on the assessments of respondents-scientists on the similarities among 36 scientific fields or disciplines, Biglan examined the relation between the scientific fields obtained in this way on one hand, and the structure and output of university departments on the other. He started from the more complex hypothesis that different research subjects presuppose and contribute to the difference in university organisation. Therefore, he studied the extent to which the said scientific fields differ in terms of scientists' social cohesion, their teaching, scientific, professional and administrative performance, and their output – their publication productivity and success in training doctors of science (Biglan, 1973a, 1973b). However, in the context of current scientific insights in the relations between publication productivity and scientific fields, his results were rather trivial. He established that the so-called hard or paradigmatic sciences – natural sciences, biosciences and (bio)technical sciences – use more succinct forms of reporting their findings. Consequently, more articles and fewer monographs were published in this area than in the so-called soft non-paradigmatic, social sciences and humanities. The applied sciences, which include (bio)technical, economic and educational disciplines, however, publish more technical reports than the pure sciences, or the natural sciences, biosciences and (other) social sciences and humanities, to be more precise (Biglan, 1973b).

Becher does not believe that a very clear statistical pattern in the publishing process could be identified from quantitative analyses of productivity! For that reason, he touched upon only three aspects of publication productivity in his interviews with top, elite scientists: a) span of time from submitting an article to a scientific journal until it is published; b) length of paper; c) number of papers that a scientist should publish within one year. All three elements showed great, easily measurable disciplinary differences. Thus, the time span from submitting an article for publication ranged from three months for a preliminary paper in physics, and two to three years for publishing a paper in a renowned journal in modern linguistics. An eminent historian or linguist is expected to publish one paper of eight to twelve thousand words (32–48 standard pages) per year, especially if writing a book at the same time. In contrast, the expected annual output in biochemistry is ten or more multi-authored papers, often with fewer than 2,000 words or 8 standard pages. Preliminary papers are even shorter – only three to four pages in physics (Becher and Trowler, 2001: 112–113).

On the other hand, when explaining the differences and patterns identified in their comparisons of different scientific areas and fields, productivity analysts often refer to typologies, the most widely known distinction between the hard and soft sciences in particular. It is used in interpretations of different quantities and qualities of disciplinary production, most often the number and citation rate of research publications, but usually without any deeper explanations of disciplinary patterns and factors of research productivity. Nevertheless, the results of those studies provide an important empirical context to evaluate the findings of this study, just as its theoretical starting points are inspired by (un)derived hypotheses on the deeper socio-cognitive conditions of the easily accessible and recordable differences in research productivity.

That is why we are interested in the findings of studies of productivity in the natural and social sciences, or even in their individual disciplines. Are there any patterns of scientific productivity typical of the two scientific areas, and, if so, how are they differentiated? Have they changed over the last twenty-five years, and in what ways? Are we witnessing a levelling out of differences, or are they replicating, perhaps even increasing? We present a brief overview of the findings of the most important comparative studies covering average scientific productivity in the natural and social sciences, and the types of publications, the share of mono-authored and co-authored papers, and, finally, the orientation towards a national and international scientific public.

The indicators of the average research productivity of scientists from individual fields or disciplines over a shorter or longer period of time are not appropriate for all scientific fields, which makes comparisons more difficult and leads to diverse results. This refers to bibliometric analyses based on selective bibliographic and citation databases, as much as to analyses based on self-reported data from questionnaire surveys. The former neglect books and all journals not indexed in the WoS (Web of Science) and similar databases, which is their greatest defect in the context of the social sciences and humanities. The latter, however, take into account all the publications, but credit one and the same paper to each of its co-authors, and they usually count every book as one publication. This approach favours the production of co-authored articles, which are typical of the natural, (bio)technical and medical fields, and therefore also discriminates against the social sciences and humanities.

Thus, disciplinary differences in scientists' output in four natural and two social disciplines examined by Cole (1979) are also inevitably overvalued to the advantage of the former field. Cole established that in the period from 1965 to 1969 the greatest number of articles was published by American chemists (13.0), with geologists, mathematicians and physicists lagging far behind, with an average of 6.1, 5.6 and 5.1 papers published in journals respectively. Psychologists and sociologists differed significantly in terms of average output, with 5.4 and 4.1 articles published respectively in the observed period (Cole, 1979: 962).

A more recent American study covering the period from 1988 to 1992 showed a similar relation between the natural and social sciences. The average productivity of university professors in graduate, doctoral training came to 9.03 articles published in journals in the field of the biosciences, 7.32 in the physical sciences and mathematics, and only 2.57 in the social sciences, including behavioural sciences (Dundar and Lewis, 1998: 620). These comparisons do not acknowledge the peculiarities of knowledge production and publication in the social sciences and humanities, but they analyse them using the same category system suitable for the natural and other sciences.

After turning all publications of Norwegian university professors from the 1979–1981 period into article equivalents, by assigning different scores to individual publications depending on their type and number of authors, Kyvik obtained two sets of different data for the observed scientific areas. Natural scientists had a greater average number of original publications than social scientists – 5.3 compared to 4.6, but the average number of article equivalents of the latter was far greater than that of the former – 5.9 compared to 3.9 (Kyvik, 1989: 208). Although based on self-reported data, the findings provide a more comprehensive and more suitable comparison of total average productivity in two fields that are often considered socio-cognitively opposites. A more recent study by the same author supports this conclusion. Using only the original data from the survey, he also established differences in favour of the productivity of university professors in the natural sciences. Over the period from 1998 to 2000, they published 10.1 papers compared to 7.9 papers published by social scientists (Kyvik, 2003: 38).

Accordingly, the previous indicators of average research productivity in the natural and social sciences are not satisfactory, since their results vary depending on the range of the covered scientists and their papers, both those indexed in highly-selective tertiary publications and those self-reported in questionnaire surveys. This makes international comparisons even more dubious, since they are restrictive in the former case, and methodologically unbalanced in the latter. However, taking into account the trends of changes in the quantum of productivity or in the quantity of publications in the scientific fields compared here, the most sensible comparisons are those within the same scientific population, whose production is measured in (almost) the same way.

This comparison indicates a marked increase in the average productivity of Norwegian natural and social scientists in the relevant period of twenty years (1980 – 2000). It grew by 190.6% with the former, and by 171.7% with the latter. These are the original data, while the real growth is significantly lower if we take into account the type of publication, co-authorship and the response rate of the three surveys. Kyvik (2003: 43) estimates a 30% growth for the overall scientific population. The systematic pressure on researchers' productivity, embodied in the old slogan *publish or perish*, is obviously not easing.

If the differences in the average output (measured by the total number of published scientific papers) are still not transparent, the differences in the importance of individual types of publications in both areas are rather expressed. They are already noticeable at the level of their proportion in the total number of scientific publications. Kyvik (2003: 39) established that books make up 9% of the total number of publications by social scientists, and 3% of natural scientists' publications. Furthermore, the share of books published in the period 1980–2000 is stable in both scientific fields, while the share of scientific articles in them increased at the expense of reports. Summing up the findings of different studies, Hicks (1999: 201) estimated that books might account for at least 40% and maybe even 60% of social science publications.

More over, disciplinary differences within the social sciences can also be great. According to a study on productivity of British social scientists, books make up 29% of publications in political science, and only 8% in statistical methods (Hicks, 1999: 210). Significant disciplinary oscillation in the proportion of books in the total output was noticed with Dutch social scientists – from 40% in general linguistics and history, to 25% in Dutch linguistics (Hicks, 1999: 196).

However, what is more important than the number and share of books is their effect on knowledge production in the social sciences. Nederhof's findings (2006: 84–85) assert that sociological books have a three times greater citation rate than scientific articles, and a similar ratio was established for economics as well. Based on an analysis of empirical papers, Hicks (1999: 201) concludes that 40% of citations in the social sciences refer to books. If citation rate is taken as an indicator of the impact or use of scientific papers, books obviously carry much greater weight in the social sciences than one would expect based on their frequency in scientific production, although the most influential books are not necessarily the most cited, as was determined by comparing the citation rate and ranking of sociological books by (one quarter of) the members of the Australian Sociological Association (Gläser, 2004).

In any case, the proportion, influence and impact of books are undoubtedly greater in the social than in the natural sciences, where journal articles dominate. The differences are, with reason, ascribed to the peculiar cognitive styles based on the different intellectual and social organisation of science. Shorter forms of reporting research findings are more appropriate to paradigmatic fields with a greater obsolescence rate of scientific knowledge, the natural sciences above all. There is no need to explain at greater length the theoretical background and research methods, because they are fully evident to those familiar with the paradigm. The age of the literature or references used is also considered an indicator of the speed of scientific knowledge obsolescence. It is lower in the paradigmatic sciences, just like the period in which a scientific paper will be cited on average. Thus, the natural and the social sciences and humanities differ also in citation distribution over time (Nederhof, 2006).

Scientific fields marked by paradigmatic pluralism – the pre-paradigmatic sciences, primarily the social sciences and humanities, according to Kuhn – are characterised by more extensive papers in journals and the greater impact of books. Scientists have to describe and support more extensively their own approach, hypothetical framework, research methods and criteria for evaluating their contribution to the investigated problem (Biglan, 1973b). Books, at least in sociology, more frequently present qualitative analyses, theoretical considerations and scientific syntheses.

The same conclusion emerges from an empirical analysis which found that American sociological books and journal articles did not differ significantly by their subjects, although books more often focused on sociological theory, political processes and institutions, as well as life cycle. They key differences between them are the methods and the data. Books most often use qualitative analyses and data (58.8%) and they rather frequently focus on textual analyses (27.5%). In contrast, journal articles rest on quantitative data and analyses (70.0%), and use qualitative analyses even more seldom than textual analysis (Clemens et al., 1995: 459). Based on these and other research findings (on citation rates of books and articles, and institutional affiliation, gender and age of their authors), it can be concluded that books and articles have different, but complementary, roles in sociology. Books are renowned and influential achievements whose impact goes beyond the very discipline, while advancement up the career ladder for the majority of scientists is based on journal articles (Clemens et al., 1995).

Furthermore, the greater role and impact of books in the social sciences and humanities, as an Australian study established, is based on their role as strongholds in knowledge production which provide everyday research with a stable focus. The impact of books can also be based on the "national" importance of their topics. These sciences have specific topics that can be uninteresting to the international scientific public, while at the same time being of extreme importance to the national scientific community. Precisely such topics have prevailed in the most influential sociological books (Gläser, 2004). Obviously, the same logic of the different international and national importance of scientific books can also be applied to numerous journal articles in the social sciences and humanities.

A very important and extremely differentiated characteristic of scientific production is co-authorship. Numerous bibliometric studies and scarce (longitudinal) surveys show very different disciplinary patterns of co-authorship. The greatest differences were found between the natural sciences on one hand and the social sciences and humanities on the other (Nederhof, 2006). Thus, Kyvik found great differences in the frequency of co-authorship in the natural and social sciences, but also important changes in both areas over the last two decades of the previous century. The proportion of co-authored publications in the total number of publications in the natural sciences increased from 57% (1979–1981) to 84% in the final phase of that period (1998–2000). The proportion of such papers in the social sciences was far lower, but it grew from 20% in the initial stage to 43% in the final stage of the relevant period (Kyvik, 2003: 42). Co-authored publications turned from a more important form of scientific production in the natural sciences to the predominant form, while they doubled in the social sciences, reaching a respectable level, not far from one half of the total scientific production.

Even more significant than the proportion of co-authored publications is the data on the number of scientists who published such papers.

The proportion of co-authors and their increase in the natural sciences followed the level and dynamics of co-authored publications, ranging from 60% at the start (1979–1981) to 86% at the end of the observed period (1998–2000). The social sciences also showed a rise in the proportion of scientists who published at least one co-authored paper from 37% to 64% (Kyvik, 2003: 43). However, the proportion of co-authors, as we can see, exceeds the proportion of co-authored papers, which supports the claims that a co-authored paper, obviously scarcer in the social scientists' output, does not bear the same weight as in the hard sciences. In addition, we could even say that it does not have the same socio-cognitive character.

Co-authorship is considered an indicator of scientific cooperation and even team work. However, that is not all. The prevalence and increasingly greater citation rate of this type of scientific paper have also given rise to the claim about their greater cognitive and epistemic value. The functional explanation of the scope and growth of scientific cooperation claims that it allows the cognitive goals of scientific communities to be met, by securing better social and material conditions of research (Wray, 2002). The importance of scientific cooperation is also explained by factors reported in the empirical studies of the scientist-respondents themselves, who rank collaborators' special competences indispensable for resolving the research problems at the top of their list, and only then mention scientific equipment and the data that the collaborators possess, and other social and intellectual reasons (Thorsteinsdöttir, 2000; Melin, 2000).

The relation between scientific cooperation and co-authored papers has been empirically investigated by studies that try to answer the question whether scientific cooperation truly encourages scientific output and/or its quality. At first sight, it seems that the findings corroborate the starting hypothesis, thanks to the greater quantity and longevity of citations earned by co-authored papers (Beaver, 2004) or due to the connection between scientific cooperation and productivity (Lee and Bozeman, 2005). However, the authors themselves are rather cautious when, in the former case, they stress the preliminary and partial nature of their findings, or when, as in the latter case, they bring attention to their ambiguity. The mentioned co-authors warn that cooperation is an important predictor of productivity when measured by the number of all publications of each of the (co-)authors. However, when measurement is made by dividing every co-authored paper with the number of authors and assigning only the resulting part of the paper to each of the authors, no significant association between cooperation and productivity is found (Lee and Bozeman, 2005). Accordingly, research conducted so far indicates that the relation is not as simple and unambiguous as the creators of science policy, and even scientists themselves, claim.

The implications of these studies are of special importance for the social sciences where research cooperation and co-authorship can have a different intellectual and social character. From the social standpoint, scientific cooperation, including team work, does not mirror the high level of specialisation and hierarchical organisation and division of research tasks typical of laboratory sciences. In the social sciences, it is often founded on thematic fragmentation or splitting of project tasks, which then makes the publishing of a series of mono-authored papers possible. For this reason, the contribution of every co-author in a co-authored paper is more marked and clearer than in multi-authored publications in the natural and other hard sciences.

International scientific cooperation often does not even include single, shared research of one and the same scientific problem. It rather refers to parallel investigations that share the subject and methodology, but are carried out separately in different countries with the aim of comparing a social phenomenon or process in different societies. Such cooperation can result in generalisations, but it usually also shows the socio-cultural, national peculiarities or even specificities of certain groups of society. Co-authored works will then be comparisons of social phenomena in different socio-cultural environments, and the collaborators' eligible complementary knowledge includes an understanding of and familiarity with the concrete social context of the country where a certain problem is investigated.

Alongside the frequency of co-authorship, the greatest differences in publication productivity between the natural and social sciences are found in the range of the scientific public to whom the findings of the research are reported, according to the differences in the universality of the phenomena studied by both groups of scientists. Thus, natural scientists are oriented towards the international scientific public, publishing their papers mostly in international journals. Social scientists more frequently communicate to the local public, due to the primary focus on an investigation of their own society, and they more often publish their papers in national and regional periodicals, books or reports (Nederhof et al., 1989; Hicks, 1999; Nederhof, 2006).

In his studies based on respondents' self-reported data, Kyvik found differences between the natural and social sciences in the (inter) national orientation of scientific publications. The frequency of papers in a foreign language in the total number of natural science publications grew from a high 80% in the period 1979–1981 to 89% in the final period (1998–2000). A significantly more dramatic growth of publications in a foreign language, mostly English, was recorded in the social sciences – from 30% in the initial period to 51% in the final period. While the proportions of natural scientists who published paper(s) in a foreign language equalled the proportion of such publications at the beginning and the end of the overall observed period, the portion of social scientists with such papers increased at a much faster rate, starting at 49% in the initial period and climbing as high as 73% in the final period under study (Kyvik, 2003: 41). These findings imply that many Norwegian social scientists occasionally publish at least one paper in a foreign language, thus making it accessible to the international scientific public.

Although the differences in the international visibility of publications from these two fields are still great, the social sciences have obviously taken a great step towards the global scientific scene, driven by the greater pressure of science policy to follow the model of the natural sciences. This is certainly not merely for external reasons, but it is also prompted by the social scientists' need for wider acknowledgement of the importance and recognisability of their own scientific efforts, especially when communicating to international colleagues with whom they share many research interests and topics, at least in developed Western countries. Nederhof and Van Wijk (1997) compared the topics of social and behavioural studies in the USA, Great Britain, France, Germany and the Netherlands, and they came to the conclusion that the bulk of the topics reflect transnational scientific interests, but also that the five countries have numerous shared political and social problems. The exceptions were some topics of the political sciences, some welfare and health care issues and geographic location. Some other groups of socially, techno-economically and culturally related countries would certainly show great similarities as well.

Differences in the international visibility and accessibility of natural and social science papers are also connected to the problem of different representation in bibliographic and citation databases, especially the most selective ones – the Web of Science (WoS), with the most renowned indexes such as SCI for the natural, technical and biosciences, SSCI for the social sciences, and A&HCI for the arts and humanities. While SCI has extensive coverage of natural science articles, even over 80% or as much as 90% in some fields, coverage of the social sciences and humanities is significantly lower (Nederhof, 2006: 90). It is markedly uneven, so SSCI's coverage of articles published by Dutch social scientists ranged from 62% in experimental psychology and only 2% in public administration (Nederhof et al., 1989: 427).

Nederhof (2006) gives these and all other mentioned differences in the production of the natural and social sciences to argue that bibliometric monitoring of publications in the fields of the social sciences and humanities must not rely on the same methodological assumptions as in the monitoring of productivity in other sciences. The analysis should be expanded to include data on the books and papers not registered in the WoS databases.

Comparisons of the published output of the social sciences in different countries also support this conclusion. For example, slighter differences were found in the citation culture of social scientists from six western countries – Australia, France, Canada, Germany, USA and Great Britain. German social scientists make the least use of papers published in journals covered by the most renowned citation databases (WoS), while their American colleagues use them the most – the former have a 35% citation rate of papers from WoS journals, while the latter have a slightly higher rate – 39% (Van Leeuwen, 2006: 139). In other words, it seems that there are great transnational similarities in the production of the social sciences.

The overview of empirical comparisons of productivity in the natural and social sciences conducted so far suggests two conclusions. The first refers to clear and significant differences in the patterns of publishing scientific papers, the cognitive and professional role in their field or area, and in (non)collective authorship, obsolescence, (inter)national public, citation cultures and their coverage by tertiary publications and/or electronic databases that index scientific periodicals. Despite the similarities arising from the cognitive and social nature of scientific undertaking in general, scientific publications, as intellectual products of the natural and social sciences, do differ. Any comparison that does not take into account these differences cannot be methodologically sound, just as any science policy that attempts to unify them instead of at least partly acknowledging their differences cannot be fruitful.

The second conclusion accentuates the great differences recorded in those same patterns, and even highlights their increasing convergence. The changes are particularly dramatic in the social sciences where some of the key characteristics of scientific publications have changed considerably in a relatively short period, over the last twenty years or so. Their resemblance to natural science production is growing, especially in terms of increasing co-authorship and the internationalisation of the public. The only plausible sociological explanation highlights the influence of the scientific system and policy, since such great changes can be explained only by systemic factors. It seems that we are indeed witnessing the coming true of the famous prophecy of the early 1980s that the expansion of science policies, and the coordination and central planning of scientific research, would promote the levelling out of differences and lead to increasing similarities in the social organisation and intellectual ideals of different scientific fields (Whitley, 1984).

Thus, we come to the biggest problem in comparative studies of scientific productivity, which is their insufficient theoretical grounding. Although they do use some of the theoretical explanations of the differences in the productivity of the natural and social sciences, these studies usually do not start from theoretical hypotheses of the socio-cognitive differentiation of individual sciences. And it is precisely such hypotheses that seem to be the key to a deeper understanding of the differences in scientific productivity.

2. Hypothetical and methodological framework of the study

Current (sociological) knowledge of scientific production in different scientific fields, especially in the natural and social sciences, as well as existing Croatian studies, encouraged a (re)formulation of the question of the productivity puzzle, as J. Cole and H. Zuckerman (1984) called it two decades ago. Despite a great number of studies on research productivity, comparisons of overall scientific areas are still scarce, both in the ever more present bibliometric analyses and in the few questionnaire surveys. The focus of comparisons is usually individual (sub) disciplines, so they lack a broader view of the similarities and differences in the intellectual production of the natural and social sciences. Furthermore, comparisons are usually directed only to some types and forms of production, thus failing to provide broader knowledge in terms of time span and the most important types of productivity. Finally, there are only few studies investigating the factors of productivity, and even fewer of them examine productivity factors for each scientific area.

Therefore, the main goal of this study focused on a comparative insight into the characteristics, patterns and factors of the research productivity of natural and social scientists. Apart from this general scientific goal, it is important to obtain broader knowledge of research production of the Croatian scientific community, or, to be more precise, of its members engaged in the natural and social sciences. Set in such a way, the basic goals of the study allow some cognitive contribution to be made to the social studies of science, and help form a scientific basis for a Croatian science policy.

Organisational theories of science present the broadest theoretical starting point of the research since they are the ones within the sociology of science that explain plausibly the socio-cognitive differences between scientific fields (Whitley, 1984; Fuchs, 1992). Thus, they provide a hypothetical and interpretative framework of the investigation of the differentiated patterns of scientific productivity. The latter can be explained and understood only if they are perceived as a manifestation of deeper differences in the intricate, but also interdependent, social and intellectual organisation of individual sciences. This study does not aim to empirically test theories of scientific fields, but we hope it will make an indirect contribution in that direction as well, since the fundamental theses of organisational theories were built into the hypothetical framework and conceptualisation of the research.

We therefore do not expect only to establish distinctions between the natural and social sciences in research productivity patterns, that is, in the frequency of some types of publications in their overall production, but also in terms of predictors of the observed types of production. If publications are a result of knowledge production, then its relevant social and organisational characteristics should also be significant predictors of researchers' productivity. Considering the differences in the social organisation of these fields and the peculiarities of their modes of knowledge production, one can expect differences in the composition, but also in the contribution that significant predictors make in explaining the major types of productivity in the natural and social sciences.

Starting from this hypothetical framework, the basic concepts are operationalised with special attention to ensuring comparability with the findings of productivity studies conducted on the overall Croatian scientific population or its strategically important subgroups, such as eminent or young scientists (Prpić, 1990, 1990, 1994, 1996a, 1996b, 2000, 2007). As in the previous studies, research productivity has been defined as publication productivity. Since it is sensitive to the observed period, it is important to know its longer and shorter time span, so this study took into account the career productivity – total scientific and professional output – and the five-year productivity of scientists.

Career scientific productivity is measured by the self-reported number of all scientific publications by respondents from the natural and social sciences in the course of their career; they were also asked to report the number of papers published in the journals covered by *Current Contents* and (S)SCI databases. In parallel to scientific productivity, career professional productivity is measured by the number of expert publications by respondents-scientists in the course of their overall career. Professional production has been monitored in Croatian research since the beginning of the 1970s, too (Previšić, 1975). Production of these types of papers, popular science and other papers targeting a wider (expert) public has been investigated in more detail in the areas of the social sciences and humanities (Nederhof et al., 1989; Nederhof and Meijer, 1995).

Five-year productivity was limited only to scientific publications by respondents over the course of five years before the survey, both mono-authored and co-authored. Furthermore, the number of their papers published in the same period in foreign publications (books and journals), regardless of the number of authors, has also been determined.

Apart from questions about research productivity, the questionnaire also included a set of other questions on the most important social, professional, and career characteristics of respondents and their scientific and organisational background. These characteristics were treated as possible predictors of productivity, and they will be listed later in the paper. The course of the first ever web survey conducted in the Croatian scientific community and the samples of scientists from the natural and social sciences are described in detail in the first chapter of the book (Golub, 2009), so there is no need to describe them again here. However, the reader should be reminded that the subsample of natural scientists consisted of 310 respondents, while the subsample of social scientists consisted of 167 respondents.

The findings were processed statistically using the SPSS package (version 11.5). After the basic analyses, univariate and multivariate methods of data processing were used. The former included t-tests and analyses of variance (with post hoc tests) in order to determine the significance of differences in the productivity of the natural and social sciences, as well as differences between individual fields in each area. Among the multivariate methods, regression analyses were used to establish significant predictors of research productivity in both observed areas.

3. What and how much do natural and social scientists publish?

3.1. Publication patterns in the two scientific areas

Different publication patterns of natural and social scientists are evident from the quantity of their overall publications as well as from particular types of works published in the course of their careers and in a five-year period. Table 1 sets out comparisons of the average number of publications by respondents (mean-M) from the observed fields, standard deviation (SD) and the result of a t-test for every individual type of publication.

Even a quick inspection of the data in the table shows that all types of productivity, except career scientific productivity, indicate significant statistical differences in both time spans. The absence of such differentiation in the average number of all scientific publications might be related to the age composition of the subsamples. The subsample of social scientists is significantly younger than the comparable population of the whole area, whereas there is no significant age difference between the sample and the population of natural scientists (Golub, 2009). The picture of career productivity obtained for the former may be somewhat distorted.

And thus starts the comparison of the overall scientific production in the course of the career and five-year period, with the social sciences faring significantly, but not greatly, better in the five-year period analysis. These findings are actually in line with the results of earlier Croatian studies of productivity on samples of the research population from 1990 and 2004. According to them, differences in the average career scientific production in these two areas are insignificant, just like the differences in the five-year output, as shown by the more recent of the two studies (Prpić and Brajdić Vuković, 2005). However, at the turn of the 1990s, social scientists were markedly more productive in the shorter period (Prpić, 1990).

Table 1. Average number of publications (mean) by natural and social scientists, with t-tests results[1]

Career and five-year productivity	Scientific area	Mean	Standard deviation	t	p
All professional publications	Natural Social	9.31 21.35	20.89 28.78	4.75	0.000
All scientific publications	Natural Social	39.31 40.84	38.05 41.64	0.40	0.686
All scientific papers in journals indexed in (S)SCI and CC	Natural Social	22.97 10.10	25.24 15.01	6.95	0.000
All scientific and professional publications	Natural Social	48.50 62.27	49.67 59.43	2.674	0.008
Mono-authored scientific publications in the five-year period	Natural Social	1.72 8.70	3.13 9.17	9.455	0.000
Co-authored scientific publications in the five-year period	Natural Social	10.81 6.66	11.36 8.76	4.068	0.000
Scientific papers published in international publications in the five-year period	Natural Social	9.26 5.36	7.99 6.99	5.308	0.000
All scientific publications in the five-year period	Natural Social	12.23 15.35	10.54 12.15	2.876	0.004

Collated to the presented international comparisons of the publication productivity in the natural and social sciences, our findings proved persistently more balanced. Considering that they also meth-

[1] The sum of average values of professional and scientific publications does not add up to the average of their total number, and the same situation repeats with mono-authored and co-authored publications whose sum does not equal the average number of all scientific publications by respondents in the five years from November 1999 to November/December 2004. This applies to both scientific areas. Differences are minimal, merely in decimal points, and they result from the missing data for one of two types of publications. Exclusion of those questionnaires would needlessly cut the size of the sample by 8 respondents in career, and by 13 respondents in five-year output.

odologically undervalue the productivity of the latter in favour of the former group of sciences, it seems that the Croatian social science community has witnessed a proliferation of publications. This is also supported by the available international comparisons, even though they are not completely fair in terms of methodology either, because our subsamples are professionally more selective. However, the data concerning the Norwegian university professors of the natural and social sciences (Kyvik, 2003: 40) show that they publish 3.4 and 2.6 works per year respectively on average. Croatian natural scientists are less productive, with their yearly average of 2.4 papers, while social scientists are more productive than their Norwegian colleagues with an average 3.1 publications published per year.

The key characteristics of the scientific system in the socialist period favoured hyperproduction in the social sciences, especially its tendency to evaluate the quantity and not the quality of publications. The criterion of quantity was not accompanied by the introduction of international evaluation standards, as was the case in the hard sciences. Naturally, the local orientation of publications prevailed which, thanks to less demanding criteria, encouraged superproductivity, also supported by opportunities for productive researchers to earn extra fees inside and outside their institution. Considering the persistency of excessive and insufficiently selective productivity, it is clear that the competitive science system introduced in the post-socialist period did not sufficiently encourage a change in the publication practice of the social sciences. The differences in other types of publications generally follow the regularities and patterns of the scientific context determined by the research and analyses of other authors.

However, let us return to the comparisons of respondents' career production. Whereas no significant differences between areas were found in its overall corpus, the difference in the number of papers published by scientists in journals and publications indexed in the S(SCI) and CC databases is statistically significant and great. The majority of natural scientists' scientific papers (58.5%) were published precisely in these publications, whereas social scientists are credited with only a quarter of such papers – 24.8%. Although the result was in line with the findings of foreign studies, it is correctly understood as a rough indicator of the relation between the observed scientific fields and not necessarily the actual share of SCI/CC papers in the career production of one or the other group of scientists.

Although the differences stem from the non-selective scientific system of the socialist period, they cannot be completely attributed to it. To be more precise, there was no tangible proliferation of this type of production in the post-socialist period either, since the bibliometric indicators in social sciences would have been significantly better than those obtained (Jokić and Šuljok, 2009). General underfunding of scientific research, especially social science projects, discouraged any deeper changes in publication practices. International social journals often prefer empirical papers, and the opportunities and the scope of such research depended directly on insufficient material support for research projects. Furthermore, publishing in foreign languages in the social sciences and humanities most often includes the costs of translation and/or proofreading, as international journals from these fields expect the text to be polished in terms of language.

The reflection of the anti-intellectual social and political climate on science policy had an additional adverse effect on the social and material position of individual segments of the scientific community in the area of the social sciences and humanities. Generalisations about the total ideological indoctrination of the social sciences and the favouring of some philosophical, sociological and pedagogical (sub)disciplines to the detriment of others with national content in the previous period were not founded on expert analyses and data. Yet, they were official because they were made public by the *National Research and Development Program* (1998: 282).[2]

Even some natural scientists could not resist the theses on the complete dogmatic ideologisation of the social sciences and humanities as the principal factor of the provincialisation of their output (Klaić, 1995). The long influence of Marxist and then national ideology on the social sciences and humanities and their publications is not disputable. However, a serious evaluation should be based on expert empirical analyses, and not on ideological qualifications of the opposing ideology.[3]

[2] Unfortunately, such assessments had a negative effect on the financial support to the "denounced" scientific institutions and researchers in the social sciences and humanities: on the funding of their research projects, publications, scientific equipment and employment of junior researchers. A future empirical analysis could confirm this statement.

[3] In sociology, such analyses were made in the early 1990s: an analysis of themes and types of sociological papers (Šporer, 1990); (citation) analysis of scientific characteristics of three sociological journals (Dukić, 1990); analysis of characteristics of doctoral theses from the field of sociology (Lažnjak, 1990); analysis of the situation and prospects of Croatian sociology based on the perceptions of eminent sociologists (Štulhofer and Murati, 1993).

Nevertheless, the chief generator of the very limited orientation of social science output towards the international scientific scene is the science system. It still generates insufficiently thought-out measures with adverse material consequences for scientific research, such as cuts in the average amount of grants for scientific projects and the "model" of project-based funding of doctoral courses for junior researchers. This is particularly detrimental to social sciences, where project funding has been significantly lower on average. To put it briefly, research and material support required for social scientists to turn more strongly to the international scene has still not been established.

On the other hand, scientific evaluation in the social sciences and humanities does not take into account the more demanding bibliometric criteria that should include at least a minimal, and for these scientific areas a suitable number of papers in the publications indexed in WoS and similar bibliographic and citation databases, at least for top scientific ranks. The social sciences cannot be equated with the natural sciences, but a combination of peer review and bibliometric indicators is usual in the developed world. It is even realistic to expect that Croatia's accession to the European Union will necessarily increase the pressure of science policy makers on boosting WoS-indexed output in order to improve the country's ranking in the international comparisons that the European R&D statistics founds precisely on these databases.

Professional publications, monitored only in the longest period, in the course of the overall career, are a special aspect of research productivity. The average number of these publications is significantly greater in the social than in the natural sciences, in line with the findings of previous studies. Furthermore, a drop was noticed in the proportion of such works in the total career publications of social scientists over the last fourteen years – from 58.9% to 53.1%, compared to the rise in a much smaller proportion of these publications in the total output of natural scientists – from 30.1% to 34.0% (Prpić, 1990: 126; Prpić and Brajdić Vuković, 2005: 70). The proportions of this type of publications found in this research, probably due to the greater professional selection of samples, are also differentiated in both areas, but they were considerably lower – 19.2% and 34.3%.

The greater frequency of professional papers in many applied and technical sciences and in the social sciences and humanities compared to the natural sciences is explained by the different types of audience scientists communicate to. Natural scientists mostly communicate to other scientists, but social scientists also do so to the widest public. Addressing the non-scientific public is related to the importance of numerous social studies for various policies (Nederhof, 2006). For the same reason, experts who are not scientists could be defined as the third type of audience that scientists address, as was already pointed out regarding papers from the technical sciences (Nederhof and Meijer, 1995). In the social sciences, such experts are also the interested competent public or potential beneficiaries of the results of social research.

Differentiated professional productivity also influences the significant differences in scientists' total career production, which covers both types of publications – scientific and non-scientific, but after the detailed analysis of career productivity it does not require any additional attention. What is more interesting are the patterns of scientific productivity in the five years before the survey. Although they indicate significant differentiation among the observed areas, the biggest differences are found in the average number of mono-authored publications, those being five times more frequent in the social sciences. The ratio of mono-authored and co-authored publications was also different, the latter being significantly more frequent in the natural sciences. Co-authored publications make up the dominant majority of production in the natural sciences (86.4%), while the number of mono-authored papers is several times lower. Contrary to that, the majority of publications in the social sciences are mono-authored publications (56.6%), although the proportion of co-authored publications does exceed two fifths – 43.4%.

Kyvik (2003) established similar proportions, already mentioned above. They indicate stable relations in the output of the natural and social sciences, which is confirmed by the results of the investigations conducted on the samples of the Croatian scientific population. The 2004 survey established an almost exact share of mono-authored papers in the production of the social sciences (56.9%), and a slightly lesser share of co-authored papers in the natural sciences – 82.5% (Prpić and Brajdić Vuković, 2005: 70). Compared to the findings of the 1990 survey, when the respective proportions came to 75.0% and 65.1%, the frequency of mono-authored publications declined considerably in the social sciences, while the frequency of co-authored papers in the natural sciences grew noticeably (Prpić, 1990: 126).

This brings us to the conclusion that the changes in the patterns follow global trends, and the most important factor of the rise in co-authorship is the increasing specialisation and distribution of research tasks, which boosts various forms of team work and scientific cooperation in general. The role of national and international science policies that encourage scientific cooperation and team work, thus affecting co-authorship, is also important. Finally, technological development, especially the expansion of e-mail, has made communication and cooperation among scientists much easier and faster.

The changes are even faster and greater in the social sciences, despite their peculiarities. The introduction of a competitive system to award grants and funding to scientific projects in Croatia spurred an expansion of empirical research in the social sciences, especially in some fields. For example, theoretical papers dominated in sociology in the 1980s (Šporer, 1990), which stimulated individual scientific work. Today, only 10% of the newly accepted sociological projects are theoretical, and the others include empirical research, or, at least, analyses of secondary data. It is clear that such scientific development will increase the role of research teams and collaborative groups.

The differences in the average number of international publications authored by respondents from the two scientific areas are also significant: they make up 75.7% and 34.9% of the total five-year scientific output of respondents from the natural and social sciences. What is the prevailing pattern for the former is still a minority publication practice for the latter. Changes in researchers' publication habits have been very dynamic in both areas. According to an older survey of the scientific population on the eve of transition, a Croatian natural scientist published 44.2% of papers in international journals and books, while a social scientist had only 6.1% of such papers (Prpić, 1990: 126). A more recent survey of the same type showed great growth in both fields. Its findings show that natural scientists already have over two-thirds (68.6%) of foreign-published papers in their five-year output, whereas social scientists have almost one quarter (24.5%). However, this is less than the findings of the web survey show, probably because it covered more selective subsamples of respondents.

Since the survey focused on respondents' foreign publications, their papers in Croatian scientific journals covered by the (S)SCI database and published in English were excluded. In other words, respondents' total scientific publications available to the international scientific public are more numerous than the papers published in foreign journals and books. This piece of information is relevant and indicative since

8 out of 10 Croatian journals included in SCI are published in English (Andreis and Jokić, 2008). In the social sciences, the proportion is much smaller since only one in three SSCI journals is published in English.

One does not have to stress that the international visibility of scientific publications is greater if they are available in English, even if they are not covered by WoS. For this reason, the findings of this study are more exclusive than Kyvik's, because he took into account precisely papers in English. Although it might not be quite correct methodologically to make any comparisons, the growth dynamics of internationally visible production in both countries reflects global trends in publication practice in the natural, but also in the social, sciences.

Only in the transition period did the Croatian social science community receive stricter criteria for scientific promotion, which for the first time conditioned employment in scientific institutions that had previously been guaranteed. For the first time, the criteria included a certain number of papers in journals indexed in the *Current Contents* database or in local publications of equal quality. Most researchers from this area advanced professionally thanks to the local CC journals and equivalent local publications, while a minority of social scientists focused more on publishing in international journals, especially in some scientific fields. In the natural sciences, the international criteria of evaluation had been present even before, in the socialist period, but a considerable growth was noticed in the proportion of international publications, which draws the conclusion that the change in the overall scientific system led to an increase in the global visibility of papers authored by Croatian natural scientists.

To conclude briefly, the natural and social sciences do indeed practise different publication patterns. They simultaneously witnessed deep changes in all observed forms and aspects of research productivity – from the relation between scientific and professional production, whose frequency and role differ in the two fields, to the reduction of great differences in the prevalence of co-authorship and mono-authorship, in the international communication of scientific results, and even in their presence in the most selective scientific publications. The difference in these patterns and the dynamics of their development can be explained sociologically only if the differences in the social organisation and the mode of knowledge production and in the cognitive styles of the natural and social sciences are taken into account. However, the reduced difference in the publication practices is not the result of an autonomous development process that would lead to a social and cognitive convergence, although the influence of the intrascientific changes is certainly present, but the convergence is strongly promoted and encouraged by the science policy.

3.2. The challenge of homogeneity of the natural sciences: disciplinary patterns of productivity

The extent to which the differences between the natural and social sciences conceal different publication patterns within each of these scientific areas can be shown by comparing individual scientific disciplines or fields. For this purpose, variance analyses were made using *post hoc* tests, which show the significance of differences in the average number of observed types of career and five-year research publications for all fields within both areas. The results for the natural sciences are presented in Table 2, and they show the average (mean) number of publications (M) and standard deviation (SD) with the significance of differences in average productivity between individual fields (ANOVA).

Differing patterns and even the quantity of research production in the natural fields are evident from the data. Almost all forms of publication productivity in both time spans vary significantly by individual sciences. In the career span, the most significant are the relations between professional and scientific papers, and the share of papers in international publications, as they indicate relevant characteristics of knowledge production – the quantum of scientists' non-scientific work and focus on the international scientific public. Professional papers, however, do not only cover publications that popularise science and target the broadest public, as they are operatively defined by some authors (Nederhof et al., 1989; Kyvik, 2003), but they also include papers targeting the widest circle of experts (Nederhof and Meijer, 1995) and also textbooks.

Differences in the production of professional publications in the natural sciences are significant, and they are manifested in the average number of such papers in the geosciences on the one hand, and physics and chemistry on the other (the level of significance is 0.004 and 0.007 respectively). On average, a geoscientist publishes almost five times more non-scientific papers than a physicist, and three (and more) times more papers than a chemist. An even more interesting and important proportion is the share of professional and scientific papers in every individual field: one third (33.7%) of all publications in the geosciences are non-scientific papers, compared to 14.3% in chemistry and half the portion, 7.1%, in physics. However, the proportion of these papers is close to one third (31.8%) in mathematics, and nearly a quarter (22.8%) in biology.

Table 2. Average number of publications in the natural sciences - means (M) and standard deviations (SD), with ANOVA results (F-ratios and their significance)*

Career and five-year productivity		Biology N = 84	Chemistry N = 97	Geosciences N = 40	Mathematics N = 22	Physics N = 56
All professional publications	M	11.35	9.98	19.46	9.77	4.04
F = 4.081; sig. = 0.003	SD	24.60	10.41	39.03	9.98	7.92
All scientific publications	M	38.44	36.41	38.35	20.95	52.52
F = 3.224; sig. = 0.013	SD	40.44	37.03	34.50	20.50	40.39
All scientific papers in journals indexed in SCI and CC	M	21.32	26.04	12.30	8.50	34.13
F = 7.254; sig. = 0.000	SD	18.95	29.69	14.82	10.67	30.02
All scientific and professional publications	M	49.86	41.76	58.49	30.73	56.58
F = 1.938; sig. = 0.104	SD	59.16	30.89	64.58	24.08	43.66
Mono-authored scientific publications in five years	M	1.39	1.52	1.55	3.55	1.96
F = 2.403; sig. = 0.050	SD	3.13	2.77	2.67	3.78	3.43
Co-authored scientific publications in five years	M	10.86	9.34	10.56	4.64	16.07
F = 5.142; sig. = 0.001	SD	13.12	8.68	8.45	4.72	14.62
Scientific papers in foreign publications in five years	M	9.12	8.48	6.70	6.36	13.50
F = 6.433; sig. = 0.000	SD	8.04	6.76	5.80	5.85	9.99
All scientific publications in the five-year period	M	11.05	10.88	12.15	8.18	18.15
F = 6.170; sig. = 0.000	SD	7.55	9.01	9.39	6.19	15.83

* The same methodological note as in the Table 1 applies

Thus, the share of non-scientific work and publications in the professional activities and publications of natural scientists shows significant variations, but also certain regularity: it is most frequent in the natural sciences whose results are at least partly applicable, but have to be presented and disseminated to specialist-users, which increases non-scientific productivity in the geosciences and individual biological disciplines. Since the latter are a part of the curriculum of biomedical and biotechnical sciences, this can also contribute to the quantity and proportion of professional papers in these fields. Professional publications in mathematics could be made up of papers dealing with applied mathematics, as well as university textbooks and handbooks for the needs of training in the natural and technical sciences.

The differences in the average output published in journals included in the ISI and WoS databases are even greater. Mathematicians, followed by geoscientists, publish significantly fewer papers in those journals than physicists, chemists and biologists.[4] The relative number of papers covered in SCI is in keeping with the said differences as well. The share of these most distinguished publications in the total number of scientific works published in the course of the career is significantly lower in the geosciences (32.1%) and mathematics (40.6%) than in biology (55.5%), and especially physics (65.0%) and chemistry (71.5%). Explanations of the differences are offered by scientists themselves from their respective fields.

For example, Šikić (1998) draws attention to the cognitive and socio-organisational peculiarities of mathematics and the basis of its distinction from other sciences, especially the natural sciences. They are the reason why in this field, with a great number of relatively scarcely populated (sub)disciplines, fewer papers are produced and published, but with long-standing relevance, citation rates are lower but long-term, and thus interest in secondary and tertiary publications is comparatively weaker too. Therefore, WoS data is not suited to cognitive and publication practice in mathematics.

Some natural scientists also indicate the different levels of generality of research in various fields. Geology is one of the sciences that study regional and national specificities alongside global phenomena. The scientific picture of the earth is often created as a mosaic – from the narrowest regional level to the supraregional and global level (Herak,

[4] The level of significance of differences between the SCI production of mathematicians compared to physicists, chemists and biologists is 0.000 in the first two comparisons and 0.001 in the third. Differences in the average number of such publications by geoscientists and physicists, chemists and biologists are significant at the level of 0.001, 0.005 and 0.047 respectively.

1998). Such a gradual cognitive course and the importance of regional and national topics is necessarily reflected in the (lesser) opportunities for publishing in journals covered by the most selective bibliographic and citation databases.

Respondents' five-year foreign/international publications partly resemble the career-long production covered by the SCI. On average, physicists publish more papers in these publications than mathematicians, geoscientists, and chemists, and the differences are significant at the level of 0.002, 0.001 and 0.030 respectively. However, an analysis of the share of foreign publications in total five-year production shows that physicists are no longer the most prolific scientists with 74.9% of their papers published in foreign/international journals (and biologists, with 74.4%, have almost the same result), lagging behind chemists and mathematicians (78.1% and 77.7% respectively), but still ahead of geoscientists with 55.3% of their papers published in foreign journals. The mathematicians' orientation to the global scientific scene is much greater than the data on SCI publications may indicate, which shows how important it is to avoid the automatic application of the same criteria to the overall area of the natural and mathematical sciences.

The structure of five-year scientific productivity regarding co-authorship is also very revealing, providing more information than a comparison of the average number of publications. Thus, the number of mono-authored scientific publications is on average greater in mathematics than in biology, and there are significantly fewer co-authored papers than in all other sciences – physics, biology, geosciences and chemistry (the level of significance is 0.000, 0.006 and 0.008 in the last two fields). On average, even chemistry has fewer co-authored papers than physics (the level of significance is 0.027).

Observing the incidence of co-authored publications in total five-year scientific production, it is evident that it is very high and similar in all the fields of the natural sciences – from 89.1% in physics, 88.7% in biology, 87.2% in geosciences and up to 86.0% in chemistry. Mathematics, with a relatively high share of mono-authored publications (43.3%) and comparatively the lowest share of co-authored works (56.7%), thus stands out from the publication practice of other sciences in this area. Team work is most prevalent in the natural sciences, regardless of their differences in social organisation and dominant type of research – laboratory research, field research or mixed-type. In contrast, thanks to the reliability of literature, smaller groups of scientists, and even individual scientists alone, can conduct research in mathematics (Šikić, 1998). A study of mono-authored papers published by scientists working at Israeli universities also showed that mathematics differs significantly from the natural sciences in terms of a relatively greater portion of such publications (27%). The author of the study assumes that the share would be even greater if applied mathematics was excluded from the study (Farber, 2005).

The findings undoubtedly confirm the assumption that the area of natural science is not homogenous in knowledge production and in its products either, and that the scientific fields have developed their recognisable patterns of career-long and five-year productivity. Each mode of knowledge production has a corresponding type of productivity. In fields such as physics and chemistry – fields whose topic and subject of study are universal, which have laboratory-based knowledge production and highly developed specialisation and team work – high average productivity dominates, along with production focused on the scientific public, the maximum international visibility of publications, and co-authorship.

In geosciences – characterised by more local, regional and national specificities in the subject of research, greater applicability and developed field research that requires team work – high productivity also includes considerable professional production directed at the non-scientific public, and a comparatively lower international orientation and a stronger national focus in publishing results, and co-authorship.

Biology shows a certain mixture of characteristics of both types of knowledge production since it encompasses some subfields whose subject of interest may have local, regional and even national specificities, such as botany or zoology. It uses laboratory but also field research, includes developed team work and, to a certain extent, applied research. Consequently, biology shows a stronger local orientation of publications and a greater share of professional papers than the "pure" laboratory fields, together with relatively high average productivity, with internationally oriented production, but also comparatively lower visibility.

Finally, mathematics is a scientific field that is characterised by prominent specificities of intellectual and social organisation: great fragmentation of its (sub)disciplines including applied (sub)disciplines, a high level of trustworthiness of results, longevity and usability of literature, and a relatively high proportion of individual work and a comparatively lower level of development of team work. These socio-cognitive characteristics and mode of scientific production are also accompanied by lower average career and short-term productivity, a considerable level of mono-authorship, a relatively high production of professional publications, and an international orientation in publishing results, which does not necessarily include most selective bibliographic and citation databases.

The implications of these results are twofold: theoretical and practical. The theoretical implications confirm that the complex typologies of scientific fields (Whitely, 1984; Fuchs, 1992) are superior to bipolar typologies in explaining different patterns of productivity within the same scientific area. The latter cannot interpret disciplinary patterns of productivity, while more complex ones can, since they classify individual natural (sub)disciplines into different scientific fields, defined according to their important socio-cognitive characteristics. The practical implications of the findings of this study warn that science policy should not encourage uniform criteria of evaluation based on researchers' productivity. Imposing the physical sciences' publication model as the general pattern – a tendency noticed in scientific policies already back in the 1980s (Whitley, 1984) – is not justified even within the natural sciences, let alone in other scientific areas.

3.3. Differentiation of research productivity in the social sciences

The heterogeneity of productivity patterns in individual social sciences has been established by various, mostly bibliometric, analyses (Nederhof et al., 1989; Hicks, 1999; Nederhof, 2006; Van Leeuwen, 2006) which have produced some partial indicators of disciplinary differences in the area. The study enables a broader comparison of basic types of research production in the main social fields. Table 3 shows the average (mean) number of publications (M) and their standard deviations (SD), with testing of the significance of differences in the observed types of long-term and five-year production between the compared social sciences (ANOVA).[5]

[5] Due to the scarce number of respondents from some social sciences, and based on their relatedness, pedagogy, special education and kinesiology were grouped together in the usual category of education sciences. The same system was, at least partly, applied for the scientific fields of the political and legal sciences (11 and 15 respondents respectively), while information sciences with 11 and social work with only 3 respondents make up the residual category of other sciences.

Table 3. Average number of publications in social sciences – means (M) and standard deviations (SD), with ANOVA results (F-ratios and their significance)*

Career and five-year productivity		Economics N = 54	Educational sciences N = 21	Legal and political sciences N = 26	Psychology N = 20	Sociology N = 25	Other sciences N = 14
All professional publications	M	27.50	30.86	20.58	10.60	12.38	21.00
F = 1.965; F- sig. = 0.087	SD	36.89	28.81	31.70	10.58	14.22	22.35
All scientific publications	M	50.24	35.33	39.19	31.25	34.80	32.93
F = 1.117; F- sig. = 0.353	SD	51.12	36.72	38.39	32.75	25.85	28.32
All scientific papers in journals Indexed in SSCI and CC	M	8.94	6.43	14.23	7.60	8.68	16.00
F = 1.397; F- sig. = 0.228	SD	13.28	5.65	24.67	5.28	8.14	19.07
All scientific and professional publications	M	77.74	66.19	59.77	41.85	47.46	53.93
F = 1.621; F- sig. = 0.158	SD	74.96	58.21	60.15	41.02	32.03	35.74
Mono-authored scientific publications in five-year period	M	10.51	5.43	12.48	2.74	7.64	6.57
F = 4.719; F- sig. = 0.000	SD	10.24	5.53	12.42	3.02	5.85	6.55
Co-authored scientific publications in five-year period	M	9.81	6.86	1.46	6.60	5.58	7.86
F = 3.645; F- sig. = 0.005	SD	9.00	8.19	1.56	8.87	11.42	8.73
Scientific papers in foreign publications in five-year period	M	9.17	3.67	3.92	2.80	2.52	5.93
F = 5.648; F- sig. = 0.000	SD	8.47	4.86	7.59	3.04	4.38	5.00
All scientific publications in five-year period	M	21.06	12.29	14.00	9.68	13.21	14.43
F = 3.878; F- sig. = 0.002	SD	12.67	11.47	11.99	9.47	11.88	10.16

* The same methodological note as in the first two tables applies

It is immediately evident from the table that there was no significant differentiation in the productivity of individual fields in the course of the career, but differentiation existed in the five-year period, which raises the question whether the social sciences are more homogenous than the natural sciences. It will be remembered that the (sub)sample is significantly younger than the population of social scientists, which might result in a lower level of differentiation of their career production, which is always strongly influenced by the scientist's age.

Furthermore, insignificant differences are not necessarily small differences, and many sociologists recommend that they should not be dismissed lightly. Such measurable differences arise in all forms of career output of social scientists, but the publication patterns of individual sciences can be more precisely read from a structural analysis. It shows that professional production is the greatest in the educational sciences, nearly one half of the total number of publications published over the course of the respondents' career (46.6%), which is understandable considering the extent of their scientific knowledge application in the overall educational system and its special segments. In the so-called other sciences, primarily information sciences, economics and legal and political sciences, the share of professional production is 38.9%, 35.4% and 34.4%, based on the need to bring scientific findings closer to application and to potential users, from the widest public, the expert public, to political, economic and social decision-makers.

Sociology (26.2%) and psychology (25.3%) stand at the rear with the lowest share of professional publications. The relatively lowest incidence of such papers in the professional activity of scientists from these fields rests on very different intellectual and social premises, especially on the application of scientific knowledge, which is developed and organised in institutionally different ways. Psychological scientific knowledge is applied in practice by numerous psychologists who work in education, the economy, health care and government apparatus, which makes up a broad institutional basis for the competent and socially rooted practical application of (new) knowledge. In contrast, the application of sociological knowledge does not have a tradition that comes anywhere close to this, nor does it have social demand, an institutional basis nor an educated critical mass of sociologists deployed in various fields of social life and decision-making. Therefore, completely different, even opposing, explanations underpin very similar findings.

In brief, our results reflect the trends of differentiation determined by other studies, whose findings show that the share of professional papers varies greatly between different fields of social science. Nederhof et al. (1989: 428) state in one study that this type of production in the social sciences ranges from 9% to 33%, while another study by the same author reports that professional publications account for up to 75% of total publications from some social sciences (Nederhof, 2006: 88).

Papers published in journals included in SSCI and CC are also differentiated by discipline. They abound in information sciences, amounting to 48.6%, which is followed by legal and political sciences (36.3%) and then, close together, by sociology and psychology (24.9% and 24.3%), while educational sciences and economics bring up the rear with shares of 18.2% and 17.8%.

Disciplinary differences established here diverge from the findings of other, primarily bibliometric, studies, which provide a different picture of the publishing habits of scientists from individual social sciences. Nederhof et al. (1989: 430) find that 62% of papers from experimental psychology and only 2% of papers from the field of public administration were published in journals indexed in the (S)SCI databases. The proportion of papers published by Australian social scientists in these journals was also differentiated – from 43% in economics, 32% in sociology to 27% in political science (Butler, according to Hicks, 1999: 196). Psychology, especially experimental, and economics are the sciences with the greatest coverage of their publications in the most selective world databases, at least in some countries with developed R&D.

On the other hand, scientific papers published by our respondents from the fields of psychology and economics are far more scarce in the global databases. The scarcity of psychology papers is especially surprising considering the general nature of their research subject which facilitates publishing in international and foreign journals, including those indexed in the WoS. The great output in the residual category of other, mostly information, sciences is also surprising, as is the relatively great WoS coverage of the legal and political sciences, especially considering the fact that it stems from greater average (S)SCI productivity in jurisprudence than in political sciences.

A reliable corrector of the self-reported data on this type of production of Croatian social scientists is their bibliometric analysis. As will be seen, it not only established that the proportions of natural and social scientists with papers indexed in WoS databases were almost inversely proportionate, but it also found great differences among social disciplines. Psychologists are in the forefront in this respect with 77.5% of scientists with one or more papers, whereas the share of such scientists in the legal sciences comes to only 4.7% (Jokić and Šuljok, 2009: 153). Although self-reported data from the survey refer to overall career productivity, and although the proportion of scientists with WoS-listed papers is understandably greater than the proportion of WoS papers in the total number of their publications, the differences are so great that they warrant a tentative explanation.

Self-reported data were obtained from highly selective samples of the natural and social sciences, but the possible distortion of obtained data is far greater in the latter. To be more precise, publishing in the most relevant international journals is an established and eligible publication practice in the natural sciences, on which the scientist's promotion depends, while in the social sciences such a practice has not been so solidly established. For this reason, the professional, age and especially disciplinary selectiveness of samples might have distorted the real picture of publication practice in individual social sciences. To be more specific, the real picture can be changed significantly by the response of several highly productive legal experts or by the absence of a few of the most productive psychologists due to the fact that the scientific personnel in both fields is not particularly numerous. Distortion of the findings can also result from the social scientists' lower awareness of the world bibliographic and citation databases and their almost complete lack of bibliometric self-monitoring or bibliometric analysis of their own production, which is conducted regularly by many natural scientists.

In other words, in terms of self-reported data, the discrepancies can be explained by methodology since they were provided by respondents of a more productive age and who were more internationally-oriented than most researchers from the social sciences (Golub, 2009). On the other hand, following bibliometric analysis, the detected under-representation of Croatian social scientists on the international scientific scene can be accounted for by the long influence of systemic factors that did not create solid conditions and strong stimuli for scientists' greater focus on publishing in the most renowned international journals. Furthermore, no matter how incomplete the indicators of productivity in the social sciences provided by the WoS bibliographic and citation databases are, scientists will have to pay more attention to them in their publication strategies in the future.

Let us see if the five-year production of international publications in scientific fields sheds more light on the (un)expected disciplinary patterns which can be more or less interpretable here since the selectiveness of the sample reaches scientific fields too. Economics proved the most productive science, outdoing sociology, psychology and educational sciences – the level of significance is 0.000 in the first two comparisons, and 0.013 in the third. From the structural point of view, the papers published in international publications make up 43.0% and 41.1% of the five-year scientific output of economists and researchers from the category of other social sciences respectively. Psychologists follow, together with researchers from educational sciences and legal and political science, who published 30.0%, 29.9% and 28.1% of their works in international books and journals respectively. Sociologists settled at the bottom of the ranking, with only 19.1% of papers published abroad.

In all the natural sciences, the proportion of international publications in scientists' five-year output is greater than the share of WoS publications in the total output in the course of their career, and the same expected pattern is also noticed in the social sciences. The biggest and the smallest discrepancies in the proportion of these two types of publications are the most interesting for interpretation. The greatest divergence is found in economics, which has the smallest share of papers covered in world databases, and, according to the bibliometric analysis, it also has a small portion of authors with such papers (Jokić and Šuljok, 2009). Contrary to these findings, economists are generally to a great extent oriented to publishing abroad and are focused on the international scientific public. This certainly applies to our respondents, although it is rather questionable in terms of the overall Croatian scientific community of economics.

A reverse, although minimal, discrepancy can be noticed in sociological output, and it results from the inclusion of the *Društvena istraživanja* (*Social Research*) journal, issued six times per year in Croatian, in the ISI/WoS database. In other words, Croatian sociologists tend to use the opportunity to publish papers in a local journal and in their own language rather than to publish in international journals and books in foreign languages. Almost needless to say, the latter papers are in fact more visible internationally than the scientific output indexed in international databases, but which in reality are accessible only at the national level. Considering the openness of the mentioned journal to other social sciences and humanities, works by social scientists published in that journal probably make up a significant, and perhaps a major, part of their total production covered by those indexes. However, such a publication pattern nevertheless renders scientific production of the social sciences more provincial, even when, formally analysed, it does not seem to be so.

Mono-authored and co-authored publications by respondents from the five-year period show significant differences by disciplines. Psychologists on average publish fewer mono-authored papers than legal and political scientists, economists and sociologists, and differences are significant at the level of 0.011, 0.000 and 0.013 respectively. Researchers from educational sciences publish fewer mono-authored papers than economists, and the level of significance of the difference is 0.025. Average co-authored production is differentiated by the fields of the social science, and a significant difference is found between economics, which has the greatest average number of publications, and the legal and political sciences, which have the lowest average output of this type.

The authorship structure in five-year scientific production is most relevant for obtaining a deeper insight into disciplinary differentiation in the social sciences. Mono-authored publications are the prevailing way to communicate research results in the legal and political sciences, and their share comes to a staggering 89.5%. Such works make up over one half of publications published in the five-year period in sociology and economics – 57.8% and 54.0% respectively. The proportion of mono-authored publications in educational and other sciences is 44.2% and 45.5% respectively, which means that co-authored works are a majority here, although not a great majority. Psychology is dominated by co-authorship and team work, with only 29.3% of mono-authored publications.

The more "in-office" scientific work, theoretical or desk research based on the use of secondary data there is in the field of social science, the greater the share of scientists' individual work, even when they are brought together in project teams. From this follows the high proportion of mono-authorship in jurisprudence (93.9%) and political science (80.8%). On the other hand, the more empirical research there is focused on collecting primary data and requiring team work, the greater the frequency of co-authored publications by researchers from that scientific field. Co-authored publications dominate psychology precisely for that reason.

Returning to the initial question on the homogeneity or heterogeneity of the social sciences, the findings allow for some, at least hypothetical, conclusions. Regardless of the relevant common features, the social sciences are very heterogeneous. Just like the natural sciences, they too differ in terms of the generality of their subjects, the regional and (trans)national peculiarities of the subject, the applicability of knowledge, the modes of knowledge production and social organisation, and, consequently, patterns of research productivity. Since selectiveness of the sample may have conditioned even greater disciplinary distortions of the picture of scientific productivity than in the natural sciences, a clear typology in terms of their production cannot be made in the social sciences as was done in the natural sciences.

It seems that every scientific field constitutes a special type of research production and productivity, even when it shares some characteristics with another field. For example, psychology and sociology show a resemblance in the proportion of professional work and publications, papers in WoS journals, average scientific and total career productivity, and papers published in international publications. At the same time, they also show important differences, primarily in co-authored and team work and, according to the bibliometric study, in their international orientation and visibility.

This internal socio-cognitive diversification of the social sciences is explained by theories of scientific fields. Their authors claim that individual subdisciplines, such as certain disciplines of economics or psychology, and even sociology, are closer to some natural sciences by their important characteristics. Other subdisciplines, however, which are markedly textual and rhetorical, are considered closer to the humanities, sometimes even to literature (Whitley, 1984; Fuchs, 1992). Differentiation of the social sciences is also confirmed by the already mentioned bibliometric analyses that measure the differences in the quantitative and qualitative characteristics of the productivity of individual fields and specialities in this area.

Despite its methodological limitations, this study has also corroborated disciplinary differentiation in the social sciences. Its findings show patterns of research productivity that can be explained only if they are observed as the result and final product of certain processes of knowledge production. Then, one can explain why orientation towards the widest public and expert public is stronger in some social sciences, and weaker in others. Then we can interpret why some (sub)fields are dominated by mono-authored publications, while others have more co-authored publications, and it becomes clear why in some social sciences publishing in international publications (but not necessarily in WoS journals) is a more frequent, and in others a less common, practice.

4. What factors can explain research productivity?

The hypothetical framework of our study includes the claim on the differences in the structure and power of the factors that interpret the career and five-year productivity of natural and social scientists. This thesis derived from earlier sociological investigations into the factors of scientific productivity. Mertonian sociologists empirically studied the social stratification of science and examined universalism in the social system of science. They were thus also interested in the relation between productivity and the important professional characteristics of scientists and the reward system in science (Cole and Cole, 1981; Allison and Stewart, 1974; Reskin, 1977; Long, 1978; Long et al., 1979; Allison, 1980; Long and McGinnis, 1981; Allison et al., 1982).

Croatian studies of scientific productivity used a more elaborate hypothetical matrix which seeks social determinants of scientific productivity in a complex of socio-demographic characteristics of scientists, the characteristics of their professional socialisation, their scientific qualifications, their organisational context and organisational roles, especially in the division of labour and influence in the scientific institution, as well as influential roles in the wider local and international scientific community (Prpić, 1991, 1994). In the last twenty years, other sociological studies have also found productivity factors in structural and organisational variables (Xie and Shauman, 1998; Teodorescu, 2000; Fox and Mohapatra, 2007).

Taking into account the theses of organisational theories on the interdependence of the intellectual and social organisation of science (Whitley, 1984; Fuchs, 1992), it was possible to go one step further. It was expected that the productivity predictors would be structured differently within individual scientific fields and areas, that is, that their research production would be interpreted with different compositions of individual, organisational and systemic factors from the same set to a different extent (Prpić, 1991, 1996a).

Thus, eight multiple regression analyses (with stepwise inclusion) were carried out for both observed areas in which the types of research productivity were treated as dependent variables. The same 29 socio-demographic, socialisational, qualificational, organisational and so-called gatekeeping characteristics of respondents made up a set of predictors or independent variables.[6] The results of regression analyses for the career and for the five-year productivity of natural and social scientists are presented in Tables 4, 5, 6 and 7.

Table 4 contains statistically significant predictors of the professional, scientific and overall career productivity of natural scientists, as well as predictors of the quantity of papers published in journals covered by the WoS bibliographic and citation databases. Significant predictors explained well the overall career productivity (56.5% of its variance), then scientific (54.3%) and SCI/CC production (52.7%), and finally the quantum of professional publications (50.6% of the variance). Three characteristics of the respondents – their older age, multiple membership in international scientific organisations, and (younger) age at the time of their doctorate – made the greatest individual contribution to explaining the career research productivity of natural scientists.

The connection between age and publication productivity accumulated over the course of the professional career is both expected and logical. Scientists as a rule have more published works the older they are. On the other hand, although an early doctorate is a common professional pattern in the natural sciences, a younger age in obtaining the doctoral degree may affect the greater career productivity of natural scientists (Prpić, 1996a). Finally, international professional integration, even at the level of membership in scientific associations, that is, at the lower level of integration, encourages productivity because it ensures communication with colleagues and regular information on the research priorities and results of the relevant scientific community. The connection is shown not only by the comparisons of the natural and social sciences in the Croatian studies of the scientific productivity of eminent and young researchers (Prpić, 1996a, 2000), but also by an in-

[6] These are: gender; year of birth; mother's and father's education; performance at university; age at doctorate; active and passive knowledge of foreign languages; type of institutional affiliation; type of research; leadership position in a scientific institution; local and international awards received; number of domestic and international projects – in total and with leadership; reviews of domestic and foreign colleagues' papers; paid invitations for participation in research, for delivering lectures or talks abroad; membership in local and foreign editorial boards of scientific publications; membership in local and international scientific organisations and their bodies; number of domestic and foreign collaborators in research; frequency of regular communication with foreign colleagues without firm cooperation.

ternational study conducted in as many as ten countries.[7] According to its findings, the same variable significantly predicts scientific productivity in some other countries as well (Teodorescu, 2000).

Table 4. Statistically significant predictors of career productivity of natural scientists (beta weights significance < 0.05)

Predictors	Publications in the whole career			
	Professional beta	Scientific beta	SCI/CC beta	Total beta
Age (year of birth)	–	–0.525	–0.497	–0.354
Age at doctorate	0.155	–0.272	–0.325	–0.135
Number of foreign languages – passive knowledge	0.178	–	–	0.143
Type of institution (academic – non academic)	–	–	0.144	–
Type of research (basic – other)	0.094	–	–0.152	–
Leading international/foreign projects (number)	–	–	0.126	–
Membership in foreign/international scientific associations (number)	0.531	0.232	–	0.399
Membership in bodies of foreign/international scientific associations (number)	–	–0.122	–	–0.097
Membership in local scientific associations (number)	–	–	–	0.120
Membership in local editorial boards	0.229	–	–	–
Reviewing local colleagues' works (number)	–	0.174	–	0.206
Reviewing foreign colleagues' works (number)	–	0.106	0.216	–
Communication with foreign colleagues without scientific collaboration (number)	–	0.112	–	–
Invited (paid) stays abroad (number)	–	0.216	0.197	0.168
Multiple correlation – R	0.711	0.737	0.726	0.752
Multiple determination – R^2	0.506	0.543	0.527	0.565
F ratio	52.477	37.512	40.420	40.641
F-significance	0.000	0.000	0.000	0.000

The significant predictors of productivity of natural scientists are distributed differently in predictor structures that contribute to the explanation of the quantity of individual career publications. The integration of scientists in the international scientific community, but at

[7] These are Australia, Brazil, Chile, Hong Kong, Israel, Japan, Korea, Mexico, USA and Great Britain.

the lowest level of membership in its associations, makes the greatest contribution to professional productivity, and is much less predicted by influential gatekeeping roles on the local scientific scene, that is, in the editorial boards of domestic scientific journals and other publications. Since researchers' age is not a significant predictor of professional output, which is even greater for those who obtained their doctoral degree at a later age, this type of productivity is evidently determined more by some contextual variables, such as disciplinary ones. They seem to be, as the previous analysis has shown, crucial for the extent and share of professional work and output.

In contrast to the simple profile of non-scientifically prolific respondents, the profile of the scientifically most productive respondents is significantly more complex and professionally more elite or more exclusive, although it also includes the (older) age of natural scientists, with their productivity growing the most with their age, and with a younger age at their doctorate. To be more precise, the publishing of the great(est) number of scientific works in the course of the career depends, apart from on age, on the intensity of communication and connection with colleagues from the international scientific community.

The internationally most visible SCI/CC scientific production is best explained by the respondents' older age, by the younger age at the doctorate, and then by more frequent international peer reviews and invited (paid) stays abroad. Productivity indexed in international databases is even more exclusive than overall scientific production, since it is more strongly associated with more reviews of foreign colleagues' papers and leadership roles in international projects.

Thus, not all forms of research productivity can be explained equally well using the same variables from the same predictor set. One regularity also appeared: the more esteemed production in these sciences is, the more exclusive its professional and social background is, too, since it is less connected with lower levels of professional integration, and is better explained by influential roles in the international scientific community.

Table 5 presents the results of regression analyses referring to the five-year scientific productivity of natural scientists, that is, the statistically significant predictors of the total number of scientific works published in that period, and mono-authored and co-authored publications separately, as well as the quantum of international publications by respondents.

Table 5. Statistically significant predictors of five-year productivity of natural scientists (beta weights significance < 0.05)

Predictors	Five-year publications			
	Mono-authored beta	Co-authored beta	Inter-national beta	Total beta
Level of mother's education	–0.125	–0.135	–	–0.175
Average grade at undergraduate studies	–	–	–	–0.155
Age at doctorate	0.128	–	–	–
Number of foreign languages – passive knowledge	–	0.207	–	–
Type of research (basic – other)	–	–	–	–0.123
Collaboration in foreign/international projects (number)	–	–	–	0.130
Number of local collaborators in research	–0.135	–	–	–
Number of foreign collaborators in research	–	0.235	0.192	0.210
Membership in foreign/international scientific associations (number)	0.232	0.192	–	0.140
Membership in local scientific associations (number)	–	–	0.135	–
Membership in bodies of local associations (number)	–	–	–0.163	–0.125
Membership in foreign/international editorial boards (number)	0.194	–	–	–
Reviewing local colleagues' works (number)	–	–	–	0.154
Reviewing foreign colleagues' works (number)	–	–	0.212	–
Invited (paid) stays abroad	0.158	0.259	0.391	0.252
Number of foreign/international awards for scientific work	–	–0.154	–0.116	–
Multiple correlation – R	0.446	0.489	0.570	0.538
Multiple determinant – R^2	0.199	0.239	0.325	0.290
F ratio	10.618	13.277	20.514	11.331
F-significance	0.000	0.000	0.000	0.000

At first glance, it is evident that, compared to the career output, the respondents' five-year productivity has been explained to a much lesser extent. This primarily refers to the respondents' mono-authored papers, with 19.9% of explained variance, the type of publications which are not characteristic of this area, and even relates to typical, co-authored papers with a slightly greater percentage of 23.9. The total amount of published scientific papers follows with an even higher portion (29.0%) of explained variance, while the respondents' international publications rank first with 32.5% of variance accounted for.

The impact of the respondents' age on their productivity disappears in this time span, and the greatest individual contribution to individual types of productivity is shown by invited and paid stays abroad, and the number of international collaborators in joint research. If membership in international scientific associations is also taken into account as the third strongest predictor, it becomes evident that the five-year productivity of natural scientists rises with the researchers' stronger orientation towards the international scientific scene. The negative relation between the level of the mother's education and the scientist's productivity is interesting, as it shows that respondents whose mothers do not have an academic education publish more works, which can be affected by another variable that has not been considered here, such as the scientific field.

Two types of five-year production are the most important for detailed analysis: the quantity of all scientific publications and of papers published in international publications. Apart from the strongest predictors, each of the two profiles of the (most) productive respondents also includes other significant factors such as membership in international associations, reviewing foreign colleagues' papers, and collaboration in international projects, which additionally indicate the key importance of international networking and the orientation of scientists for knowledge production in the natural sciences.

Some of these factors have greater importance in the five-year production than in the career output, due to the dominant influence of the variables of age and years of professional activity on the overall quantum of publications. However, even in that long time span, the contribution of international scientific engagement to scientists' productivity is seen precisely in the respondents' most visible works. The predictors of the short-term and career productivity of natural scientists confirm the already shown key importance of international networking and integration in this scientific area (Prpić, 1996b).

International orientation and communication in science can also be connected to the concept of social capital which is used increasingly more in sociological empirical studies of gender differentiation, but also in studies of productivity in science (Etzkowitz et al., 2000; Lazega et al., 2006; Ziherl et al., 2006; Prpić, 2007). As important as it is for scientific production in the natural sciences, international social capital can be even more important in smaller scientific communities with modest material resources.

A finding of a bibliometric study which shows a great rise in international co-authorship in six different natural disciplines over the last decade of the previous century is very important for this discussion. The study did not find any significant differences in growth rates.[8] The author of the study concludes that global dynamics is a more important determinant of scientific cooperation than the differences in the intellectual organisation of individual fields (Wagner, 2005). The said findings still cannot form firm empirical verification for broader generalisations, but they are in line with the results we obtained for the eminent Croatian natural scientists and the population of natural sciences. International cooperation is the key factor for the interpretation of high scientific productivity in the natural sciences.

The predictors of the career productivity of social scientists and the extent to which they contribute to its explanation are presented in Table 6. The first discernable difference between the observed scientific areas refers precisely to the extent to which the variances of individual types of career productivity were explained in the social sciences. The proportion ranges from 49.5% of variability in scientific production, 47.6% of variance in all professional and scientific publications, 41.9% of variability in professional production and the lowest 17.9% of explained variance in our respondents' WoS publications. The latter papers are not really a typical pattern of productivity in social sciences (yet). Significant predictors explain scientific productivity noticeably less in the social than in the natural sciences. The smallest difference is found in overall scientific production, while the greatest difference is, expectedly, observed in the level to which the publications indexed in (S)SCI and CC databases are explained.

At the same time, it is evident that age has once again the greatest individual influence on different forms of career productivity, as well as the age at the doctorate, and invited stays abroad to some extent. An older age again has a cumulative effect on productivity which is on average greater in the older than in the younger generations of scientists. A younger age at the doctorate is also a good predictor of the future pro-

[8] Compared disciplines were selected considering the different level of importance of exchanging data, use of expensive scientific equipment, exchange of rare or unique resources, or exchange of ideas. They were: astrophysics, mathematical logic, polymer science, soil science and virology.

duction of scientists, especially since a degree in the social sciences was obtained at a later age, and natural scientists were also more successful in this respect among our respondents (Golub, 2009). Finally, paid stays abroad are a sign of the already noticed scientific quality of invited scientists, but they also boost their productivity. With regard to career productivity, similarities of its strongest predictors confirm that in both areas the same benefits of the previous scientific performance accumulate over the course of the scientific career (*cumulative advantage*).

Table 6. Statistically significant predictors of career productivity of social scientists (beta weights significance < 0.05)

Predictors	Publications in the whole career			
	Professional beta	Scientific beta	SCI/CC beta	Total beta
Age (year of birth)	–0.216	–0.561	–0.334	–0.520
Level of father's education	0.145	–	–	–
Age at doctorate	–	–0.354	–	–0.283
Number of local collaborators in research	0.129	–	–	–
Number of international collaborators	0.195	–	–	–
Membership in foreign/international scientific associations (number)	–0.325	–	–	–
Membership in bodies of local scientific associations (number)	–	0.266	–	–
Membership in local editorial boards (number)	–	–	–	0.143
Membership in foreign/international editorial boards (number)	0.170	–	–	–
Reviewing local colleagues' works (number)	0.142	–	–	0.162
Invited (paid) stays abroad	–	0.286	0.211	0.168
Number of local awards for scientific work	0.149	–	–	0.201
Number of foreign/international awards for scientific work	0.309	–	–	–
Multiple correlation – R	0.647	0.704	0.423	0.690
Multiple determination – R^2	0.419	0.495	0.179	0.476
F ratio	10.238	32.898	14.839	19.868
F-significance	0.000	0.000	0.000	0.000

Apart from the expected influence of age, the composition of significant predictors of the respondents' professional (non-scientific) productivity differs from the composition of factors that explain the quantity of scientific publications. The non-scientific productivity of scientists is most connected to less frequent membership in international scientific associations and to more international/foreign awards for scientific work. The connection is contradictory and interesting since the two predictors are related in content – both concern international communication and recognition – but opposite in direction. Since the social sciences are an area with a relatively high common but disciplinarily differentiated share of professional output, it is possible that the different context is the intervening variable that stands behind the seemingly illogical connections. The next two significant predictors – more international collaborators in research and the greater frequency of membership in editorial boards of international/foreign scientific publications – show the prominent international orientation of respondents, thus paving the way for the interpretation that the contribution of such an orientation towards greater professional production is even greater in the social sciences than in the natural scientific fields.

The strongest predictor of social scientists' scientific output is their age, with which the number of their published works also rises. The impact of the younger age at the doctorate is also relatively high, and is on average greater in respondents from the social sciences. Thus, it is no wonder that those who obtained their doctorate at a younger age published more scientific papers in the course of their careers. Paid stays abroad and more frequent membership in bodies of local scientific associations also have a significant role in explaining the variability of career scientific output. The top three most influential predictors overlap the top three strongest predictors in the natural sciences, which leads to the conclusion that career scientific productivity is similar in both areas, at least in terms of the factors that interpret it the most. They are connected with the accumulative character of career productivity, with the earlier acquired scientific qualifications (doctorate), and with integration in the international scientific community.

In contrast to the relatively high and, in terms of the composition of predictors, rather complex explanation of the production of WoS papers in the natural sciences, only two variables in the social sciences – older age and more frequent invited stays abroad – predict a greater quantity of these allegedly globally most visible publications, which is rather dubious due to the prevalence of journals in the Croatian language. In short, social scientists also simply accumulate this type of paper as well in the course of their career, as do those who are (were) more often invited abroad. Overall scientific and professional productivity is best predicted by the scientist's age and the age at the doctorate. High productivity of this type is tied mostly to the domestic scientific scene, but the profile of highly productive scientists turns out to be very exclusive professionally because of their gatekeeping roles, and due to their local as well as international awards.

The predictors of five-year scientific output in the social sciences are presented in Table 7. As expected, all types of scientific productivity of this span are accounted for to a lesser extent than the career output, but they are not significantly behind the comparable output of the natural sciences, since the proportions of explained variance were 30.3% for foreign publications, 27.9% for mono-authored publications, 26.2% for all five-year publications, and 24.4% for co-authored papers. The publishing of mono-authored works is of course explained better in the social than in the natural sciences.

Table 7. Statistically significant predictors of five-year productivity of social scientists (beta weights significance < 0.05)

Predictors	Five-year publications			
	Mono-authored beta	Co-authored beta	Foreign beta	Total beta
Gender	0.182	–	–	–
Level of mother's education	–0.197	–	–	–
Age at doctorate	0.156	–	–	–
Number of foreign languages – active knowledge	0.264	–	–	–
Cooperation in domestic projects (number)	–	0.237	–	–
Leading domestic projects (number)	–	–	0.315	–
Leading foreign/international projects (number)	–	–	–0.160	–
Membership in bodies of domestic scientific associations (number)	–	0.378	0.150	0.281
Membership in domestic editorial boards (number)	–	–0.206	–	–
Reviewing local colleagues' works (number)	–	0.278	–	0.265
Invited (paid) stays abroad	0.344	–	0.339	0.256
Multiple correlation – R	0.529	0.494	0.550	0.512
Multiple determination – R^2	0.279	0.244	0.303	0.262
F ratio	10.080	10.652	14.534	15.485
F-significance	0.000	0.000	0.000	0.000

The first comparison of average scientific productivity predictors reveals some similarities between the two fields. To be more precise, the respondents' invited stays abroad also make the biggest individual contribution to explaining all types of production (except co-authored publications) in the social sciences. They are followed by more frequent participation in the work of executive and working bodies of domestic scientific associations, a peculiarity of the social area. In other words, high productivity is moulded through international connections and networking here as well, but it is also predicted well by influential roles in the local scientific community.

What is the professional profile of the most prolific producers of mono-authored papers in the social area? These are largely scientists (most) often invited abroad to participate in research, lectures and science conferences, and respondents proficient in more foreign languages. The profile of prolific co-authors from the social sciences indicates their full focus on the local scientific scene: they are more often members of bodies of local scientific societies, they review more papers by their local peers, they participate in more domestic projects, but are less frequently engaged in gatekeeping roles in local scientific journals. The findings also show an apparent paradox in the scientific output of social scientists. While high mono-authored production is connected to international contacts, even invitations for cooperation, co-authored production stems from intense scientific activity in the domestic scientific community. The finding seems paradoxical only if observed through the patterns of natural science which show a rather high correlation between international and co-authored production ($r = 0.65$), and half the correlation between mono-authored and international publications ($r = 0.32$). These correlations are lower and less discrepant in the social sciences ($r = 0.56$ and 0.42, respectively). Accordingly, in the publication practice of the social sciences, mono-authored productivity is more strongly related to the scientist's greater international orientation than co-authored production is.

Invited stays abroad and a more frequent leading role in local projects are the best predictors of the greater quantum of international publications of social scientists. The obtained predictor structure connects the real globally visible production of respondents with their international communication, but also the leading organisational, project roles in the Croatian scientific community. In other words, the most important conditions for publishing in international journals and books are invited cooperation which requires a certain degree of international networking, but also key roles in local scientific projects, which ensures the greatest influence on knowledge production and, consequently, on publishing results in the country and abroad.

The quantity of all five-year scientific publications of social scientists, regardless of authorship and their orientation on the global or local scientific public, is explained to a significant degree by the predictors that also represent a mix of domestic and international scientific activity – prominent roles in local scientific associations, local reviewer roles and, of course, invited stays abroad.

What conclusions or/and assumptions follow from this comparative analysis of possible factors of research productivity in the natural and social sciences? The basic conclusion refers to the established, and expected, differences in the power and structure of significant predictors. Those in greater proportion explain career, professional and scientific productivity, especially the quantity of WoS publications by natural scientists. However, the differences are smaller when production is observed over a shorter time span, except for respondents' mono-authored papers which were explained better in the social sciences.

The composition and structure of the significant predictors of research production also differ in the two observed scientific areas. This refers to both career and five-year research productivity. In brief, the variables of international scientific integration, connections and cooperation are more important in the natural sciences than in the social sciences which show a greater influence of the locally oriented professional activity of the respondents on their output.

The structure and prediction power of the productivity factors are noticeably different, but not as much as was determined in a comparison of the productivity predictors of eminent Croatian scientists when a similar, but not identical, set of independent variables was used (Prpić, 1996a). Due to the methodological differences, we cannot conclude, although we can assume, that the factors of research productivity in the natural and social sciences may have also changed. This may have resulted from the systemic changes in the conditions of knowledge production in the period between the two studies, and especially from the changes in the system of promotion and evaluation in science. Mandatory and time-conditioned scientific promotion also applied to researchers from institutes who were previously usually exempt from such obligations. The criteria of scientific promotion, especially in the social sciences and humanities, were made stricter by including internationally renowned and equivalent publications.

Apart from the determined differences that are smaller than those found in earlier studies of Croatian scientists, this study also established certain common features in the factors that contribute to the scientific productivity of natural and social scientists. This primarily refers to predictors that best explain the career and five-year publications of the observed groups. For the former, they are age, age at the doctorate, and invited stays abroad, and for the latter they are, again, invited stays abroad for research, teaching, and science conferences. Thus, the latter factor is the "common denominator" of productivity in both cases and in both periods, which is in line with the significant association of different types of international communication with scientists' productivity found in other studies as well (Kyvik and Marheim Larsen, 1994; Teodorescu, 1994).

Since it also includes the most intensive forms of international scientific cooperation, such as work in joint research or in the communication of scientific results in university teaching and presentations at conferences, the factor indicates that the scientist's presence on the global scientific scene is an important basis for scientific production. Even more, the predictor is a good indicator of scientists' social capital because (more) intensive international cooperation as a rule presupposes their good international connections and networking.

If the picture of scientific productivity might be distorted due to the unrepresentative samples of natural and social scientists, agreement with the results of previous and other studies indicates that the convergence of the natural and social sciences may not be taking place only in the patterns of research productivity, but might also be occurring in their underlying determinants.

5. Socio-cognitive differentiation in science and research productivity

Returning to our goal and the hypothetical framework of this study, it is necessary to assess to what extent it has fulfilled its scientific tasks and corroborated the starting hypotheses. Naturally, the methodological limitations of the study, primarily the selectiveness of the sample of natural and social scientists,[9] which has not been expressed the same in both cases (Golub, 2009), have to be taken into consideration. A statistical check determined that the sample of natural scientists was representative of the population of doctors of sciences all the way down to the level of scientific fields in this area, allowing reliable conclusions at the level of the overall sample, and consequently some generalisations at the level of the natural sciences. The sample of social scientists is not representative of their overall area, or even of individual sciences, which call for far greater caution in drawing conclusions. By covering the overall population of natural and social scientists, bibliometric analysis makes up for the methodological deficiencies of this investigation of the productivity of the two observed areas (Jokić and Šuljok, 2009).

The basic thesis of the study, which expected significant differentiation in patterns and factors of research productivity of natural and social scientists, was empirically supported by the results of the research.

Firstly, the thesis, as well as the findings of other, mostly less comprehensive studies, that the natural and social sciences do indeed practise different publication patterns has been confirmed. The principal forms of career and five-year productivity differ significantly. With almost equal career production, the research productivity of the social sciences is marked by twice the number of professional papers, whereas the natural sciences produce two times more WoS-indexed papers. While the natural sciences are dominated by co-authored papers, the social sciences still have more mono-authored publications. Such patterns and their changes over the last fifteen or so years can be interpreted by differences in intellectual and social organisation, the mode of knowledge production, and the cognitive styles of the natural and social sciences.

Secondly, significant differentiation of scientific productivity does not stop only at the level of scientific areas, but can be found within them as well. Individual scientific fields developed their own recognisable patterns of career and five-year productivity, and each mode of knowledge production has its own type of productivity. The natural sciences manifest significant socio-cognitive differences between laboratory sciences such as physics and chemistry, geosciences with their

[9] The often used methods in science studies, postal, and especially electronic surveys, have a serious weakness besides a number of advantages, and that is the selective response of scientists.

emphasis on field research, and biology as a mixed (type of) field, and the distinctiveness of mathematics. Thus, the main forms of their research productivity also differ significantly.

Similarly to the natural sciences, the social sciences also differ by the generality of their subjects, their regional and national peculiarities, the applicability of knowledge, the mode of knowledge production and social organisation, as well as the cognitive style. Thus, they also differ significantly by patterns of research productivity, which are not as clear typologically as those from the natural sciences.

Thirdly, the expected difference between the natural and social sciences in the composition and contribution of significant predictors of the basic types of productivity has also been established empirically. The career professional and scientific productivity of natural scientists, especially the number of their WoS publications, has been explained better than that of social scientists, while the differences were slighter in five-year production. The composition of productivity predictors also differs considerably, so the researchers' international cooperation and connections are the most important factors in the production of the natural sciences, whereas the social sciences also show the greater influence of the orientation of the scientists' professional activity on the local, domestic scientific community.

At the same time, our study also identified the predictors with the greatest individual contribution to scientific output in the natural and social sciences. One of them – invited stays abroad for research, teaching and science conferences – explains productivity well in both areas and in both time spans. It is also an indicator of the scientists' social capital as it presupposes their international integration.

Fourthly, comparisons with the results of earlier Croatian and other international studies indicate that deep structural changes have taken place in the principal forms of research productivity: in respect of scientific and professional productivity, co-authorship and mono-authorship, and the international visibility of results and their inclusion in the world's most selective bibliographic and citation databases. The similarity of the most powerful individual predictors of research, especially scientific production, indicates, however, the possibility that the convergence of the natural and social sciences does not take place only in productivity patterns, but also in its underlying determinants. Convergence in the development of publication practices and modes of knowledge production, taking place over a relatively short period, cannot be interpreted sociologically with the intrascientific process of social and cognitive uniformisation. It was undoubtedly strongly policy-driven and sociologically predicted long ago (Whitley, 1984).

Fifthly, these findings have wider theoretical implications. Although the study did not have the task of empirically testing the theories of scientific organisations (TSO), it does make an indirect contribution. On the one hand, it provides some kind of empirical support to their theses on the mutually intertwined intellectual and social organisation of the fields of science and their socio-cognitive differentiation, and, on the other, it indicates that without a suitable theoretical basis, these results would constitute merely common-sense empirical data, whose meaning and importance could escape even the most attentive of observers.

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Productivity and its impact in the ISI and Scopus citation databases from 1996 to 2005

1. Introduction: problem, previous research, theoretical and hypothetical starting points

The need to empirically investigate and describe the specificities of scientific communication, bibliometrically defined by published papers and citation analyses in individual fields and disciplines, usually arises from the competitive relations and limited financial resources of scientific research. The results of such studies underpin the theoretical basis of scientific communication and generate insights into the development of science and individual scientific disciplines. Indeed, they are one of the segments of the sociology of science, that is, the science of science.

In almost all countries, the system of evaluation of scientific work is based on bibliometric analyses, peer reviews, or a combination of the two approaches. Until recently, the citation databases of the Institute for Scientific Information, Philadelphia, USA(ISI), the Science Citation Index (SCI), the Social Science Citation Index (SSCI), and the statistics database Journal Citation Reports (JCR) were the basic instruments of bibliometric studies. With the establishment of the Scopus (Elsevier)[1] citation database late in 2004, the system of the evaluation of scientific output gained a new dimension. The development of Google Scholar[2] will also certainly have an influence on the evaluation system in sciences.

The organisational concept of the ISI citation databases, SCI, SSCI, A&HCI (Arts&Humanities Citation Index), known today under the commercial name WoS (Web of Science), and that of Scopus differ fundamentally. While the idea of the selection and inclusion of journals in the ISI citation databases is based on Bradford's law of scattering,

[1] http://info.scopus.com/overview/what/ (retrieved on July 9, 2007).

[2] http://scholar.google.com/intl/en/scholar/about.html (retrieved on July 9, 2007).

Scopus has a much broader definition of inclusion of primary sources of information. Even though Google Scholar will not be included in this research, we believe it deserves mention as a new system in evaluating scientific work. Google Scholar has a much greater range of sources of scientific literature than Scopus and a greater capacity for monitoring their citation rates, and it is intended to eventually cover all more or less relevant electronically available sources of information from around the world. This provides the global scientific community with the opportunity to evaluate the relevant sources itself, without any restrictions, conditionally speaking, instead of letting commercial secondary sources make the selection. Since the topic of this paper is to empirically investigate scientific productivity and its impact, the issue hinted at here is too broad to be considered in greater detail in this paper.

Let us first explain Bradford's Law in order to more easily understand the differences between the ISI and Scopus citation databases. Bradford's Distribution, the Law of Scatter, or the Law of Scattering of fields in journals, states that the greatest number of articles discussing a certain problem is found in a smaller number of journals, or, in other words, that the greatest number of journals cover these problems in one or two articles (Bradford, 1934). The most productive journals in a given field are called the "core", which consists of a relatively small number of journals with the greatest number of articles on a certain problem. Depending on the field, there are two or more zones of journals that include proportionally fewer articles on a certain topic, but in a greater corpus of journals. Such distribution can be defined in the approximate ratios $1 : n : n^2$ ...

For precisely this reason, ISI's citation databases have been covering less than 10% of global scientific production in all fields since they were established in the 1960s, thus generating the so-called "core" of the world's knowledge. In practice, SCI was covering around 600 journals in the field of the natural and applied sciences in the 1960s, and today, the number comes to around 7,000! The citation database WoS, consisting of all three citation databases (SCI, SSCI and A&HCI), covers around 9,000 journals from across the world today. Since the number of journals has increased just over ten times on the global level, the percentages remain the same.

For almost every scientist in the world, being part of the so-called *core of the world's knowledge* is a formal acknowledgment of the scientist's value and is part of the existing global evaluation system. In a smaller scientific community, such as Croatian, where, in addition, English is not the mother tongue but a *lingua franca*, inclusion in the core of the world's knowledge is certainly an important indicator of the evaluation of its scientific work.

Furthermore, the inclusion of papers in ISI citation databases certainly implies that the papers were subject to international review procedures, which differ in strictness, but require that the formal conditions of the journals be met and that the paper be eligible both in terms of the topic and content. Being listed in the most selective databases may offer scientists the opportunity to become more visible to the overall scientific community. Their papers' citation count, still one of the fundamental indicators of assessing the impact of a scientist's work, can reveal how interesting and useful their work is to the global scientific community.

New technological achievements offer new ways of measuring the extent to which a paper is read, browsed or saved, which is certainly an indicator of the potential impact of the paper. One of the more recent proposals of methodology for evaluating scientific work was presented and implemented by Chen et al. (2007). They introduced the PageRank Google algorithm which covers the network of citations of a certain journal or scientist, and ranks a certain paper based on the number of citations and type of sources citing it.

The originators of Scopus were led by an idea to select journals into their database that was somewhat different from that of ISI. Scopus, like WoS, is a multidisciplinary bibliographic and citation database processing the content of over 15,000 journals, more than 750 collections of papers presented at conferences, patents and other sources of information[3] from across the world. It seems that the idea of this bibliographic and citation database is to offer scientists relevant, scientifically and professionally selective, multidisciplinary sources on a significantly broader platform than ISI's. There is reason to assume that this approach to the organisation of the citation database came from the relatively large discontent of European scientists, primarily those from the Nordic countries, France and Germany, with the ISI/Thomson's selection of journals covered by WoS, that is, its selection policy. To be more precise, the excessive domination of Anglo-American journals, especially in some fields (Carpenter and Narin, 1981; Sivertsen, 1993),

[3] http://info.scopus.com/overview/what/ (retrieved on 25 September 2007)

and not only in the social sciences and humanities, but even biomedicine, is considered one of the key deficiencies of WoS. This problem also certainly affects citations and the principle of the general accessibility of scientific information.

In order to obtain as comprehensive a picture of the publishing productivity of Croatian social and natural scientists as possible, we used the capacities of both citation sources. We assumed that there was a difference between individual fields of science, or the social and natural sciences respectively, in the number of published papers and citations, simply due to the different concepts of the selection of sources of information in WoS and Scopus. Since Scopus covered over 60 Croatian journals from all scientific fields, and WoS indexed 13 Croatian journals in the same period from 1996 to 2005, it is logical to expect that the number of papers will show significant differences in some scientific fields.

Whether a paper was published in a local or international journal is a relevant factor for an assessment of the paper, just like the status of the journal within a discipline. It is not at all the same to publish a paper in an international journal with an established and clearly defined review procedure, which also usually includes two competent reviewers (alongside the editor), and in a national journal in the mother tongue with perhaps one review. The scientific field makes a difference as well. A paper in the field of the humanities or dealing with a specific problem in the social sciences could be of much greater importance for the local scientific audience which it targets if it is published in a national journal than if it is published in a WoS journal which does not attract any significant interest at the international level.

However, this claim would hardly hold water for the majority of works in the field of the natural science. For this reason, one should be quite careful when assessing scientific productivity in the natural and social sciences respectively. Moed (2005) points out that the social sciences and humanities, unlike the natural sciences, do not have a well-defined methodology for evaluating scientific activity. The adoption of the evaluation system of the natural sciences, and its "mechanical" application to the social sciences and especially to the humanities, is hardly justifiable in theory. It is extremely important to bear in mind the specificities of a particular field, such as scientific communication, publishing habits (preference of monographs, domestic or foreign journals), as well as the citation system. The social sciences are a rather heterogeneous group of disciplines. Psychology, psychiatry and fields closer to biomedicine (classified as social sciences by ISI in all of its classifications), but also economics, are closer to the natural sciences in terms of methodology, and citation database analyses are to a certain extent suitable for them. Moed claims that sociology, political science and anthropology tend more towards the humanities, that the book is a crucial communication medium, and that the so-called national publication model is much more relevant for them than the citation databases.

For some social science fields, such as law or some disciplines of political science or geography as a field of natural science, national sources are considered the key communication channel since they deal with the specific problems that are of greatest concern to the local scientific and professional community. However, as far as a more extensive study or development of an idea that could interest the wider scientific community is concerned, it is important to publish in prestigious international journals, thus contributing to the development of the discipline, but also to the recognisability of the author, or the institution and the country.

The impact of a certain scientific paper is at the time mostly measured by the citation count and analysis. Citation analyses include differentiation between different types of citations, self-citation and independent citations, clusters, qualitative citation analyses, analyses of journals and authors cited, the context in which the paper is cited, positive or negative citation, etc.

Measuring the number of citations that a certain paper earns requires great caution. Not only different disciplines, but also individual branches and narrow fields within one discipline cannot be compared without additional indicators and explanations. It is especially dangerous to compare the scientific productivity of the natural and social sciences uncritically. The methodology of some fields of the social sciences, such as psychology, information science, kinesiology, and economics is closer to that of the natural sciences, so citation databases are much more applicable to them than to legal science or some disciplines of political science.

Apart from the number of published works, the number of citations earned, and the average number of citations per paper, in this study we applied for the first time in Croatia a relatively new bibliometric indicator, the *h*-index. The physicist J. E. Hirsch (2005), aware of the weaknesses of the existing indicators of scientific productivity, the number of papers published, and their impact, measured by the total number of citations, the average number of citations per paper, and the number of papers with an above-average number of citations, attempted to introduce an indicator that could be used to measure the wider impact and recognisable influence of the work of an individual scientist – the *h*-index.[4] A scientist has an *h*-index of *h* if he or she has *h* publications that are cited at least *h* times. In practice, if an author published 10 papers over a certain period, and if each of those ten papers was cited at least ten times, the author's *h*-index will be 10. Batista et al. (2006) purport that the *h*-index has several advantages: it combines productivity with impact and it is not sensitive to extreme values in the sense of papers without citation or with few citations, as well as to papers with an above-average number of citations. It also directly indicates the most relevant papers in terms of citations obtained. However, the *h*-index is sensitive to the comparison of fields, even within one discipline, for example of theoretical physics and high energy physics (Egghe, 2007). Batista et al. and van Raan (2006) warn that it is important to investigate the effect of the number of authors on the total number of citations in the interpretation of the *h*-index. They proved that the higher the number of authors, the greater the number of self-citations, which can directly boost the *h*-index unless self-citations are excluded.

In practice, the exclusion of self-citation, an option inherent in both Scopus and WoS, is still not reliable. Furthermore, it is important to define the precise scope of the term self-citation. The manual search and extraction of self-citations requires a great amount of time, and it is very difficult to conduct on a greater sample of authors.

Batisa et al. assume that the frequency of publication and delays in publishing also affect the *h*-index, and Van Raan points out that the type of article also affects the *h*-index. It has been proven that review papers are cited much more frequently than original scientific work. The scientist's age is also relevant. Apart from the most widely used bibliometric indicators for evaluating scientific activity, the *h*-index is (apart from the above) also an important indicator for the interpretation of an individual scientific field or discipline.

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[4] The *h*-index was developed by Jorge Hirsch, a physicist from the University of California in San Diego in 2005. Hirsch's goal was to qualify the impact and quantity of scientists' individual production. http://info.scopus.com/june_07/#2 (retrieved on 6 July 2007)

With this study, we wanted to gain insight into the scientific productivity of doctors of science in the fields of the social and natural sciences, and the impact of those papers, as measured by their citation count. Furthermore, we expect the results to indicate the extent to which the applied bibliometric indicators are actually appropriate for individual scientific fields. We decided to compare Scopus and WoS starting from the hypothesis that Scopus is the more appropriate database as a relevant source of information for works created in Croatia, especially those in the field of the social sciences. We also started from the hypothesis that Scopus was more suitable to evaluate papers from some natural science fields, such as geography and geology, which are classified as so-called national sciences in Croatia.

2. Methodology

The starting point of our study was the identification of the population of doctors of the natural and social sciences. To be more precise, the study covered all Croatian scientists holding a doctoral degree in the natural or social sciences and employed in registered scientific institutions[5] in Croatia. The data were obtained from the Ministry of Science, Education and Sports of the Republic of Croatia, reporting the situation in June 2004.

In total, 1,938 Croatian scientists, doctors of science, were identified and classified in 9 fields of the social sciences: psychology, pedagogy, legal science, economics, political science, sociology, special education, kinesiology, and information science, and 6 fields of natural sciences: mathematics, chemistry, physics, biology, geography, and geology.

We embarked on an investigation into scientific output and its impact as measured by the number of citations earned by searching the WoS (SCI Expanded and SSCI) ISI/Thomson citation database, and the Scopus citation database (Elsevier) for the period from 1996 to 2005. Both databases are available to the Croatian academic community in the internet version at the following URL addresses: http://portal.isiknowledge.com/portal.cgi and http://www.scopus.com/scopus/home.url.

Since the time span is an important indicator in our study, it is necessary to stress that the database search by year may include a

[5] Doctors of science who were not employed in registered scientific institutions, but, for example, in companies whose core activity was not science and research, were not included in the list of scientists and researchers delivered by the Ministry.

smaller number of papers from the previous year. For example, journals published near the end of 1995 and processed in WoS in 1996 will be reported as papers published in 1996 in the search. There is also the possibility, but a much smaller one, that 2006 is covered in 2005 because some journals, especially those with more intensive publication dynamics, might be published ahead of time.

Since we had a familiar population of scientists, the most reliable way of obtaining accurate data was to search by surname and forename, or by the initials of each of the 1,938 researchers. The main reason for this approach of collecting data is based on the fact that there are a greater number of scientists with the same forename and surname. It happened also that sometimes even up to 5 scientists from our sample had the same forename and surname, and were engaged in completely different fields. In order to obtain relevant data, each scientist had to be matched to their own paper. A useful tool in the WoS database is the option to link an author with the field or fields they are active in. The option is currently of far greater quality in WoS than in Scopus. We assume that it is because ISI has a more sophisticated classification of scientific fields and the fields relate to the journals indexed by WoS and are statistically processed in its JCR (Journal Citation Reports) database. Since Scopus does not have such tools at hand, and for other reasons, it is not reliable to use the option of the field as an additional indicator to determine authorship more easily.

The problem we encountered while looking into the scientific activity of female scientists is their inconsistent use of two surnames, that is, the use of different variants of the surname. To illustrate, we report possible variants: Jurić-Perić, A.; Perić-Jurić A.; Perić, A.; Jurić, A. Unless we are aware of this fact, the possibility of making mistakes is not insignificant.

The mistakes that were more noticeable in Scopus than in WoS were wrongly assigned addresses of authors, which required additional research. The same goes for linking individual authors with their classification of the fields. A paper was often classified in several different fields, which did not correspond to the actual situation. Another specific problem was the female scientists who had two surnames, and WoS and Scopus would register them under their forename, and both surnames would be given as initials. We solved this problem by using our own long experience in database search and our knowledge of the authors.

Thus, the collected data are based on an analysis of papers and their citations for each scientist, that is, for each individual author. In our case, we made a distinction between scientists and authors, because some scientists from this population did not publish any works. Each author, regardless of his position in a co-authored paper, was assigned equal authorship. In practice, if a paper was authored by two or more scientists, and they were all a part of our sample, the paper was ascribed to each of the authors as theirs.

The software used at the time of the search did not offer a reliable option of selecting types of works included in the analysis. For that reason, we used all types of works and contributions in searching the number of registered works by one individual author in WoS and Scopus. In practice, this means that, apart from articles, that is, original scientific articles, the analysis also included meeting abstracts and letters. The difference that the exclusion of all other publications except articles from our analysis would make to the findings on the scientific activity of scientists from our sample could only be researched later. However, looking into the categorisation of articles in WoS and Scopus, based on our own experience, we determined that there was no consensus. Professional papers and even reviews were often classified as articles or scientific papers.

The data on the number of citations refer exclusively to papers published by the authors from our sample in the period from 1996 to 2005. It is extremely important to point out that we took the number of citations both from WoS and Scopus based on their options of automatically ascribing citations and the number of citations to a specific paper. However, we did not analyse mistakes in the process, such as whether the forename and surname, journal or bibliographic data connected to the paper were written correctly.

Due to the limited time, we did not embark on citation analyses at the level of separating self-citation from independent citation in this study. Although both databases offered the option to exclude self-citation from the search, we did not use the option because we tested the option and determined that the results were unreliable. This remark refers to Scopus in particular.

It is very important to say that the search was conducted in the course of one week, in July 2007, because WoS and Scopus are updated once a week, usually at the beginning of the week. In practice, this means that the data in the databases remained unchanged during that week. If we had extended the search to two or more weeks, the data on the number of citations would no longer be the same, and the *h*-index value might also be different.

We took the values of the *h*-index for each individual author directly from both databases. Both WoS and Scopus offer the automatic option of using the *h*-index, which made our work much easier. However, even though we said that self-citations were not excluded from the citation count, it should be noted that self-citations were not excluded in the *h*-index either, which might significantly change the findings regarding some of the authors, or individual scientific fields.

Thus, the number of published works in the period from 1996 to 2005, the number of citations from those papers and their *h*-index in the WoS and Scopus databases were determined and examined for each author, or, more precisely, 807 doctors of the social sciences and 1,131 doctors of the natural sciences, which was a very time-consuming task.

Since scientific fields are an important socio-cognitive framework of scientific productivity, and since earlier studies had determined the existence of disciplinary peculiarities, that is, differences in productivity in certain fields (Biglan, 1973, according to Prpić and Brajdić Vuković, 2009; Prpić and Brajdić Vuković, 2005; Kyvik, 2003; Prpić, 1991), we believed that each area (and field) should be approached independently. For that reason, we calculated the average number of papers per scientist for each individual scientific field, the range of the number of published papers, the percentage of doctors of science who did not publish any papers within the given period, both in WoS and in Scopus. Extreme values of the number of papers, citations and *h*-index were expressed, and specificities in publishing in Croatian journals included in WoS were highlighted. Descriptive analyses of differences, that is, specificities in terms of the mentioned indicators, were made for the social and natural sciences.

Since this paper is just the first step in more extensive research of scientific productivity and its impact, the task is primarily descriptive – to bring attention to an overview of the major characteristics of production and the impact of every individual field or area, leaving more complex analyses for future studies.

3. Results of the study

3.1. Productivity and visibility of social scientists

The social sciences, as well as the natural sciences, possess specificities that are expressed through the dominant type of publications in which the findings of studies are published, through the number of journals, citation habits, or, in one broader definition, through differences in scientific communication. In Croatia, the term "social sciences" encompasses the already mentioned fields of psychology, sociology, pedagogy, economics, legal science, special education, kinesiology and information science.

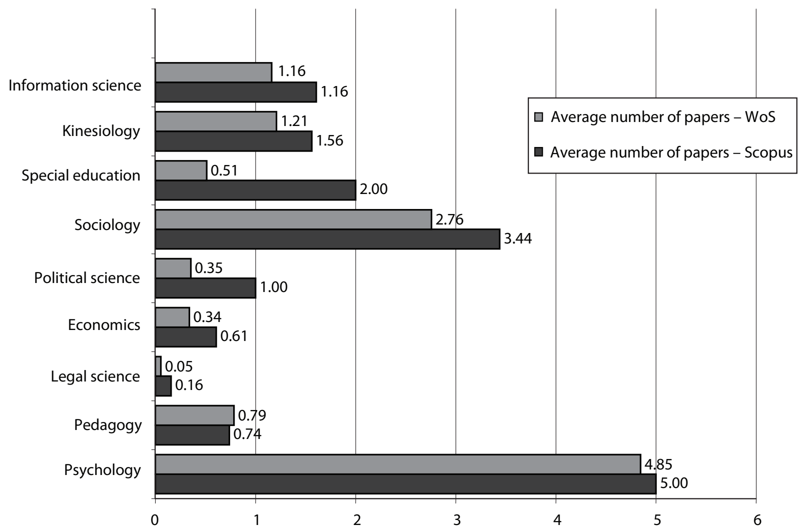
The study covered the population of 807 doctors of social sciences from the said scientific fields who published a total of 831 papers (Table 1) in the period from 1996 to 2005 according to the data from the SSCI-WoS database. The findings show that the average productivity of doctors of social science was 1 published work in a ten-year period.

Table 1. Scientific productivity of doctors of social sciences according to WoS and Scopus data in the period 1996-2005

Scientific field		0 papers (%)	1 – 5 papers (%)	6 – 9 papers (%)	10 and more papers (%)	Total papers
Psychology	**WoS**	**22.5**	**38.0**	**28.2**	**11.3**	**344**
(N=71)	*Scopus*	*16.9*	*40.8*	*31.0*	*14.1*	*355*
Pedagogy	**WoS**	**61.9**	**35.7**	**2.4**	**0**	**33**
(N=42)	*Scopus*	*61.9*	*35.7*	*2.4*	*0*	*31*
Legal science	**WoS**	**95.3**	**4.7**	**0**	**0**	**7**
(N=128)	*Scopus*	*89.1*	*10.9*	*0*	*0*	*20*
Economics	**WoS**	**84.5**	**14.9**	**0**	**0.6**	**105**
(N=309)	*Scopus*	*69.9*	*28.5*	*1.3*	*0.3*	*188*
Political science	**WoS**	**87.5**	**10.4**	**2.1**	**0**	**17**
(N=48)	*Scopus*	*79.2*	*16.7*	*0*	*4.2*	*48*
Sociology	**WoS**	**36.4**	**47.0**	**12.1**	**4.5**	**182**
(N=66)	*Scopus*	*37.9*	*40.9*	*12.1*	*9.1*	*227*
Special education	**WoS**	**69.2**	**30.8**	**0**	**0**	**20**
(N=39)	*Scopus*	*25.6*	*69.2*	*5.1*	*0*	*78*
Kinesiology	**WoS**	**62.5**	**33.3**	**2.1**	**2.1**	**58**
(N=48)	*Scopus*	*50.0*	*45.8*	*2.1*	*2.1*	*75*
Information sc.	**WoS**	**73.2**	**23.2**	**1.8**	**1.8**	**65**
(N=56)	*Scopus*	*60.7*	*30.4*	*5.4*	*3.6*	*90*
Total	**WoS**	**73.0**	**21.2**	**4.0**	**1.9**	**831**
	Scopus	*61.8*	*30.6*	*4.8*	*2.7*	*1112*

Analysing the share of productive scientists, that is, those who published at least one paper in the relevant period, we determined that the share is only 27%. This means that as many as 73% of doctors of social sciences did not transmit any scientific messages via the so-called most prestigious journals included in the SSCI-WoS database. The number of papers published per author ranged from 1 to 38, with only one author at the extreme end with 38 published papers. The highest percentage of scientists, 21.2% of them, published from 1 to 5 papers, while only 1.9% of them produced 1 or more papers per year. The papers published by the most productive 1.9% of scientists make up 29.1% of the total number of published papers. The average values of scientific productivity for individual fields within the social sciences are presented in Graph 1.

Graph 1. Average number of papers per scientist for particular fields of social sciences according to WoS and Scopus



The 831 papers published were cited 1,873 times in total, or 2.25 times per paper on average. We obtain a slightly different picture of the citation status when we take into account that out of 27% of scientists who published at least one paper, 61% of them earned one or more citations of their works, including all types of self-citation, while 39% of authors remained unnoticed as regards the citation of their papers.

Since there were not many comprehensive bibliometric studies made for the social sciences as a whole, there were few data to compare our findings. We took the data offered by ISI/Thomson in its commercial product, the statistics database Essential Science Indicators (1995–2005), as one of the landmarks.

According to these data, the average number of citations per paper in the social sciences at the global level was 3.38, not including economics. Considering all the specificities of the social sciences, especially their national orientation, our finding of 2.29 citations per paper, excluding economics, indicates much lesser visibility of papers from the social sciences created in Croatia (Table 2). However, when making this claim, one should certainly bear in mind the methodological limitations of the research arising from the fact that we did not study the precise time when the papers were published. More exactly, it is not at all irrelevant for the citation count whether a paper was published in 1996 or in 2005.

Table 2. Citation of doctors of social sciences according to data from WoS and Scopus in the period 1996–2005

Scientific field/ citation (author)		No citation (%)	Citation (%)	Total citations	Average number of citation per paper
Psychology	**WoS**	**14.5**	**85.5**	**1064**	**3.1**
	Scopus	*6.8*	*93.2*	*1489*	*4.2*
Pedagogy	**WoS**	**75.0**	**25.0**	**1**	**0.4**
	Scopus	*62.5*	*37.5*	*17*	*0.5*
Legal science	**WoS**	**66.7**	**33.3**	**9**	**1.3**
	Scopus	*85.7*	*14.3*	*18*	*0.9*
Economics	**WoS**	**43.8**	**56.2**	**211**	**2.0**
	Scopus	*64.5*	*35.5*	*167*	*0.9*
Political science	**WoS**	**50.0**	**50**	**6**	**0.4**
	Scopus	*50.0*	*50*	*16*	*0.4*
Sociology	**WoS**	**42.9**	**57.1**	**180**	**1**
	Scopus	*29.3*	*70.7*	*388*	*1.7*
Special education	**WoS**	**83.3**	**16.7**	**4**	**0.2**
	Scopus	*55.2*	*44.6*	*23*	*0.3*
Kinesiology	**WoS**	**5.6**	**94.4**	**247**	**4.3**
	Scopus	*25.0*	*75.0*	*268*	*3.6*
Information science	**WoS**	**53.3**	**46.7**	**140**	**2.2**
	Scopus	*54.5*	*45.5*	*245*	*2.7*
Total	**WoS**	**39.0**	**61.0**	**1873**	**2.3**
	Scopus	*44.5*	*55.5*	*2631*	*2.4*

It was possible to calculate the values of the *h*-index for the social sciences as a whole only for the mentioned 61% of authors who published at least one paper or were cited at least once in the relevant time span according to WoS data. The values obtained ranged from 1 to 6, with the majority of cited authors recording an *h*-index value of 1 (57.9% of them). Only 9% of authors had an *h*-index of 4 or over (Table 3).

Table 3. Values of the *h*-index for social sciences (cited authors) according to WoS and Scopus (expressed in %)

Scientific field / *h*-index		1	2	3	4 and higher
Psychology	**WoS**	**46.8**	**29.8**	**12.8**	**10.6**
	Scopus	*50.9*	*21.8*	*12.7*	*14.5*
Pedagogy	**WoS**	**100.0**	**0**	**0**	**0**
	Scopus	*83.3*	*16.7*	*0*	*0*
Legal science	**WoS**	**100.0**	**0**	**0**	**0**
	Scopus	*100.0*	*0*	*0*	*0*
Economics	**WoS**	**66.7**	**22.2**	**7.4**	**3.7**
	Scopus	*72.7*	*24.2*	*3.0*	*0*
Political science	**WoS**	**100.0**	**0**	**0**	**0**
	Scopus	*80.0*	*20.0*	*0*	*0*
Sociology	**WoS**	**66.7**	**16.7**	**4.2**	**12.5**
	Scopus	*58.6*	*27.6*	*3.4*	*10.3*
Special education	**WoS**	**100.0**	**0**	**0**	**0**
	Scopus	*100.0*	*0*	*0*	*0*
Kinesiology	**WoS**	**35.3**	**47.1**	**5.9**	**11.8**
	Scopus	*50.0*	*22.2*	*10.0*	*16.7*
Information science	**WoS**	**57.1**	**28.6**	**0**	**14.3**
	Scopus	*60.0*	*10.0*	*10.0*	*20.0*
Total	**WoS**	**57.9**	**25.6**	**7.5**	**9.0**
	Scopus	*63.2*	*20.5*	*7.0*	*9.4*

In contrast to the scientific production of Croatian social scientists referenced in the WoS database as described above, our expectations regarding the Scopus database were somewhat different. We assumed that the data obtained from the Scopus database would provide a slightly different picture, at least in terms of the number of published papers. Our assumption was based on the fact that Scopus includes a greater number of local and international journals than WoS. The data obtained (Table 1) show that our corpus of scientists published more papers indexed in Scopus than in the WoS base, 1,112 in total. The average number of publications per scientist was 1.4. However, only 38.2% of scientists published, or, in other words, 61.8% of social scientists did not publish any papers in the analysed period. The number of published papers ranged from 1 to 41, with only one scientist publishing the extreme number of papers. On average, only 2.7% of scientists published 1 or more papers per year in the relevant period, with only two authors publishing 35, or 41 papers within the ten years. Those 2.7% of scientists published 30.26% of papers in total.

The published papers had 2,631 citations in total, which is 2.4 citations on average per paper. In fact, 55.5% of authors had 1 to 404 citations of their works in the period 1996–2005. In other words, 44.5% of scientists who published at least one paper, and in reality as many as 6 papers, were not cited once. In this case too, as in the case of WoS, the warning applies regarding the methodological limitation of the study regarding the lack of information on the time the papers were published.

According to the citation count, 171 scientists had an *h*-index value of at least 1, which makes up 21.2% of scientists in total. The *h*-index ranged from 1 to 7, with 63.2% of scientists for whom the value could be calculated scoring 1 on the *h*-index. Only 9.4% of cited scientists had an *h*-index value of 4 or higher.

A more comprehensive overview of the specificities of scientific activity of our population of scientists, measured by publishing production and impact as reflected in the number of citations for overall social sciences, is obtained by an analysis of each individual field (Tables 1, 2, and 3, and Graph 1). Since there was a wealth of data for every discipline, we are not able to analyse each of them individually. Instead, we focus on making a synthesis and in summing up the most relevant and most interesting findings.

As we can see from Graph 1 and Table 1, psychology stands out as the social discipline with the biggest average number of published articles in the analysed period. Sociology follows with lower average production, which, however, still stands out noticeably from the average production of the other social disciplines. Our data, WoS and Scopus, indicate that these two fields also have the lowest proportion of unproductive scientists who did not publish a single article in ten years. Psychology is the absolute leader here as well, with "only" 22.5% of unproductive researchers, a share very similar to that of the natural sciences. Another relevant piece of information is that over one half of papers authored by psychologists were published in renowned international journals. The share of papers that psychologists publish in the local journal *Društvena istraživanja (Social Studies)* is also relatively high. However, although psychology and sociology are the most productive social disciplines, it is important to highlight the differences between them. Thus, it is obvious that psychologists are not only more productive than their colleagues in the field of sociology, but they are also focused on renowned international journals.

The leading position of psychology, followed by sociology as the most productive social disciplines can be partly explained by the nature of the subject and topics of these two social disciplines, especially psychology. The general nature of the topics of psychology favours publication in international journals. At the same time, the relatively high average production in sociology can be explained by the relatively high frequency of local sociological journals in the analysed databases, especially in Scopus. Thus, it is logical for the quantity of their scientific communication, measured by publishing, to be significantly higher than average in the social sciences.

In terms of the average output referenced in the WoS and Scopus databases, scientists in the field of information science and kinesiology are lagging slightly behind psychologists and sociologists, with an average output hovering around the social scientists' average.

It is very interesting that economists, one of the most productive groups of social scientists on the global scientific scene, turned out to be the least productive, together with legal scientists. Unfortunately, the real reasons for the extremely low scientific output of the greatest number of doctors of economic sciences in the world's most prestigious economics journals remains to be investigated in the future. With regard to legal science, one should have in mind the specificities of scientific communication within the legal sciences as a field, as well as the potential interest of the international scientific public in the law of a small transitional country. It is also important to consider the publishing habits and the system of evaluating the published works of our scientists–lawyers. It is well-known that all law schools in Croatia have their own journals and that the majority of scientists, who are also university professors, publish various monographs.

Graph 1 also indicates that social scientists are in general somewhat more productive in the Scopus database than in WoS. This is most evident in two social fields: special education and political science. As we have already explained, the Scopus database covers a much broader spectrum of journals, at least those preferred by Croatian disability and political scientists, but also social scientists. Doctors of special education from our population largely publish in local journals, primarily in *Hrvatska revija za rehabilitacijska istraživanja (Croatian Review of Rehabilitation Research),* and this in over 80% of cases. It is also interesting that the majority of papers, over 90% of them, represented in the Scopus database published by political scientists, were published in Croatian journals of a relatively broad spectrum – ranging from the journal *Socijalna psihijatrija (Social Psychiatry), Promet (Transport), Građevinar (Civil Engineer), Pomorstvo (Journal of Maritime Studies), Socijalna ekologija (Social Ecology), Alcoholism, Društvena istraživanja (Social Studies)* to *Hrvatska revija za rehabilitacijska istraživanja (Croatian Review of Rehabilitation Research).*[6] A lesser number of papers was also published in internationally renowned journals such as *Electoral Studies* or *International Social Work*.

If we analyse the citation count (Table 2), we will see that kinesiologists (alongside psychologists) are among the social scientists whose papers have the biggest impact. The two fields also have the lowest share of uncited authors. The results for psychology were expected. Even though we initially found an explanation for the high citation of publications authored by kinesiologists in the interdisciplinary nature of the field and its methodology which is close to that used by the natural and biomedical sciences, the real reason was determined only after a more detailed citation analysis. The above-average self-citation rate influenced the relatively high number of citations per paper. For this reason, the data, which at first sight suggest a relatively high level of visibility of Croatian kinesiologists in the WoS, distort to a certain extent the real picture of the impact of kinesiology papers.

The least cited publications are those authored by scientists from the fields of pedagogy, political science and special education. If we attempt to explain the results, we should certainly consider the specificities of these social disciplines that can explain their slighter impact. However, the most probable causes lie in the publishing habits. Primarily, the habit of publishing in Croatian journals, which publish only papers in the Croatian language, makes these works inaccessible to the potentially interested international scientific community. The existing system of evaluating scientific work and of promotion to academic degrees and scientific ranks which does not encourage scientists to publish in prestigious international journals presents an additional problem. We believe that the fact that the field of pedagogy has the

[6] The *Politička misao (Political Thought)* journal, as the leading Croatian political science journal, was not indexed in the WoS and Scopus databases in the analysed period.

longest tradition in publishing a scientific journal also carries weight. The *Napredak* (Progress) journal has been issued without any interruptions, and with several changes of title, since 1857 and is in a way a landmark in scientific communication. This is the reason why our results concerning the publishing and visibility of papers in pedagogy were to a certain extent unexpected.

Information science and economics earned citation rates very close to the average for social scientists' publications, but only in WoS publications. It is interesting that economics, one of Croatia's least productive social disciplines, has a citation rate for its publications in the WoS database very close to the average citation rate for social sciences. A possible explanation is that economics publishes "little, but of quality". Furthermore, since economics is a very extensive and "densely populated" discipline, with the greatest number of scientists of all social sciences (in Croatia), it is clear that the number of persons potentially interested in various topics is much greater than in some "scarcely populated" disciplines.

From the aspect of the *h*-index (Table 3), which combines citation and average productivity, psychology fared best, followed by kinesiology, sociology and information science. If we compare our findings for information science (Table 3), for example, with the data obtained by Cronin and Meho (2006) and Oppenheim (2007), we would hardly be satisfied. Cronin and Meho were the first to conduct a study comparing the *h*-index and the total number of citations for information science. However, since this was an analysis of the 31 most cited scientists from information science faculties in the USA in the period from 1999 to 2005 according to the *SSCI most cited IS scholars,* and our analysis is based on all scientists, it would be unfair to draw comparisons. We can only mention incidentally that the *h*-index ranged from 5 to 20 in the said study. The authors proved that there was a strong positive correlation between the *h*-index and the number of citations, suggesting that the total citation count was indeed a reliable indicator of the impact and influence of scientists' papers. The mean value of the *h*-index for information science was 11, with the highest extreme reaching 19, and the lowest 5, excluding self-citations. Oppenheim analysed British scientists from the field of Library and Information Science, calculating the mean *h*-index value at 7. Since the findings of his study do not refer only to eminent scientists, they are comparable to ours. Table 3 shows that Croatian information science scholars largely have an *h*-index of

1. Alongside the fact that information science is a young and smaller field (Cronin and Meho, 2006), and especially in Croatia, the findings of our study could be additionally explained by the specificities in the subfields, the smaller pool of scientists, or the lack of critical mass, as well as by the extremely great dispersion by various institutions.

3.2. Productivity and visibility of natural scientists

The situation regarding the classification of natural sciences seems much clearer at first sight when compared to the specificities of the social sciences in Croatia and in ISI. However, difficulties arise when the two systems have to be harmonised. ISI/Thomson uses different classification systems depending on the database. Thus, in the case of the JCR (Journal Citation Reports) database, the natural and applied sciences are classified in 169 fields and subfields, while the Essential Science Indicators database uses a system of 22 fields for the whole science. If we decide to follow the Essential Science Indicators system, which we consider more acceptable in terms of depth of classification, difficulties arise concerning biology and chemistry, and even more so in the case of physics. The field of biology is a single field according to the Croatian classification system, but it includes as many as 5 out of 22 fields according to ISI, these being: Biology & Biochemistry, Environmental Sciences/Ecology, Microbiology, Molecular Biology & Genetics, and Plant & Animal Science. We present this example only as an illustration, in order to avoid misunderstandings in the interpretation of results.

Our population of natural scientists is made up of 1,131 doctors of science from the fields of mathematics, physics, chemistry, biology, geology and geography.

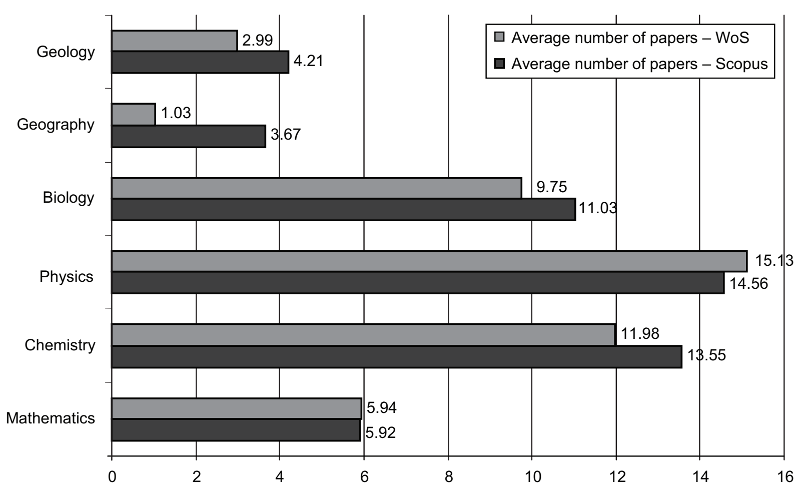
According to the SCI-expanded WoS data, the scientists published a total of 11,925 papers in the period from 1996 to 2005, an average of 10.5 papers per author. Statistically, every scientist published at least 1 paper for every year of the studied period. In fact, papers were published by 88.4% of scientists, while 11.6% of doctors of natural sciences published no papers registered in the SCI Expanded WoS database (Table 4).

The number of papers published per author ranged from 1 to 162, with 44.2% of authors publishing 1 to 16 papers per year on average. These 44.2% of authors published 77.1% of the papers. Average scientific productivity values for individual fields within the natural science are presented in Graph 2.

Table 4. Scientific productivity of doctors of natural sciences according to the WoS and Scopus data in the period from 1996 to 2005

Scientific field		0 papers (%)	1 – 9 papers (%)	10 and more papers (%)	Total papers
Mathematics	**WoS**	**26.8**	**57.5**	**15.7**	**754**
(N=127)	*Scopus*	*26.8*	*59.1*	*14.2*	*752*
Chemistry	**WoS**	**6.4**	**46.6**	**46.9**	**5031**
(N=420)	*Scopus*	*7.4*	*39.8*	*52.9*	*5693*
Physics	**WoS**	**3.0**	**38.8**	**58.2**	**3510**
(N=232)	*Scopus*	*4.3*	*38.3*	*57.3*	*3377*
Biology	**WoS**	**6.2**	**59.6**	**34.2**	**2369**
(N=243)	*Scopus*	*7.0*	*49.0*	*44.0*	*2680*
Geography	**WoS**	**60.6**	**39.4**	**0**	**34**
(N=33)	*Scopus*	*6.1*	*84.5*	*6.1*	*121*
Geology	**WoS**	**36.8**	**56.6**	**9.2**	**227**
(N=76)	*Scopus*	*17.1*	*71*	*11.8*	*320*
Total	**WoS**	**11.6**	**49.4**	**39.1**	**11925**
	Scopus	*9.5*	*47.1*	*43.4*	*12943*

Graph 2. Average number of papers per scientist for individual fields of natural sciences, according to WoS and Scopus



The 11,925 papers published in journals indexed in the WoS database earned a total of 74,842 citations, with an average of 6.3 citations per paper (Table 5). Out of the 1,000 scientists who published at least one paper, 5.4% of them did not receive a single citation, including self-citations. We were not able to make a comparison with the Essential Science Indicators that we made for the social sciences due to differences in the classification of science.

Table 5. Citation of doctors of natural sciences according to the WoS and Scopus data in the period from 1996 to 2005

Scientific field/ citations (authors)		Uncited (%)	Cited (%)	Total citations	Average number of citations per paper
Mathematics	**WoS**	**12.9**	**87.1**	**2105**	**2.8**
	Scopus	*17.2*	*82.8*	*2233*	*3.0*
Chemistry	**WoS**	**2.8**	**97.2**	**31395**	**6.2**
	Scopus	*3.1*	*96.9*	*35678*	*6.3*
Physics	**WoS**	**0.9**	**99.1**	**28702**	**8.2**
	Scopus	*1.8*	*98.2*	*24292*	*7.2*
Biology	**WoS**	**6.6**	**93.4**	**11345**	**4.8**
	Scopus	*3.5*	*96.5*	*13625*	*5.1*
Geography	**WoS**	**76.9**	**23.1**	**21**	**0.6**
	Scopus	*48.8*	*51.2*	*59*	*0.5*
Geology	**WoS**	**8.3**	**91.7**	**1274**	**5.6**
	Scopus	*20.6*	*79.4*	*1464*	*4.06*
Total	**WoS**	**5.4**	**94.6**	**74842**	**6.3**
	Scopus	*6.6*	*93.4*	*77351*	*6*

Values of the *h*-index for scholars from all the natural sciences together ranged from 1 to 20 and could be ascribed to the majority of 83.6% of scientists, that is, 94.6% of authors. The *h*-index could not be calculated for 16.3% of doctors of natural sciences who make up the group of doctors of natural sciences who did not publish any papers or who did not receive any citations. An *h*-index value of 1 was determined for 15.5% of cited authors. An *h*-index value of 10 and above for the natural sciences taken as a whole is considered a very high value, which means that each of the authors published at least 10 papers and that each of the papers received at least 10 citations (Table 6). The category of the most productive and most cited authors is made up of 4.6% authors.

As we have already mentioned, the *h*-index was introduced as a scientometric indicator in 2005, which is the reason why relatively few study results have been published so far. The results obtained by Iglesias and Pecharroman (2007) can serve for at least a partial comparison with our findings. Their data show that biologists have an almost two times greater *h*-index than physicists, which was not established in our case.

Table 6. Values of the *h*-index for natural sciences (cited authors) according to WoS and Scopus expressed in (%)

Scientific field/ h-index		1	2	3	4 and higher
Mathematics	**WoS**	**40.7**	**28.4**	**11.1**	**19.8**
	Scopus	*39.0*	*26.0*	*10.4*	*24.7*
Chemistry	**WoS**	**10.7**	**14.9**	**18.1**	**56.3**
	Scopus	*11.4*	*15.4*	*13.3*	*59.9*
Physics	**WoS**	**9.4**	**11.2**	**18.4**	**61.0**
	Scopus	*10.1*	*11.5*	*17.9*	*60.6*
Biology	**WoS**	**18.8**	**21.1**	**18.8**	**41.3**
	Scopus	*15.1*	*18.3*	*19.3*	*47.2*
Geography	**WoS**	**33.3**	**66.7**	**0**	**0**
	Scopus	*75.0*	*25.0*	*0*	*0*
Geology	**WoS**	**25.0**	**36.4**	**22.7**	**0**
	Scopus	*30.0*	*28.0*	*26.0*	*16.0*
Total	**WoS**	**15.5**	**17.8**	**17.9**	**48.8**
	Scopus	**16.2**	*16.8*	*15.9*	*51.0*

According to the data obtained from Scopus, our population of doctors of science from all fields of the natural sciences published 12,943 papers in total, which averages 11.4 papers per scientist. In reality, 90.5% of scientists published that number of papers, that is, 9.5% of scientists did not publish any papers in the given period. Furthermore, 43.3% of scientists published one or more papers per year on average. The number of published papers ranged from 1 to 156 in total, with only one author publishing 156 works. This finding bears even greater relevance due to the fact that the papers are from the field of mathematics, where at the global level the average number of works published per author in one year was considerably lower than the result achieved by the author from our population!

The mentioned 12,943 papers received 77,351 citations in total, which makes up an average of 6 citations per paper. The authors who did not receive a single citation made up a group of 2.8% of the overall population of doctors of natural sciences, and 6.6% of authors were not cited at all.

The values of the *h*-index ranged from 1 to 22 per scientist. For 15.6% of scientists from the total population of natural sciences it was not possible to calculate an *h*-index, while 13.7% of them had an *h*-index of 1. Values of 5 and higher were determined for 31.5% of scholars.

A more comprehensive picture of scientific productivity and its impact on individual fields of natural sciences can be obtained on the basis of the information from Tables 4, 5, and 6, and Graph 2.

We have to point out once again that we are not able to analyse every discipline individually due to the excessive amount of data, which is why we will focus only on summing up the most relevant findings.

If we look at the findings for scientific productivity, citation and the value of the *h*-index, we notice that the physicists from our corpus rank first. They have on average the greatest number of papers per scientist, the greatest number of authors with 10 or more papers in the said period, that is, they have the most authors with at least one paper per year, and this according to both WoS and Scopus. Their papers also have the greatest average number of citations, and the authors have on average the greatest *h*-indices. According to Hirsch (2005), the creator of the indicator, a "successful physicist" should have an *h*-index of 20 over 20 years, while an "extraordinary physicist" should have an *h*-index of 40, and a "truly unique individual" 60 and more. If we take into account that our study covered a period of ten years, we already have physicists who meet the criteria of "successful physicists". To be more precise, 9.5% of physicists from our population have an *h*-index between 10 and 20 (Table 6).

Chemistry follows physics in all criteria, and biology ranks third, while geology ranked third only in terms of the average number of citations per paper.

If we compare our results with the global average according to the 1995–2005 Essential Science Indicators for an average number of citations per paper in these three fields, then physicists have above-average results, chemists are relatively close to the global average, and biologists have considerably poorer results on average. The said finding can be explained by the established standards of scientific communication in these fields, and by the relevant ministry's evaluation system. Physicists, chemists and the majority of biologists, especially molecular biologists and geneticists, are simply not recognised within relevant scientific circles unless they publish in prestigious international journals. It is important to point out that none of the Croatian physics journals is included in the WoS-SCI Expanded database, which means that all physicists' papers were published in prestigious international journals. However, some chemists published a greater share of their papers in the Croatian journals *Croatica Chemica Acta* and *Chemical and Biochemical Engineering Quarterly*. At the same time, it is important to say that even the most productive chemists published in the most prestigious international journals. This especially refers to the chemists from the Ruđer Bošković Institute. In order to give a full overview, we should also state that all the mentioned papers were co-authored by five or more authors per paper, which is an accepted publishing model in chemistry at the global level.

The biologists from our sample are engaged in a relatively broad spectrum of research in the field of biology – from botany, zoology, marine biology, ecology to molecular biology, which is also evident from the 36 different institutions in which they are working. This diversity is manifested in the specificities of scientific communication, and it is difficult to expect equal scientific productivity from biologists engaged in plant biology or zoology, environmental research, biodiversity or molecular biology. Our preliminary studies show that biologists, unlike physicists and some chemists, cooperate less with colleagues from abroad, and they publish papers with fewer co-authors. In order to obtain a more comprehensive insight, it should be mentioned that some of their works were published in Croatian journals indexed in WoS – *Periodicum biologorum* and *Collegium antropologicum*.

Mathematics has a special place in our study for several reasons, but primarily due to a high average number of citations per paper (Table 5) compared to the global average, which came to 2.6 citations per paper in the period from 1995 to 2005 according to Essential Science Indicators. It also has a special place for having one author publish 162 papers in ten years, which is rare even in the world's strongest scientific communities. However, the fact that this scientist is an editor of the *Mathematical Inequalities & Applications* journal, which has been indexed by SCI since its first issue, might shed some light on this peculiarity. The third specificity of this discipline is the relatively high share of authors who published at least one paper per year in the studied period (Table 4).

Geology has for a long time had the status of a so-called national science in Croatia. In practice, this has included the administrative control of publishing research results, which did not necessarily favour publishing in international journals. However, the presented findings indicate that the situation has been changing significantly (Table 4, 5 and 6, and Graph 2). It is especially important that geologists' published papers received 5.6 citations on average, which can be considered relatively satisfactory, compared to the 1995–2005 Essential Science Indicators (7.49 citations per paper). According to the data from WoS, all these papers were published in relevant international journals.

Geography certainly has a special place in the natural sciences. Anglo-American classifications of science categorise geography partly as one of the geosciences, and partly as a social science, which is also important for the interpretation of the data obtained in this study (Table 4, 5 and 6, and Graph 2). Thanks to its peculiar characteristics in the system of natural sciences, geography unsurprisingly manifested significant discrepancies from the model of scientific communication of other natural sciences. As expected, Scopus produced a significantly greater number of papers than WoS, since it covers Croatian journals from the field of geography. We expected the papers to be potentially interesting to the European scientific community, but that was not the case. One of the reasons may be the fact that the papers were written in Croatian and they were not quite accessible to potentially interested scientists. An analysis of journals where the mentioned papers were published showed that over 90% of them were Croatian, most of all *Društvena istraživanja (Social Studies)* and to a lesser extent *Periodicum biologorum*.

4. Conclusion

This study is the first in Croatia to show precise data on the scientific productivity (and its impact) of doctors of the social and natural sciences in the period from 1996 to the end of 2005, based on a search of the WoS (SSCI and SCI-expanded) and Scopus citation databases.

However, let us highlight several important facts first. First, bibliometric analyses such as this one that cover exclusively output published in journals indexed in the WoS and Scopus databases favour the natural sciences. The limitations of this method have to be highlighted in order to avoid inaccurate generalisations of results to overall production, which in social sciences also includes journals indexed by other relevant databases. It is also indisputable that the share, importance and influence of books are incomparably greater in the social than in the natural sciences, which are dominated by journal articles (Prpić and Brajdić Vuković, 2009).

Secondly, co-authorship is the prevailing form of scientific production in the natural sciences (Kyvik, 2003), while the proportion of co-authored papers is lower in the total number of publications in the social sciences (Prpić and Brajdić Vuković, 2009). Since co-authored articles were ascribed to each author in this study, it is very likely that the natural sciences were additionally favoured in terms of the quantity of papers, since co-authorship is still much more common to the natural sciences.

Thirdly, natural scientists are more focused on the international scientific community and are more inclined to publish in international journals. Social scientists, however, more often publish in national and regional journals due to their primary focus on the study of their own society. However, social sciences are also ever more present on the international scientific scene (Nederhof et al., 1989; Hicks, 1999; Nederhof, 2006).

The fourth fact concerns bibliographic and citation databases, especially WoS. Journals from the natural sciences are far more represented in that database than those from the social sciences (Nederhof, 2006), and thus it is logical to expect natural scientists to have greater output.

Considering the facts stated in the recapitulation above, we are driven to the following conclusions. The first is that there are various differences in the analysed characteristics between the two fields. Although the natural sciences are probably favoured for the above-stated reasons, the existing differences are still sufficient to draw tenable conclusions.

Thus, the natural sciences absolutely dominate the social sciences in terms of WoS and Scopus productivity, citations and the *h*-index. The fact that, according to WoS, the average number of papers per scientist in the social sciences was 1, and in the natural sciences 10.6, is very indicative. In the social sciences, 73% of scientists did not publish a single paper referenced in the WoS, while there were only 11.6% of such scientists in the natural sciences. In terms of the impact of scientific activity, measured by the number of citations (WoS) for social sciences as a whole, the average citation rate was 2.25 per paper. The impact of scientific activity was very different in the natural sciences – the average number of citations per paper was 6.3. The *h*-index for the social sciences ranged from 1 to 6, and it could be calculated only for 16.5% of scholars. The natural sciences, however, had an *h*-index ranging from 1 to 20, and the values could be calculated for as many as 87% of scientists.

It is important to point out that the natural sciences, compared to the social sciences, not only keep up with the average international figures, but often fare above average. Thus, in the natural sciences, physics and mathematics are above average by all indicators compared to other fields, but also compared to average global results.

Social scientists, however, still lag behind the global indicators, which can be explained in the following way. Firstly, Croatian social scientists are more focused on investigating their own society, and they are thus more inclined to publish in national journals. Secondly, only a small share of the local social journals is indexed in the WoS database. Thirdly, Croatian social scientists publish in Croatian journals that are included in the WoS, with the *Društvena istraživanja (Social Studies)* journal holding a special place. There is no need for any special discussion on the importance of publishing papers in English for transmitting scientific information to the relevant scientific community. National journals included in WoS have a special place in the natural sciences as well, especially in biology and chemistry, but, unlike the *Društvena istraživanja (Social Studies)* journal, they publish all their papers in English. The fourth reason why social scientists lag behind can also be found in the internal norms, that is, the "criteria and models" of scientific communication that exist in different social disciplines. We could say that there has been much less encouragement in the social sciences to publish in renowned international journals than in the natural sciences.

The second conclusion of our study undoubtedly indicates that the differences in the basic characteristics that we have analysed show a relatively great oscillation between disciplines. Each field has its own peculiarities and the criteria that seem suitable for one field do not have to be appropriate for all disciplines. Thus, for example, one certainly needs to question the validity of using the WoS or Scopus database as a measuring instrument (in awarding a scientific rank, or the like) in fields such as legal science, where over 90% of scholars have been excluded. Furthermore, although it is categorised only as a natural science in our official classification of scientific fields, geography is much more similar to the social than to the natural sciences in terms of the results obtained regarding its scientific productivity and impact. Thus, not only should the bibliometric monitoring of publications from the field of the social sciences and humanities not rest on the same methodological assumptions that apply to the natural sciences (Prpić and Brajdić Vuković, 2009), but it is also clear that different disciplines within the same area have different patterns of scientific communication. One should certainly bear this in mind when creating a science policy and criteria for promotion in science.

The third conclusion of this study regards the comparison of the two bibliographic and citation databases used in the research. Even though we assumed that scientific output would be much greater, especially for the social sciences, the results do not completely support this thesis.

To conclude, our comparative study of productivity in the natural and social sciences and their respective individual disciplines supports the already familiar thesis on the specificities of scientific fields and their patterns of productivity. It confirms that the indicators and standards of average scientific output and impact that apply to the natural sciences cannot be uncritically transferred and applied to the social sciences.

Since this study has provided only indications of scientific productivity and impact for the social and natural sciences in Croatia and on a specific population, a deeper insight into scientific productivity referenced in the WoS and Scopus databases would require additional research and analysis.

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Part II.

The cognitive convictions of natural and social scientists

Sven Hemlin

What is scientific quality?

1. Introduction

Scientific quality is judged and evaluated by scientists in a number of ways, for example when a manuscript is submitted to a journal and reviewed by peers, when a grant application is reviewed, when a candidate for an academic position is scrutinised, and on other occasions. Most of these evaluations of scientific quality are made by scientists themselves. This is done by means of the peer review system. In addition, scientists also make use of scientific indicators to evaluate science and its actors.

However, it is not only scientists that evaluate science. Actors outside the scientific community are also interested as recipients of scientific results and applications, and therefore have an influence on how it is assessed. For example, of interest to people are the clinical therapies for strokes or depression, environmental technology innovations that reduce pollution, and the manner that different organisational problems may be overcome. Furthermore, the commercial sector and politicians depend on the results from a scientific community. If science is not of high quality, if it does not give rise to new knowledge and advanced technologies, and if it does not contribute to commercially exploitable innovations and increase the wellbeing of people, then it will not prevail.

Therefore, scientific quality is dependent on the perceptions of various individuals and social groups in science, and also in society at large. This means that we must take into account the social psychology studies of scientific quality. How is scientific quality perceived by scientists, and also by others? What perspectives do they have on scientific quality? What criteria of scientific quality are used in the judgments and evaluations of scientific outcomes? Is there a common view of scientific quality? How do perceptions of scientific quality vary between actors in science and in society at large? Such questions can be answered by social psychologists and in empirical studies of scientific quality (e.g. Feist, 2006; Hemlin, 1993; Shadish, 1998). Previously, this was an issue mostly dealt with by philosophers of science and approached in a normative way. Psychological studies can bring empirical research findings on perceptions of scientific quality to elucidate how quality is viewed.[1] Moreover, and importantly, empirical research can analyse how quality perceptions are used in practice, that is, when assessments of scientific contributions are conducted.

This chapter will start with a description of a framework for viewing scientific quality. Secondly, a presentation is made of a number of empirical findings concerning scientific quality. Finally, current changes in the views and assessment practices of scientific quality are outlined, and conclusions are drawn. The analysis of scientific quality and the empirical results in this chapter are based on a body of theoretical and empirical studies by the author of this chapter and by colleagues.

2. Theoretical framework of scientific quality

Research assessments or evaluations of scientific quality are part of a context where several different factors interact and where the interplay between the factors is essential to understand the concept of quality in science.[2]

Figure 1 presents a system of factors which is, I argue, important in research evaluations. The systems model bears some similarity to previous attempts to describe how research develops in interaction with external factors (e.g. Törnebohm, 1983). However, this model is new in that it should be viewed as a description of factors influencing evaluations of research and scientific quality.

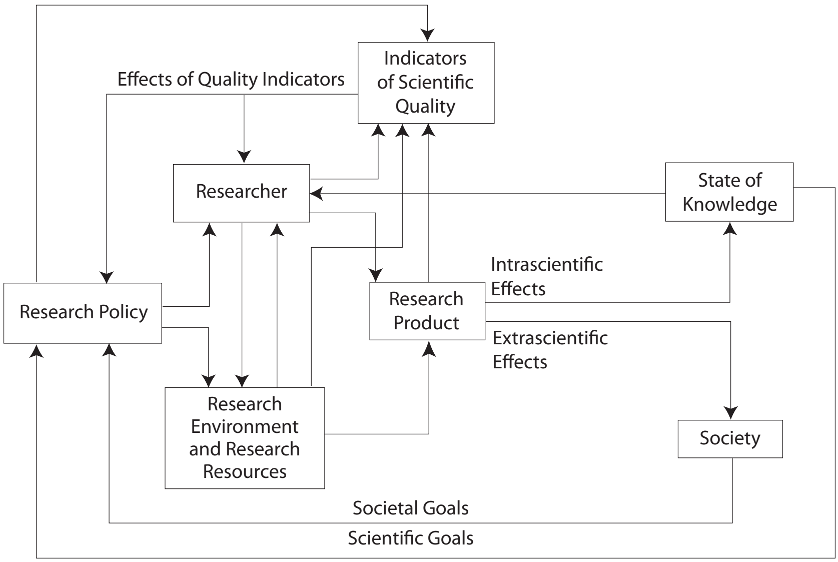
All factors in Figure 1 have a number of characteristics. The interplay between the factors means that these characteristics will be influenced. Further on, I describe each of the factors in the figure and present examples of the features of each factor, as well as relevant literature connected to the features.

The six factors in the framework are: the research product, the researcher, the research environment, research effects, research financing, organisation and policy, and research evaluation. In my view, all of these factors are to a greater or lesser extent taken into consideration in the evaluation of scientific quality by those who carry out the evaluation.

[1] Of course, other disciplines such as sociology and political science can also be helpful.

[2] This is further complicated by the fact that not only is the real interplay between different factors important, but also the evaluators' conceptions of this interplay.

Figure 1. Context factors in research evaluations



2.1. The research product

The object of evaluation is the research product, i.e. the end-product of research. This may be all the research carried out within a discipline, or just one scientific article. Relevant characteristics of the research product might be its breadth, depth, the clarity of the problem statement, the fulfilment of methodological demands, etc. These characteristics are supposed to be connected with the research product itself, and form the starting point for evaluation.

When scientific quality is evaluated, the object of evaluation is typically one or several documents which describe the research effort. These evaluations may be based on empirically generated, as well as normatively or theoretically formulated, quality criteria. A number of criteria have been suggested in the literature. For example, Smigel and Ross (1970) found that scientists ranked highest (in order) the criteria "interesting", "significant, meaningful", "well written", "informative and useful", "good methodology" and so on. Kuhn (1977) also suggested normative criteria related to scientific theory, which should show "accuracy", "consistency", "scope", "simplicity" and "fruitfulness". In a volume on the psychology of science, McGuire (1989) discussed criteria of scientific quality. He made a distinction between intrinsic criteria (e.g. internal consistency, novelty) and extrinsic criteria (e.g. the author's status, usefulness for valued human goals) in evaluating scientific explanations. In the same volume, Shadish (1989) added a distinction apart from the internal – external one. Science aims to achieve certain goals, e.g. truth, but also uses inputs and operations to achieve these goals, for example falsification. Shadish named these two components "outcome" and "process". Further analysis, review and categorisation of quality criteria in the literature can be found in Hemlin and Montgomery (1990).

2.2. The researcher

A research product is carried out by one or several researchers whose world view, knowledge, interest, intelligence and personality influence the direction and accomplishment of the research product. A number of authors have pointed out that the competence and the personality of the researcher is important for the quality of the research (see reviews by Feist, 2006; Hemlin et al., 2004). According to studies using a factor analysis of personality traits, the creative researcher should be ambitious, compulsive, enduring, seeking definiteness, intelligent, intellectually curious, dominant, orderly, authoritarian, non-seeking of help and advice, not fun loving, aggressive, showing leadership, independent, defensive, not meek, impatient, motivated and non-supportive. The three best predictors of research effectiveness were achievement, motivation and ambition according to Rushton et al. (1983) in studies of professors of psychology. Type A behaviour, i.e. strong and continuously forceful behaviour to achieve more in a short time and under pressure, was found among successful, male researchers (Matthews et al., 1980). The contribution of intelligence above an IQ score of 120 to successful research was small, according to a review of studies by Albert (1975). In his review of the literature (2006), Feist found the following characteristics to be more salient of creative scientists than less creative scientists: in the cognitive domain, openness and flexibility; in the motivational domain, a scientist was driven and ambitious; and finally in the social domain, the traits of dominance, arrogance, hostility, self-confidence, autonomy and introversion were typical of high-quality scientists. However, we still lack evidence of the directional influence between personality traits and scientific excellence.

Scientists have traditionally been viewed as more rational than others. However, Mahoney (1979) rejected the picture of the scientist as "rational man". Researchers, no less than other people, are affected by motivational and emotional factors, which in turn affect science and rationality. These ideas also go along with the results of Mitroff's study (1974), where the author found that Apollo moon scientists possessed deep intellectual, affective and personal commitment in their endeavour.

Age and creativity were reviewed by Simonton (1988) who found that lyric poetry, pure mathematics and theoretical physics showed early peaks (around the early 30s or even late 20s) in the age curves for creative output, while peaks were late (the late 40s or even 50s) in history, philosophy, and medicine. However, in many disciplines, researchers reached a maximum output rate in the intermediate years (around 40 years). Simonton also reported that the correlation between the eminence of psychologists and the age at which they contribute their most influential work was almost exactly zero (a result that goes for the arts as well). According to Feist (2006), the relation between age and productivity (quantity and quality) in science can be viewed as an inverted U. The peak across all fields is found at the age of forty, but different peaks occur for various disciplines, that is, they happen earlier for mathematics and later for biology, to take two examples.

A path analysis of the publishing productivity of psychologists showed that ability (a multiple indicator based on four data sources, mainly test scores), graduate programme quality, early productivity, the quality of the first job (i.e. ratings of departments on the quality of the faculty and its effectiveness in training scholars) and the gender of the researcher were causal antecedents across disciplines (Rodgers and Maranto, 1989). More interestingly, it was found that ability played an important role for all other predictors, suggesting the crucial role of the person, the researcher, and his/her competence. Another finding of importance reported by Rodgers and Maranto (1989) was that gender had a significant effect on the quantity, but not on the quality, of research. This finding indicates that women in psychology produced less than men, but they produced at the same level of quality. Earlier results have shown large gender differences in rank and salary that cannot be explained by differences in productivity or departmental prestige (Cole, 1979; Rodgers and Maranto, 1989). Studies by Cole (1979) in the 1970s among women with PhDs in the natural and social sciences showed that women were less productive as well as less cited than men. In the same study, ability and IQ measures of researchers with PhDs were high for both men and women.

2.3. The research environment

Immensely important for the research product is the research environment. For example, colleagues, students, premises, and the supply of research resources such as economic means and equipment form a scientist's research environment. The environmental and resource factors might influence the research effort more or less directly, but also indirectly through the relevance of the environment for the motivation and interests of the individual researcher.

An early review by Barron (1963) demonstrated that research creativity was stimulated by environments characterised by great freedom and lack of order. Research effectiveness, measured as productivity per time unit and group member and number of citations for the group, was found in one study to increase in the technical area with larger groups (Wallmark et al., 1973). However, group size was shown in another review not to be correlated with the individual output of scientists (Hicks and Skea, 1989).

In a study of successful researchers and information habits (Kasperson, 1978), it was found that the creative researcher was active in seeking information and exposed her/himself to an abundance of information inside and outside the research area. Leadership in high performing research groups was characterised by the experience and competence of professors and senior lecturers (Pelz and Andrews, 1966; Stankiewicz, 1980). A recent review of the literature on leadership and creativity revealed that apart from expertise it was essential for members of research groups to receive leadership support in various ways (Mumford et al., 2002).

In conclusion, the reviewed studies concerning the researcher and her/his environment present a picture of the successful researcher as one characterised by strong ability, an IQ score of around 120 but not necessarily higher, strong motivation, ambition and achievement. According to recent studies of creative knowledge environments, a scientist's environment can be summarised and divided into three main factors, i.e. cognitive, social, and physical factors, where it is clear that the first two exert the most direct and dominating influence. Further, it is shown in several studies in this review that the psychosocial climates of research groups are connected to the creative output of scientists. One repeated finding is that research group climates should mainly be open and allow freedom to scientists. Secondly, a heterogeneous composition of the group is important to promote creativity. Thirdly, it was found that group leadership, as mentioned above, influences group creativity in two main ways, that is, by expertise and social support to groups. Finally, rich information sources, good knowledge management, and access to frontline knowledge are typical of creative knowledge environments (Hemlin et al., 2004; Hemlin et al., 2008; Hemlin, 2006).

2.4. Research effects

Research can be viewed as having two main effects, i.e. intrascientific and extrascientific effects (e.g. Elzinga and Jamison, 1984). The intrascientific effects denote effects on the current state of scientific knowledge within the research area (e.g. if the research effort leads to the development of theories or methods). There might also be long-term effects (e.g. if the research product leads to a situation where new theories will be more easily formulated in the future). The extrascientific effects might concern the effects a research product has on society in the broad sense, e.g. groups of individuals in a country, the whole country, or all humankind. The extrascientific effects may be more or less direct or long term, and may be positive or negative. Positive effects are, for example, cures for diseases, new technologies such as safer vehicles, and improvements in the welfare of people. Bad research effects which could be judged as negative are the development of military arms or environmentally harmful technologies.

Intrascientific and societal factors are not only influenced by different research products, but they too influence research or rather how a researcher chooses problems and the methods to accomplish the work. Within the scientific community, as well as in society generally, value systems, ideologies, politics and markets exert an influence on the research carried out and also on how the research is evaluated. Several scientists have noticed the significance of different scientific views or paradigmatic views for the evaluation of scientific results (De Mey, 1982; Kuhn, 1970; Törnebohm, 1983). The significance of societal factors on science was emphasised early on by Hessen and Bernal (see Elzinga and Jamison, 1984), and by Merton (1938) in his classical study on influences from the military area and from the mining industry on the direction of research in England in the 1800s. The Swedish sociologist Brante (1984) presented a number of examples of how positions in scientific disputes can be explained with reference to personal and political factors. Proponents and followers of the Strong programme in Great Britain claim that all scientific knowledge is of social origin, or, as it is now coined, is socially constructed (e.g. Mulkay, 1979; Woolgar, 1989).

According to several authors, the extrascientific or societal effects of research are of the highest importance, although intrascientific effects are not neglected as an indirect means for the advancement of man and society. To this group of authors, one could include Hessen and Bernal (see Elzinga and Jamison, 1984), who were among the first to focus on the science and society link. This school of thought, based on pragmatism and Marxism, views basic and applied research as if it had the same ultimate goal, that is, positive effects on society. According to this school, quality in science should be viewed by the effects of science on society.

A large number of philosophers of science (e.g. McMullin, 1983; Niiniluoto, 1990) emphasise the intrascientific effects of science, i.e. whether the results contribute to scientific progress and ultimately the truth (or truthlikeness) of a phenomenon. The intrascientific effect of the research process must, in the opinion of these authors, be the primary purpose of science, independent of the societal effects. According to this view, the quality of science must be assessed by its internal effects.

2.5. Research financing, organisation and policy

The influence that intrascientific and extrascientific factors exert on research and its evaluation can be directed by research policy, which is the term for all activities aimed at steering research. This activity is often carried out by research councils and other funding authorities. It can also be carried out within the scientific community itself. For example, editors of scientific journals and researchers arranging scientific conferences have a more or less pronounced policy for their activities.

The direction of research within the frame of a research policy cannot easily be separated from societal interests originating more or less from outside the scientific community. As Fridjonsdottir (1983) re-marked, we can talk about a process of interaction between a national direction of research policy and activities within the scientific community. Similar views were proposed by Toulmin (1964) who emphasised that the successful direction of research presupposes that the research community is well integrated into society. Lakatos (1976) also showed a clear interest in society's role for science. He claimed that universal criteria, as opposed to elite criteria, should be applied to distinguish progressive research from bad research. According to Lakatos, scientists themselves should not decide on the criteria alone. Instead, they should guide societal committees (consisting of researchers and laymen) in the distribution of research funding. This is also a common topic in certain EU research programmes and in national contexts within the EU, for example in Denmark.

The criteria used for directing research are supposed to be similar to the criteria used for the evaluation of research products. Therefore, it should be relevant to distinguish between internal (intrascientific) evaluation criteria and external (societal) evaluation criteria (see De Mey, 1982; Fridjonsdottir, 1983; Weinberg, 1963). The emphasis laid on these criteria and the way in which they are measured by means of quality indicators are apparently dependent on the prevalent research policy. In this way, evaluations are part of an ever-changing cycle in which the criteria for quality assessments occasionally change through the effects of previous research on the current state of scientific knowledge, on society, and on research policy.

The relations between scientific quality and financing, and organisation and research policy have not been empirically investigated to the same extent as the previously mentioned factors, but they have indeed been very much debated. However, attempts have been made to study the differences in research output for basic, government and research council financed research versus research financed by sectoral funding.[3] In the Swedish case and in many other countries, research funding is channelled through four main sources. First, grants are channelled to research directly following governmental decisions to universities as block grants (to hire research staff and as basic resources for equipment). Secondly, research councils can fund scientists for projects after peer review (approved grant applications). Thirdly,

[3] Sectoral funding denotes government funding to societal or political sectors such as the military, construction, and energy sectors. Sectoral organisations in Sweden conduct research on their own and hire university researchers on contract research.

sectoral organisations such as the Energy Authority can provide money for university research on assignment or after an application from university scientists. Sectoral research in countries other than Sweden (e.g. Germany, Norway) is often done by scientists at institutes rather than at universities. Fourthly, industry or other private funding sources can fund research at universities.

An interesting point regarding funding sources is that they influence the perceived quality of research. It is often found that sectorally funded researchers regard sectoral financing as a good means for increasing the quality of the research output. However, researchers funded in other ways, especially researchers with grants from research councils, often have negative views about sectoral funding as a means to enhance the quality of the research. Sectoral funding of research was criticised by Elzinga (1988). He argued that sectoral funding of short-term and quasi-research projects leads to "deinstitutionalization", which results in a negative change and dissolution of the disciplinary structure of academic research. Hence, it is tempting to draw the conclusion that the "deinstitutionalization" of academic research described by Elzinga will have an impact on scientific quality. However, more positive views from scientists on external funding and its consequences for science were found in a Finnish study by Nieminen (2005).

Studies on research organisation were carried out by Foss Hansen (1988) who claimed that a number of control mechanisms influence research activities. She stressed mechanisms such as dialogue (within or between research departments), scientific norms (universalism, disinterestedness, etc), markets (the publishing market, the grant market, etc.), bureaucracy (exerted by funding agencies, university councils and local departmental offices), and democracy. The latter two mechanisms were proposed to work indirectly in influencing the conditions for research. Bureaucracy was excluded from the list of "good" mechanisms, since it is suitable only for routine tasks, and those tasks are not characteristic of science. Markets are also less "good" than the others, because researchers who adjust strongly to different markets may affect the scientific quality in a negative way (e.g. choosing a research problem might be influenced by opportunism). In sum, according to Foss Hansen (1988), a favourable research policy for scientific quality should de-emphasise bureaucratic control and set restrictions on market mechanisms. The quality of research might also, according to this line of reasoning, be attributed to how governments finance research and the way funding agencies and bureaucracies work (see also Elzinga, 1988).

Figure 1 above also presents two other causal cycles. One cycle concerns the effects the result of an evaluation has on the present research policy, which in turn can lead to a change in the research evaluation criteria. This cycle might presumably, and in the normal situation, be viewed as smaller changes to the present evaluation criteria within the frame of intrascientific and societal goals. The second cycle is viewed as the direct effects of an evaluation on the researcher, which might lead to an adjustment of his/her research in favour of the criteria used. This effect might in the next period increase the possibilities for an improved outcome in new evaluations. Such processes of adaptation can evidently become serious problems for future research on research evaluation, and for research itself.

2.6. Research evaluations

Finally, Figure 1 shows that evaluations (in the box labelled Indicators of Scientific Quality) might be influenced by factors external to the research product under scrutiny. On the one hand, the researchers' characteristics, such as position, age, or personality, influence the evaluation. On the other hand, environmental factors might be important, e.g. the status of the department that the researcher belongs to. How background factors influence the final outcome of research evaluation is an issue which is often discussed in the literature. Moreover, as can be seen in the figure, other factors may also influence evaluations.

2.7. An attempt to define scientific quality

The system presented in Figure 1 shows in a number of ways why it is difficult to precisely define the concept "scientific quality". First, scientific quality might correspond to a smaller or a larger part of the framework. A simple way of solving the problem would be to let scientific quality correspond to the methods used to assess scientific quality. The definition would then correspond to the box labelled Indicators of Scientific Quality in Figure 1 and be equivalent to an operational definition of scientific quality. However, such a definition makes it difficult to discuss how to assess scientific quality in the best way. It is important to know which aspects one wants to assess in order to make judgments on different methods or indicators. Scientific quality might then be defined in terms of the different characteristics of a research effort (stringency, originality, etc.). Another possibility is to widen the definition to encompass the intrascientific and extrascientific effects of a research effort that have either taken place or are forecasted.

I have now touched upon another difficulty in defining scientific quality, namely that this concept might correspond to uncertain effects and to effects that have not yet occurred. This problem implies that it will be difficult to achieve a precise definition because there might be different views to decide upon the research effects that have not yet occurred. In the history of science, there have been many examples of such unpredictable effects. A depressing example is the development of the atomic bomb as a consequence of research into atomic physics.

The conclusive difficulty in delimiting precisely what is meant by scientific quality concerns the nature of research itself, in which perceptions of what constitutes good or bad research vary between different scientific fields and time periods. The causal cycles depicted in Figure 1 imply that suitable assessment methods and quality indicators, desirable characteristics in research products, and intrascientific and extrascientific effects are permanently changing. These changes are the results of a process of interactions between new results in science and events in the world outside the scientific community.

This does not imply that it is not worth trying to pursue the meaning of scientific quality. I do not want to exclude that consensus is possible among scientists on a number of generally formulated, universal criteria on good research. Let us imagine that good research corresponds to the creation of clarity, the revelation of new connections and the beauty of a good theory or interesting results. The emphasis put on different aspects of research and the precise meaning of the suggested aspects might of course change. To allow such diversity in the meaning of good research is probably one of the most important preconditions for science to develop fruitfully.

3. Empirical research on scientific quality

As was evident in the previous sections on scientific quality, empirical research in this domain is here viewed as a relational concept. It is dependent on at least the presented six factors and their given interplay.

I will now make an attempt to delimit quality in research to its characteristic features. To test our framework and discover how such features are perceived and conceptualised, we asked scientists from various disciplines in Sweden what they believed was characteristic of good science in their fields. This study encompassed 22 scientists and gave us a first indication of scientists' perceptions of important quality concepts such as novelty, correct methods and a clear writing style which could be viewed as properties of the final research product. As a result of the study and the literature, we formulated a conceptual system that distinguished between different parts of the research process comprised of problem, method, theory, results, reasoning, writing style (*aspects*), and the value attached to each part, for instance an original result, a stringent method and a clear writing style (*attributes*) (Hemlin and Montgomery, 1990;1993). To validate our conceptual system, we constructed a questionnaire for a larger stratified random sample of scientists (n = 224) in the main research areas of academia (medicine, natural sciences, social sciences, technology, as well as the arts and humanities). In the questionnaire, we asked scientists to rate the importance of each aspect in relation to a number of chosen attributes as previously described. In addition, we asked scientists to rate the importance of the factors in the above framework when assessing the quality of science more generally. However, this approach to the study of scientific quality was focused on scientists' perceptions, which does not tell us how scientists behave when assessing scientific quality. To that end, we also wanted to know how scientists assess scientific quality in their science practice, that is, what criteria are used in peer reviews. In other words, we wanted to know not only what scientists perceive of research quality, but also if and how they apply their conceptions. To study scientists' quality assessment behaviour, we analysed the documents of the peer reviews of candidates for the position of professor (31 cases, from 1975 to 1984) (Montgomery and Hemlin, 1993). This method is feasible in Sweden (and perhaps in some other countries) since peer reviews of the candidates are done in writing and the reviews are publicly available documents. In addition, we analysed peer review documents of psychology grant applications submitted to the Swedish Science Council (Hemlin et al., 1995). The results of these studies will be described and compared in the following sections.

Our findings have been supported, to an extent that is surprisingly high, by similar studies in three other Nordic countries (in Denmark by

Andersen, 1997; in Norway by Gulbrandsen and Langfeldt, 1997; and in Finland by Kaukonen, 1997).[4] The results from the other Nordic countries were in agreement with our framework and the notion of a concept of scientific quality as a common language composed of aspects and attributes. The general finding was that scientists could easily rate aspects and attributes of research products to assess quality. For example, to use correct methods was perceived as one of the most important signs of scientific quality. The findings support our view that a common language among scientists could be used to assess the scientific quality of research products.

The results across all scientific fields including the arts and humanities showed that originality and correct methods were regarded as the highest ranked concepts of scientific quality. Some variations were found between the different data sets, but methods and novelty were generally the highest ranked quality concepts (see Table 1).

Table 1 also shows that researchers were united in perceiving methods, problems and results in connection with research quality in all studies. Only in the rating data set did we find a deviation where reasoning was emphasised above results. Novelty (originality), stringency and correctness were the most favoured attributes, but depth was also ranked high in the questionnaire study (Hemlin, 1993). In Hemlin and Montgomery (1995), the activity/productivity of the researcher featured more frequently than correctness. Breadth was more stressed than depth, except for in the rating data. Intrascientific and extrascientific relevance were equally stressed. However, intrascientific relevance was more emphasised than extrascientific relevance in the interview and rating data. In the data from the free answers, the results were reversed. In all the data sets, the most frequent combinations of aspects and attributes were correct or stringent methods. In an analysis of dif-

[4] ANDERSEN, 1997: Structured interviews – a formal questionnaire where data were collected in personal interviews/confrontations. A stratified random sample of 876 researchers: 680 in the social sciences, 99 in computer sciences, and 97 in the sciences and medicine. The response rate was 90.0% (788 respondents). GULBRANDSEN and LANGFELDT, 1997: Semi-structured personal interviews (a large number of rather open questions). N = 64 researchers from a non-random but purposeful selection of disciplines in each major academic field (30), from research institutes (22) and business companies (12). KAUKONEN, 1997: The survey was based on interviews (in 1989–1990) of all active research personnel (professors, lecturers and junior researchers) in six university departments/disciplines: zoology, biomedicine, automation technology, systems engineering, mathematics and statistics, and social policy. N = 217 (covering 87% of potential persons, varying between 80 and 100% per discipline. Both closed and open questions were used.

ferences between the soft (social sciences and the arts and humanities) and the hard sciences (medical, natural and technical sciences), it was consistently shown that soft scientists focused on the theory, reasoning, writing style and to some extent on the problems aspects, and on the stringency attribute when assessing scientific quality. In comparison, hard scientists almost uniformly stressed international relations as the best indicator of scientific quality.

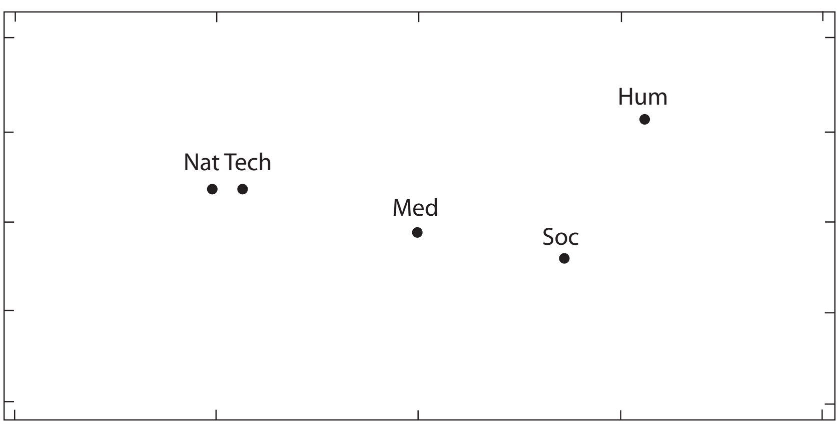
Table 1. Emphasis on specific aspects and attributes in four data sets

Emphasised aspects or attributes	**Hemlin and Montgomery, 1990** *(interviews)*	**Hemlin, 1993** *(free answers)*	**Hemlin, 1993** *(ratings)*	**Hemlin and Montgomery, 1993** *(documents)*
The three most emphasised aspects	Method Problem Results	Method Problem Results	Reasoning Results Method	Method Results Problem
The three most emphasised attributes	Novelty Correctness Stringency	Novelty Stringency Correctness	Correctness Stringency Depth	Stringency Novelty Activity/ Productivity
Emphasis on Breadth vs. Depth	Breadth Depth	Breadth Depth	Depth Breadth	Breadth Depth
Emphasis on intra-vs. extra-scientific relevance	Intrascientific Extrascientific	Extrascientific Intrascientific	Intrascientific Extrascientific	Intrascientific Extrascientific
The three most emphasised combinations of aspects and attributes	Correct method New results Stringent problem	Stringent method Correct method New problem	Correct method Correct results Correct reasoning	Stringent method Stringent writing style New results

Adapted from Hemlin and Montgomery (1993)

The differences between the scientific fields are summarised and shown through a multidimensional scaling procedure of results from the analysis of responses to all parts of the questionnaire (Figure 2). Figure 2 clearly shows different perceptions by hard and soft scientists, which is seen in the way the medical, natural and technical science respondents cluster together to the left in the figure, and the social sciences and arts and humanities respondents cluster to the opposite side (horizontal axis). Secondly, we can observe that the fields within the hard sciences differ with respect to the closeness to or distance from the soft sciences. The natural scientists are the hardest of the scientists, then come the technical scientists, and closest to the soft are the medical scientists. Among the soft scientists, it is clear that the social scientists are closer to the hard scientists, and the arts and humanities respondents take the most extreme position in the perceptions of scientific quality in comparison with the hard ones. If the vertical axis is considered, we will find that also here the arts and humanities take the most extreme position in comparison to the others and, rather surprisingly, they are farthest away from the social sciences.[5]

Figure 2. Multidimensional scaling showing scientific quality conceptions by Natural (Nat), Technical (Tech), Medical (Med), Social (Soc) scientists, and researchers in the Arts and Humanities (Hum)



Adapted from Hemlin (1993)

[5] The multidimensional scaling procedure does not lead to fixed labels for the axes. Instead, they must be inferred theoretically. The horizontal axis in Figure 2 is suggested as a hard-soft sciences quality perception continuum, while the y-axis is more difficult to title. The y-axis distinguishes between the arts and humanities, the hard sciences and the social sciences at the other extreme.

A more detailed picture of the differences between scientific fields is shown in Table 2 below. In this Table, the arts and humanities scientists are the most distinct representatives of the soft scientists. From the results one can see that they were *less* interested than the hard scientists in physical research environments, in international contacts, in successful research, in intrascientific relevance, in more directed research in industrial and sectoral financing, and in research evaluations. Instead, the arts and humanities researchers favoured reasoning and the writing style of papers as quality features. In addition, they supported the political and cultural effects of research and increased research grants. They also stressed the stringency attributes and theory aspects of research efforts, as well as creative research. Another significant feature of the arts and humanities researchers was that the individual researcher's brightness was perceived as important. Together with the social scientists, they differed from one or more of the hard sciences in regard to the favoured aspects of the research effort, that is, theory (in free answers), reasoning and the writing style.

Soft scientists laid less stress on international relations, emphasised political-cultural effects, were against external influences on research, and were less positive to research evaluations than hard scientists. In some areas, social scientists came close to the opinion of the natural and technical scientists. Productivity and international contacts were rated higher by social scientists than by the arts and humanities scientists, but both the researcher's brightness and increased research funding were rated lower. However, not surprisingly, social scientists rated political-cultural research effects more highly than the hard scientists. Technical scientists regarded extrascientific relevance as a criterion of scientific quality more than the natural scientists did. Natural scientists favoured economic resources more highly than the technical scientists.

Our results showed agreement on the fundamentals of science. They supported the framework, and the components of scientific quality appeared in the scientists' interview answers and were found important to scientific quality in the ratings. The aspect and attributes distinction in judgments on scientific quality was generally supported in the ratings and was by and large in agreement with the free answers. In general, international contacts, intrascientific effects, and varied research funding were considered essential for scientific quality.

Table 2. Significant differences in index variables between research fields

Index variable	**Arts & Humanities**	**Medical sciences**	**Natural sciences**	**Social sciences**	**Technical sciences**	**P**
Problem	>Nat**					.0045
Reasoning	>Tech*			>Tech*		.0073
Writing style	>Nat**			>Nat*		.0009
Stringency	>Nat**, >Tech*					.0050
Extrascientific relevance					>Nat*	.0213
International relations			>Hum*	>Hum*	>Hum*	.0001
Creative research	>Tech**					.0025
Successful research			>Hum**	>Hum*		.0001
Personal brightness	>Soc*, >Nat**					.0001
Physical environment		>Hum**			>Hum**	.0001
Material-economic effects				>Hum*		.0150
Political-cultural effects	>Med*, >Nat**			>Med**, >Nat** >Tech*		.0001
Against external influence on research	>Nat**, >Tech**	>Tech**		>Tech**		.0001
Block grants increase scientific quality	>Soc*, >Tech*		>Tech*			.0025
External funding increases scientific quality		>Hum*				.0087
Favourable attitude to research evaluation		>Hum**, >Soc**	>Hum**, >Soc*		>Hum*	.0001

Adapted from Hemlin (1993)

It was possible to identify differences supporting a distinction between the hard and soft sciences, since this distinction implies a differential emphasis on different factors and characteristics of scientific quality. Hard scientists de-emphasised all aspects of the research product, which may be an indication that the basics in science are not debated, which supports the conclusion. The theory aspects were stressed by the soft, but not by the hard, scientists. This is in line with Kuhn's paradigm theory (1970) where the pre-paradigmatic sciences debate fundamental theories enthusiastically, while the paradigmatic (normal) sciences focus rather on fact-gathering activities to strengthen already existing theories. However, another result contradicted Kuhn's theory, since the soft scientists favoured precision in research just as much as the hard scientists, even though one might expect hard scientists to be more interested in greater accuracy of results.

Whitley's (1984) differentiation of scientific fields into restricted and configurational sciences could be applied to the results. The hard sciences' de-emphasis of theory aspects of scientific quality concords with Whitley's restricted sciences as characterised by the sharing of common theoretical ideals and basic conceptual assumptions, besides being task specific and prone to using mathematical formalisms. In contrast, objects studied by the soft sciences are approached from competing theoretical perspectives in accordance with the features of the configurational sciences. Our finding that reasoning and writing style are stressed by the soft sciences researchers is also similar to Whitley's idea that configurational sciences make use of a greater variety of definitions and analyses of objects than restricted sciences.

Finally, the quality criteria in assessments of psychology grant applications were studied to validate previous findings from data on the perceptions of scientific quality and data from peer review documents where candidates for professorship were assessed. We analysed the review protocols (n=413) of grant applications to the Swedish Council for Social Sciences and the Humanities between 1988 and 1993 (Hemlin et al., 1995). The findings corroborated previous studies to a great extent, although some differences were found. The theory and method aspects, in that order, were the most frequently used aspects by peers in psychology. This result coincides with the previous results on favoured aspects in the social sciences from the ratings, but in reverse order. The stringency, novelty and correctness attributes, in that order, were frequently used to assess grant applications in psychology. In comparison with previous results from the social sciences, we can observe that novelty, stringency and extrascientific relevance, in that order, were most favoured. Apart from the third-ranked attribute (correctness), these results are similar to those of the grant application peers. This had been ranked as attribute number four in previous findings. However, extrascientific relevance was applied as an attribute in reviews by peers in psychology, but ranked one place lower.

In conclusion, peers in psychology appeared to share basic values in their reviews of psychology grant applications but also in the way they wanted to justify their recommendations to the applicants and to other members of the Board of the Social Sciences and the Humanities who make the final decision on grants. We should also take into account that rhetorical purposes, as well as notions about what is socially expected from the review protocols, may disguise some of the criteria that were applied in the reviews. It is well known that influences such as nepotism, sexism (Wold and Wennerås, 1997) and other biases may distort peer reviews.

4. Future changes in scientific quality perceptions and criteria

The final section of this chapter is devoted to the future of scientific quality. We have noticed in the period since the empirical studies on the perceptions of scientific quality and quality criteria used in peer review (from the 1980s up to the mid 1990s) that a lively debate on the changes in science and its conditions in society generally has been unfolding. This debate has occurred as much within the scientific community itself (e.g. the "science wars") as outside, with societal actors taking part more intensively. We have witnessed a science policy discussion, starting in the 1990s, about a new mode of science, an on-going shift from mode 1 (traditional science) to mode 2 (context dependent science) (Gibbons et al., 1994) and science in a steady state (Ziman, 1994) and the triple helix of universities, industries and governments which it is suggested blurs the borders between science and society (Etzkowitz and Leydesdorff, 1997).[6] All these observations on scientific development are still weakly supported by empirical data. However, there are some studies that seem to give partial evidence of this "new" science (Hemlin, 2000; Hicks and Katz, 1996). If these trends are taken to be

[6] However, an early observer of changes in scientific knowledge production called it "industrialized science" (Ravetz, 1971).

true, it would be surprising if they did not cause changes to scientific quality assessments and even to scientific quality itself. The big questions are only how these will change, what factors are changing, and what aspects and attributes will be favoured.

In a rather recent paper we discussed the issue of changing quality criteria in research evaluations and the consequences of such (Hemlin and Rasmussen, 2006). In Table 3, a draft is shown of what we believe is happening in the scientific community and its relations to society at large in connection to quality criteria and assessment. Our argument in the article is that developments in science and new perspectives on science are transforming academic quality control into a quality monitoring system that has a process rather than product orientation, uses new criteria, has other foci and goals, uses different peers, different evaluation times, and brings new and organisationally based perspectives to science and technology studies.

Table 3. The transition from quality control to quality monitoring in science

Dimension	**Quality Control (product orientation)**	**Quality Monitoring (process orientation)**
Criteria	Scientific	Scientific and social
Focus	Individual researchers	Organisations, networks
Goal	Valid, reliable knowledge	Socially robust knowledge, learning
Evaluator	Traditional peers	New peers, users, consultants, lay persons
Evaluation time	After production	Continuously
Science study perspective	1st order: Philosophy and sociology of knowledge	2nd order: Knowledge management, organisational learning

Adapted from Hemlin and Rasmussen (2006)

The drivers of this change, we argue in the paper, are new forms of organisations in knowledge production that are erasing the public and private distinction (e.g. Hemlin, 2001). It is not only universities that produce socially demanded knowledge in contemporary societies, but private knowledge enterprises, knowledge brokers, consultancies and think tanks. It appears also that the boundaries in science and society are dissolving, such as the distinction between basic and applied research, disciplinary structures (within academia), and the previously strict borders between university, industry and government. For example, we have a wide range of university-industry relationships, but also a number of university links with the public community. We have also noticed a more pronounced end-user orientation in science policies at large. There is more emphasis on applications, social accountability, and a capitalisation of science in science and science policy discussions. For instance, the commercialisation of scientific results is nowadays an important research policy goal in many countries. Finally, scientists' behaviour is changing in that heterogeneous skills and knowledge (e.g. interdisciplinarity), reflexivity (e.g. putting scientific actions into a societal perspective), new careers (e.g. in the private sphere), new organisations (e.g. semi-public-private institutions), and new forms of science (e.g. by means of visualisations in medical fields) are becoming more frequent.

In addition, we also have noticed new views of science influencing quality control. They are summarised in the following observations. The first is an *external view*[7] of science as expressed, for instance, in the book *The new production of knowledge* (Gibbons et al., 1994) that has its roots in the Mertonian tradition of science studies which is empirically based on a critical realist tradition. As opposed to this stance, there is simultaneously an *internal view* of science, as can be found in the works by, for example, Latour (1987), which is conceptually rather than empirically based and is characterised by a social constructivistic epistemology.

The internal view would imply that scientific quality is a relative concept resulting from negotiations between scientists in each scientific field, or rather sub-field. This would mean that quality conceptions were no longer founded on the evaluation of empirical research, methods and findings. Instead, quality issues would be linked to social and scientific influence and power, negotiation skills and rhetoric. For example, "old boy networks", the prestige of universities and journals, and other social characteristics in the scientific community would win. In Merton's terms, the norm of universalism would no longer be an option.

[7] External means in this context a view of scientific knowledge which does not admit that social factors can penetrate the epistemological core, but only influence or possibly distort it. Accordingly, the epistemological core can only be changed by epistemic arguments. In contrast, the internal view of science argues that scientific knowledge is solely socially constructed and that the epistemic domain is collapsed into the social (see e.g. Cole, 1992).

Another feature of the new views of science concerns the problematic distinction between basic and applied science, which is so often pronounced nowadays. A number of authors criticised this traditionally fundamental divide in the sciences as outdated and historically biased (see Stokes, 1997). Moreover, Ziman (2000) argued that basic and applied science can both be used as terms about the same research activity, depending on the context and who addresses the research. A scientist may carry out basic research, although the grant for the research will be designated as funding for applied research by the funding body, and where the departmental unit where the research is taking place is named "Applied Psychology".

We have also witnessed a shift in the view of knowledge, from certified knowledge ("justified true belief") according to the philosophy of science tradition, to socially robust knowledge (Nowotny et al., 2000). The latter view is based on a number of features where the most important ones are: a pragmatic view of science where knowledge is established through its use rather than on certified knowledge; an emphasis on interdisciplinarity applied in trading zones where different disciplinary-oriented scientists collaborate; and value-integrated knowledge where societal values are merged with the intrascientific views of what is typically good science.

Another trend in the literature, particularly in science policy contexts, emphasises less the individual researcher than the knowledge producing organisation in quality assessments by focusing on both truthlike knowledge and trustworthy management, as well as the demand for collaboration or collective research (e.g. in networks, centres of excellence). This view of science brings the knowledge producing organisation, rather than the individual scientist or research group, into the foreground of quality control.

Furthermore, the division between science and society is viewed in a new light. Science is now more of a reflexive, social knowledge working institution and an open system, which establishes itself by continuous evaluations, and through science and social partnership. This means that the distinctions between science and society are no longer as important, but are rather viewed as interacting parts or aspects of one system. The traditional social contract between science and society in Vannevar Bush's terms is re-negotiated.

In summary, we argue first that the shift in academic quality control is related to the skills and abilities of the knowledge environment to learn (this environment can be seen, for instance, as a group, a department or an organisation). Quality control will change from being purely cognitive and epistemological to becoming more than a social and organisational phenomenon. This will influence researchers in the field of science and technology studies to interact more frequently with researchers who have organisations (or organising) as study objects.

Knowledge management and organisational learning will become a scientific task rather than a management task. This is the consequence of the observation that science depends to a large extent on its ability to reflect and act on its cognitive, social and institutional base. Basically, knowledge management is also a task that universities, rather than businesses (where the term was invented), should be able to handle professionally.

Organisational learning in science will be based on both internally and externally oriented processes and should be based on an open system perspective, where double loop learning can take place (Scott, 1981). Such organisational learning processes will internally entail ways of building, supplementing, sharing and organising knowledge and routines. Moreover, the organisational learning processes directed to the external environment of scientific organisations are processes that aim at adaptation and change. An organisational learning perspective on quality issues in scientific organisations as outlined here will probably be a crucial task for conceptual and empirical research in the future.

5. Conclusion

This chapter has presented a relational view of the scientific quality concept. Different factors can be taken into account when we conceptualise scientific quality. It can be viewed in terms of a research product (e.g. an article), a research environment (e.g. colleagues, premises), research effects (e.g. new theories, new medical drugs), research financing, organisation and policy (e.g. support to centres of excellence), and research evaluation (i.e. how scientific quality is assessed). It was further suggested that these factors interact with one another. For example, a certain research policy may promote a new field in science which favourably meets societal needs. A way to delimit scientific quality was suggested by focusing on the research product and its properties. According to this view, quality in science could be described in a common language of aspects (e.g. methods) and attributes (e.g. originality).

The relational view of scientific quality is a conceptual model which is valid over time since it is flexible in the context of changes in the perceptions of scientific quality. The latter part of the chapter looked ahead at scientific quality and its assessment. It was suggested that changes are occurring in how quality is perceived in science and society. We argued that this change would lead to a process rather than a product perspective of scientific quality. This implied that the quality criteria drifted from science to society, the focus shifted from individuals to organisations, the goals changed from valid and reliable knowledge to socially robust knowledge, the evaluators incorporated new actors, the evaluation times occurred more frequently, and the science studies perspective shifted to knowledge management and organisational learning perspectives.

The new perspective on scientific quality is compatible with the previous framework in that it shifts the focus onto factors other than those previously (or currently) applied. Whether or not this is a true picture should be subject to empirical tests. And whether or not this is beneficial should be discussed by scientists, research policy analysts and others. Ultimately, we should be convinced that scientific knowledge is never fixed.

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How do scientists perceive scientific quality?

1. Main directions in scientific quality studies

Studies of scientific quality have been at the centre of attention of the sociology of science since its very beginning, usually associated with Merton and his followers (Ben-David, 1978). The very first publications, but especially the most important works in the new field within the Mertonian theoretical landscape, discussed scientific quality, which was initially understood as scientists' (most) important cognitive or scientific contributions to the body of knowledge of a certain field (Hagstrom, 1965; Merton, 1973; J. Cole and S. Cole, 1981; Zuckerman, 1977). The establishment of the Science Citation Index and citation analysis, of which Derek de Solla Price (1965) is generally believed to be the founding father, spurred investigations into scientific excellence, not only in the sociology of science, but also in the wider field of the social studies of science, and the broadest research in science studies.

Scientific quality is not a topic reserved exclusively for researchers of science – philosophers, sociologists, historians, psychologists, political scientists, scientometricians, and information scientists – as it has attracted other researchers from all scientific areas and from the most diverse scientific fields. For the practical needs of their (sub)discipline, they attempt to define professional, cognitive and ethical standards, specified criteria of promotion in science, or simply set down instructions for reviewers of scientific publications and projects. Observing the widest circle of researchers of science, and especially the more narrow circle of social scientists in that area, we can identify three major streams of empirical research and evaluations of scientific quality.

The first stream includes numerous bibliometric studies of scientific excellence, which is often identified with the visibility of scientific production, mostly articles by individual scientists, research teams, individual fields or specialities, university departments, individual institutions or even whole universities, and even countries or regions of the world. Other important indicators of quality, such as the impact factor of science journals, are also based on citation rates. Despite the numerous and well-founded criticisms that they reduce scientific quality to citations, bibliometric methods have established themselves as a methodological tool that can be very useful in obtaining a deeper insight into scientific excellence when combined with other approaches and methods (Garfield, 1979; Gläser and Laudel, 2001; Van Raan, 2004; Leydesdorf, 2005). In the research practice of the hard sciences, bibliometric indicators of scientific quality (citations received) are one of the key measures of scientific promotion, research funding and, in Bourdieu's terms (2004), other symbolic forms of recognition transformed into resources and awarded to scientists for their scientific contributions.

The second stream focuses on investigating the oldest evaluation system, that is, the qualified judgments or assessments of scientific work, or peer reviews. Being liable to subjective influences, peer reviews are a frequent topic of various studies that often aim to determine the level of universalism in evaluating the quality of individual papers, the scientist's overall research work, the production of project teams or even of some (sub)specialties (for example in review studies). The studies investigate the criteria and adequacy of judgments, the forecasting accuracy in the evaluation of future research (project proposals), the evaluator's or reviewer's bias, and the influence of the researcher's professional position and standing in evaluating research and publications (Chubin and Hackett, 1990; S. Cole, 1992; Hemlin and Montgomery, 1993; Luukkonen, 1995; Hemlin et al., 1995; Frankel and Cave, 1997; Gläser and Laudel, 2005). Normative studies, which focus on critical analysis of the criteria for evaluating scientific excellence, trying to enhance them in the hard sciences (Buchholz, 1995), as well as in the social area (Breuer and Reichertz, 2001), also belong to this course of research. Regardless of subjective influences in the process and result of evaluation, peer review is still considered irreplaceable in the science evaluation system.

Due to the disadvantages of both evaluation systems – the quantitative type, especially bibliometric procedures, and peer reviews – there is also a third, mixed type of approach that investigates and compares the results of peer reviews and bibliometric analyses. However, this is not a new trend in sociological and psychological studies. It was precisely the high correlation of citation rates and peer reviews that formed the basis for identifying quality with the visibility of scientific papers (Cole and Cole, 1981). The two approaches were connected in later studies as well, showing (depending on the field or problem under study) various relations between the evaluations of competent colleagues and citations. Some of the studies confirmed the great concurrence of the two evaluation procedures (Rinia et al., 1998; Bornmann and Daniel, 2006b). Others brought attention to the bias of peer reviews, while the third stressed citation counts as a good, but fallible, indicator of the quality of most creative works (Shadish et al., 1995; Bornmann and Daniel, 2006a). The fourth group of studies draws attention to some of the weaknesses of both evaluation procedures (Aksnes and Taxt, 2004; Reale et al., 2007), while the fifth group shows a lack of significant correlations between the scientist's citation rate and peer reviews (Sonnert, 1995; Gläser, 2004). Despite the rather disparate findings, both procedures are used in the evaluation practice of a number of hard fields, and investigations into their successfulness and interrelation are very promising (Tijssen, 2003; Van Raan, 2004).

A separate, smaller corpus within the second research stream consists of the studies of perceptions of scientific quality. The studies are based on various theoretical starting points, and they use qualitative methods such as interviews and open-ended questions and/or quantitative methods such as ratings of closed responses/items on multi-point scales. In order to determine our theoretical and methodological starting point, it is important to provide a brief analysis of studies, excluding the already presented studies from the Nordic countries (Hemlin, 2009).

In contrast to the already mentioned study by Smigel and Ross (1970), whose analysis of assessments by reviewers of the Social Problems journal established that papers were usually accepted because they were found interesting, important or significant, or well-written, Chase started off from Merton's theoretical claims on scientific norms. Out of the ten criteria offered for evaluating scientific papers, respondents from selected departments of the top ten American universities ranked logical rigour, replicability of research, clarity of style, and conciseness and originality as the most important criteria. Significant differences were found among (105) natural scientists and (86) social scientists in ranking the importance of the majority of criteria, including the most significant ones. The former valued replicability and originality as the most important standards, while the latter considered logical rigour the most important criterion. The two groups of scientists showed no significant differences in ranking clarity of style and conciseness (Chase, 1970).

In interviews with 90 scientists from the Nordic countries whose work was subject to evaluation procedures, Luukkonen (1995) also asked the respondents about the criteria which they believed were used in the evaluation procedure. Most of them listed the usual criteria of quality such as originality and innovation. In addition, some other criteria, such as experiments, verifiability, international publication, visibility and international cooperation, also dominated the fundamental natural sciences.

Another Nordic study also determined disciplinary differences in the concepts of quality, and this on the basis of 33 semi-structured in-depth interviews with Finnish scientists from four fields of science – physics, biology, sociology and history (Kekäle, 2000, 2002). Physicists avoided defining quality and focused on the methods of its evaluation. In their opinion, the international review system was objective, reliable and the best way of evaluating quality. Biologists highlighted the same aspects of quality evaluation, but they did not show such firm conviction in the objectivity of international peer reviews. Sociologists defined quality using general terms such as *interesting* or *fruitful* study, but they also pointed out some general common criteria of high quality: good questions related to appropriate paradigms, extensive literature, reflexivity, and, especially, new perspectives created by the research. Historians highlighted reliability and accuracy as the main criteria of quality research (Kekäle, 2002: 73–74).

We can also draw indirect conclusions on the criteria of scientific quality on the basis of the importance that Croatian scientists, both eminent and young, attached to the professional values or standards of their field. Eminent natural and social scientists ranked conceptual precision at the very top, at the same time ascribing great importance to some other characteristics of scientific work, but nevertheless rating them lower. They did not differ significantly in evaluations of general logical rigour and stylistic precision, but they showed significant and great differences in evaluating the importance of precise measuring (Prpić, 1997: 75–76). Young researchers also attached the greatest importance to conceptual precision, ranking it first (natural scientists) or second (social scientists). Logical rigour and stylistic precision ranked much lower, and no significant differences were noticed in those above-average evaluations of its importance as were seen in the importance given to precision in measuring (Prpić, 2004).

More recent studies, just like the Nordic studies presented in the previous chapter, show marked similarities in the concepts used by practising scientists to determine scientific quality, regardless of whether they are allowed to freely state their opinions or whether they are asked to rate the significance of predefined elements of quality. The similarities certainly provide good foundations for defining the category system important in the empirical analysis of scientific quality, assuming that such a study is epistemically relevant.

2. Approach and methods

2.1. Goals, hypotheses and methods

As the overview and analysis of empirical studies show, studies of scientists' perceptions of scientific quality are indeed scarce among the impressive body of works focusing on bibliometric evaluations of quality and peer reviews. With the exception of a few older works, most of the studies of scientists' perceptions were conducted in the 1990s in the Nordic countries. These countries had adopted the Swedish research policy which was formed in the 1970s and 1980s, so that, in addition to the scientific interest of Nordic science researchers, changes in the scientific, and especially evaluation systems, also stimulated their investigations into scientific quality.

Both cognitive and policy interests have driven this study of the perceptions of quality of the Croatian scientific community. To be more precise, regarding the former dimension, it is not sufficient to know only the evaluation procedures and the criteria that the so-called gatekeepers or elite reviewers really use when evaluating scientific contributions in their field. It is equally important to gain insight into the broader intellectual and value landmarks of the members of the scientific community, especially because their citation practices or selection of references determine another form of evaluation in science – citation rate. Although interest in this topic is minimal within the constructivist understanding of scientific quality, its relevance is none the lesser. A comprehensive insight into the evaluation process in science, including its understanding (in the Weberian sense), is not possible without knowing these professional values and standards, despite the fact, or precisely because of the fact, that scientific practice deviates from them to a lesser or greater degree.

Alongside the cognitive aspect which is especially important to the Croatian scientific community because its perceptions of quality have not been investigated and are not yet known, the goal of the planned research has its social and practical aspects. In other words, the scientific system, especially its evaluation subsystem, will have to be subjected to newer and more difficult changes in order to adjust to European and world standards, and especially in order to rectify the crucial weaknesses manifested in the evaluations of scientific work. The inadequacy, inconsistency and lack of transparency of the criteria for judging scientific quality and the insufficiently defined position of bibliometric indicators remain the biggest problems of the Croatian evaluation system in science. In brief, with empirical insight into the scientists' criteria for judging quality, that is, insight into the social or value capital of the Croatian scientific community, the coming changes in the system will be more efficient.

Although conceptions of scientific quality do not represent scientists' cognitive convictions in the strictest sense of the word, they are nevertheless inextricably connected to the perceptions of science and the criteria of recognising and acknowledging contributions to knowledge, which are usually the standards for scientists in their own work as well. In the sense of the normative or value standards and ideals of scientific research, we can understand the conceptions of scientific quality as a form or even an indicator of scientists' epistemic concepts.

The theoretical starting point of the research is twofold. The wider theoretical framework of studying scientific quality, as well as the new tendencies in its evaluation that may be brought about by changes in the relation of science and society, has been presented in detail in the previous chapter (Hemlin, 2009), so there is no need to repeat it here. The category system inspired by the framework (also) used in this study will be described in the following subsection. However, the basic hypotheses of the empirical analysis of scientific quality are not as tightly connected to the framework as they are to the even wider sociological approach of the whole study.

This approach starts from the basic assumptions of the theories of scientific fields (Whitley, 1984; Fuchs, 1992). However, the hypothetical framework has been modified by integrating the thesis on the nucleus of the shared socio-cognitive characteristics of science which distinguishes it from other forms of cultural and intellectual production in society (Prpić, 1997). According to this starting hypothesis, scientists' concepts of scientific quality in the natural and social sciences would have to share some relevant characteristics, especially those referring to the general properties of quality. On the other hand, they would also have to differ in the two observed scientific areas since their cognitive practice and style, connected to the corresponding mode of knowledge production, also differ.

The most suitable approach in the first study of quality perceptions in the Croatian natural and social science communities was the respondents' free expression of their opinions, revealing their definitions of scientific quality and the characteristics they ascribe to it. In short, respondents were not offered already formulated answers and definitions of quality. We also wanted to investigate whether Croatian scientists would, like those from the Nordic countries, clearly distinguish the research process from its attributes. Finally, we wanted to know whether their perceptions would correspond to the concepts of quality expressed by scientists from other scientific communities.

The first web survey of natural and social scientists thus also included a question on scientific quality. The first chapter (Golub, 2009) described in detail the scope of the planned population of scientists, its response rate, as well as the characteristics of the obtained samples of researchers.

After a brief introduction encouraging respondents to cooperate and focusing their responses on their own disciplinary context (Prpić, 2009), respondents were asked the following questions: *What is scientific quality in your opinion? Can scientific quality be measured?* In total, 264 natural scientists and 141 social scientists answered the first question, securing high response rates of 85.2% and 84.4% respectively. Furthermore, 267 or 86.1% of the former and 141 or 84.4% of the latter responded to the second question, thus posting the same or almost the same response rate. These are also the final samples of respondents (N) for these scientific areas in the analysis of scientific quality perceptions.

2.2. Categorial system of perception analysis

The more recent qualitative studies of perceptions of scientific quality have developed somewhat different categorial starting points than those found in older research. Gulbrandsen (2000) distinguished among four major aspects of quality research based on interviews with 64 respondents from universities, institutes and industry. The first is solidity, which rests on well-founded conclusions, sound documentation and data, on consistency and coherence, factual interpretations, impartiality, clarity and stringency. Originality is the second aspect, and it can refer to academic novelty or it can be practical in nature and refer to practical problems. The third aspect is scientific relevance which rests on cumulativity (complementarity to other contributions and the opening of new research fields) and generality – general principles and research methods. The fourth aspect concerns practical utility, long-term or short-term, for specific users or broader social sectors – health, economy, and environment. Furthermore, he even assumed and showed that tension and even conflict among these aspects of quality were unavoidable (Gulbrandsen, 2000, 2004).

An even broader category system had been developed earlier in the studies of perceptions of Swedish scientists (Hemlin and Montgomery, 1991; Hemlin, 1993, 2009). It is theoretically more elaborate because it brings into play more factors that participate in creating scientific quality, and on which it depends, and these are: research itself or its product, the researcher, the research environment, extrascientific and interscientific research effects, as well as funding and the organisation of research. It remains to be determined whether Croatian scientists would identify some of these factors, since they were not requested to rate them, as the Swedish scientists were (Hemlin, 1993).

The concept of scientific quality rests on the distinction between its aspects and attributes. *Aspects* refer to parts or constituents of the research process, from the selection of the research problems and theoretical framework of the research, method, reasoning, all the way to the final stages of the research: results and style of the published paper. *Attributes* are the properties that are or can be ascribed to any of the constituents or phases of the research process, which include: novelty or originality, rigour, accuracy, extrascientific and interscientific importance, width, depth and productivity (Hemlin, 1993: 10). In theoretical terms, the distinction between aspects and attributes of scientific quality can be useful because it allows quality to be understood as a property of the overall research process or its product, but also as a property of its individual stages. However, Gulbrandsen's classification of attributes of scientific quality is probably more consistent and economical. In principal, it is possible to combine both classifications, thus establishing the third one which includes partly modified aspects and attributes of scientific quality.

Theoretical reasons and the consistency of individual categories of aspects and attributes of quality were not the only criteria in the modification of the categorial system, and they were supplemented by their adequacy in the classification of the obtained empirical material: the respondents' open-ended responses. In other words, we intended to build a categorial system that would have a double foundation – theoretical and empirical. For that reason, we reduced the original aspects of scientific quality, or parts of the research process, to *problem, method, results/cognitions* and *publication/production,* which means that three original aspects – *theory, style* and *reasoning* – were excluded from the system as separate categories, and *production*, an attribute in the original categorisation, was added as an aspect.

Theory appeared extremely rarely in the respondents' answers – only in two responses of natural scientists and eight times in the responses of social scientists. Even then, theory was not mentioned as a special aspect of research, but rather as its sub-aspect, usually as a framework that connects and explains new cognitions or scientific results, and more rarely as a starting point in the articulation of the research problem.[1] It is important to respect the respondents' line of reasoning in such situations, so we classified the references to theories in line with their original categorisation as aspects of scientific results/cognitions or research problems.

The rare explicit mention of theory should not be interpreted as the respondents' indifference to theory. It is more likely that they treat it as a given framework, as a measure of quality, and not as its aspect. Such a relation could be logical in the paradigmatic sciences that are characterised by the saturation of research, with theory in the so-called normal phase (Fuchs, 1993; Becher and Trowler, 2001). The pluralism of theoretical orientations in the social sciences is usually considered as the grounds for controversies and disputes (Fuchs, 1993), which does not undermine the importance of theory in research. On the contrary,

[1] Here follow several examples of context and meaning where respondents mention theory: "Connecting the results of different types into a general theory"; "... whose final results are also new theories that can be empirically verified"; "effort to contextualise the known results and to draw up a theoretical model".

disputes only indicate the importance that a certain theory holds for its advocates.

The importance of theory for scientists is also indicated by the studies of the professional, cognitive and social values of eminent and young scientists, since both groups rated the precise concepts and integrating role of theory very highly in both the natural and social sciences (Prpić, 1997, 1998, 2004, 2005). Finally, Swedish scientists also mentioned theory as an aspect of scientific quality more rarely than *method, problem* and, partly, *results* (Hemlin, 1993).

The *style* of a science paper was also rarely mentioned in the respondents' answers: nine times by natural scientists and four times by social scientists, more often being mentioned as a component of the scientific product, that is, publication: "the good structure and clarity of a publication", "clarity and simplicity of presentation of one's own knowledge". Thus, we listed style as a new aspect of scientific quality: production or publication.[2] *Reasoning* was usually connected to the interpretation of results and data in respondents' open-ended answers, but not to other stages of the research process, although it is necessary in all of them. Having in mind the way respondents themselves understood reasoning, stressing its importance in the final part of the research process, we also put that aspect into the category of results and cognitions.

The latter category included both results and new knowledge (cognitions) because respondents do not make a clear distinction between the two. They call research results answers to the posed scientific question, an advancement in a specific field of science, while the link between the results and knowledge was expressly stressed by one respondent who said that high-quality results represented "a certain breakthrough, that is, bringing a new cognition...". Thus, inclusion of results and cognitions together into the same research aspect is also based on the perceptions of the respondents themselves. Finally, publication of results or scientific production is more often understood as

[2] Empirical comparisons of the style of scientific publications, especially clarity, showed interesting differences among the natural sciences, social sciences and humanities, particularly in sentence length, use of the passive voice, and readability. The results of various studies are not uniform. Papers in the social sciences and humanities usually use longer sentences and less passive voice than natural science papers whose readability, measured by the special Flesch Reading Ease score indicator, is often greater than that of papers in the social sciences. However, there were also disciplinary differences, which indicates a need for further research (Hartley et al., 2004).

an aspect, sometimes an indicator, of scientific quality than as its attribute.[3] Since publishing is usually the final stage of the research process, it is reasonable to treat it as an aspect of scientific quality, which is also in line with the respondents' perceptions. Naturally, there is also ground for the opposite standpoint since some studies show that the quantity of production is the best predictor for peers' quality assessments of the scientist's body of work (Sonnert, 1995). However, in this case we have an indicator, and not an attribute, of scientific quality.

We classified the attributes of scientific quality using the typology of minimal requests or criteria of scientific quality (Gulbrandsen, 2000). Accordingly, we distinguished among *solidity, originality, scientific and social importance.* The mentioned author speaks of academic and practical value, while others differentiate between extrascientific and interscientific relevance (Hemlin, 1993). However, the terminology has to be made as precise as possible and it even has to be brought up to date, and needs to establish a conceptual connection with more recent sociological theories that insist on the social accountability and reflexivity of scientific research (Gibbons et al., 1997). For this reason, we use quite precise syntagms of scientific and social relevance. According to our respondents, the first refers to a significant contribution to the field of study, to a "lasting contribution to science" and all the way to the results that are interesting and important to the scientific community, findings that become "a part of the citations in the scientific literature". The other, as in Gulbrandsen (2000), has two dimensions – practical, useful and applicable, but also of (the) broad(est) – social and humanistic importance: a "contribution to the culture of the society to which the scientist belongs, and thus also the culture of humankind", something new that "improves the lives of people in any way" or "makes the world better".

Originality, like the categorisation of the open-ended answers of other authors, included alternative terms used by the respondents, such as *new, innovative, creative. Solidity* denotes a whole set of attributes, some of which are very similar, and even identical, to those that both Norwegian and Swedish scientists stressed as indicators of scientific quality. The biggest subset within the solidity category refers to *objectiv-*

[3] This is evident from the following respondents' answers: "show the obtained results in internationally renowned journals"; "scientific results published in scientific papers"; "production and presentation of scientific results"; "results published in renowned scientific journals"; "publishing a scientific paper in a certain science journal indicates scientific quality".

ity and the related attributes of the research process and products, such as truthfulness, reliability, replicability. The second subset consists of demands for the most *comprehensive* and complete research endeavour and outcome, and these are, according to the respondents themselves, systematic quality, thoroughness and comprehensiveness. The third subset includes coherence, precision, accuracy, adequacy, rigour, clarity and similar qualifiers that suggest the perfection of the design and conduct of research. Accordingly, solidity in general refers to the highest standards or norms of scientific work, professional mastery, or research conducted according to the best professional criteria.

3. Natural and social scientists' concepts of quality

Based on the described categorial system, the respondents' open-ended answers were categorised and quantified. Table 1 shows the results of measuring the frequency of mentions of certain aspects and attributes of scientific quality in those answers.[4] Having in mind this methodological comment, it is clear that natural and social scientists more often state attributes than aspects of scientific quality. Their understanding of scientific quality seems to be more related to the relevant characteristics of quality than to individual stages of the research process whose excellence can be evaluated. In this respect, they differ significantly from the Swedish scientists where no such discrepancy was noticed. The Swedish respondents referred to attributes slightly more often than they mentioned aspects of quality (Hemlin, 1993). In other words, our respondents also distinguish between different phases of scientific research and their qualifiers or quality designators, but judging from the differing frequency of mention, they tend to emphasise the distinction more. According to their views, it seems that excellence is relatively more often understood as a property of the whole research

[4] It is important to make a remark regarding methodology which naturally also has substantive effects. Only the respondents who expressly mentioned at least one aspect or attribute were included in the count. The number of such respondents (N) was the basis for calculating the percentages. Considering that many answers mentioned several aspects or attributes, this was a multiple choice situation. A first look at the number and percentage of respondents who highlighted at least one aspect of scientific quality shows that their number is lower than the total number of respondents, despite the multiple choice. In terms of attributes, their number by far exceeds the number of respondents, which means that more respondents mentioned attributes (at least one) than aspects. The multiple answers were precisely the reason why chi-square tests were calculated on the basis of frequencies, and thus in fact show the significance of differences in the structure of answers, and not of respondents.

cycle, from the problem choice, to publications, since the individual stages of the cycle are less frequently stressed. Due to such perceptions, the aspects mentioned by Croatian scientists are reduced to four basic ones, in contrast to the perceptions of Swedish scientists.

Table 1. Frequency of highlighting individual aspects and attributes of scientific quality

Categories of scientific quality	Natural scientists N = 248		Social scientists N = 131	
	F	%	F	%
ASPECTS OF QUALITY				
Research problem	29	11.7	18	13.7
Scientific method	26	10.5	29	22.1
Scientific results/cognitions	90	36.3	48	36.6
Publications/production	48	19.4	14	10.7
Chi-square = 11.707; df = 3; p = 0.008				
ATTRIBUTES OF QUALITY				
Originality	67	27.0	33	25.2
Solidity	97	39.1	84	64.1
Scientific relevance	73	29.4	34	26.0
Social relevance	28	11.3	13	10.0
Chi-square = 8.912; df = 3; p = 0.030				

Swedish scientists, however, also ranked method, problem and results in the first three positions (Hemlin, 1993, 2009), which shows that their understanding of scientific excellence also focused on those three aspects of research. They actually make up the key points or backbone of the research process from start to finish.

Let us look at the differences identified in the views of respondents from the natural and social sciences. Scientific results and/or cognitions rank at the top in both fields. Even the proportion of respondents who most frequently link scientific quality with research results is almost equal, which indicates the relatively higher importance given to the outcome or the final part of research when evaluating quality. Other aspects of scientific excellence appear with different frequency in statements by respondents from both scientific areas, and the slightest differences are identified in stressing the research problem, which ranked third both in the natural and social sciences (Table 2).

Table 2. Most frequent aspects and attributes of scientific quality in respondents' answers

Aspects and attributes of scientific quality	Natural scientists	Social scientists
The three most frequent aspects	Results/cognitions Publications/production Research problem	Results/cognitions Method Research problem
The three most frequent attributes	Solidity Scientific relevance Originality	Solidity Scientific relevance Originality
The three most frequent combinations of aspects and attributes	Scientific relevance of results Originality of results Solidity of method	Solidity of method Solidity of results Scientific relevance of results

Significant differences clearly relate to the importance of method and production in judging scientific quality. In the natural sciences, evaluation of excellence focuses more on publications that present new results and knowledge, and in the social sciences on methods, which may seem paradoxical at first sight considering the theoretical and methodological pluralism of the social, soft sciences. Moreover, such an accent seems contradictory to the social scientists' lesser inclination to stress methods of research in their definitions of objectivity (Prpić, 2009), but it may be connected to the disciplinary selectiveness of the sample and the greater response rate of members of the empirically oriented social disciplines (Golub, 2009). Significant differences between the natural and social sciences were also found in the distribution of attributes of scientific excellence. Even though the attributes ranked equally in terms of their relative frequency (Table 2), the difference in the frequency of stressing the second-ranked solidity of research is especially great. It is mentioned by slightly over one-third of natural scientists and almost two-thirds of social scientists! This is a surprising result which requires at least a hypothetical interpretation. The different degree of consensus regarding the research rules and procedures in the two fields can be the reason for differences in accentuating solidity. In the natural sciences, the level of researchers' agreement regarding scientific standards is much greater, and consequently they are more often taken as a given in the open-ended questions. The situation is the opposite in the social sciences: there is much less agreement, so the opinions on scientific quality more frequently emphasise the rather unfeasible principle of procedural impeccability.

Scientific relevance is the second-ranked characteristic of the quality of research and its output in both areas. Several respondents pointed out that excellence was incompatible with trivial or irrelevant cognitive contributions. Not only in the paradigmatic sciences is it required for new studies to fit into the hierarchy of the relevance of scientific problems and results, since this obviously goes for the social sciences as well. In each of these sciences there can be several parallel hierarchies of scientific importance as a result of different scientific schools and orientations but, in spite of this parallelism, such a hierarchy is cognitively valuable for social scientists, too. Social relevance was highlighted the least often in both fields, which is not that surprising in the case of the natural sciences which have a greater share of basic research (Golub, 2009). The social sciences, in contrast, have a greater proportion of applied and mixed-type research, and, consequently, relatively more professional papers (Prpić and Brajdić Vuković, 2009; Nederhof, 2006). Thus, a greater role attributed to the social importance of research, as a constituent part of scientific quality, was expected. The lack of this greater role, however, is not illogical considering the concrete (Croatian) social context. To be more precise, social scientists do not have many positive experiences with the willingness of the holders of social power to actually apply the results of social research, and emphasis on the social relevance of such investigations is thus often declarative, and less grounded on their real applicability.

Originality, which Merton (1974) pronounced the supreme standard in science back in the 1940s, did not reach the top position in our scientists' open-ended responses, but it ranked third in terms of frequency of mention in both fields. In contrast, Swedish scientists stressed originality the most in their open-ended answers, but it ranked only sixth in closed responses (Hemlin, 1993: 10). Has originality been undervalued by practising scientists, or is it also largely considered as a given, which can also be said for the most often emphasised solidity of research? Deeper investigations into scientific originality and more extensive empirical findings on originality perceptions are needed in order to be able to answer this question.

First of all, researchers of science have been warning recently that the concept of originality in the natural sciences cannot suitably be applied to the social sciences and humanities. While the natural sciences usually define originality as the production of new results and theories, the social sciences and humanities have a much broader understanding of originality. This finding resulted from 71 interviews with eminent scientists who were members of evaluation panels in competitions for research grants in those fields. The panel members most often used *originality* for an original approach, more often than for an original theory, topic, data, methods, insufficiently explored fields or results. Furthermore, the originality of the approach had a much wider meaning than the used theories and methodologies (Guetzkow et al., 2004: 197).

No matter how broad their understanding and what their definition of originality is, natural and social scientists do not differ considerably in the frequency of mentioning originality. Only future studies will determine whether such answers are underpinned by scientists' awareness that it is precisely the scientific elites who are the chief producers of the most important novelties, and not the majority of researchers, or that a certain dose of originality in science is taken for granted, or that originality is mentioned more rarely because it is a constituent part of scientific excellence which is difficult to describe and even more difficult to measure. And, finally, we must not completely exclude the option that the understanding of scientific quality in one part of the scientific population simply does not include originality as the most important characteristic of high-quality research! The possibility of a similar perception of scientific quality is indirectly indicated by a statement from the opposite end of the continuum of attitudes to scientific excellence that says that quality is: "Originality! The rest is just craft!"

Finally, let us look at the most frequent combinations of aspects and attributes of scientific quality (Table 2). Although as many as two combinations feature in both rankings of the most frequent combinations, differences are obvious in both their order and content. In the natural sciences, the first positions belong to two combinations that describe scientific creativity more, and a solid method which is objective, strict, reliable, precise, verifiable and replicable in this scientific context ranks only third. Viewed as a whole, this combination partly agrees with the findings of an empirical study where among eight possible types of originality scientists most often stress the following combination: new hypotheses/previously used methods/new results (Dirk, 1999). To be more precise, the rankings by the surveyed Croatian natural scientists primarily include cognitively important new results, obtained by solid, thus reliable and proven, methods.

Social scientists put solid, thus objective, adequate methods and solid or well-founded, and then cognitively relevant results in the first two positions. The fact that originality does not appear in one of the most frequent combinations may be explained by the help of the mentioned research of originality in the social sciences and humanities. In other words, the authors point out that originality is only one of the many standards of academic excellence found in the statements by evaluators-respondents among relevance, well-foundedness, interdisciplinarity, clarity and others. Sometimes, the criteria go hand in hand with originality, but they also often squeezed originality out, such as with original research proposals that were also insignificant or trivial at the same time, methodologically incorrect or theoretically chaotic (Guetzkow, et al., 2004: 206). Although solidity is not a derivative criterion as a precondition for acknowledging originality only in this field, its relatively greater relevance is certainly connected with lower consensus regarding scientific standards.

At the very end of this part of the analysis which has presented and commented on all the obtained data, we will also provide several open-ended answers by respondents from both fields, because only in this way can we understand what no analysis can show – the whole statement, expression and tone of the researchers' concepts of scientific quality. Below, several original responses by natural scientists are given:

> *Scientific quality is adherence to all the rules of scientific work that are already familiar: knowing literature about the field and the problem studied, formulating a hypothesis, conducting experiments, processing results, interpreting results and publishing obtained results in a suitable way.*

> *Scientific quality has to be based on research conducted according to all the rules of the profession which has yielded results that provide answers to open scientific questions. We can distinguish between the quality of the research process and the quality of the product – publication, that is, the scientific article. High-quality scientific research has to be based on well-defined goals and the problems it undertook to resolve, a comprehensive approach that resolves the problem, and the objectivity and accuracy of the procedures and observations.*

> *Scientific quality has several aspects. These include maximum precision in expressing results and the originality of research. The two aspects are dialectically (in Hegel's terms) connected. Sometimes, grandiose discover-*

ies are based on precision (the case of the Moessbauer method), and sometimes on the fantastic ingenuity of the author.

Scientific quality is the capacity to change some general cognitions, thanks to the results of one's own scientific investigations, but also the courage to even embark on re-evaluating already established knowledge.

This is very difficult to define unambiguously. It could be said that it is that type of scientific work that has a significant influence on other scientists and on the wider scientific community. However, sometimes scientists engage in a relatively small scientific field with a narrow circle of experts. Then, the influence on the wider scientific community is also limited, but the quality of scientific work can be greater than in the former case.

I don't know, but I am certain that it is not "the race for the quantity of papers" and fake co-authorships with ten or more authors in a publication, even if they are published in a CC journal. Today, for example, a book that has received a top Croatian award for scientific work (Josip Juraj Strossmayer or Ruđer Bošković) or a chapter in a book by the world's most eminent publishers are not valued as "scientific quality" for promotion into the scientific ranks, while a paper of 1 to 2 pages with 15 co-authors is considered "top quality"...

Selected responses by social scientists follow below:

Scientific quality presumes the selection of a scientifically (socially) relevant research subject, knowledge of the body of scientific facts about it, an appropriate theoretical framework, the selection of the best possible research method, objectivity and thoroughness in the collection and processing of data, and creativity in the formulation, interpretation and connecting of old and new cognitions.

Scientific quality is made up of a number of parameters and attributes of scientific work, such as complexity of the content and scope of scientific cognitions, their coherence and logical accordance, their good and full argumentation, objectivity and verifiability, and the theoretical and practical relevance and fruitfulness of scientific knowledge.

The capacity to identify relevant and new scientific questions and study them in a systematic way, using scientific methods, which results in new knowledge and new theoretical concepts.

Scientific quality is "added value" in science, that is, what is new, what may not have been known before or has not been clarified enough by previous *studies. Scientific quality is characterised by impartiality and relevance. Not all scientific research is relevant and important – it depends on its influence on the concrete field that the research is engaged in.*

The concept of quality is very difficult to define, even in the case of scientific quality. It is something more to be felt, experienced. Besides, quality is a process, not only a result. I would evaluate scientific quality in educational sciences primarily in terms of the extent to which the results of research contribute to improving educational practice.

I can hardly define it clearly here. Maybe it is that characteristic of somebody's scientific approach/research and overall work which the relevant scientific group/community of scientists from some field of science – after some time – determines as the best thing that was done/produced/achieved in a given field!!!

How do these open-ended answers contribute to the interpretation of the quantitative data? Their contribution is precisely their comprehensiveness. In terms of the content of the respondents' statements, three types of answers can be identified in both areas. The first type offers a relatively comprehensive understanding of scientific quality with the precise listing of its basic aspects and attributes, or mentioning those aspects and attributes that the respondent seeks to highlight. Such answers are easier to analyse and quantify. Interestingly, these answers tend to be more precise the more they focus on solidity of research, while the statements that emphasise originality or novelty tend to enumerate less. The second (less frequent) type of answer puts an emphasis on the difficulties in defining excellence, but also offers a key criterion, which ranges from the applicability of the results and the advancement of some activities, to the comprehensiveness of the scientific approach (as in these examples). The final answer, which stresses the broader approach, and which was not the only such answer given by social scientists, is very similar to the dominant characteristic of originality as perceived by renowned American evaluators from the social sciences and humanities (Guetzkow, et al., 2004). The third type of response is actually a criticism of the evaluation system and of scientific practice that adjusts to it, especially to the dominance of quantitative criteria where the respondent gives up on determining scientific excellence. From that follows the key message: scientific quality is a recognisable property of research, but scientists who cannot, do not know how to, or do not want to define it are scarce. This does not indicate in any way that they cannot recognise excellent studies and their final products – scientific papers, that is, that they cannot distinguish between high-quality and low-quality publications. Quality in scientific practice certainly partly escapes precise definition. Whether it is measurable, according to scientists' perceptions, will be analysed in the next section.

Before that, we will highlight the theoretically important factors of scientific quality (Hemlin, 1993, 2009) recognised by our respondents, apart from the research process and product that have already been elaborated. Both the natural and social scientists more often stated researchers' characteristics (22.6% and 27.5%) than highlighted the characteristics of the research environment (9.3% and 1.5% of respondents). Obviously, social scientists were slightly more likely to highlight the researcher's personal characteristics on which scientific excellence depends, but they were far less prone than natural scientists to mention the characteristics of the research environment – scientific equipment, team work and cooperation, and the international scientific community. This is also in line with the different socio-cognitive patterns of these two areas.

It is interesting that intellectual capacities were mentioned the least often as important characteristics of researchers, probably because their relatively high level is simply presumed. Familiarity with problems, a broad insight into the research field, and then ethics, commitment to work or diligence were mentioned most often, while independence/autonomy, open-mindedness and openness to cooperation and intelligence/genius were mentioned rarely. Thus, the scientist's scientific excellence entails superior knowledge of a field, integrity and work habits. These are also the personal characteristics that lead to the excellence of the research and the research product. The scientist's competence and general working abilities were also stressed by Swedish scientists (Hemlin, 1993), while the scientist's ethics or integrity was mentioned by eminent American evaluators in the social sciences and humanities as an important criterion in assessing the scientist's originality. The characteristics of morality mentioned here are those that are important for people in the world of science – courage or willingness to take on (intellectual) risks, seriousness, commitment to work and the production of cognitively and socially relevant knowledge and similar aspects of morality (Guetzkow, et al., 2004).

4. Measuring scientific quality – (im)possible?

Considering the extent of use and influence of quantitative, especially bibliometric, indicators in the evaluation of scientific quality, primarily in the natural, (bio)technical and medical sciences, but also increasingly more often in the social sciences and humanities, we were interested to know what our respondents thought about measuring quality, especially since the two scientific areas stand at opposite poles in the use of quantitative criteria of excellence. That is why we assumed that (significant) differences might appear between the natural and social scientists' perceptions of the (im)possibility of measuring scientific quality, either in its basic evaluation or in the strength of the respondent's conviction, as shown by the content, mode and expression of the freely stated opinions.

The respondents' answers are classified into three categories: claims that scientific quality is measurable; claims that it is only partly measurable; and claims that deny its measurability. The results of the classification of open-ended answers are shown in Table 3.

Table 3. Structure of open-ended responses to the possibility of measuring quality (in %)

Measurability of scientific quality	Natural scientists N = 264	Social scientists N = 141
Measurable	54.9	50.4
Partly measurable	36.7	45.4
Not measurable	8.3	4.2
Chi-square = 4.300; df = 2; p = 0.117		

The structure of answers of these two groups of respondents does not differ significantly, as was shown by the chi-square test. Although statistically insignificant, the differences are not negligible; quite the contrary, they are indicative, and even provocative. To be more exact, natural scientists more often express their conviction that scientific quality can be measured, and, more rarely than social scientists, pronounce it partly measurable, which was expected and in line with the relevant characteristics of the cognitive practice and style of the two compared areas. The former's generally stronger conviction in measuring and in research procedures and methods also extends to the perceptions of measurability and procedures for evaluating scientific quality. The latter are marked by weaker consensus on the theoretical and methodological approaches to research as well as by lesser conviction in the possibility of measuring the quality of research. The finding that there are almost twice as many natural scientists than social scientists who believe that scientific quality cannot be measured is all the more interesting. Although this is less than one tenth of the total number of natural scientists, it is surprising that they are nevertheless more frequent than social scientists with the same opinion.

A qualitative analysis of answers will be necessary in order to obtain a more specific conclusion, and one should also remember the differences in the modes of evaluation that might also have generated differences in perceptions. Precisely due to the dominance of quantitative, especially bibliometric, indicators of quality, and also due to a greater insight into the problems of such measurements, natural scientists may be more prone to deny the measurability of scientific quality than social scientists, who use bibliometric methods to a much lesser extent in their field, and thus have many fewer encounters with the weaknesses of such evaluation practices. In any case, slightly over one half of natural scientists are convinced in the measurability of quality, while the share of those convinced and (most) sceptical in the social sciences are almost equal. Even if the differences are not significant in terms of quantity, there could nevertheless be important differentiation among the statements in terms of their quality, content and expression.

With natural scientists, measurability often rests on bibliometric indicators, but they have a different degree of conviction in the validity of those indicators. The relative majority of specified answers stress bibliometric measures of quality, especially citations and journal impact factors, and some respondents also introduce other indicators of quality, such as patents, books, work with young researchers and their training, but also symbolic capital and collegiate and institutional acknowledgments in the form of invited lectures and other indicators of a scientist's (international) reputation. We present below several original opinions of natural scientists on the measurability of scientific quality:

It is absolutely measurable, but the criteria need to be uniform.

It is easy in the natural sciences with citation counts, number of publications, number of co-authors and the like for individual fields.

Definitely. One of the better ways are citation rates (without self-citations) of CC papers.

Of course it can. Physicists know exactly how much Newton's mechanics, Einstein's relativity theory, quantum mechanics... etc. have contributed to knowledge. We know (more or less) who participated in the construction of that knowledge, so we can speak about the quality of scientific results of certain people.

It can be measured by the number of published CC papers, the impact of indexed journals, the number of citations, patents, surveys, published books, training of younger scientists and so on.

It can be measured by the number of citations of published papers. The system itself is relatively slow. The response of the scientific community to a certain paper depends on the number of scientists engaged in a scientific field and on the time span in which the paper is available to the scientific community. There is also the applicable quality of the scientific paper, especially in societies that do not have adequate resources for basic research, which could be evaluated by the number of patents granted.

Even though genius is immeasurable (and it often takes several years to recognise how ingenious a discovery was), at least 90% of scientific quality is made up of diligence, persistence and outgoingness, and the result obtained this way can be measured with the professional (NOT amateur) application of scientometric indicators.

Yes. Naturally, the great discoveries ultimately reveal "themselves" as such. In the everyday life of an "average" scientist, group and institution, networked bibliographic data (CC papers, citation rate, invited lectures, reputation in one's own community, international reputation in the field, the education of young scientists...) correlate greatly to the scientific quality of a person, group, and institution.

These statements range from absolute conviction in the measurability of scientific quality using bibliometric indicators, to the relatively frequent opinions that add quantitative measurements such as awards, doctoral degrees, engagement in scientific associations and so on. The differences in the degree of conviction in the objectivity of measuring quality within the natural sciences, between physicists and biologists to be more precise, have been empirically determined by a Nordic study (Kekäle, 2000, 2002). The use of the expression *everyday life* in contrast to great scientific achievements is interesting, as it directly reminds us of Kuhn (1999), as well as the distinction between normal science and front-line research with a different social organisation and epistemic orientations (Fuchs, 1993).

Despite their general belief in the measurability of quality, some respondents also expressed some scepticism about quantity and the citation rate as the principal indicators of quality, and even regret that the quantitative criteria had not been identical for related sciences. Other respondents advocate applicability as the principal criterion, and a third group stresses the necessity of a complex approach that would take into account the scientist's overall scientific activity. These points can be seen in the statements below:

One of the key measures of scientific quality here is the number of published papers or number of citations, which is completely wrong since scientific papers are not necessarily of high-quality, and citations can also have negative connotations. Scientific quality can be measured only by the real applicability of scientific results and by their benefit to society in general.

Quality can be measured. When measuring, one has to consider all of the scientist's activities, but I would attach greatest importance to a body of scientific work and successful collaborators. Training a successful scientist requires a lot of knowledge and deliberation and a plethora of good ideas. A good scientific paper can be measured by the journal in which it was published. The citation count is not the only criterion, because fashion exists in science as well. However, a good citation rate is certainly a good parameter.

Yes, but there is no absolute criterion. It can be a CC paper, but in many CC journals in mathematics almost trivial results are published; it can be the length of a paper, but many hefty papers are just overblown; it can be the number of papers, but many mathematicians with a huge number of papers are of minor relevance for mathematics (I know some myself); it can be the number of citations, but many groups cite each other uncritically (I myself was asked directly to cite a person in my paper even though there were no grounds to do that); it can be invitations to conferences and the like, but this is similar to the former situation, etc.

Scientific quality is measurable, but one needs to use a complex approach, and not only the number of published scientific papers, especially when evaluating the work of a scientist, and not just an individual scientific contribution (which is much easier to evaluate).

In Croatia, scientists' scientific quality is nowadays measured by the number of papers – and if those who evaluate applicants (peer committees at the level of scientific fields and areas) were really objective, this would not be a problem – the minimal criteria are known and all that is left to be done is to evaluate the applicant's other activities. But forget objectivity when the number of papers that hardly meet the criteria for a research associate in biology (not to mention chemistry or physics) is enough to become a full professor at the faculty of agronomy, veterinary medicine, biotechnology (to mention only related professions). So where is objectivity here? How can such great differences be possible? Or is there something wrong in these prescribed criteria?

On the other hand, social scientists who consider scientific quality to be measurable can be divided into two subgroups. The smaller subgroup consists of respondents who, similar to their counterparts from the natural sciences, believe bibliometric indicators to be the best indicators. The subgroup of respondents who do not consider the criteria sufficient is much larger. We will also report several opinions from the first group which are rather succinct and manifest a high degree of conviction that quality can be measured on the basis of journal references and ranking in international bibliographic and citation databases.

Yes. Scientific quality is measured by publishing findings in top scientific publications in certain fields (international journals and books) referenced in international databases.

It can, by comparing the impact of individual research on the development of the specialty in the narrow or broader sense. It can be assumed that scientific papers with greater response (citations) than average in that line of study are of scientifically greater quality than those that are under average.

It can. It is measured by citation of papers. The more cited the paper, the deeper the trace it has left in a certain research field.

It can. There are some criteria in every scientific discipline, among the most important being citation of an author's papers in other, especially foreign, journals and papers, and the contribution to the development of scientific discipline.

The other group includes opinions that the measuring of scientific quality cannot stop at bibliometric indicators. Some statements are somewhat longer because they explain the specificities of scientific production in this area, which prevent measuring from being the major or only procedure in judging quality, and/or indicate the importance of other, standard evaluation procedures (*peer review*) and the use of the wide(st) scientific public. Other statements are shorter and they also insist on using more complex quantitative and qualitative procedures in judging scientific quality in the social sciences.

> *Everything is measurable in this world – very objectively. BUT there are some fields where the measuring would be too expensive and too long, so that it is not really opportune. Scientific quality is measurable too – but the measuring cannot be based only on presence in CC and other secondary publications. TO MEASURE quality, one has to use a more complex method than the existing rating system and ADDITIONALLY use the institute of the public: this means that any candidate for a scientific rank would have to present his scientific achievements to the public.*

> *Not only is it measurable, but it has to be measured. The measure used today based on the published paper has been exaggerated to absurdity, so that, for example, younger scientists are not in the least interested in professional work, teaching, and so on, but only in publishing in journals that are often of rather poor quality, but have been pronounced to be of high quality and are counted as such. More attention should certainly be paid to the grades of our students, graduates, postgraduates and doctorate candidates. Educational work is not valued at all, especially not its quality.*

> *Scientific quality can be measured quantitatively, but I think that the number of published scientific articles and citation rate are in no way measures of quality. Published articles differ in quality and even sciences differ in their publication principles, while citation rate is only the capacity of attracting "readership" to an attractive theme. I think that competent peers' subjective evaluation of criteria such as innovation, relevance, impact, scientific daring would sometimes be more appropriate than counting articles, even if conducted with some delay.*

> *All elements of work can be measured according to a methodology that can be determined in advance. Not all relations have to be quantitative in order to be measured. Descriptive elements can be measured by comparing them with a selected benchmark and with each other. Measuring can also be expressed descriptively, and also by ranking.*

> *It is measurable indirectly, mostly by measuring the number of other scientists that consider a scientific work to be of high quality and relevance: high grades in peer review procedures, citation rate by other scientists, etc.*

It can be estimated, and then also measured using psychometric, technometric, econometric and sociometric techniques.

The slight differences in the share of natural and social scientists who believe in the measurability of scientific excellence hide inner qualitative differences that primarily refer to the unequal importance given to measuring quality using bibliometric and scientometric methods in the two areas. While in the natural sciences the measurability of scientific quality is relatively more often connected to publishing in relevant and renowned journals, which is then measured by their impact factor and the citation rate of individual papers, the situation is different in the social sciences. Although respondents believe that quality can be measured, and do not completely reject bibliometric methods, they nevertheless do not consider such methods best and most appropriate, let alone the key or the only indicators of scientific excellence. In this context, the differences between these two areas are greater than they were first shown to be by the first one-dimensional quantitative analysis. At the same time, theoretical agreement that the measuring of scientific quality is possible leads to the claim that it is impossible to engage in science without a system of evaluating scientific quality, even if such a system is fallible, imperfect, as both groups of scientists often see it.

The claims that scientific quality is only partially or hardly measurable make up the second category of open-ended answers. Natural scientists explain such claims or doubts regarding measurability by the shortcomings of scientometric, primarily bibliometric, procedures and indicators when used as the only/key ones. The most important theoretical objection to citations and impact factors is their unreliability, for various reasons, with manipulation or trading citations among research teams being mentioned several times. Disciplinary differences are also especially important within the natural sciences, as both scientific production and opportunities for publishing in international journals are not the same. The criticism is sometimes underlined by resentment over the tendency to automatically unify the criteria for different fields and specialties of the natural sciences, which is incidentally advocated by some natural scientists – including some of our respondents. The most important characteristic of scepticism regarding the full measurability of quality is the indication or explicit claim that quality almost necessarily contains some elusive, subjective and immeasurable aspect. For some, it is precisely its most important aspect – originality.

Quality can be measured only by a brain trust of people with integrity. Scientometric data can provide certain information in order to determine the minimal chances that something is of quality. Precision can be measured, but, for me, the most important aspect of originality is immeasurable, and even manipulable!

It is most often recognisable, but difficult to measure, because evaluation is approached formally, and different fields, different circumstances, different interest communities, politics and other factors help distort the importance of individual scientific achievements and scientists.

It is difficult, in terms of measuring, which results in figures. It could be done using certain methods ("descriptive"!?). Also, we are sick of the so-called elite, boot-licking and imposing CC papers in the natural sciences (chemistry, physics) as the only measure of a good paper-article, a paper considered as a criterion for appointment. Croatian journals crave articles, they are paid by the Ministry, and they accept CC criteria. Absurd, isn't it? Let us not forget, the major part of geology and geography is locally, nationally oriented.

It is difficult to fully measure objectively. The much-vaunted impact factor makes sense if approached individually, within your field, since it depends on the population of scientists engaged in the field. Thus, it makes sense to use an impact factor to measure the value of a paper published by a molecular biologist in the field of molecular biology, or by an entomologist in the field of entomology, but it is insane and completely inappropriate to compare and evaluate the impact factor of a journal in which the entomologist publishes a paper to the impact factor of a journal in which the molecular biologist publishes.

Hardly! Numerical data, whatever they refer to (number of papers, for example) do not contribute more than around 60% to the objective evaluation. I particularly believe that the number of citations is a very subjective measure (although I have rather good results in this respect!). Papers with more than 3 co-authors should be measured in reverse proportion to the number of collaborators for all co-authors, except for the first co-author.

It is very difficult to measure scientific quality. There are indirect measures that rely on reviewers and editors of science journals. This is a very simplified procedure that rates journals on the one hand, and counts citations of individual articles on the other. There is much evidence that the measure is not crucial for the quality of scientific results, but it is more indicative of the *dependence of citations on the journal in which it was published. There are also negative citations, when authors are cited for their mistake, silly statement made in a paper, criticism, etc. There are also groups that cite each other according to the backscratching principle, pumping up the number of citations artificially this way. In conclusion, it should be repeated that it is very difficult to measure scientific quality because its evaluation depends on many subjective parameters.*

Scientific quality can be measured, but not fully. There are a number of factors for measuring quality in the natural sciences, such as the number of published papers, the quality of journals in which the papers are published, the number of citations that the published papers attract, and others. The issue is a subject of continuous discussion (and disagreement). I personally believe that quality can be assessed with around 70-80% certainty in my field. The remaining 20–30% depends either on subjective interpretations, or on insufficiently identified factors.

Social scientists express their reservation about the overall measurability of scientific quality mainly as doubt about the applicability of its bibliometric criteria to the social sciences. The doubt is often extended to other quantitative indicators of quality. Their use, as a rule, is considered limited, and is supplemented by assessments or peer reviews. Only few respondents believe that internationally reviewed and cited papers can be an acceptable indicator of quality, even in a very narrow field, despite the weaknesses of these quantitative evaluation procedures. A more frequent opinion among respondents is that such indicators, when applied uncritically, only distort the real picture of the quality of paper(s). Some respondents express even more general doubt about the measurability of all dimensions of quality in science. In their opinion, quality is partly elusive and immeasurable. It can be reached only by the scientific community of a certain research field where, according to some respondents, there is also a certain level of agreement in evaluating its members and competent scientific evaluators:

I am afraid that some (tentatively) quantitative aspects of quality can be measured, but I believe that the substantial aspects of quality can be perceived only with valid and fair evaluations/reviews by competent scientific reviewers.

There is a science called scientometrics, that is, measuring science, but I do not consider it completely reliable. To be more precise, the number of *published papers does not imply a scientist's contribution. Sometimes, only one paper contributes to a revolutionary breakthrough in science.*

It is not easy to measure scientific quality in the social sciences. However, the scientific community of an individual field of science, especially in a small country like ours, evaluates the value of its members quite reliably. Quantitative measures of scientific achievements, according to experience, often lead to wrong assessments.

Not completely. It can be estimated by the number of science papers published in international or local journals where anonymous international peer review is guaranteed, and by the citation of papers by other authors. However, these criteria can be used only for comparing authors from the same scientific field because the number of scientists and scientific journals differs significantly in different fields.

Scientific quality can be measured by rigid criteria, such as the number of published papers, invited participation at conferences and symposiums, but there is also a significant part that is not measurable, and in jurisprudence in particular this refers to the effect on the organisation of the legal system.

Scientific quality can be measured using some scientometric indicators combined with some form of objective peer review; without awareness of the context of a paper, the citation rate can provide a distorted picture of quality.

Scientific quality cannot be measured exactly. In a scientific article, for example, this could be the percentage of new claims or new evidence for already existing claims that can be verified in a certain way. Unfortunately, it is impossible to set up committees to check this, since it would take up too much time. Thus, the citations, patents, number of publications and similar "quantitative" procedures will continue to be the criteria for identifying a "quality" scientific paper.

Scientific quality can be judged, but not strictly measured. Usually, there is agreement among the scientific public or narrower scientific community (from one field) on what is of quality, and what is not.

Scientific quality is extremely difficult to measure due to the high share of subjective attitudes, experiences, perceptions of problems, etc., of the possible "arbiter". However, the application of universal, objectivised standards of measuring to all the social sciences (especially to ALL fields of science) is *not very feasible considering the specificities of individual fields. However, I support the adoption of attitudes/criteria that would put greater importance on the international aspect of research – such as the comparative method, for example, of studying the wider legal environment – international publishing, co-authorships with international colleagues.*

Finally, statements which deny the measurability of scientific quality, at least in their own field of research, make up the third category of responses. Although scarce in general, they are relatively more frequent in the natural sciences. By denying the measurability of scientific quality, natural scientists actually refer to the inability to measure it reliably and objectively, and sometimes express resignation regarding the situation in the Croatian scientific environment and in umbrella scientific institutions (Croatian Academy of Sciences and Arts, HAZU):

No, it cannot be measured, although I am aware that it should be measured. In what way, I do not know. But as long as there are people who have no internationally recognised papers sitting in our Academy, what is the point of discussing the issue at all.

No. It cannot be measured objectively; not in a short time span and in a small environment. Only scientific idleness and low quality can be measured objectively and accurately. No work – no quality. It does not go the other way around. Maybe it could be measured, but after several years or centuries when it becomes evident what discoveries were really important for humankind.

There is no reliable quantitative criterion: for example, citation rate can be a reflection of somebody's inane results, that is, interpretation – I personally often quote such publications, while citations are not necessary for generally accepted facts.

Social scientists who deny the measurability of quality express this in three types of opinions. First, opinions denying measurability without any explanations and arguments, but pointing out that quality is recognisable. We have already encountered claims on the recognisability of scientific quality in the social sciences, but propounded by some natural scientists, too. The second type of opinion expresses doubt that anyone, except the most eminent scientists, can recognise excellence at all, and it is also highly critical of the Croatian practice of measuring quality. The third perception is borderline – it completely denies the possibility of measuring originality, and considers publications a primitive measure of quality in science, even in terms of craftsmanship or profession.

> *It is not measurable, but it is recognisable.*
>
> *If this refers to measuring conducted by an institution, I sincerely doubt it. Only the most excellent can recognise excellence. All measuring attempts used in our country (for example, CC, citation index) have provided quite ridiculous results in my field of work.*
>
> *In the segment of originality – there is no measuring. In the segment of professionalism and standard of craftsmanship – the (provisional, rather primitive) measure is publication in standardised scientific journals.*

It is interesting that the qualitative differences in the perceptions of natural and social scientists were least noticeable in the claims of the partial measurability of quality, also reappearing in the claims of its immeasurability. Namely, scepticism about the total measurability of quality in both groups of respondents is founded on their doubt in the adequacy of bibliometric evaluation procedures, and both groups are also convinced that scientific quality is simply immeasurable in one part. These key elements of the sceptical view of the measurability of quality are similar in both fields. The theoretical denial of the measurability of scientific quality has different starting points: in the natural sciences, it is the explicit or implicit denial of the reliability of measuring, while in the social sciences it appears in several forms of deep disbelief in the feasibility and practice of measuring scientific quality.

5. Scientific quality and its recognisability, measurability and elusiveness

Another qualitative study was conducted within the framework of the web survey of the Croatian research population in order to gain insight into natural and social scientists' perceptions of scientific excellence. This goal had a cognitive and social or policy purpose. Cognitively, the aim was to determine how practising scientists define scientific quality and whether they find it measurable. This would deepen the existing knowledge of scientists' professional values and standards and reveal the concrete benchmarks they use in their everyday scientific work, which requires them to regularly and constantly evaluate the quality of research and papers in their own field. The social importance of the study is underpinned by the expected enhancement of the evaluation system (within the Croatian science system) whose design and implementation will be made more suitable and efficient if we are aware of scientists' perceptions of excellence.

The basic hypothesis of the study was derived from the theoretical framework resting on sociological theories of organisations of science (Whitley, 1984; Fuchs, 1992), but it also modified some of their theses (Prpić, 1997). Consequently, the concepts of scientific quality were expected to show resemblance in the natural and social sciences, especially in the perceptions of the general characteristics of quality, but also in the peculiarities connected to the differences in the cognitive practice/style and knowledge production in these areas. Such differences could also be expected to extend to individual scientific disciplines, but this level of analysis was not the task of our study.

The categorial system of the study modified the categories used in the previous qualitative investigations in Swedish and Norwegian scientists' perceptions of quality (Hemlin, 1993; Gulbrandsen, 2000). The respondents' open-ended answers were categorised according to the aspects of scientific excellence, these being the parts of the research process – *problem, method, results/cognitions* and *publications/production*, and according to the attributes or characteristics of research and its output – *solidity, originality, scientific* and *social importance.*

In sum, the principal findings of the comparison of perceptions of quality in the natural and social sciences show both similarities and differences in the characteristics of quality, and in the perceptions of its measurability. Differences in stressing individual aspects and attributes of scientific excellence are statistically significant, but the similarities are also incontestable. When it addresses individual parts of the research process, excellence is in both areas most often related to scientific results/knowledge, and the differences in the third-ranked research problems are not significant. The biggest differences were noticed in the prominence given to methods, which is greater in the social sciences, and to scientific production, which is more strongly stressed by the natural scientists.

Attributes of scientific excellence, however, ranked the same, but solidity of research was far more often emphasised in the social sciences. The results are very similar to the perceptions of quality expressed by Swedish scientists, who also ranked method, problem and results in the top three positions, and originality and two attributes included in the term "solidity" – rigour and accuracy (Hemlin, 1993: 10). The finding that social scientists give greater prominence to solidity and method in their concepts of scientific excellence than natural scientists is somewhat surprising. However, considering the lower level of agreement regarding scientific standards, including methodological standards, in the softer, social sciences (Fuchs, 1992; Becher and Trowler, 2001), the emphasis given to the ideal of solid, reliable research by scientists from that area is understandable.

The perceptions of the measurability of scientific quality do not differ significantly among the two areas. Both areas have the relatively biggest groups of respondents convinced about the measurability of quality, but sceptics are also quite numerous, especially in the social sciences. However, smaller quantitative differences hide the greater qualitative differences in the importance given to measuring excellence using bibliometric and scientometric methods in both areas. In contrast to the natural scientists who consider these methods and indicators reliable to a greater degree, the social scientists who believe that quality is measurable do not consider them the best indicators of scientific excellence.

This final part of this Chapter deals with the social and scientific implications of the study, in that order. We believe that the practical implications of the empirical insight into the perceptions of scientific excellence in the Croatian natural and social science community are extremely important. To be more exact, the findings suggest two, partly different, science policies that would have somewhat converging effects.

Firstly, it is clear that there is no complete consensus in the natural sciences regarding the dominant role of the scientometric and bibliometric methods of evaluating scientific research and papers. If almost half of the natural scientists believe that scientific quality is only partly or barely measurable (including the minority who completely deny measurability), and here they primarily refer to the mentioned methods, then this is a serious signal to the creators of science policy. The signal suggests that the levelling of the evaluation criteria, which is evident in the system of the scientific promotion of researchers from that area, with the geosciences standing slightly apart, is problematic, at least to a certain extent. We have seen that numerous scientists have strong grounds to criticise the absolute domination of quantitative criteria in evaluating excellence, even pointing to the differences in knowledge production and the communication of scientific results within the same field.

These findings drive an impartial observer to the conclusion that evaluation criteria certainly have to be reconsidered and adapted to the socio-cognitive peculiarities of the individual fields of natural science. The dominance of the criteria of the physical sciences in all the natural sciences does not have firm empirical grounding, and it was more likely imposed by the scientific elites (Whitley, 1984). Thus, the expected changes in the evaluation criteria in the Croatian research system are an opportunity for empirically grounded discussion and for transformation geared to more efficiently increasing scientific quality in this scientific area.

Secondly, judging by the statements of the social scientists, half of whom believe that scientific quality is measurable in their field, but not exclusively or primarily using bibliometric methods, these sciences are not as soft as they are usually thought to be. We also have to consider the disciplinary distortions of the sample which favours the fields oriented to so-called field research where data is collected from respondents and which may have influenced the perceptions of the measurability of scientific excellence. Here we also have to consider the enormous disciplinary differences which were strongly empirically supported by the first bibliometric analysis of their production (Jokić and Šuljok, 2009).

Despite all reservations to and respect for the peculiarities of the social sciences, the subjective observer-insider, one interested in advancing the area, has to draw attention to the need to change the criteria for evaluating scientific excellence. However unpopular it may sound, social scientists will have to be exposed to bibliometric methods of evaluating the excellence of their research and final outputs – papers. It is clear that bibliometric monitoring must not be the chief method of evaluating scientific quality in this area, that it has to be adjusted to the specificities of the cognitive practice of the social sciences (Nederhof, 2006), that evaluation must not be based on the same criteria as for all the social sciences, but it has to acknowledge the peculiarities of individual fields. For this reason, the coming changes in the evaluation subsystem of science are an opportunity for empirically-grounded discussion and for the introduction of carefully selected, and, to begin with, minimal, bibliometric criteria for the scientific (career) advancement of scientists, at least in some scientific disciplines/fields. Otherwise, social scientists might be taken aback by the implementation of such measures imposed by scientific elites in the social sciences, similar to those imposed by their colleagues in the natural sciences, with the prevalence of bibliometric elements for evaluating scientific quality, or they can settle for the formalistic application of those criteria arising from publishing in the WOS journals, but in the Croatian language.

The scientific implications of our research findings are two-fold: some refer to investigations into scientists' perceptions of excellence, and others to a significantly broader theoretical framework created by the key theories of science. Thus, the question is to what extent the findings of this study fit into the narrow or broader body of sociological and other knowledge about science.

Empirically, the analysis has contributed to a better understanding of the perceptions of scientific quality. First, it shows that researchers from different types of societies, with a different economic, scientific and technological level of development and different socio-cultural characteristics, form fundamentally similar understandings of quality (Hemlin, 2009). This does not apply only to the USA or the Nordic countries, which, among other things, also share similar science policies, but also to a completely different type of society, usually called post-socialist. In brief, the claim that there is an established set of transnational professional values and standards has been empirically supported. Naturally, some specificities that may be marked by the Croatian socio-cultural and techno-scientific milieu have also been revealed. For example, the predominant stress of social scientists on (methodologically) solid research can partly be a defence mechanism of a scientific area that is (or has been) more exposed to the ideology of the socialist, but also postsocialist, period.

Secondly, the study has given a broader insight into scientists' understanding of scientific excellence to take in their perceptions of the measurability of scientific quality which are an important constituent of quality concepts. It suggests that the concepts do not necessarily include the conviction that quality can be reliably measured. Furthermore, not even a majority of researchers from the natural sciences, who usually show a more rigid cognitive style, share such an opinion. We cannot say whether a certain degree of scepticism regarding the measurability of quality and even the conviction that it is somewhat immeasurable can be credited to the transdisciplinary and transnational common nucleus, since no similar studies have been made so far. Let us hope that future studies will cover this neglected constituent of scientists' concepts of quality.

Finally, in our opinion, the study's consistency with and contribution to the theoretical framework of scientific quality also have a bearing on the further development of the categorial system of the qualitative and also quantitative analysis of quality perceptions. Our empirical material certainly shows that the categorial system of quality analysis can be logically and theoretically improved, and at the same time its empirical adequacy can also be expanded. Besides improving the analytical system, the findings of the study might contribute to attempts to articulate theoretical hypotheses on scientific quality, hypotheses that would not try to explain the discrepancies between the universalist criteria and particularist scientific practice at any cost (intellectual acrobatics), or explain the particularism of practice with particularist scientific criteria, but would include the partial immeasurability of quality or, at least, its recognisability, which practising scientists themselves cannot analyse, describe or fully explain.

At the broadest theoretical level, which includes the connection to the most important and most fruitful sociological theories of science – organisational theories of science (Whitley, 1984; Fuchs, 1992), the findings on the perceptions of scientific quality are yet another empirical argument in their favour and in favour of the need to modify their basic claim. The minimal nucleus of shared transdisciplinary perceptions of scientific quality, but also the significant differences among scientific areas (and presumably individual disciplines), support the claims on socio-cognitive differentiation in science, certainly not the claims on the excessive atomisation of the concepts of science which see science as different types or groups of sciences with hardly any resemblances. Both similarities and differences among them have been empirically confirmed. However, they should also be theoretically articulated in the future.

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Franc Mali

The category of scientific objectivity in the social sciences

1. Introduction

The category of scientific objectivity has been a topic of theoretical discussions and opposing epistemic opinions since the beginnings of science. If nothing else, the controversies have made at least one great contribution in that scientific thought has proven how difficult it is to attain scientific objectivity based on some degree of consensus. In brief, it is impossible to reach objective knowledge in a simple, let alone quick, way. In general, we deem the result of scientific study to be objective if it is independent of subjective judgments and attitudes. A look into the history of cognitive theory reveals that classical philosophy had emerged from the differences between objective knowledge and subjective belief, even before contemporary scientific thought. Within the framework of this pre-scientific thought, what belonged to a person's opinion was called "subjective" and what went beyond subjectivity and was liable to intersubjective verification was called "objective". Contemporary theories of science usually interpret objectivity in the broader sense of the word, but the term nevertheless refers primarily to scientists' endeavours to make the object of their study as independent of any subjective bias as possible.

Within the framework of the modern social sciences, both nomothetic and ideographic approaches have emphasised the importance of objective scientific truth. However, these approaches have not always shared the same understanding of the category of scientific truth. The nomothetically orientated social sciences have tended to avoid the danger of subjectivity by maximising the "hardness" of the findings, their measurability and comparability. The ideographically oriented social sciences have tackled the problem differently. They favoured primary sources, still untouched by mediators, that is, other scientists. At the same time, they also supported data that were expected to make scientists more personally involved in the production of databases.

Naturally, there has always been conflict between the proponents of one and the other approach. These disputes remain current even to this day, in the same or in another form – let us just remember the disputes on the pre-eminence of the quantitative or qualitative approach in sociology.

These disputes are often forced from outside. At the time of the establishment of modern scientific thought, a wide range of scientific disciplines sprang up. Mathematics and the experimental disciplines of natural science stood at one end, and the humanities, headed by philosophy, and including the first, new social disciplines (economics, sociology, etc.), were positioned at the other end. These final two were relatively late to enter the widening gap of the knowledge division (the natural sciences versus the humanities), leading to an increasingly greater division regarding the fundamental issues of epistemology. Dating back practically to the very beginnings of modern science, these disagreements survive in the different names of individual groups of sciences. At some point, there was talk of the differences between the exact and non-exact sciences, at another time it was about the differences between the hard and soft sciences. Naturally, other terms were also used. Since the principle of indeterminacy has become the fundamental epistemic principle for the natural sciences, and after the development of the quantum theory and relativity theory, the division into the less and more exact scientific disciplines has today become rather outdated. In this respect, one should certainly agree with John P. Van Gigch who says that "... these dichotomies (exact/inexact, hard/soft) are much too simplistic to describe the spectrum of ontological, epistemological and methodological differences and similarities among scientific disciplines" (Gigch, 2002: 552).

Many theoreticians and methodologists of science still doubt that the effort to sociologically "understand" reality has ever really been a sufficiently consistent alternative to the "explanation" of the natural sciences. A relatively long history of positivist discourse in Western intellectual thought (surviving in some parts to this day) could be said to doctrinally exalt the following epistemic principles:

1. the idea of unified science that claims that since the world is homogenous, one-dimensional and causally ordered, man's (experiential) learning of the world is based on a universal method of scientific research and a universal language of science;

2. the idea of empiricism, stating that overall scientific knowledge is based on immediate experience in the form of sense data, observational language or common sense;
3. the idea of objectivism which maintains the strict separation of the subject and object of knowledge, thus excluding every possibility of any interaction between subject and object in the process of scientific research;
4. the idea of value-free science based on the assumption of the clear separation of values and facts, descriptive and normative statements, which should lead to the ideal neutral science – free of all moral, ideal and broader social values;
5. the idea of instrumentalism that puts greater focus on technical manipulation than on understanding the world, and the closely related view that the only function of science is observation, and perhaps prediction, and nothing else could be its essence;
6. the idea of technicism where "techniques" or "paths" to research results are exalted to the extreme, while the findings of the research and the consequential development of knowledge are neglected (Delanty, Strydom, 2003; Roth, 2003).

We will resist such simplified explanations of the relationship between the social and natural sciences in our exposition. We will also be interested in when and how the first steps were made in putting different methods on a more equal footing, which can only contribute to the cognitive progress of science. This will admittedly take our discussion slightly back into the history of scientific thought, but it is precisely this approach that will help show that sometimes even the newfangled discussions that we are witnessing today uncritically forget that many seeds of thought about the value and objectivity of scientific claims have already been presented by the greats of sociology. As we will show more comprehensively later, Max Weber clearly demanded that every scientific interpretation of social phenomena required a procedure of verification, even if we did not always have proper data based on immediate observation at hand. Weber believed that if we had nothing else at our disposal, it was useful to rely at least on the procedure of mental experiment, which, when we theoretically explain the possible developments of an event or phenomenon, brings us closer to explaining its causes.

We must not forget another important fact: despite the recent extensive talk about connecting qualitative and quantitative scientific methods in the social sciences, the epistemic grounds for connecting different types of scientific discourse were in fact laid relatively early. We are often aware that both from the aspect of its internal cognitive development and the aspect of the new social challenges coming from the outside, the development of contemporary science requires (especially in the field of the epistemology of science) increasingly more bonds, and not separation, or even mutual exclusion. The connection is made both on the horizontal and vertical level, and the trends of transdisciplinary scientific knowledge finally eradicate the borders of individual scientific disciplines. Demands for the applicability of science make the traditional linear innovation models arising from the rigid division into basic, applied and developmental research rather pointless. We could also list several other examples. We must not forget within these cognitive and social changes in contemporary science that a hundred or more years ago the very epistemologies of science that resisted the positivist interpretations of scientific knowledge had planted a number of crucial seeds of the current processes of the integration of scientific knowledge.

We have already said that Max Weber had one of the most important roles in the development of the new methodology of research in the social sciences which represents a unification of the nomothetic and hermeneutic lines of thought. He was one of the first modern thinkers to show that the objectivity of the social sciences does not correlate with their submission to the epistemic principles of the natural sciences. With Weber, the positivist ideal of objectivity in the social sciences lost ground. For this reason, the current chapter will devote the greatest attention to Weber's methodology of the social sciences. Naturally, other important theoreticians of science who have made a significant contribution to the understanding of objectivity in the social sciences will also be mentioned.

2. Objectivity of research in the natural and social sciences

The starting point of our discussion is the assumption that objectivity in the social sciences cannot always be reduced to a mirror image of objectivity in the natural sciences. If we want to understand or explain the phenomena that form social reality, we certainly cannot stop at an interpretation of natural factors. Within the framework of an analysis of the social world, we have to be interested in values, motives, and the activities of people as well. To explain the natural world within the framework of the natural sciences most often means to subsume it under some general law of nature, and to do this for every individual phenomenon or for the event that we are investigating.

The term *law of nature* usually refers to the general claims of cause-and-effect relationships between phenomena or events in nature. In this sense, the natural laws are not only a guarantee of order in the world, but also a guarantee of its rational cognition. The term *scientific law* has in a way become the central point of explanation of modern natural science. At the time of the establishment of modern science in the eighteenth and nineteenth centuries, the model of research used in the natural sciences was the general ideal for social science as well. This was influenced by different socio-historical and epistemic factors. The reasons why such importance was assigned to the search for general scientific laws in the modern natural sciences also cannot be explained exclusively by epistemic factors. The emergence of classical natural science is thus a consequence of social factors. For example, until the eighteenth century *lex naturae*, that is, the law of nature, usually meant something completely different from what it means today. The category of natural law referred then to something that we would today call the "moral principle", and which would be ascribed to man or god, depending on our worldview. Even Newton held that the claims we today call natural laws were *principia naturae*, the first principles from which the special theorems about nature are derived. The contemporary meaning of the term *law of nature* was created primarily by analogous deduction of the existence of a divine order from the existence of regularity in the natural world. Based on the analogy used for the first time by natural scientists, events in nature were not only considered regular, but also universal and necessary. In order for classical natural science to emerge, the two basic principles – theory (regularity) and experience – had to unite, and the first problem encountered in its later development was the method of proving the necessity of the laws. As long as it emerged from, to use metaphorical terms, Leibniz's metaphysical principle of sufficient reason, there was no problem with a deterministic explanation of the natural world, where there is a necessary and unavoidable connection between cause and effect. The emergence of quantum physics and relativity theory ultimately upset the principle of causal determinism on which the knowledge of classical natural science rests.

In the light of such development of natural science, one should also study the deductive-nomological type of scientific explanation which is a type of epistemic model of natural science research. This is known as the Hempel-Oppenheim model of scientific explanation since it was published by Carl Hempel together with the famous natural scientist Paul Oppenheim in the article *Studies in the Logic of Explanation.* The article was published in 1948 in the journal *Philosophy of Science* and was reprinted later in Hempel's collection *Aspects of Scientific Explanation* (Hempel, 1965). According to the Hempl-Oppenheim model, known in the epistemology of science as the covering-law model, a phenomenon or event is interpreted by subsuming it under a universal law, where the law acts as a strictly universal or statistical law.[1]

In modern natural science, which has taken an important step forward from the classical mechanistic world view, the fundamental laws of the world of science have probabilistic and statistical importance. That is why it is of extreme importance for the model of the final scientific explanation that the explanans includes the probabilistic and statistical law in the place of the universal law. In reality, it was Hempel, and especially the numerous epistemologists of science studying different models of scientific explanations, who accepted the existence of probabilistic-statistical explanations, and not only the existence of strict causal laws in the explanans of scientific explanation. Within the framework of this explanation, we refer to the statistical laws that determine the incidence of a certain property in the whole population of investigated objects. For example, the descendants of hybrid beans are deductively explained by Mendel's laws of heredity which determine the probability or relative incidence of a particular property in descendants (Nagel, 1974: 15).

[1] The term *covering-law model* was introduced by W. Dray. Dray extended the term to include all types of interpretations that subsume the object of interpretation under a general law. At the same time, in the spirit of methodological realism, he was aware that the demand for one unified scientific law within the framework of a comprehensive model of scientific explanation cannot tolerate criticism. We can certainly fully agree with that because some general laws in science can be applied to a number of other laws. Both Hempel and Oppenheim, the authors of the deductive-nomological model of scientific explanation, were well aware of that as well. Carl G. Hempel thus says that we can explain the accord between Galileo's and Kepler's laws only by proving that they are both special instances of Newton's laws of motion and gravity. They can be interpreted anew by being subsumed under the even more general law of the relativity theory (Hempel, 1972). Our knowledge is certainly developed and built up by subsuming laws under more general covering laws or theories.

Just like the deductive-nomological model, the deductive-statistical models of scientific explanation use a nomological type of explanation, since both presume the existence of a universal law. Contrary to this, inductive-statistical explanations refer to statistical, and not strictly universal, types of laws. For that reason, the arguments on which these explanations are based have inductive and not deductive importance. That is why we talk of inductive-statistical explanations, because in them statistical probability goes hand in hand with induction.

On the whole, we rarely work with complete (deductive-nomological) models of scientific explanations in contemporary scientific research. Even epistemology is becoming increasingly aware of the pragmatic aspect of scientific explanations. What we ascribe to an acceptable explanation primarily depends on the context that the given explanation refers to. However, we must not overemphasise the pragmatic aspect of scientific explanation. It seems that B. Van Fraansen was the one to go the farthest in stressing such use of scientific explanation. However, if we followed his epistemic principles, we would find ourselves in an absurd situation where we could explain anything with everything!

Models of deductive-nomological explanations generally do not take us far in social sciences either. In order to understand social reality, we need to comprehend what others do or think, and why they behave or think that way. Usually, the meticulously met conditions of deductive-nomological explanation cannot help us much in this process.

It is true that the beginnings of modern sociology developed on the premises of deterministic mechanics. Within the framework of this premise, sociology was also determined as an effort to discover the necessary and universal laws of the world (Hollis, 2003; Montuschi, 2003). Or, as Alexander Koyre said, "The infinite Universe of the New Cosmology, infinite in Duration as well as in Extension, in which eternal matter in accordance with eternal and necessary laws moves endlessly and aimlessly in eternal space, inherited all the ontological attributes of Divinity" (Koyre, 1988: 224). The *positivist* ideal of the social sciences was modelled on the natural sciences. Marx and Comte, the grandfathers of social science, still wrote their works in the shadow of the triumph of the classical natural sciences (Giddens, 1989; Hollis, 2003). They endeavoured to establish a science about society that would create the power of explanation by studying man's social life equal to the one that the natural sciences already had. When Comte revived the term *social physics*, he clearly showed his cognitive and theoretical (epistemological) interests. Immanuel Wallerstein claims that the triumph of natural science as the model for all other sciences was verbally asserted in that period, and it has kept its power in many respects to this day. Anglo-Saxon and Romance languages still use the word *science* to mean primarily or only *natural science* (Wallerstein, 2000: 15); everything else is obviously considered closer to the arts than to science. If we approach this issue from another angle, unburdened by the value hierarchy of the probably more or less *scientific* sciences, this connection between the social sciences and the arts seems even attractive. Like the arts, the social sciences are also very deeply involved in the creative mediation of forms of human life. Both the arts and social sciences arise from the source of mutual knowledge in order to develop a dialogue, thus increasing self-understanding by understanding others. However, we will discuss this later.

The positivist concept of science, which requires overall social science to subject itself to the model of natural science, has its proponents even today. But, albeit for different reasons, even they are abandoning their conviction that the social sciences may be able to reach the power of explication enjoyed by the less developed natural sciences. Anthony Giddens speaks with a great dose of irony about how in the minds of some social scientists there is still a yearning for the coming of a *Newton of the social sciences*, although today there are more of those who doubt such a development than those who still hold out some hope. "Those who still wait for a 'Newton of the social sciences' are not only waiting for a train that won't arrive, they're in the wrong station altogether" (Giddens, 1989: 13).

As a rule, the arguments that the method of social science needs to completely follow the model of research in the natural sciences refer to three levels. Incidentally, these levels are discussed in detail by Martin Hollis. The first level is ontological, and proves that the social world is a part of the natural order. This is a naturalistic explanation of the theory of scientific objectivity. The second level is epistemology. It considers knowledge about society as absolutely reliable, and, consequently, we should be able to obtain knowledge about society by experience only. And finally, the third level is methodology. At the level of methodology, it is proved that the empirically inductive method is the model for all sciences. This last assumption is positivism *par excellence* (Hollis, 2003: 8–30).

From the point of view of our discussion, it may be interesting to learn the great expectations of such a positivistic approach, whether they are: (1) universally valid predictions of social events; (2) universally valid quantifiable accuracy; (3) universally valid laws of social phenomena. The majority of such expectations have naturally never been met. Let us stay at the never-fulfilled assumptions of the universally valid and absolutely authentic predictions of social events. Namely, social theories that succumbed to eschatological ideologies turned to the belief that social phenomena can be predicted as accurately as those in nature. The theories held that, if we can predict natural phenomena such as an eclipse of the sun generally accurately, then we can do the same and with equal accuracy with all social changes in the future. The assumption that social phenomena can be predicted just as well as natural phenomena led to the conclusion that prediction in natural and in social science is identical. In truth, predictions of social phenomena, just like predictions in astronomy, which are among the most reliable, are possible only if two conditions are met – *rebus sic stantibus* (in these circumstances) and *ceteris paribus* (all other things being equal). Modern societies are prone to great changes, and there is also a great interconnection of all social factors. Mario Bunge gave an important warning concerning this issue: "The rate of success of social forecasting is notoriously low. (Examples: Nobody predicted the Great Depression, the massive entry of women into the labour force in the 1970s, the oil crisis, the breaking up of the Soviet Union, etc.). In light of the foregoing discussion, there are several possible reasons for such poor forecasting performance. One is that some processes are inherently unpredictable because they occur in unstable social systems. Another is that behaviour is partially determined by learning and expectations. A third reason is the dearth of well-corroborated social theories and the fragmentation of social studies. A fourth is the wrong approach often adopted by social forecasters" (Bunge, 1996: 162).

Even though the logical structure of prediction is the same both in the social and natural sciences, it should be pointed out again that the methodology of the social sciences needs to consider the convictions, interests and motives of people to a much greater extent than is the case in the natural sciences. In this regard, I would like to mention the issue of the *self-fulfilling* or *self-destroying* prophecy. The fact that actors are aware that their actions have been predicted can help fulfil the prophecy, or it can prevent the prophecy from coming true. Self-fulfilling prophecies in the social sciences are the prophecies that first misconstrue the situation, which sets off new behaviour that finally makes the originally mistaken prophecy come true. Robert Merton says in this regard: "This specious validity of the self-fulfilling prophecy perpetuates a reign of error. For the prophet will cite the actual course of events as proof that he was right from the very beginning" (Merton, 1971: 146). He called this the *perversity of social logic*. With this thought, Merton splendidly highlighted the *differentia specifica* of the social sciences. Naturally, there are also examples when public revelation of a prophecy prevented it from coming true. These are *self-destroying prophecies.* The specificities of predictions in the social sciences, compared to the natural sciences, raise another set of interesting questions, but they will not be our concern in this discussion.

3. "Understanding other minds" in methods of social research

Expectations of reaching ideal scientific objectivity in the social sciences based on universal scientific laws are certainly out of place today. Even the modern natural sciences have finally freed themselves of the narrow conception of objectivity based on the conviction that a scientific principle has to deny innovation and variety in the name of the eternal, universal law. According to Prigogine and Stengers, natural science has finally opened up to unpredictability, which is no longer a sign of complete ignorance and sparse control (Prigogine and Stengers, 1988: 524).

If modern natural science is understood as an area that has opened a dialogue with nature, as an area that is constantly searching the open world we belong to, the world in whose creation we also participate, then this applies even more to the social sciences. In the natural sciences, the rule of thumb is that science analyses its subject of study, not that it turns to the topic of the study for an opinion. The social sciences are completely the opposite. They are an area of research where the "subject" of their study, people, entangles with researchers in the most varied forms of interaction. To put it briefly, in their field of study, the social sciences (quite contrary to the natural sciences) are more engaged in the relation of subject to subject, than subject to object. Furthermore, we need to draw attention to another important epistemic difference between the natural and social sciences, discussed by Fay and Moon (1996). This difference is the formation of concepts and categories used in one or the other type of science. In the natural sciences, the forming of concepts is determined by two interconnected preconditions: theory and measuring. Such a framework is expected to give rise to concepts that would allow the establishment of theories, which can usually be tested, where all other categories are excluded, especially those derived from common (everyday) language. The forming of concepts and categories in the social sciences and humanities is not so strictly isolated from common (everyday) language. The terms we use to describe, interpret and understand an actor's actions are derived precisely from the social world which is the topic of our study, and not only from narrowly defined and strictly formalised perception theories. This applies at least to the initial stages of the research since an actor's original decision on how to act depends precisely on how the actor himself understands the significance and the sense of this action. For this reason, the concept we use to explain the actor's actions must appropriately encompass that significance and that sense. This greater direct connection between ordinary (everyday) language and the terminology of the social sciences sometimes leads to the wrong impression that some fields of the social sciences are actually some kind of semi-science. Of course, this is not true because every field of science develops its own terminology which never coincides with ordinary (everyday) language. The reasons why laypersons feel invited to deny scientificity to the social sciences, but not to the natural sciences, are more axiological than epistemological in nature. To put it simply, natural scientists speak of nucleoids, isotopes, genes, galaxies, etc. Sociologists, on the other hand, speak of different social actors. Since the latter as a rule do not see themselves as nucleoids or isotopes, and they do identify with one of the ideal types used by sociologists in their studies, their value judgments of the status of individual sciences refer more to the social sciences than to the natural sciences.

The social sciences face the issue of "double hermeneutics" (Giddens, 1989: 174), or, in more philosophically general terms, the issue of "understanding other minds". As Martin Hollis puts it, "this is the philosopher's problem of Other Minds. It becomes central for the social sciences as soon as one thinks of understanding action as involving an interpretation of interpretation, a 'double hermeneutics', as it is commonly called" (Hollis, 2002: 151).

Hollis uses the following example to show the slightly different epistemological substance of the social sciences: when an astronomer in the role of an active research subject notices events in the far skies and explains the behaviour of that ordered domain, he starts from the assumption that nature is independent of man's opinion and conviction. When performing the role of observer, the social scientist is in a rather different position. Admittedly, he is also trying to reach the final explanation of what he sees. Metaphorically, as an onlooker, the social scientist can see at least as much of the game as the players themselves. In this case, he first reconstructs the viewpoint of the player, and this is precisely the significant difference between the social and natural scientist. Martin Hollis says: "There is a fundamental difference between understanding and explaining, since what happens in the social world depends on its meaning for the agents in a way without parallel in the realm of the stars" (Hollis, 2002: 152).

Anthony Giddens has a similar opinion. He is convinced that all types of social research require communication with persons or groups who are the *subject* of this research in a certain sense. Giddens says that in some examples, such as participant observation, questionnaire surveys, interviews and similar methods, this takes place as real interaction between the observer and the subject (Giddens, 1989: 173). For this reason, as Giddens goes on to say, the terms used by members of society and the concepts used by observers-sociologists or terms coined as neologisms need to be reciprocal. This is indispensible to social science, even though the positivist category system of the majority of schools of "orthodox" sociology has already blurred that fact.

Since the epistemology of the social sciences focuses more on the subject-subject relation than the subject-object relation, it is certainly reasonable to expect differences in the logical structure of scientific generalisations in the natural and social sciences. We have already touched upon the specificities faced by predictions in the social sciences. We can thus assume that the general laws in the social sciences also imply a series of unchangeable relations, expressed either as a probability or as a general cause-and-effect relationship. In contrast, within the framework of structural (nomothetic) analyses, causal relationships that do not express theoretical generalisations in the social sciences do not refer only to cause-and-effect relations as established in nature, but also to the consequences of human actions. All theoreticians and epistemologists of the social sciences who encourage discussions on objectivity criteria in the social sciences, and these are Giddens, Hollis, Wallerstein and several others, admit that the causal generalisations in the social sciences are in many respects similar to the laws of the natural sciences. However, they do differ in some important aspects, since they depend on the (scientific) replicability of intentional and unintentional human actions and their social consequences.

Fritz Machlup studied the presence of some basic epistemic principles in the methodologies of research in the natural and social sciences (Machlup, 1996). His studies brought him to the conclusion that the social sciences can in no way be said to be inferior to the natural sciences. Let us take a brief look at some of his claims:

1. The principle of replicability of observation has been stressed expressly throughout the history of the natural sciences. The basic idea behind this principle is that it would be hard to imagine science if phenomena, and their scientific observation (verification), did not repeat themselves, and if they were a kind of structural constant. Physicist Robert Oppenheimer once asked whether, if the universe was a unique phenomenon at the level of theory, we may assume that everything can be derived from one supreme proposition. Oppenheimer naturally knew very well that even in the world of physics phenomena are not as universally homogenous as we may like to think. Of course, the opposite is also true: phenomena in the social world are not so heterogeneous that the principle of replicability of observation would not apply to them, although in a somewhat less restrictive form.
2. In the epistemology of science, we often meet the thesis that the verification of hypotheses in the social sciences is extremely difficult compared to the case in natural science. Machulp agrees that differences exist, and, although opposing any exaggerations in that respect, he says that "... with respect to the verifiability of hypothesis, we found that the impossibility of controlled experiments combined with the larger number of relevant variables does make verification in the social sciences more difficult than most of the natural sciences" (Machlup, 1996: 16). At the same time, he adds that even in natural science we have to distinguish between the so-called *high-level hypothesis* or even complete theoretical systems, and so-called *low-level generalisations*. The former are most often only postulated and

never verified directly. When the natural sciences investigate phenomena that are impossible to reproduce and regularities for which controlled experiments cannot be devised, they have to rely on postulated and not completely verified hypotheses.

3. We have already said in the introduction of this chapter that the criterion of exactness is in no way suitable for ranking different types of sciences. Machulp also warns that the main difficulty regarding the criterion of scientific exactness is its rather random use. Those who propose greater exactness of the natural sciences never say precisely what this exactness actually refers to. Does it refer to measuring? Or to predictions of events? Does exactness refer to the level of (mathematical) formalisation? Those who claim that the social sciences are less exact than the natural sciences are usually not sufficiently familiar with either type of knowledge.
4. In terms of the quantitative measuring of phenomena in the area of the natural as well as the social sciences, we have situations where we have a multitude of data at hand, but without knowing what to do with them. On the other hand, we can have important scientific discoveries even with less measuring and data if we have elaborated good theoretical models. The availability of quantitative data is not in itself a guarantee of the better development of a scientific discipline. Malchup believes that the methods of natural science would not at all be found at the top if scientific fields were rated by the criterion of qualitative measuring. Economics is the only scientific field where the primary experiential material is already expressed in the form of numeric data. Economics looks at prices, sums of money and other numeric data. However, in the area of the natural sciences, researchers first have to establish all conditions for measuring in order to obtain numerical data. A physicist, for example, has to reveal and prepare a whole complex of scientific instruments which will only help establish numerical values of the investigated phenomena. If we follow Lord Kelvin's famous phrase that *science is measuring*, both in the social and natural sciences, science would not deal with the key research problems or any convincing criteria on the basis of which one could assess whether immeasurable phenomena are more frequently found in the natural or social world.

Analysing fundamental epistemic principles, Fritz Machulp has convincingly proven that there are no less or more superior fields of research in the world of science. The first and most important step in freeing the methodology of social science from positivism was made at the beginning of the previous century by Max Weber. We will even find a number of epistemological germs in his views that are still applicable today. With his method of interpretative explanation (verstehende Erklaerung), he paved the way for such a balance of forces between the methods of the natural and social sciences where the former would no longer be seen as an (unreachable) ideal model for the latter, but where the natural and social sciences show two different research approaches that are complementary despite the differences in their topics of research. Furthermore, Max Weber also warned that contemporary science has to be interested in discovering and resolving the problems of this world more than in dividing itself into subject-based fields of research, which even critical rationalists accept (Albert, 1999). Before an institutional division into numerous fields of research took place, Weber had developed a certain vision of transdisciplinary scientific knowledge even within social science. He may have shown best in his sociological analyses that in studying the social world, it is not possible to go "only from within", to use Hollis's words (Hollis, 2002: 147), and using methods that were significant for the hermeneutical view of science at that time. As a social theoretician and epistemologist, Weber always tended to unite the nomological and ideographic types of scientific explanation.

4. Explanation and understanding in classical social thought

According to Max Weber, scientific objectivity in the social sciences cannot be reached by *a priori* valid judgements, but by experience. In his methodological papers published posthumously in the collection *Gesammelte Aufsaetze fuer Wissenschaftslehre* (Weber, 1988), Weber inferred that causal explanation is reached via *objectively* valid scientific truth, where only relevant empirical evidence could say whether this task is attainable. The assessment of what is *subjective* and what is *objective* is not only a consequence of unchangeable historical sources, but also of the current historical conditions of the object of the research. Based on such categories of the *subjective* and *objective*, Weber concluded that social science is always founded on a system of values accepted by a certain scientific community. For this reason, no analysis of the social sciences can strive to reach a final or universally valid category of scientific objectivity. While astronomy, an example of a borderline natural science, is interested in the quantitatively and exactly measurable relations between celestial bodies, the social sciences study qualitative aspects in investigated phenomena. Thus, the issue of scientific objectivity needs to include more factors, and not only causal regularities. Weber gave the following example: the interest of social scientists in research activity focuses on the exchange value of money because it is a general phenomenon in modern societies. However, an imperative that allows us to obtain new knowledge on the general principles of the exchange value of money still does not provide an answer to the question why this is so important in modern society (Weber, 1988: 176).

Weber rejected the metaphysical system of values whose task was to determine the objective validity of scientific knowledge. Numerous researchers of Weber's methodology admit that Weber's epistemology has in this respect stepped out of the field of absolutely valid judgments and scholastic metaphysics of values (Ringer, 1997: 50; Baert, 2005: 45; Mommsen, 1990: 114). The system of values that regulates scientific research is, according to Weber, socially and culturally conditioned. According to some, Weber would, in classical epistemological terms, cancel the lines between the so-called context of justification in science and the context of discovery in science precisely due to the introduction of value and social and cultural assumptions into the process of scientific research. To be more precise, his methodology relied on the social anthropology of man as a cultural being (Keyes, 2002; Burger, 1988/89). In this respect, Weber branched off from his theoretical predecessors (Dilthey, Windelband, Rickert), especially in shifting his scientific interest from the question "what makes a fact worth studying?" to the question "what explains the inclusion of a certain fact into a certain type of science?" However, attempts at explaining Weber's epistemology of science that say that he avoided determining the content of the criteria of scientific validity by formalising the term *science*, and that he was close to the mathematical formalism of logical positivism in this respect sound rather unjustified (Wagner and Zipprian, 1994).

Although Weber was aware of the meaning of "nomological experiential knowledge" which is a condition for obtaining objective knowledge on how people behave in given social and historical situations, he never understood the phrase in the deterministic sense of natural science. For Weber, social science is the type of knowledge focused on analysing the phenomena of life in terms of their cultural significance (Weber, 1988: 175). The significance of these phenomena cannot be derived from such a final nomological model of scientific explanation because in the social sciences we always have to work with values, goals and motives of human actions. Scientists' research interest must be an analysis of social phenomena, and not only their universality, but also their particularity. Another point of view has to be added to Weber's earlier inference. Weber touched upon the issues of increasing specialisation and differentiation of scientific knowledge at the turn of the twentieth century in one of his most famous works, *Wissenschaft als Beruf* (Weber, 1988: 582–613). He did not lament this trend in the development of science, nor did he glorify it. He was a realist with regard to the analysis of the methodological issues of science, and was aware that the differences among both the natural and social sciences were more axiological than ontological in nature. He believed that it was precisely this that made the bridging of the epistemic and methodological gap between the areas easier.

Weber's stand on the specific cognitive interest of the social sciences presented above and derived from the system of cultural values at least partly explains why he attributed such great significance to the concept of "ideal types" in the social sciences. He found the creation of theoretical constructs necessary to identify and categorise social phenomena according to their cultural and historical significance. Scientists determine the same ideal type in very different ways, depending on their research interest. No ideal-type construct can encompass total reality because it is always infinite. However, it is certainly very important that every ideal type contributes to reducing the complexity of reality to a great extent, which makes the reality more systematic.

The goal of Weber's interpretative sociological method was to find out the meaning of social activity. He thought that being an experience-based science, sociology was not about discovering absolute metaphysical sense, but the sense that any real actor has in his thoughts in a historically given example, or actors on average, or the approximation of a given quantity of examples, or an actor in a conceptually construed clear type. Max Weber has described as social that activity which one or more actors perceive as referring to others and which is used as a guideline in their behaviour. He understood the category of *action* (Handlung) as human behaviour when and insofar as the actor or actors attach a subjective meaning to it. When discussing a course of action, Weber primarily referred to determining relations between inner (psychological) processes and external (social) manifestations.

Weber was interested neither in the actor's internal condition, nor solely in the actor's external behaviour, but the action determined by both internal (psychological) and external (social) factors at the same time. In line with this, he tried to unite the category of *understanding* and the category of *explanation*. His epistemological or methodological maxim was best expressed in his connection of two epistemic categories: the category of immediate understanding *(aktuelles Verstehen)* and the category of explanatory understanding *(erklaerendes Verstehen)*.[2]

1. Immediate understanding *(aktuelles Verstehen)* refers to recognising opinions, behaviours and actions significant for the actor himself, and which are the subject of the study (for example, cutting wood, somebody's anger, or a pointed gun).
2. Within the framework of explanatory understanding *(erklaerendes Verstehen)*, an outside observer is analysing the motivation of an actor's opinion, behaviour and action in order to determine why he acted or thought in a certain way. Thus, we understand the chopping of wood or the aiming of a gun in terms of the motive if we know that the woodchopper is working for a wage or is chopping a supply of firewood for his own use or is possibly doing it for recreation (rationally), or he might also be working off a fit of rage (an irrational case). Similarly, we understand that a person aiming a gun is doing so because he was commanded to shoot as a member of a firing squad in order to defeat an enemy (rational), or that he is doing it for revenge (affectually determined, and thus in a certain sense irrational) (Weber, 1988: 547).

[2] He presented the interdependence of both methodological approaches in his two methodological papers: *Ueber einige Kategorien der verstehenden Soziologie* (1913), and *Soziologische Grundbegriffe* (1921). The two papers, which form two independent chapters in the posthumous *Gesammelte Aufsaetze zur Wissenschaftslehre* (Weber, 1988), were published several years apart, and the latter is actually a reworking of the former. They are both coordinated and extremely complex in content. Later interpreters of Weber's epistemology and methodology mostly referred to them since they were presented together without Weber's extensive comments on his contemporaneous theoreticians (which were inherent to most of his other methodological papers). For this reason, these papers are considered to present the gist of his thoughts on epistemology and methodology.

The mentioned role of the outside observer cannot be considered only in some *mediating variable* in the physical, but must also be seen in the wider metaphorical sense, as Rudolf Richter said. It is social change and change on the level of interpretation (Richter, 1995). In brief, it is the issue of understanding *other minds*, which we have already discussed in the introductory part of this chapter.

If we ask ourselves here about the reasons for Weber's division into "immediate" (aktuell) understanding and "explanatory" understanding, we must not disregard the fact that he had already established an indubitable difference between the so-called inner processes that determine the meaning of action, and the so-called external actions marked by that meaning in his 1904 essay *Die Objektivitaet sozialwissenschaftlicher und sozialpolitischer Erkenntnis (*Weber, 1988: 146–214). He was not interested in every individual aspect of understanding respectively, but their mutual relation. He had also already proposed in this work that the social sciences should investigate the causal relations between internal meaning and external behaviour. Within the framework of explanatory understanding, we respond to the question about the causes of action. We do not interpret a situation which involves an actor on the basis of intuition but on the basis of wider knowledge of the social mechanisms that affect the actor's actions.

According to Weber, the problem of the interpretative explanation of causal relations between the inner meaning and external behaviour of (social) actors naturally refers to the basic (epistemological) issue of *adequacy of meaning (Sinnadequanz)* and *causal adequacy (Kausaladequanz)*. The problem of adequacy which became a centrepiece in later discussions of sociological epistemology refers to the question of the relationship between the hermeneutical task of mediating a description of life and "technical" concepts developed in the social sciences. After Weber, many interpretative sociologists came to the conclusion that the social sciences can legitimately use concepts that they, to whom the insights refer, do not know.

5. Interpretative explanation in the social sciences

The foundations for understanding social reality in the sense of double hermeneutics, which was discussed later by Anthony Giddens, were mostly developed by Max Weber. According to him, the category of explanatory understanding meets the conditions of adequacy of meaning if it is undoubtedly evident. Since every interpretation necessarily remains at the level of hypothesis, and considering it might also arise from something as evident, Weber says that explanatory understanding also has to be causally adequate. Naturally, he also allows for the reverse as well: every causally adequate claim comes down to mere indecipherable statistical probability unless it is also adequate in meaning.

In his methodological texts, Weber was highly critical of the category of emphatic understanding (*nachfuehlende Verstehen*). He claimed that "... one need not have been Caesar in order to understand Caesar" (Weber, 1988: 543). With this statement, he wanted to stress that the capacity to produce the same type of action is not a prerequisite to understand the action. Considering Weber's criticism and scepticism of the category of "emphatic understanding" and his effort to prove that inarticulate insight, or intuition, is not satisfactory in procedures aimed at revealing other people's feelings, but that interpretation always has to be a result of stringent critical analytical consideration, the claims that Weber was a belated response to Dilthey's hermeneutic psychologism seem amiss. Weber believed that the methods of the social sciences need to start from a person's motives and goals, but they need not stop there. Weber went from the level of the individual to the intersubjective and farther on to the social level.

Before we credit Weber with unbridgeable polarisation between the subjective-individual and the socio-functional, we must first admit that all his works are an exciting mix of epistemic elements. Weber's content analyses of individual social phenomena – religion, economics, politics – prove that he was avoiding both psychological reductionism and sociological functionalism. It is not possible to give an objective explanation of social phenomena and events unless we go from the individual psychological level to the general social level, and vice versa: we cannot remain at the level of general sociological generalisation which would not acknowledge the actor's subjective meaning of actions. An analysis of subjective motives within the framework of sociological science has to be put into a wider social context. In order to obtain knowledge of a phenomenon, we must know its marginal social conditions as well. However, our intuitive identification with the motivation of an individual actor does not suffice here and we also need to rely on the more general knowledge of social laws that govern the actions of individual actors. At this point, we also have at least to mention that Weber believed it was cognitively unproductive to resort to scientific abstractions which have no other purpose than themselves. As he says, the more general or abstract the laws, the less valuable they are because they may be more devoid of content and more distant from the richness of reality (Weber, 1988: 178). The conclusion that can be drawn from Weber's deduction is clear: since people never keep to the same rules, and they violate them in reality, we are always condemned only to claims of probability.

Here, within the framework of activity of social actors, we do not have the opposition between *chance* and *necessity*, but only *adequacy*. The construction of causal relations thus refers to the relative frequency of a type of action. This is why we can ascribe objective probability to this type of causal relationship.

Finally, the whole of Weber's methodological credo is most coherently reflected precisely in his method of ideal types in science. The method of ideal types is a good example of bringing together nomothetic and ideographic elements in the procedures of scientific cognition. It is a theoretical construct that aims to encompass complex social reality. We will not ponder on every characteristic of the method of ideal types in science in this chapter. It is best explained as a category used in every procedure of research in order to more forcefully grasp complex social reality. In metaphorical terms, it is like taking up binoculars when we want to see a faraway object as clearly as possible, and then putting them down again.

It should be pointed out that the method of ideal types in science is completely free of any positivist factualism. For Weber, the social and historical sciences are not only about *determining concrete facts* (Weber, 1988: 193) but also about the search for the cultural meaning of one, even simple, individual act (Weber, 1988: 193). He always reaffirmed that ideal types were not the goal, but only a tool of the social sciences. He denied the possibility of creating a complete reflection of reality using these tools. Accordingly, he also refuted the system of theorems from which reality could be deducted. He emphasised that he wanted to understand reality, and not dissolve it into empty formulas (Weber, 1988: 37). Ideal types developed from historical material, to which they also apply. If social practice is changing, the old ideal types can no longer be used and new ones have to be created. However, this does not mean that Weber wanted to free interpretative sociology (*verstehende Soziologie*) from the scientific demands for forming categories. Every science has to arise from a system of scientific categories, but the question is what those categories have to offer as a means in the cognitive process of a certain discipline. It is not about achieving maximum congruence, but the maximum divergence of theory from reality.

In Weber's time, individual social disciplines that were strongly influenced by the natural sciences derived from rigid formal principles used to investigate social actors strictly as *Homo economicus* who consistently follows the logic of goal-driven rationality. With his method of ideal types, Weber was far from following that line of thought. For him, the activity of the social actor as *Homo economicus* is only a border-line example that interprets how social actors would act if they were led by the principles of absolute economic rationality. Such action would be similar to a mathematically programmed model. Weber was aware that we do not work with such omnipotent and reason-driven economic actors in social reality. In social reality, people do not act only with regard to rational rules, but also with regard to other motives, which are completely irrational. For this reason, Weber developed arguments for *Homo sociologicus* who differs from *Homo economicus,* who existed before him.

6. Category of objectivity and the method of critical rationalism

In the context of our discussion, it should be pointed out that none of the later and varied interpretations of Weber's method of ideal types in science understood that Weber's intention was not to put all the actions of social actors into a Procrustean bed of sterile objectivism or rationalism. To be more precise, Weber did not stop at the idea that the value of social science methodology can be assessed only in relation to the actual advancement of scientific knowledge. His approach is rather similar to critical rationalism. Like Popper, the most important proponent of critical rationalism, Weber also expressed his belief that science and its methods can advance only by resolving real problems. According to Popper, theoretical speculations, completely unattached to real research problems, can be of little help. He said in the text *Die Logik der Sozialwissenschaften* that, just like all other sciences, the social sciences can be successful or unsuccessful, interesting or hollow, fruitful or unfruitful depending on the relevance and attraction of the problem they study (Popper, 1970: 105).

Popper repeatedly warned against erroneous perceptions of methodological naturalism and methodological scientism (Popper, 1957, 1970, 1974). Naturalism, or scientism, required the social sciences to finally learn to follow the method that would lead to objective scientific knowledge. The guiding principle of methodological naturalism was: start from observations and measuring, and then use induction to make generalisations and develop theories. Such perceptions propose that inductive observation is the only path to achieving objective scientific knowledge. Methodological naturalists, of course, always question whether such objectivity is attainable in social science. Popper rejected methodological naturalism and claimed, in line with his method of critical rationalism which will not be expounded here (Mali, 2006), that there was no pure inductive science, but only sciences that follow experiential verification of theoretical propositions to a greater or lesser extent; this applies to the social sciences as well (Popper, 1970: 119).

According to Popper, an analysis of the social situation is the origin of every explanation in social science. In this regard, he wrote: "The fundamental problem of both the theoretical and the historical social sciences is to explain and understand events in terms of human actions and social situations. The key term here is 'social situation'. In my view, the idea of a social situation is the fundamental category of the methodology of the social sciences" (Popper, 1994: 168).

The model of research within the framework of the social situation proposed by Popper is reminiscent of Weber's research model based on "immediate" (aktuell) and explanatory understanding. Popper also sees the exact and detailed reconstruction of the problem situation, as felt by the actor who is the object of study and observation, as the first step of the research subject (observer). We could say that this first step is the hermeneutical part of the analysis of the social situation. The researcher, naturally, cannot stop here. The actor's understandings of his motives of action and of the circumstances in which he acts are usually limited or even distorted and irregular. For this reason, if the scientist (external observer) wants to obtain a complete explanation, he needs to detach himself from the actor's understanding, but must not neglect it. Put briefly, acknowledgment of the actor's internal motives and goals is the first, but not the last, step in research (observation) procedures.

The rationality principle has a central part in Popper's method described above. Popper reaffirmed the relevance of the objectively hermeneutic approach in the social sciences with the claim that an analysis of the social situation includes the use of the rationality principle (Popper, 1974: 199). In his paper *Rationalitaetsprinzip*, he explained that the principle has nothing in common with the assumption that people are always rational because they act rationally in every situation. According to Popper, this is a less ambitious principle because it does not assume anything more than that our actions respond to the problem situations the way we see them; even if we do not always consider it true, these are the reasons to see it as a good path to come closer to the real event. If used in this way, it considerably reduces the randomness of our behaviour and actions (Popper, 1995: 359).

The method follows from the hypothesis that any action, or knowledge of individual actors, even if proven wrong later, can be understood as a rational reaction to given social and historical circumstances. In situation logics, this assumption works as the regulating principle which leads us to an objective understanding of social reality. With Karl Popper, the leading proponent of critical rationalism, the category of objectivity in the social sciences is thus also based on a balanced combination of the hermeneutical and critical-analytical approach to the object of research. An additional element that takes Popper's concept of objectivity in the social sciences even farther from positivism is his understanding that the method of scientific research allows only a gradual approach to scientific truth. We speak of coming closer to the truth (verisimilitude of truth), and not of absolutely reaching the truth!

At the end of our discussion, let us point out once more that the later epistemic theories that studied the category of objectivity in the social sciences largely recognised the relatedness of Weber's and Popper's views, whereas some even ignored any connection between the views. More recent constructivist and relativist approaches to the issue of the truthfulness and validity of scientific knowledge have undoubtedly taken another important step forward from the unchangeable positivist explanation of scientific objectivity. Their criticism of the classic positivist ideal of scientific objectivity was welcomed enthusiastically in the frontline scientific fields, since the promotion of several issues or predetermined research rules is doomed to fail here. These are the fields of scientific research brimming with unpredictability, controversies, etc. Work at the scientific frontline contains more *interpretative* or *hermeneutic* contents. This aspect was also highlighted by Kuhn (1998) in the book *The Structure of Scientific Revolution*, albeit in another context. How else should we understand the division into the phase of normal science and the phase of scientific revolutions within the framework of Kuhn's model of scientific development? As is known, Kuhn's discussion of conflicts between paradigms at the times of scientific revolutions started from the hypothesis that there was no uniform collection of scientific problems or a uniform collection of scientific rules to resolve them. This is so since these conditions have never been met completely in reality and the conflicts between paradigms can never end with a very standardised result (for example, by counting successfully resolved problems). However, we will not discuss this issue here in more detail.

Unfortunately, precisely due to neglecting the fact that this issue also involves an evolutional line of thought, modern epistemologies of science have often brought great confusion to the topic under study. Within the framework of an analysis of more recent sociological theories of (scientific) objectivity, Stephan Fuchs has brought attention to a number of weaknesses of these recent constructivist theories of scientific objectivity (Fuchs, 1997). Let us take rhetorical theories of scientific objectivity as an example. Despite its recent popularity, the viewpoint that objectivity in science is a purely rhetorical issue has a number of weaknesses. It has not developed a single convincing argument yet why one claim in science has the status of an objective scientific claim, while another has only the status of an objective opinion. In truth, rhetoric can be one of the elements why one scientific proposition can be incorporated more easily into an existing body of scientific knowledge than another proposition, but it cannot explain in itself why a great number of scientific propositions have disappeared from the scene, despite the rhetoric that was completely imbued with objectivism. Rhetoric is just one, but certainly not a sufficient, condition for determining the criteria of objectivity in the social sciences. Constructivist explanations that make a connection between scientific objectivity and social power face a number of weaknesses. Although explanations of scientific objectivity as social power have a very long tradition, and even enjoy the support of some philosophers (Husserl, Heidegger, Nietzsche, Marcuse), they nevertheless work with very unconvincing arguments. The category of scientific objectivity is for them just another form of manipulation of the dominant *logocentric* narration of occidental rationalism disseminated by modern science and technology.

7. Conclusion

The purpose of this chapter was to warn that the issue of objectivity in social research dates back to the beginning of the social sciences.

Among individual scientific disciplines that are today classified within the wider category of social science or are at least related to it, classical sociological thought has made a very important contribution to epistemological issues. Our primary goal was to show that the majority of questions concerning the basic epistemic principles of social science can be found in the methodology of Max Weber. Like other great theorists of science, Weber also developed a vision of social research that strived to integrate, and not separate, different methodological approaches. This vision, which became the focal point of epistemological discussions throughout the twentieth century, has unfortunately not been realised to this day.

Even today, we still sometimes encounter positivist views of the methods of social research. These views connect the objectivity of scientific research exclusively with nomothetic scientific approaches and related scientific quantification, neglecting a whole series of paradigmatic movements in the natural sciences of the previous century which introduced a greater degree of relativism into the overall mode of scientific thought.

This chapter has tried to show that in the field of the social sciences it is heuristically more productive to follow the epistemological principles that bring together the elements of a critically-analytical and hermeneutical approach. In the words of practical methodological research, we could say that we favour the convergence and not the divergence of quantitative and qualitative methodology. Epistemology is usually the first step in the direction of understanding the social and cognitive-theoretical laws of the development of modern science. Without understanding the epistemological organisation of modern science, we cannot understand its social organisation either. And it has lately been moving in the direction of the integration of narrow specialised fields.

It is interesting that precisely the borderline fields of scientific research which today work across different categories of human knowledge, such as genetics and nanosciences, often use methodologies that were first used in social science. Here, I chiefly refer to different types of systemic methodologies. In brief, the heremeneutical way of thinking, first promoted by Max Weber in the social sciences, is an indispensible methodological tool in the natural sciences as well. For this reason, the categories of scientific objectivity in the natural and social sciences cannot be totally different, but in the best of cases they can complement each other.

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Katarina Prpić

Scientists' concepts of scientific objectivity

1. How do practising scientists understand scientific objectivity?

The initial question generates a sequence of (sub)questions, like the following: does the scope, complexity and development of philosophical and sociological concepts of scientific objectivity affect the perceptions of practising scientists? Have they been moulded and changed under the influence of the previously analysed conceptions of one of the key epistemological categories? Are scientists still captives of their classical scientific worldview (scientism) and its understanding of objectivity? Can they constantly question their own epistemological position, including social scientists who are expected to engage in such self-reflecting practices? Or are scientists necessarily inclined to epistemological realism, even positivistic orthodoxy, as some authors suggest? Finally, what is known generally about scientists' perceptions of objectivity?

The opinions that sociologists of science ascribe to practising scientists and their basis in the (empirical) sociological, psychological and philosophical research of the epistemic concepts of scientists could be a good starting point for this study. We will first start with the viewpoints of sociologists of science, comparing them later with the available findings on the cognitive convictions of scientists. Two fundamental standpoints on scientists' cognitive orientations can be identified. One credits scientists with the traditional view of the nature of science, so Cole (1992) assumes that positivism is the prevailing opinion of sociologists, natural scientists and the educated public. The other viewpoint differentiates scientists' epistemological orientations, and Elkana (1978) thus claims that (natural) scientists are necessarily realists, and historians are relativists, while philosophers of science have the opportunity to choose between being realists or relativists, but they can also combine both views at different levels.

Theoreticians of scientific fields or organisations even establish theoretically wider views of the major epistemological orientations of scientists. Whitley (1977, 1984) does not pay them full attention, although they stem from his concept of the intertwined intellectual and social organisation of science which is manifested in every type of scientific field in its peculiar way. Fuchs went farther in elaborating the connection between the cognitive and the social in scientists' perceptions. He believes that realism is the epistemological view pertaining to scientific fields of great social density and interdependence. Their cognitive style is characterised by rather absolutist and authoritarian standards of objective knowledge. Scientific fields of a loose social and organisational structure develop relativism or suffer from a lack of solid epistemic foundations (Fuchs, 1992).

The same author described positivism as an organisational myth of science which is not only its façade, but also directs the transformation from actual research to the public presentation of that research (Fuchs, 1993a). He develops an even more elaborate typology of epistemological orientations of three groups of scientists who engage in different types of research. Thus, pragmatism is a philosophy of research fronts that constantly produce changes and innovations; positivism, however, suits normal science typical of the majority of contemporary (natural) scientists engaged in producing facts; finally, hermeneutics is the philosophy of loose textual fields with a high degree of decentralisation and the production of discussion, not facts (Fuchs, 1993b).

This view allows for the parallel, different understandings of objectivity in different scientific areas, and even within one and the same area. However, objectivity is not conceived in the sense of the correspondence of knowledge to reality, but in the sense of confidence in reason and evidence in science (Fuchs, 1996). According to Fuchs (1997), objectivity is a mode of communication in science, and as long as one is engaged in offering communications as scientific communication, this code cannot be avoided.

Are epistemological views of scientists really rather uniform, as some authors claim, do they show typological diversity, as others believe, or are they even more complex and ambivalent than theoreticians expect? Contrary to many predominantly psychological studies of the epistemological beliefs of high school and university students,[1] empiri-

[1] The studies in question were adapted to the population of knowledge receivers, and not the creators of new knowledge, and thus they focus more on investigating the cognitive convictions of students concerning the structure of knowledge, the stability of knowledge, the speed of learning and learning capacity (Paulsen and Wells, 1998; Schommer-Aikins et al., 2003; DeBacker and Crowson, 2006). One of the most famous investigations into the subjective side

cal insight into scientists' epistemological orientation is inexplicably scarce, narrow and partial.[2] Scientists' understanding of objectivity has hardly been investigated empirically. Some conclusions can be made about it based on Becher's famous research, a small number of studies of some epistemic concepts of scientists, and investigations into the research ethos.

Becher's (empirical) classification of science includes attributes of knowledge in the hard-pure natural sciences and in the soft-pure social sciences and humanities. The epistemological orientations of practising scientists can be discerned from them. The natural sciences are thus characterised by: cumulative knowledge; atomism; concern with universals, quantities, simplification; impersonal, value-free knowledge; clear criteria for knowledge verification and obsolescence; consensus over the significant questions to address now and in the future; results in discovery/explanation. The area of the social sciences and humanities shows the opposite features: reiterative knowledge; holism; concern with the particulars, qualities, complication; personal, value-laden knowledge; disputes over criteria for knowledge verification and obsolescence; lack of consensus over the significant questions to address; results in understanding/interpretation (Becher, 1994: 10). The different cognitive styles of the two scientific areas also include a different understanding of scientific objectivity, or even a discussion on whether or not it is possible.

Qualitative research on a small non-random sample of natural scientists (and three engineers) from a mid-size Canadian university provided more specific results. All thirteen scientists rejected the traditional (positivist) and post-modern relativist views of science. They described their epistemological position as somewhere between two extremes, or claimed an evaluativist view of science, according to which knowledge is temporary and open to repeated consideration, and scientific method is not reduced to a single group of procedures. The re-

of science is the study conducted by Mitroff (1974), where in-depth interviews were conducted with a group of 42 top scientists, participants in the Apollo programme. All interviewed scientists said that the perception of an objective, emotionally disinterested scientist was naive. They believed that the perception was prevalent in the widest public and in first-year students. Furthermore, in their opinion, scientists have to have an emotional attachment to their ideas.

[2] Moreover, not only the epistemic concepts of scientists, but also their views of the cognitive and social role of science, and their professional values and ethos are rarely studied. There is even lesser interest in their extrascientific activities – cultural, religious or political. This could be a consequence of the output orientation of science studies, so interest in the creators of scientific knowledge is focused on the social and individual preconditions of their productivity.

spondents described the nature of science using terms such as: disputes, arguments, testing of hypotheses, tentative, best current idea, development towards more accurate perceptions (Yore et al., 2004).

An analysis of responses to scientific models made on the basis of interviews with nine eminent British natural scientists also indicates their epistemological orientations. Their opinions on the relation between the models and reality cover a range between the strictly realistic claims that models refer to reality, views that they at least partly concern reality, to the suggestion that models are, depending on one's opinion, either human constructs or the best way to capture nature. It is indicative that none of the scientists advocated an extremely constructivist claim. The author of the study believes that these scientists' opinions are to a certain extent the result of the scientists' individual worldview and taste. One can also notice a view among the respondents that models should not be described as accurate or false, truthful or untruthful, although the truth remains the ideal. There are even some opinions that models do not have to be true, but that they can nevertheless concern reality (Bailer-Jones, 2002).

A study also based on qualitative data, but wider in scope, provided the most interesting results. In-depth interviews covered 60 natural and social scientists from one large university in the USA. It showed that positivism and constructivism are equally widespread and accepted among both groups of scientists. Moreover, natural and social scientists did not show any significant differences in the prevalence of various philosophical hypotheses on the relation between theory and data. The author of the analysis draws the conclusion that most scientists are able to articulate and use more than one epistemological perspective in their works (Chia, 1998).

An investigation into the cognitive convictions of (mostly social) scientists was based on standardised interviews on a sample of 788 respondents from all Danish universities and government research institutes. It determined statistically significant differences between the social scientists and natural, computer and medical scientists in perceptions of certainty and universal validity of knowledge in their own field. Respondents from the latter group showed a great level of agreement with the statement that some basic findings will have enduring validity, while the former agreed with the same statement less frequently – the average result on the seven-point scale was 6.2 and 4.9 respectively. On the other hand, the social scientists were more often inclined to agree with the statements about the relativity of knowledge validity in their field (Andersen, 2001: 278). Thus, they showed a tendency towards the relativistic perception of science, as opposed to the natural, computer and medical scientists, who were more inclined to objectivism.

Furthermore, the majority of the social scientists believe that the social sciences have their own foundation (54%) or that they are most similar to the humanities (22%), while only 9% of the respondents observe similarity with the natural sciences, and 15% notice similarity with both scientific fields (Andersen, 2001: 273). In brief, the social sciences have developed both similar and (somewhat) different epistemic concepts compared to the natural sciences, but social scientists have gained self-awareness about the intellectual peculiarity of their own field.

Croatian empirical research of the ethics and professional values of eminent and young scientists, based on samples of 320 and 840 respondents respectively, also provides information on the epistemic concepts of natural and social scientists (Prpić, 1997, 1998, 2004, 2005a, 2005b). The research established that natural scientists value the importance of theory, objectivity and precise measurements the most. Respondents from the social sciences and humanities also value highly the first two sets of values, but, in their opinion, the precision of measurement and the verifiability and replicability of research are much less important characteristics of scientific work and results in their field.

A study of scientists' perceptions of the cognitive (and social) characteristics of science conducted on a sample of 833 respondents also shows epistemic similarities and differences between the fields in question. Although the differences in accepting certain statements on the cognitive features and on the role of science are not great between these two groups of scientists, they are nevertheless indicative. A picture of rational and objective, and cognitively unlimited science is supported mostly in the natural sciences, although it is also accepted by respondents from the humanities and social sciences, but to a lesser extent. The latter show stronger cognitive scepticism, i.e. they accept the claims more than the natural scientists do that not all science is reliable and that it cannot provide a total and truthful image of the world (Prpić, 2005c). Despite the differences that indicate the contextual variation of the positivist and relativist views of science, both views are found in each of the fields. To be more precise, both natural scientists and scientists from the area of the social sciences and humanities accept to a relatively large extent both types of claims on the nature of science.

If we compare the findings of these few studies with the assumptions of researchers of science, it seems that the empirical picture of the epistemic concepts of scientists and their perceptions of objectivity are more complex and contradictory than the theoretical elaborations and categorisations of these perceptions. Almost all empirical studies, those conducted on smaller samples of researchers as well as those conducted on large samples, qualitative studies as much as quantitative ones, clearly indicate mixtures of different, even opposing cognitive convictions. This is characteristic not only of wider scientific areas, but the duality and plurality of views also appear within the areas themselves. Theoreticians have either presumed that scientists share a common positivist view of science and objectivity, or they have allowed for a diversification of the cognitive convictions of scientists from different scientific fields. What most of them have failed to notice is that, contrary to the logic of models and ideal types, researchers within the same field may have, or may even bring together, various epistemic perspectives and orientations.

2. Hypothetical framework and methods of research

A certain gap between the theoretical theses and fragmentary data, as an indicator of the cognitive orientation of scientists, does not present a problem, but is rather an enrichment of the hypothetical starting point of the research. It indicates that duality, even ambiguity, inconsistency, ambivalence and contradiction are not necessarily a worrying sign of the lack of intellectual logic of the scientist as a researcher, but could primarily be a reflection of the life logic of the value-laden foundations of the scientific profession, that is, epistemological and even broader philosophical assumptions about scientific activity.

The starting, hypothetical framework of the study relies on organisation theories that offer a convincing argument of the differentiation of scientists' epistemic views, contrary to the thesis of one common orientation of scientists accompanied by a uniform understanding of scientific objectivity. However, the thesis on disciplinary differences in scientists' views can simplify the interpretational framework of research. A more complex theoretical approach presumes one nucleus of shared cognitive and social characteristics of science that differentiate it from other types of intellectual and cultural production. Therefore, it can be expected that there is a minimal common denominator even in the concepts of scientific objectivity which Fuchs (1996) sees in the importance assigned to reasons and evidence. This minimum on which there is a relatively high level of agreement among scientists is not an obstacle to the diversification of their views, either between various scientific fields, or even within each individual field.

In other words, natural and social scientists' perceptions of scientific objectivity can manifest certain similarities, but also differences that correspond to the prevailing cognitive style in those fields. Yet each scientific area presumably also contains a mixture of elements of other (untypical) objectivity perceptions. This is why natural scientists can show a greater inclination to positivism, just as there can be more cognitive scepticism and relativism in the social sciences. Studies clearly indicate even the possibility that various understandings of scientific objectivity can be intertwined in the views of individual scientists. Some authors bring the typically clean epistemic orientations of scientists into question, and with good reason. For example, minimal realism does not necessarily include the whole set of positivist views – "absolute" truth, certainty, correspondence, linear causation, reductionism, universal laws (Paley, 2005).

The aim of this study was determined in line with the findings of the previous conceptual and empirical analysis of scientific objectivity. The conceptual analysis presented and explained the complexity of the philosophical and sociological views of objectivity in the natural and social sciences (Mali, 2009). The empirical insight into objectivity proves to be very modest, indirect and indicative, not clear and comprehensive. Since sociological studies of science have not developed a category system that could be used for the empirical investigation of such a complex, and as yet unexplored, phenomenon, the initial empirical study of scientists' perceptions of scientific objectivity was explorative, using the qualitative methods that give the greatest freedom to respondents to express their opinions.

The planned research set a suitable goal – to gain the first open-ended information on how natural and social scientists perceive scientific objectivity. The expression of scientists-respondents was not limited by any offered definition of scientific objectivity that would direct their statements to any of the most common meanings of objectivity.

Janack (2002) found thirteen different meanings of the term *objectivity* in literature. Hanna (2004) divided various concepts of objectivity into two basic categories. Internal or methodological objectivity refers to the methods science uses to study the world, while external or representative objectivity concerns the truthfulness of the representation of the world. Fuchs (1997) also drew attention to various meanings that could be classified into several groups. Objectivity can be observed as the capacity of individual(s) to make impartial and disinterested judgments. Sometimes objectivity is perceived as a quality of research methods and rules, whose function is to discipline arbitrary and accidental impacts on knowledge. Finally, when perceived as a feature of knowledge, objectivity refers to claims of some independent and external reality.

Thus, there was no intention to draw the attention of respondents to any of the mentioned aspects of objectivity, since one of the most precious pieces of information expected from the research was precisely their definition of objectivity. Natural and social scientists' perceptions of scientific objectivity were investigated within the first web survey of Croatian scientists. The description of the research, covering the overall population of natural and social scientists, the response rate, and the characteristics of the samples are presented in the first chapter of this book (Golub, 2009).

The questions about scientific objectivity and quality were preceded by a short introduction, motivating respondents and contextualising their responses in terms of discipline.[3] Then, the following question was asked: *What is scientific objectivity, and to what extent can it be achieved in your field of study?* The question was answered by 272 natural scientists, making up a very high response rate of 87.7%, and 148 or 87.0% of social scientists, with almost the same response rate. These are also the sizes of the two samples (N) and the basis for calculating the frequencies of certain categories of answers.

3. Natural scientists' perceptions of scientific objectivity

3.1. What is objectivity in the natural sciences?

In total, 226 respondents who answered the first part of the question of the survey tried to define scientific objectivity. They make up a significant majority (83.1%) of those who wrote any opinion on objec-

[3] The introduction said: "Understanding scientists' opinions on scientific **objectivity** and scientific **quality** is very important in science studies. Therefore, please state your opinion on those characteristics of scientific work in **your** scientific **field** in the answers to the questions below."

tivity, but also the greatest share (72.9%) of the overall sample of natural scientists. The data are very indicative of the importance that natural scientists give to scientific objectivity, which they confirmed by the great response to the question, in an effort to explain its true nature.

Since the respondents' opinion on scientific objectivity had not been directed to any of its specific characteristics or definitions, the category system, which will be the basis of the classification of respondents' open-ended answers, is of great importance. The preliminary analysis of respondents' opinions that extracted eight groups of perceptions also suggested their further narrowing.

Fuchs's (1997) classification of definitions of objectivity was assessed as the most suitable, both theoretically and empirically. It was used in a slightly changed form, so it included: a) definitions that ascribe (un)objectivity to scientists' characteristics; b) definitions that take objectivity as a feature of the research process, primarily of its procedures, methods and rules; c) those definitions that refer to the property of scientific knowledge, primarily the relation between knowledge and reality. This typology is not only analytically appropriate for the collected empirical material (respondents' opinions), but it also has certain theoretical advantages, since it includes all the elements of the cognitive triad – the cogniser, the cognitive process and its result. Consequently, it allows scientists' views of objectivity to be analysed according to each of those constituents of scientific activity and to establish the importance ascribed to each of them by practising natural and social scientists.

Before we present the results, we must make an important note concerning the methodology and the content of the respondents' answers. Few respondents (25 of them) expressed more complex opinions that refer to at least two, and some of them even all three, aspects of objectivity. Their opinions will be treated as multiple answers, since taking into consideration only one of the aspects of scientific objectivity expressed in the answer, even if it is the dominant aspect, would impoverish the empirical insight into the respondents' views. Just as in any other analysis of multiple answers, the number of answers (expressed aspects of objectivity in this case) does not equal the number of respondents.

Natural scientists most rarely perceived objectivity as a feature of knowledge, and they most often perceived it as truthfulness in relation to an independent, external reality. Only 9.7% of all respondents who answered the question expressed an opinion that clearly indicates so-called naïve epistemological realism. Usually, it was a very concise opinion or even a parenthesis within a statement, most often using the following terms: *truth, truthfulness, scientific truth.* Formulations vary from the laconic to more complex sentences, from neutral, impersonal, to emotionally charged statements:

> *Objectivity is a derivation of truth.*
>
> *Scientific objectivity is a reality that exists independently of scientists' knowledge, opinion and evaluation, and it reflects reality as it is.*
>
> *Scientific objectivity is the truth. The derivation of truthful conclusions based on already proven claims. Lack of objectivity is rare in mathematics. Even if a mistake is noticed in one's line of thought, it does not mean that it was completely wrong, but only that it did not cover all the cases to the full extent.*
>
> *In my opinion, scientific objectivity is the deep personal need of a human being to realise the truth about the world one lives in regardless of the culture, convictions and level of knowledge in the milieus one grew up in.*
>
> *In my field, one knows exactly whether a claim is true or not, or if its truthfulness (or untruthfulness) simply cannot be proved yet under the defined conditions. Accordingly, there is no doubt about the objectivity of scientific facts under the given conditions.*

Based on this information, one cannot firmly claim that only a minority of natural scientists accept the theory of correspondence, or even that epistemological realism is characteristic of only a relatively limited group of researchers in the whole scientific area. What is more, studies of scientists' professional ethics lead to quite the opposite conclusion. Eminent natural scientists largely assessed the unconditional dedication to the pursuit of truth as (very) important in their fields, and, accordingly, they ranked it second on a list of thirty-four offered items or values (Prpić, 1997: 76). Young scientists from the same fields also assigned above-average importance to this value, but they ranked it only 21^{st} – 22^{nd} together with environmental awareness and concern for (experimental) animals (Prpić, 2004: 155). Furthermore, the greatest inter-generational differences were found precisely in connection with this value, which leads to the tentative conclusion that the epistemological orientation of scientists is not static, but liable to change

(Prpić, 2005a). Observed from that standpoint, the results of this research might correspond to a greater extent to the observed changes in the natural scientists' perceptions of science.

Although the preliminary character of the study does not allow us to make far-reaching generalisations which require deeper investigations into their epistemic convictions, it is important to note that the truthfulness of knowledge is the priority of the minority of practising scientists when they speak about objectivity. Even if such realism is far more accepted in this scientific population than our findings show, it does not necessarily have to be the scientists' primary concern. It is possible that natural scientists simply eclectically combine realism with the more or less expressed feature of instrumental orientation for which the truth is not of crucial importance, as Bailer-Jones (2002) established. In any case, most of the respondents did not clearly declare themselves realists, even if they did usually accept such an epistemological orientation.

One third (33.6%) of all respondents who tried to define it see scientific objectivity as the capacity and/or willingness of scientists to investigate and to judge their own and others' scientific contributions non-subjectively and impartially. Let us look how and with what words natural scientists define scientific objectivity:

Scientific objectivity is the ability to evaluate/describe a phenomenon/event regardless of one's own attitudes and the attitudes of society.

Scientific objectivity is the evaluation of the scientific value of a person's work regardless of their own personal characteristics.

Scientific objectivity is the lack of any subjectivity in the design of research and in the analysis of results.

Objectivity, as an impartial and impersonal relation to a certain phenomenon, is one of the basic principles of science.

It is the impartiality of conducting scientific research, as well as presenting and processing the results of scientific work in a certain scientific field...

These respondents often stress that objectivity refers especially to the presentation of one's own findings. Objectivity, according to them, includes the presenting of all findings, so they criticise adapting and selecting results that are in line with the expectations, hypotheses or theories of researchers:

Objectivity is when you do not manipulate the results of research to make them the way you would like them to be and when you interpret your results for what they are, without favouring what you think they should be.

In my field – experimental physics – objectivity would mostly include as little touching up (doctoring) of findings as possible, as well as not neglecting (sweeping under the carpet) the findings that do not support the interpretation whose accuracy we would like to prove.

In a nutshell, scientific objectivity is research that the scientist carries out correctly; for example, in conducting experimental measuring, the scientist does not take into consideration, and later on present, only the results that agree with his thesis or theory, i.e. those that turn out to be the way he wishes them to be; the scientist should state the conditions in which the measuring was conducted so they may be replicated by other scientists later.

The cited opinions already imply the importance of scientists' professional ethics, but they do not communicate it explicitly. However, the respondents frequently expressly claim that impartiality in assessing the work of other scientists and the provision of comprehensive information to the scientific public about their own research, their methods and results depend on the *ethics* or *integrity* of the researcher:

Scientific objectivity is a realistic and fair assessment of merit in the field of science. It can refer to a scientific field, the scientific work of one particular scientist, the specific study, the specific approach to research.

For me, taking into consideration the term "objectivity", scientific objectivity ... is an impartial, fair relation of the scientist to the interpretation of results of scientific research, considering the applied methodology.

Scientific objectivity is an approach to scientific work which unconditionally requires impartiality, critical thought and ethics.

A conscientious and fair approach to scientific research and the wholly truthful presentation of facts – the results obtained in the course of scientific research.

It is the fair, impartial and public assessment of some and somebody's scientific activity, which it is possible to conduct, but which depends on human integrity, morality and ethics.

Scientific objectivity means presenting the results of your work in an objective and fair manner regardless of whether they meet your expectations.

Accordingly, the perceptions of scientific objectivity as non-subjectivity and impartiality are brought into connection with scientists' ethics. Ethics is least often mentioned when the respondents see objectivity as non-subjectivity in research, while it is most often indicated when they speak of objectivity in terms of the evaluation of other scientists' work and the presentation of one's own scientific work. These statements seem to imply the scientists' belief that scientific procedures and methods prevent against subjectivism in research, and that the influence of subjective factors is stronger in the presentation, interpretation and evaluation of scientific work and its results.

The content of the reported respondents' opinions corresponds to the high ratings of the importance of the non-subjective presentation of one's own results, and the evaluation of scientific ideas and contributions that natural scientists expressed in the study of scientists' professional ethics. The assessments of eminent natural scientists and the emerging new researchers in this field were the same (Prpić, 1997, 1998, 2005b). But the differences are found also in the prevalence of opinions on the importance of non-subjectivity among former and current respondents; in favour of the former, of course. The differences are methodological in nature, and they arise due to the two types of questions and the related answers – ratings and open-ended answers. All offered answers (items) are rated by the respondent, while open-ended answers indicate what the respondent is trying to stress, taking some unsaid principles for granted. Thus, it is correct to observe them as respondents' highlights, but not as their overall opinion.

The majority of respondents, 156 or 69.0% of those who answered this question, perceive scientific objectivity as a feature and as a result of a research process, primarily as the application of scientific procedures: scientific rules, criteria, research techniques and methods. As many as 48.1% of respondents who belong to this majority define objectivity in general terms – as adherence to general scientific criteria, rules, procedures and (other scientists') findings in research. Respondents who hold such an opinion most often stress that objectivity relies on intersubjective, *peer consensus* in their field:

An approach that is an accepted attitude to scientific work which includes the best established and accepted criteria in a certain field.

Resolving scientific problems based on the latest methodologies in line with the collected results, and detailed comparisons of these results with those obtained from international literature.

An approach to a scientific problem that takes into consideration all the rules of the profession and respects the opinion of colleagues who have already studied the problem or are currently studying it.

Scientific objectivity refers to how correctly we succeed in evaluating the quality, relevance and importance of scientific conclusions that we make in our scientific work compared to general (international) knowledge in the specific scientific field.

Scientific objectivity is the agreement of evaluations of several different and preferably mutually independent experts. If we try to express the correlation between different evaluations in mathematical terms, the factor should not be under 0.9.

Scientific objectivity is the relation to the results of one's own and others' scientific work, determined primarily by an analysis of various aspects of work (e.g. approach to work, quantity and quality of results...) conducted by a substantial number of experts from the same or similar field of work.

A second, somewhat larger, group is made up of respondents (51.9% of them) who stressed and specified three main aspects of objectivity that sometimes intertwine in the responses. These are: a) objectivity perceived as the experimental and mathematical verifiability or provability of claims or hypotheses; b) objectivity viewed as the replicability (reproducibility) of research and research results; c) objectivity based on measuring the phenomenon under study.

In this group, the majority of respondents (60%) perceive scientific objectivity very similarly to analysts of science, especially some philosophers, as the verifiability and provability of scientific theses, results and the overall process of scientific research. Science rests on experiential, as a rule experimental, and/or mathematical evidence. This divide, or *differentia specifica* of science, is also its foremost and most important characteristic in the opinion of professional practising scientists:

I believe that what can be proved by applying relevant scientific methods is scientifically objective. In some fields (those relying on drawing conclusions based on results of experimental research), what can be verified by applying several different methodologies is considered scientifically objective. In *my field (mathematics), a scientifically objective result is one that has been verified by stringent mathematical proof (in some mathematical theory).*

Scientific objectivity is the capacity to make a research hypothesis on the basis of established scientific knowledge and to discard or verify the hypothesis on the basis of legitimately conducted scientific experiments, by using objective scientific methods.

I do not understand what you refer to with "scientific objectivity". If you are referring to the "objectivity of scientific results" then the answer is the following: S.O. is the systematic verification of knowledge (including theories, knowledge in the widest sense) by controlled observation and the change in knowledge in line with the observation. That is all in physics.

The perception of scientific objectivity as a precondition and outcome of the replicability of research and research results is related to the previous respondents' epistemic concept, although the connection is not always made explicit. Twenty percent of respondents from the group of natural scientists specifying their opinions on objectivity expressed such a view. Let us consider them:

Objectivity has to be based on conclusions that are made on the basis of closely and carefully measured and replicable results of measuring. In the field of physical chemistry, in which I am engaged, measuring and replicability are the only criteria that ensure objective and correct conclusions. Without objectivity there would be no chemistry, and no other natural sciences.

In natural sciences, someone's subjective opinion becomes objective when it can be proven, repeated several times by several mutually independent persons. It is certain that today's limitations in technology do not allow many subjective dreams to become objective.

Scientific objectivity is the replicability of results verified by several experimental techniques, whose interpretation is related to the results of earlier research and data from literature. In the field of experimental chemistry, it is limited only by experimental conditions (equipment) and the capacities of the researcher.

The replicability of experiments does not necessarily include the *practice* of repeating the research. This is the conclusion based on interviews with 20 British and American physicists, which indicate that replication is not the standard mode of verification in physics, but it is used when experimental results contradict the prevailing theory, or when their outcomes are unsatisfactory (Becher, 1990). It is clear that natural scientists perceive verifiability and replicability in conjunction with measuring. However, measuring has been highlighted as the basis of scientific objectivity in the next group of perceptions. The same relative number of respondents (20%) as in the previous group share this opinion. Measuring is the only objective element in science, whereas conclusions and interpretations can be subjective:

> *Natural sciences teach us to be objective. Everything derives from the findings of objective measuring. Assumptions (theories) have to be verified by an experiment. If the results of an experiment and the hypothesis are not consistent, the hypothesis has to be changed. In my scientific field, everything is based on measuring. The results are as reliable as the instruments you have at hand.*

> *Sc. objectivity in my field (physics) was and has remained the model for all sciences. Its foundations rest on the capacity to express measuring in numbers, and the wider conception and understanding of experiments have been expressed in theories that use the language of mathematics as its own language. This is seen best in the words of Lord Kelvin: "I often say that when you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind".*

> *Scientific measuring is objective, while conclusions can be subjective, depending on the organisation of the experiment. We try to be objective and declaratively sceptical when we are not confident in the objectivity of the conclusion.*

The reported respondents' opinions about scientific objectivity are comparable to the findings of the studies of scientists' ethics, according to which natural scientists, both eminent and young, rank highly the importance of precision in measuring, and the verifiability and replicability of research and its results (Prpić, 1997, 1998, 2005b). For the methodological reasons already mentioned, the position of the same aspects of scientific objectivity is not the same in the ratings of the offered responses and in the ranking according to the frequency of open-ended responses. However, the importance that the respondents give to the same aspects when they rate them on a scale and when they freely describe aspects of objectivity leads to the clear conclusion that those characteristics of research are important in the area of the natural sciences.

3.2. Scientific objectivity in the research practice of the natural sciences

Overall, 147 or 54.0% of respondents who wrote down any opinion on objectivity answered the second part of the question which referred to the possibility of attaining scientific objectivity in their field. At the same time, their share in the overall sample of natural scientists comes to 47.4%. Thus, somewhat less than one half of all respondents from the natural sciences, and slightly more than one half of those who answered the question, expressed their views on the attainability of scientific objectivity. However, it is clear that the respondents put more focus on defining scientific objectivity than on assessing its actual presence and applicability in the natural sciences. The attainability of objectivity is probably simply self-evident for many of them.

Most of the respondents who expressed their opinion on this aspect (112 or 76.2%) believe that scientific objectivity can be achieved in their field. However, there are also noticeable differences of opinion. Some are apodictic in their claims that scientific objectivity is unquestionable in their discipline or in the natural sciences. They most often credit scientific objectivity with being: *absolutely possible, practically absolute, fully possible or possible in full, certainly possible, complete, almost guaranteed, necessary, possible and absolutely necessary, not only possible but also indispensable.* This type of attitude related to scientific objectivity is marked by responses such as the following:

> *Physics is the field where objectivity is present and necessarily attainable by definition.*
>
> *There would be no chemistry, or any other natural science, without objectivity.*
>
> *It is not only attainable in my field of research, but almost guaranteed.*
>
> *It is absolutely possible in natural sciences.*
>
> *It is entirely present in my field of exact natural sciences (physics).*
>
> *Scientific objectivity is possible to the full extent in fundamental exact research.*
>
> *Scientific objectivity is utterly possible in the field of mathematics.*

The stated answers are closest to what is usually called the cognitive style of the hard sciences, or the positivistic unquestionability of natural scientists' attitude to objectivity. However, this is not the prevailing type of understanding of objectivity in the natural sciences: it is advocated by slightly fewer than one third (31.2%) of the respondents who believe that objectivity is achieved and absolutely attainable in their field.

The other, much larger group is made up of slightly more critical respondents (68.8% of them), whose opinion is that objectivity is attainable in their sciences to a great extent, but not fully. To be more precise, they claimed that objectivity is: *mostly possible, almost always possible, possible to a very great extent, largely possible, possible in 90% of the cases, possible in most cases, possible to a great extent.* Typical representatives of such a softer view are the statements on scientific objectivity found below:

Yes, scientific objectivity is a constituent part of good scientific and research practice in my field.

It is mostly possible in my field of research.

I believe that a satisfactory level of objectivity can be attained in the field of natural science in which I am engaged.

It is possible in the majority of cases in my field.

It is largely possible to attain objectivity in the field in which I work.

I think that it is quite possible in my field, especially compared to other fields.

According to the statements reported above, the view that the natural sciences rely on objectivity and that they attain objectivity to a high level is prevalent in these fields, but an important finding is also that the majority of respondents do not perceive objectivity as a completely attainable condition. This finding relativises the theses on the rigid, authoritarian cognitive style of natural scientists.

A second, less prevalent type of concept was expressed by 30 or 20.4% of the respondents to whom objectivity is neither an absolute nor totally attainable precondition in science. These convictions clearly reveal a critical detachment from complete confidence in scientific objectivity. The prevailing tone still includes the rather high certainty of the objectivity and exactness of science, but their limits are also discernible. These respondents elaborate on their views at length, they affirm the limitations of extra-laboratory research, the limits of science, the personal equation of scientists, and even possible social influences. They also highlight the gap between the objectivity of experimental results and their often subjective interpretation:

> *Scientific objectivity is valid only within the framework of laboratory research, within reduced methods and narrow models. The fewer parameters there are to affect a system, the more possible scientific objectivity is. Therefore, scientific objectivity is a rather ungrounded behavioural phenomenon in the real world.*

> *I think that absolute scientific objectivity is not possible (regardless of the field), because scientists are only human after all. I believe that scientific objectivity depends on the objectivity of the scientists writing about science.*

> *Scientific objectivity is the objectivity according to the rules of science. It is attainable only to the limits of science. Science has its limitations, especially in the area of natural science.*

> *Science is exact and rather determined, but scientific objectivity is a complex term because it includes not only facts but their interpretations which are affected by various sociological and political, and even religious factors. Therefore, absolute scientific objectivity does not exist.*

> *Objectivity in measurements is very possible, but being somewhat unobjective in interpreting the findings is also possible. Objectivity primarily includes confidence in the data obtained in measuring, but, in interpretation, one finding can sometimes be explained in several ways.*

> *Scientific objectivity is just fiction, an ideal. It is possible to a certain extent, but it is unattainable in its essence, just like any other ideal.*

The statements of the few respondents who say without any doubt or hesitation that objectivity is only partly attainable in their field belong to the same group. Although one can discern from their formulations that their ideal is the pure experimental or laboratory sciences, geoscientists and bioscientists draw attention to the cognitive peculiarities of their fields:

> *Scientific objectivity is the making of an interpretation and conclusions based strictly on the data and results of processing. There are "parts" of ge-*

ology where objectivity is possible, especially in terms of quantitative methods. However, one greater part of geology is chronically dependent on the viewpoint of the researcher and the way of understanding certain geological phenomena, especially those inaccessible to direct observation, those from the depths of the Earth, about which we only get indirect information.

Objectivity implies a one-sided approach to a problem and verification of obtained results. It is not always possible because the field I am engaged in (geography) is not completely exact (measurable, as chemistry or physics is, for example), but it involves a certain level of individual judgements based on knowledge and experience.

In the field of biomedicine – research in people, – objectivity is largely limited, i.e. it refers primarily to observations of the concrete population group under study while applying strict criteria of selection and very careful interpretation of results in order to reduce the possible influence of other relevant factors (environment pollution, lifestyle, including diet, stress, smoking and alcohol, genetic predisposition, etc.).

Only five or 3.4% of the respondents believe that objectivity in their field, or in science in general, or in our country, does not exist, and that it is not possible. Unfortunately, only one person explained such a claim.

Scientific objectivity is to notice how good something done in science actually is. That cannot be achieved by merely counting the papers and looking into the number of co-authors of a scientific publication. I believe that objectivity is rather unattainable in any field of scientific work, including mine.

The overall answer provided by the respondent suggests that the denial of scientific objectivity, as well as its perception, refers to the evaluation of scientific work. The criticism of assessment based on bibliometric methods, which is one of the most important evaluation procedures in natural science, is also evident.

3.3. Summary and an outline of epistemic concepts of natural scientists

Returning to the initial questions concerning the epistemic concepts or even the orientation of practising scientists, the need arises to recapitulate the fundamental results of the investigation into the views of natural scientists and to tentatively conclude whether their fundamental epistemic concepts comply not only with the theses on the necessary positivistic orientation of natural scientists, but also with the few empirical findings that indicate that the views are not unambiguous. But in the process, we have to keep in mind the preliminary, explorative character of the study, which does not allow a deeper investigation into scientists' perceptions of objectivity.

A summary of the main findings of the qualitative study in a quantitative form (Table 1) shows that the majority of natural scientists define objectivity as the feature and outcome of the research process, primarily as the application of research procedures. Two large subgroups of respondents have been identified, one of which highlights the general scientific standards and rules as the guarantees of objectivity, while the other is made up of a slightly bigger group of other respondents who specify at least one of the three aspects of scientific objectivity. They largely believe that the role of verification and providing evidence is crucial in science (60%), while the replicability of research and measuring are mentioned three times less often. One third of the respondents perceive scientific objectivity as impartiality and non-subjectivity, often highlighting the ethics of the researcher in their answers. The smallest share of natural scientists are the advocates of naïve realism and correspondence theory (Table 1).

Table 1. Summary of natural scientists' perceptions of objectivity

Objectivity concepts	% of respondents
DEFINITIONS*	
Objectivity as a constituent of the research process	**69.0**
– general research standards and rules – 48.1%	
– verifiability, replicability, measuring – 51.9%	
Objectivity as researchers' impartiality and non-subjectivity	**33.6**
– often includes researchers' ethics	
Objectivity as truthful knowledge of the reality	**9.7**
FEASIBILITY	
Objectivity as attainable and attained in natural fields	**76.2**
– largely attainable – 68.8%	
– absolutely attainable – 30.2%	
Objectivity and its complete realisation doubtful	**20.4**
Objectivity as impossible or nonexistent	**3.4**

* The definitions of some respondents included more than one aspect of objectivity

Natural scientists also differ in terms of their perceptions of the attainability of objectivity in the research practice of their field. Most of them believe that objectivity is possible and has been attained in the natural sciences, but the views of most of that majority are not rigid, while the claims of the remaining minority are apodictic. Nevertheless, the number of natural scientists who deny even the theoretical possibility of absolute objectivity, as well as its complete realisation in the research practice of the natural and all other sciences, is not small, as opposed to those who consider scientific objectivity impossible or non-existent (Table 1).

What is the importance of these briefly stated results and how to interpret them? Firstly, we have to point out their general compliance with the theoretical hypotheses on the cognitive style of the natural sciences on the one hand, and empirical studies on the other. Compatibility with theoretical theses is manifested in the greatest importance that the respondents generally assign to the application of research procedures, rules and methods in ensuring scientific objectivity, with special emphasis on verification and evidence. Impartiality and non-subjectivity do not have a prominent role at all in their perceptions of objectivity, not because they would not be perceived as a threat to objectivity, but because it is probably believed that they are efficiently controlled by the research procedures. The understanding of the majority of natural scientists that objectivity is not only an eligible cognitive ideal, but that it has also been attained in the scientific practice in their field, belongs within that mindset.

This is a brief outline of the epistemic concepts of the paradigmatic or hard sciences (Biglan, 1973a, 1973b; Becher, 1994; Becher and Towler, 2001), the concepts of socially dense scientific fields (Fuchs, 1992), or concepts typical of normal science (Fuchs, 1993b). Epistemological realism, theoretically characteristic of the natural sciences, is indeed manifested in the depiction obtained from the respondents' open-ended answers. Such an epistemological orientation of natural scientists is also confirmed by some empirical studies on scientists' cognitive convictions and professional values, especially those carried out on larger samples of respondents (Andersen, 2001; Prpić, 1998, 2005a, 2005b, 2005c).

However, these findings also indicate a certain theoretical, ideal-type simplification of scientists' epistemic concepts. Natural scientists do not have cognitive concepts as rigid as they are attributed in various typologies. Rigidity, established on the basis of acceptance of the thesis on the correspondence between the scientific picture of the world and reality, or on the basis of belief in the absolute objectivity of the natural sciences, is noticeable in a minority of respondents. Naturally, the rigid minority are opposed by the other minority of natural scientists, those who expressly doubt or even discard the possibility of absolute objectivity. Although the obtained results do not allow firm generalisations, they can be seen as indicators of the three types of wider epistemic orientations of natural scientists. Rigid positivism, or its orthodox version, seems to be characteristic of the smaller part of this scientific community. Judging from the perceptions of objectivity, moderate epistemological realism might be the second, major orientation of natural scientists. The third type of perception of objectivity, which is marked by a clear critical detachment from positivism, is also a minority perception in this scientific field. Whether the natural scientists who express this view are advocates of interactionist epistemology as opposed to the spectator theory of knowledge, or whether they are more inclined to realism with tinges of instrumentalism, cannot be determined without further and deeper studies. It can be assumed that the practising natural scientists do not have to be familiar with the epistemic concepts advocated by the philosophers of science who, in line with the message of the Copenhagen interpretation, do no perceive scientific research as a reflection of reality, but as an intervention embodied in an experimental device (Lelas, 1990). If practising natural scientists do not subject their scientific work to metascientific analysis that would lead to more subtle epistemic concepts, it is nevertheless certain according to the findings of the study that the majority of them do not share the views of naïve realism or strong positivism.

4. How do social scientists perceive objectivity?

4.1. Definitions of objectivity in the social sciences

A total of 117 respondents (79.0%), who make up 68.8% of the overall sample of social scientists, set out their definition of scientific objectivity. Compared to the natural scientists, the portion of respondents who tried to define objectivity was 4.1 percentage points lower both in the sample and among those who stated any opinion. The differences are small and do not alter the claim that social scientists also find the topic of scientific objectivity important.

Naturally, the same category system used for the natural scientists was also used in this analysis, and the differences are discernible in terms of the frequency of certain categories (answers), their content and even the linguistic characteristics of the statements. It is interesting that the same number of respondents (25) presented more complex views on objectivity here as well, and their opinions will be treated as multiple answers, just as in the analysis of the natural sciences.

From the very first glance at the structure of definitions of objectivity, some differences are seen among natural and social scientists. The perception of objectivity as a feature of the research process is much less frequent among the latter (its share is 16.0 percentage points lower), while the perception of objectivity as a characteristic of the researcher is much more frequent, being 21.1 percentage points greater. The concept of objectivity as a feature of knowledge is represented only to a limited level in both fields, so the difference in proportions is small – 3.1 percentage points in favour of social sciences. Although this is only a rough quantification without any insight into the content of the answers, it is clear that these are important indicators. According to them, scientists in the social sciences are as concerned with the impartiality and non-subjectivity of researchers as with the research procedures. The prevalence of procedures in the definitions of natural scientists reflects their confidence in procedures, while social scientists obviously do not regard them as that powerful in suppressing the subjective influences on science, which are consequently seen as a (more) serious threat to scientific objectivity.

The smallest number of researchers in the social sciences perceive objectivity as the mirroring, truthful knowledge of reality (15 or 12.8%). They express these opinions rather concisely, while they are inclined to elaborate more extensively on other aspects of objectivity. The original statements of the respondents are evidence of this:

Scientific objectivity is the aspiration to learn the "true order of things", i.e. objective reality.

In the field of kinesiology, it is possible to approach every problem objectively, since all kinesiological problems have real existence, independent of the attitude of the researcher.

Scientific objectivity is an unbiased, real, neutral and fair relation to a certain phenomenon, subject or object that exists regardless of the subjects, their observations and opinions.

To be fully and uncompromisingly open to the studied reality, to "allow it to speak for itself" and not to subject it and adjust it to any a priori scheme and subjective expectations.

These opinions, just like the corresponding opinions of the natural scientists, undoubtedly express epistemological realism. Respondents connote the correspondence of scientific knowledge to reality even when they do not state it explicitly. Only one opinion contains an element of doubt in the absolute correspondence, apart from the basic realistic epistemological view, since the respondent alludes to the Copenhagen interpretation or the message of quantum physics, but the thesis remains unelaborated, ending jokingly, if not trivially:

Scientific objectivity is to identify things and see them exactly as they are. Things objectively are of a certain nature, but also according to well-known recent findings (from quantum physics, I think) – as they would say on "Who Wants to Be a Millionaire", "I am not an expert in this" – I may be wrong.

A methodologically correct comparison of the cognitive convictions of natural scientists and their counterparts from the social sciences may once again benefit from research of the professional values of eminent and young scientists. The studies showed that the majority of respondents from the social sciences and humanities also rated "unconditional commitment to the pursuit of truth" as (very) important in their field. Similarly to the natural scientists, significant generational differences arise in the ranking of the mentioned statement. To be more precise, eminent scientists put this value high – from 4th to 5th place, together with openness to all relevant information, which also shows the great importance of objectivity in their professional ethos (Prpić, 1997: 76). However, young social scientists, who also find this value important, rated it lower than their older mentors and teachers – positioning it in 17th place (Prpić, 2004: 155). The same trend of generational differences in objectivity ratings in both fields, but also in other sciences, may be indicative of changes in the epistemic concepts of more recent scientific generations. In this case, even a relatively small proportion of natural and social scientists who share similar perceptions of objectivity does not have to be a coincidence. So-called naïve realism may simply have a falling number of advocates in both fields. This, of course, does not imply that the epistemic concepts are very similar in both fields. We will be able to compare how similar they are in the rest of the analysis.

Unlike the two-thirds (and more) of natural scientists, only slightly more than one half of respondents from the social sciences (62 or 53.0%) consider research procedures the most important aspect of objectivity. Only one respondent among them (1.6%) believes that the replicability of research and research results is a guarantee of objectivity, six respondents (9.7%) assign the role to measurement, while one respondent (1.6%) denies it altogether, and 20 (32.2%) assign key importance in science to verifiability and evidence. The remaining 34 or 54.8% of respondents hold the opinion that objectivity is based on research procedures, without giving special prominence to any of them.

Whereas replicability has a completely marginal position in the epistemic concepts in this scientific area, the importance of measurement is especially highlighted by only a minority of respondents. They consider measurement the key precondition and indicator of scientific objectivity. Although this is not an experimental type of research and measuring, as in the majority of the natural sciences, respondents put special emphasis on the key role of the metric characteristics of the instruments and on measuring procedures.

Results of research in the social sciences should also be based on quantitative scientific methods.

Scientific objectivity includes the correct use of the measuring instrument, its application, the reading of the obtained results, the correct application of methods for analysing the results, and publishing only the data that have been verified and that are verifiable. The basic problem in my field is the measuring instrument.

Scientific objectivity is impartiality in drawing conclusions. It can be attained if we have an instrument for/mode of measuring the research subject.

Scientific objectivity primarily concerns the impartiality of the researcher and the validity of the measurement procedure. The objectivity of the researcher is a precondition in my field of research, and it is attained relatively easily. The validity of the measurement procedure and the measuring instrument is often problematic and it imposes significant limits on the interpretation and generalisation of the research results.

One opinion, sceptical of the measurability of all phenomena in the area of the social sciences, belongs alongside this group that stressed the importance of measuring. Starting from the theoretically acceptable claim that not all social phenomena and processes are measurable, and skipping all other options for narrowing down subjectivity in science, the respondent believes that the characteristics of the researchers, their scientific competence, and personality, are the only guarantee of objectivity in science:

> *Since I am engaged in social research (economics), I think that objectivity is very, very relative. Figures in particular, statistical or mathematical research, cannot be fully objective indicators, since not all phenomena can be expressed in numbers. That is why subjective judgment has to pervade in my field, and the issue of its objectivity depends on the competence, knowledge, but also human characteristics of the researcher.*

The only view stressing the replicability of research procedures and results in social sciences, and also the perception of scientific objectivity as a construct and mode of communication between the hard (nomothetic) and soft (idiographic) sciences, is expressed as a problem:

> *Scientific objectivity is a fiction that can (and must) be OPERATIONALISED THROUGH the replicability and (internal and external) validity of the research. Scientific objectivity is (nevertheless) a construct, a mode of communication between nomothetic and ideographic sciences.*

According to the majority (71.4%) of respondents from this group which specifies the most important aspects of scientific objectivity, the key aspects are precisely verification and evidence. Social scientists even express this opinion relatively more often than the (three-fifths of) natural scientists:

> *It is based on the possibility of the comparative verification of the results, procedures and all other elements of scientific research by any other researcher.*

> *Scientific objectivity includes establishing evaluation criteria that can be verified later in the offered material. This does not have to be strict falsifiability, but there has to be an intention of intersubjective verifiability of scientists' claims.*

> *In my opinion, scientific objectivity denotes founding one's scientific research on the assumptions and facts that can be verified and scientifically*

proven, or they have already been verified and scientifically proven, which means they are not only a reflection of somebody's subjective opinion.

Scientific objectivity in my field of research is not reflected primarily in results, but in the method, which is unbiased, well-argued, corroborated and verifiable; furthermore, an objective study pays attention to the wider (comparative) context, and it evaluates the phenomenon from that standpoint.

Verification and evidence are crucial in the social sciences as well, but, unlike the majority of the natural sciences, experimental research and verification do not prevail here. Respondents thus hardly stress the replicability of research findings, since this makes sense only if it is possible to control all the conditions under which research is conducted, and this can be done primarily in experiments. Experiments are a rarely applicable, and ethically often problematic and unacceptable research method in the social sciences, so the perceptions of objectivity and verification do not relate to the replicability of (experimental) research.

The studies of scientists' ethics showed the greatest differences between the natural and social sciences precisely in the aspects of objectivity analysed above. While prominent natural scientists rated the importance of precision of measurement fourth, eminent scientists in the social sciences and humanities positioned it in the penultimate, 33rd, position in the importance ratings. Great and also significant differences in favour of the natural sciences have also been established in the ratings of the verifiability and replicability of research (Prpić, 1997: 76). The same tendencies were also identified with the young scientists from the two fields (Prpić, 2004, 2005b). However, these values were important only to a (slightly) larger share of the eminent scientists than the beginners, either in the natural or social sciences.

What conclusions can be drawn from this comparison of the perceptions of scientific objectivity and the similar, but not identical, professional values of scientists? Verification and evidence are a very important standard and criterion for most social scientists, but they are not taken together with replicability, which they confirmed by rating the pair low in the list of professional values. In the open-ended answers, the respondents from these fields simply omitted replicability as a criterion, since it was obviously not a constituent part of their cognitive conviction.

Comparatively the greatest number of respondents who highlighted the role of research procedures did not single out those that are crucial for scientific objectivity. Some, like their colleagues from the natural sciences, briefly mention the general rules of research and scientific standards of their field:

Scientific objectivity is compliance with the standards.

In the affirmative definition of scientific objectivity, I would like to stress the great level of compliance with the currently generally accepted scientific standards of individual science.

For me, scientific objectivity is adherence to the rules of scientific work, the methodology of research

Other social scientists give particular prominence to the multilateral approach to the scientific problem and a diversity of methods as important preconditions for attaining objectivity in the social sciences. In scientific fields and disciplines with paradigmatic pluralism and a competition of various, often even opposing, theories and related streams of empirical research, this can indeed be a fruitful scientific approach. Furthermore, the complexity of social phenomena and processes also requires plural description and various research methods (Montuschi, 2004). Some of respondents' statements on the topic are reported below:

Education is the field that requires a multilateral study of the problem, it is almost like observing a diamond, in order to achieve scientific objectivity.

Scientific objectivity entails investigation of a problem from several sides, with the necessary reduction of the subjective component – the focus has to be on the object.

Scientific objectivity is marked by a multilateral approach to the object of research and the elimination of the researcher's judgement.

The ability to enlighten the scientific problem from the standpoint of different theories by using various methods of collecting data.

A distinctive group of opinions is made up of descriptions of research rules or the course of procedure where respondents list scientific procedures, rules and criteria that a research process should have to adhere to in order to achieve scientific objectivity – from choosing a problem and the hypothetical framework, to the interpretation of results:

The effort to accept the possibility that one might obtain expected and unexpected results of research and find their interpretations. The optimal situation would include starting from the zero hypothesis, the application of the phenomenological method as the basis for constructing the questionnaire and the rating scales, the inclusion of the judgements of a greater number of evaluators, consultations with experts in the field, relying on statistical and psychometric analyses, the inclusion of high-quality control of the greatest possible number of systematic variable factors – in research designs, the use of quality (random and stratified) samples of respondents.

It differs according to scientific areas; in general = 1. In the scope of the research problem (already in the approach itself), it is important to include all the relevant facts/data, without avoiding/leaving out the series of data that might threaten the attitude that the person/researcher a priori (usually) has. One also has to verify the findings of the research using several methods, and to avoid and not to leave out unwanted findings (which can often be unexpected/unwanted for the author/scientist) in the interpretation of the results.

Finally, social scientists relatively (most) often defined objectivity as impartiality, non-subjectivity, that is, as the feature of the cogniser or the researcher – propounded by a total of 67, or 54.7%. Their views are similar to the views of the natural scientists, but they also show some of the peculiarities of the social sciences. The least difference is found in the understanding of objectivity as impartiality, as the exclusion of personal wants, preferences, prejudice, a worldview:

Scientific objectivity is an impartial approach to a scientific problem (phenomenon), independent of a researcher's needs and attitudes.

Scientific objectivity is the full and unbiased study of a problem, without any previously determined standpoint about the problem.

On the individual level, openness to various theoretical approaches, criticism, effort to reduce the researcher's "personal equation" to the minimum.

In scientific work, there is no room for prejudice, personal preconceptions, emotions, researcher's bias.

It is precisely that – objectivity and impartiality – the main characteristics of scientific activity in the field of social sciences – in political sciences. If there is no objectivity in the scientific activity, then we have ideological knowledge, and not scientific knowledge! Of course, there is no room for theory where ideology rules!

Similarity is also discerned between these epistemic concepts of the natural and social scientists in the respondents' propensity to connect non-subjectivity to the ethics of the researcher, especially when presenting one's own results and evaluating the work of other scientists:

Scientific objectivity is conducting research in a fair way, and the honest and truthful presentation of the results of the research. It is also the capacity of an individual to evaluate one's own and other persons' work in an objective manner. There is a tendency to make a bad evaluation of a study only because of its author, and not because of the quality of the research. In our small country, it is always widely known who does what, so there are no anonymous reviews.

Scientific objectivity in my field is actually scientific integrity or, put simply, basic integrity.

Scientific objectivity is the ability to evaluate scientific work only on the basis of the quality of the results which are presented without the interference of other factors, such as the name of the author, institution where s/he works and similar.

A combination of a professional, ethical, well-argued and unbiased approach in defining and stating the research problem and goals.

The main difference in the perceptions of scientific objectivity between the scientists from the two observed scientific areas is in the evaluation of the presence and danger of external, social and political influences on scientists. They were explicitly mentioned by only one of the respondents from the natural sciences, while they are more often mentioned here as threats that scientists have to resist, even at the cost of their own inconvenience or even to their own detriment:

Scientific objectivity is the unbiased consideration of certain scientific issues, without the influence of the environment or certain persons. Since I am engaged in the social sciences, which are by definition often a part of everyday politics (economics), I think that it is much more difficult to maintain scientific objectivity in these fields than in the natural sciences.

Scientific objectivity means that one has to act objectively when investigating and describing a social problem, to be above the current political or other situation and give one's own judgment regardless of the unpleasant consequences.

Why would scientific objectivity be anything different from objectivity in general, and that is not letting various external or personal influences, prejudice, intentions, feelings affect the process of analysis, appraisal and so on, and the inferring of (scientific) judgement.

Scientific objectivity means presenting the results of research without any personal engagement of any kind. In the field of history, which I am engaged in, the greatest threat to scientific objectivity is political attitudes and orientations.

Independent choice of research topics, without any type of external influence.

Scientific objectivity excludes a personal worldview, political, religious and ideological beliefs in presenting scientific results, and any (foreseeable and recognisable) external non-scientific influence.

Not to let oneself be convinced of something by incompetent persons, not to be under political and lay pressure. To have arguments; to be constructive and ready for dialogue, for a conflict of opinions. The field does not depend on itself, but on the person (the person's character, sternness, integrity, reputation and such like) to present their opinions in science in an objective manner, to present them and stand firmly by them, regardless of possible pressures or hypocritical servility which many highlight as a way of building one's career.

As shown by the opinions reported above, scientific objectivity in the social sciences presupposes the extreme professional integrity of the researcher who will not succumb to external pressures in their work – to the (everyday) political manipulations and attractions of professional and other benefits. The complexity of the relation of the scientist to subjective and external influences may increase the demand for value or ethical neutrality, which can be read in and between the lines written by some respondents:

Scientific objectivity is manifested in the absence of value judgements in the research process.

> *Scientific objectivity should be separated from personal beliefs in terms of the value system, and it should draw attention to the possible effects of a certain legal system, for a comparison to be made with the value system which is to be protected or established.*

Only one respondent explicitly expressed the demand put on researchers by the new mode of knowledge production, in which the social responsibility of the researcher is expected, desirable, and even a necessary value within the concept of applicable science. The social responsibility of scientists is irreconcilable with the traditional, positivistic concept of value neutrality. Value or ethical neutrality is thus replaced with reflexivity, in the sense of acknowledging the needs of the public and its segments (Gibbons et al., 1997). Thus, scientists are increasingly expected to have an extremely developed awareness of their own value position. However, only one of the respondents highlights this:

> *Since it is impossible to avoid normative judgments in the social sciences (they are often implicit in the hypotheses themselves), objectivity is expressed through the high level of self-awareness of those judgements. Furthermore, objectivity is expressed by the willingness to be critical of one's own work and the work of those you cooperate with, or those you depend on in a way. Objectivity is finally expressed in a non-selective approach to the facts, arguments and theories, which might make your own opinion, claim or theory doubtable.*

The findings on the study of the professional ethos of both social and natural scientists show ambiguity in the perceptions of value neutrality. Although eminent scientists from both fields rated the importance of the social responsibility of scientists and the humanistic goals of the development of knowledge and science rather highly, all the while positioning ethical neutrality at the bottom of the rated professional values, it nevertheless gained greater importance than was appropriate for the ethos of social responsibility (Prpić, 1997). Furthermore, the rising importance of ethical neutrality was recorded in the young scientists in both areas, especially those in the social sciences, along with the high ratings of the values of scientists' social responsibility (Prpić, 2004).

To sum up, despite the different models of science offered by sociological theories from which different views of value neutrality can be inferred or have even been explicitly stated, the ethics of practising scientists in fact shows far greater inconsistency and ambivalence than the models predict. Social scientists can conceive ethical neutrality as a regulatory standard that is never actually attained, such as truth, for example (Schmidt, 2001). Despite the generally convincing assumption that there is no value-neutral knowledge and cognition, practising scientists, by insisting on non-subjectivity, the rejection of external influences and pressures, and less often on ethical/value neutrality, accentuate a set of socio-cognitive values which act as their landmarks in their professional efforts to rely on reason and evidence in their scientific work, i.e. to be objective.

4.2. To what extent is objectivity possible in the social sciences?

While some of the respondents from the natural sciences were surprised to see the second part of the question about the possibility of achieving objectivity in their field, and while the majority of them answered the question rather tersely, since it was an inherent property of research in the natural sciences, the social scientists reacted differently. First, they offered longer answers, which is indicative of their inclination to express more complex opinions. This implies that the opinions that bring the attainability of objectivity into question are probably more frequent. The structure of answers, categorised the same way as those provided by the natural scientists, support this thesis.

But first let us present the basic data, according to which the subquestion was answered by 99 or 66.9% of respondents who expressed an opinion on objectivity; they make up 58.2% of the total sample of social scientists. Their response rate is thus 12.9 and 10.8 percentage points higher than that of the natural scientists. The structure of answers is also significantly different, since the share of scientists who believe that objectivity is attainable is 23.7 percentage points lower than in the natural sciences, while the share of partly or wholly sceptical respondents is 9.9 and 13.8 percentage points greater than in the natural sciences. In comparison, conviction in objectivity irrefutably belongs to the cognitive style of the natural, but not necessarily social, sciences, where cognitive scepticism is much more expressed.

Conviction in the possibility, attainability and attainment of scientific objectivity was expressed by 52.5% of respondents (52 persons). Slightly more than one half of them (55.8%) answered briefly that objectivity was possible, usually possible or mostly possible in their field. Another 13.4% of respondents who also believe that objectivity is possible under certain conditions, usually connected to the professional ethics and behaviour of the researcher, can be assigned to this group as well. Comparing the hard sciences with the social sciences, some respondents underline attainability, but also differences in the properties of objectivity:

> *It is also possible in the field of the social sciences, and even in the field of jurisprudence, but with the consistent application of the principles and rules of the profession.*

> *In my field, it is possible to ensure scientific objectivity with necessary effort and principled behaviour.*

> *... it is possible, depending on whether you keep the above-stated in mind – and with an open spirit, integrity and tolerance of unexpected developments.*

> *It is possible if the researcher understands the problem, and if there are no obstacles (usually fear) in the way.*

> *In my opinion, scientific objectivity is possible in every field, but the scientist's attitude to scientific objectivity is crucial.*

> *I personally believe that scientific objectivity in my research field is possible, although not in the same ways as in the area of the natural and technical sciences.*

> *Scientific objectivity is the capacity to express sufficiently precise knowledge, i.e. models of a certain problem field. My basic education is in the field of electrical engineering, but I am engaged in the social sciences now (modelling of tourist behaviour, for example), and my biggest problem is to attain objectivity in this new field. Scientific objectivity is possible in this social area as well, although its nature is very different from that in electrical engineering. The difference is in the nature of expressing the knowledge and in the level of accuracy of models created in this way.*

It is interesting that the share of the group of scientists firmly convinced of objectivity (30.8%) in the social sciences is almost the same as in the natural sciences (31.2%). Their opinions, however, are much less apodictic, since they are less prone to use the terms *absolute* and *guar-*

anteed objectivity. Nevertheless, they also use qualifiers such as *wholly possible, possible to a high degree* or *possible to a great extent, possible and necessary.*

> *It is fully possible.*
>
> *It is almost always possible in my field.*
>
> *Since I am working in a quantitative field, scientific objectivity is possible to a great extent.*
>
> *Science in itself includes objectivity, so scientific objectivity is not only possible, but also inevitable.*
>
> *An objective approach to a scientific problem is certainly possible. I believe that it is certainly possible also in the field of research in which I am engaged.*
>
> *The criteria of scientific objectivity can be met to a rather high degree in the scientific field of civil law. To be more precise, although jurisprudence always includes value judgements that depend on personal understanding and, to a certain extent, also the moral attitudes of the researcher, civil law is a very old legal discipline that has an elaborate set of scientific instruments and it is thus possible to achieve a satisfactorily objective approach to problems.*

As we can see from the cited open-ended answers, the level of respondents' conviction in the attainability of scientific objectivity is greater than in the previous group of social scientists. Despite being less resolute than the corresponding statements of the natural scientists, these beliefs in the high certainty of scientific objectivity in the social sciences are indicative of the presence of positivistic epistemological orientations among social scientists too.

The partial attainability of scientific objectivity or even its questionability in the traditional positivistic sense is emphasised by 30 or 30.3% of respondents. Some of them, just like the natural scientists, point to the differences in objectivity between individual subdisciplines in their scientific fields, or to subjectivity in the interpretation of results. Others, however, express scepticism about the possibility to control their own subjectivity and/or the external influence on science, especially on the social sciences.

That varies greatly in my field, depending on the discipline of psychology one is engaged in – i.e. I believe objectivity can be attained more easily in so-called neuropsychological research than in the field, for example, of social or political psychology.

It is possible in terms of conducting research and in the analysis of data, but not completely in the field of data interpretation in the selection of the very problem of research.

It is possible in my field, but it is often under the influence of ideologies (of various orientations).

I believe that this is a relational concept, depending on various factors, such as the availability of relevant information, the scope of knowledge, value judgements and the worldview of the scientists themselves, their possible prejudices, as well as the ideologies and political conditions in which the scientist works. It is probably easier to establish in the sciences that can (if at all they can) be tested experimentally.

In my field of research, scientific objectivity is possible to the extent to which I can personally recognise my own exposure to a non-scientific influence (which generally determines each of us), while the objective non-scientific influences are in my case concretely connected to access to data marked confidential to some degree.

Since the object of study in my field is usually the human being, many intentional as well as unintentional mistakes are possible. Measuring instruments mostly estimate (and to a lesser degree measure) certain capacities and characteristics of the human being. The number, type and quality of measuring instruments, as well as the inability to control external influences, can often be the causes of the mistake.

There are different interpretations of one and the same findings/data in economics (macroeconomic policy); some parts are determined beforehand – with the selection of the starting points & methods – but a significant part of the results can be adapted and interpreted according to the subjective criteria of the author (most often to flatter the authorities, or to confirm the author's own political convictions).

This group of perceptions is marked by the researchers' implicit conviction that objectivity is possible in principle, but it is more difficult to attain, or it can be attained only partly, in the research practice of the social sciences. Judging by these data, there is no epistemological relativism behind these views, but some form of realism. To be more precise, objectivity in scientific practice is here also assessed by the same subjective and external conditions listed by the respondents who explicitly claim that it is attainable. Differences have been found either in the assessment of the research practice which the more sceptical social scientists believe to be more problematic and susceptible to subjective, ideological and political influences, or to evident limitations of the methods, measuring instruments, and availability of data.

The third and smallest group includes 17 or 17.2% of respondents who quite clearly express complete distrust in objectivity, deep doubt in its general attainability, or (more rarely) disbelief in its attainability in the Croatian scientific community and society:

> *I am a psychologist and I do not believe in scientific objectivity.*
>
> *An ideal, almost unfeasible, but imperative. However, without deeply building one's personality (subjectivity) in scientific work, objectivity is truly unattainable.*
>
> *Objectivity is the construct of a scientist and it means distance from the object of study. The principle of objectivity was a norm in its time, but today, however, it is brought into question.*
>
> *Objectivity is loose in the social sciences in my experience because their object is like that, this type of science is like that, and the researcher as well.*
>
> *On account of numerous influential factors, since these are social studies and specific institutions – very hard to attain.*
>
> *The object of study is people who cannot be "objects", so the "objectivity" of the discipline is very dubious or impossible.*
>
> *Scientific objectivity is the ability to differentiate between a person with a significant scientific contribution and a mere quack. It is relatively easy to establish scientific objectivity at the global level, although it is not always achieved. In our small scientific community, where everybody knows each other, it is almost impossible. Considering the fact that there is no will to apply objective criteria at the level of the whole of society, there is no real reason for things to be different in the scientific community, regardless of what the members of the community think about themselves.*
>
> *And what is truth? What is scientific truth? Can I be objective if I investigate human behaviour that varies due to strong bio-psycho-social influ-*

ences? Individual differences among people, i.e. differences in human behaviour in the field of special education – or to be more precise, the field I study: the phenomenon of deafness and hearing loss – also require a strictly individualised approach in research. Some rules of human behaviour and study can be "put into a system" but they also often change. A scientifically objective scientist is one who leaves open the possibility of finding new systems, new solutions, better programmes.

Questioning, scepticism and the denial of objectivity are typical of postmodernism and the accompanying epistemological relativism that is pronounced characteristic of the social sciences and humanities. However, only one third of respondents manifested such opinions, which is far from the predominance of relativism that the bipolar classifications of science attribute to this field. The majority of researchers in the social sciences nevertheless remain faithful to objectivity, which many sociologists determine anyway as a mode of communication (Fuchs, 1997) or as a social value (Williams, 2006).

4.3. Epistemic views of social scientists between realism and relativism

A recapitulation of the qualitative analysis of objectivity in the social sciences shows that there were no greater differences in the observed scientific areas in terms of the response rate to the open-ended question on scientific objectivity, which indicates the relatively equal interest of both groups of researchers in this distinctive characteristic of science in general.

The definitions of objectivity provided by social scientists also belong to three groups (Table 2). Just as in the natural sciences, the least frequent are the perceptions of objectivity as a reflection of reality in scientific knowledge, which support the concept of what is known as mirroring realism.

Unlike the natural sciences, where objectivity is perceived as a feature of the research process by more than two-thirds of researchers, in the social sciences their share is considerably lower – somewhat more than one half of the respondents. A bigger proportion among them believe that research procedures, rules and methods guarantee objectivity in their field, without ever highlighting any of them. From all the specified aspects of objectivity, most respondents underline verifiability and evidence. Opinions that stress the crucial role of measuring are far less frequent, while replicability is of wholly marginal importance (Table 2), and the perceptions of these very aspects of objectivity are considerably different in the observed scientific areas.

Table 2. Summary of social scientists' perceptions of objectivity

Objectivity concepts	% of respondents
DEFINITIONS*	
Objectivity as a constituent of the research process	**54.8**
– general research standards and rules – 54.8%	
– specified procedures, mostly verifiability and evidence – 45.2%	
Objectivity as researchers' impartiality and non-subjectivity	**54.7**
– often includes social and political influence on scientists	
Objectivity as truthful knowledge of the reality	**12.8**
FEASIBILITY	
Objectivity as attainable and attained in social fields	**52.5**
– attainable – 69.2%	
– absolutely attainable – 30.8%	
Objectivity and its complete realisation doubtful	**30.3**
Objectivity as impossible or nonexistent	**17.2**

* The definitions of some respondents included more than one aspect of objectivity

The definition of objectivity as impartiality and non-subjectivity was more frequently expressed by social scientists who pointed out that objectivity is also often threatened by external, social and political pressures on researchers (Table 2). At the same time, natural scientists obviously find research procedures to be their greatest protection against bias, since they give them greater importance than the characteristics of the researchers themselves.

Finally, important differences can be discerned also in the views of natural and social scientists about the attainability of objectivity in the research practice of their own scientific fields. The differences are not only quantitative, which is obvious from the considerably bigger proportion of those convinced of the attainability of objectivity in the natural sciences. One can also notice qualitative differences between the two compared groups which are manifested in the lesser belief of the social scientists in the attaining of maximum objectivity. Accordingly, the latter are also more inclined to express opinions on partial objectivity and the denial of its attainability than natural scientists (Table 2).

The cognitive style of social sciences identified on the basis of this analysis confirms the basic theoretical claims that it is characterised by the less firm (rigid) cognitive convictions of researchers and their lesser consensus on the importance of all parts of the research process than the style of natural sciences. Although social scientists also perceive objectivity as an essential characteristic of the scientific effort, which is confirmed by their response rate and the emphasis put explicitly on its crucial importance in (social) science, they define it in a different way, and assess the attainability of objectivity differently. Equally often, their views include scientific rules, criteria and methods on the one hand and the characteristics of the scientists on the other. The importance of this finding lies in the fact that objectivity depends both on the scientific standards and the researcher, personality, and professional scientific integrity which includes not only control of one's own subjectivity, but also external, social influences. Perceptions of the attainability/attainment of objectivity are also more relative in such a scientific environment. The empirical insight gained in this study roughly complies with the presumed epistemic concepts of scientists from the preparadigmatic or soft sciences (Biglan, 1973a, 1973b; Becher, 1994; Becher and Towler, 2001), the cognitive orientations of researchers in scientific fields of low social density (Fuchs, 1992), or the persistently questioning epistemic orientations of textual scientific fields (Fuchs, 1993). The obtained picture of the peculiarity of social scientists' epistemic concepts is also shown by the more extensive empirical studies of scientists' cognitive convictions or professional values (Andersen, 2001; Prpić, 1998, 2005a, 2005b, 2005c).

Much as in the natural sciences, the analysis shows that the theoretical positions on the epistemic concepts of the social scientists also suffer from oversimplification. Social scientists do not prevalently develop relativism, which is ascribed to them by the authors of various social theories and typologies. An expressed relativism is the epistemological orientation of a minority of respondents. The three types of broader epistemological orientations that can be discerned in natural scientists can be recognised here as well. Positivism, less orthodox than in the natural sciences, is developed by the smallest segment of social scientists, contrary to the opinion of S. Cole (1992). The other two views are more moderate epistemic realism and relativism, which can appear and intertwine in theoretically illogical and unexpected combinations. Based on the respondents' answers, we could even assume that realism is the point of view of the relative majority of social scientists, provided that we do not take into consideration only those who perceive objectivity as possible, or those who see scientific procedures as a barrier against subjectivity, but also those who demand a high degree of professional integrity or self-control of one's own subjectivity. There are certainly many more relativist conceptions here than in the natural sciences, but the data do not allow or support the thesis that it is the primary orientation of social scientists.

Finally, perhaps Pleasants gave good advice to social scientists on how to avoid the traps of uncritically looking up to the natural sciences and of the metaphysical discussions that frequently unroll in the social sciences. He recommended that they keep contemplating their scientific practices, but forget the assumed ontological foundations of their discipline and focus on the production of "work that is interesting, relevant, thought-provoking and enlightening" (Pleasants, 2003: 83).

5. A look from the other side: scientists' positivism and relativism

The final generalising summary of the findings includes a review of their scientific and practical implications. Organisational theories of science explain the results of this and other rare studies of scientists' perceptions of science, their cognitive and social values, as well as research practices, better than other theoretical models, especially the popular distinction between the hard and soft sciences. According to these theories, scientific fields differ in their socio-cognitive characteristics, so their scientific practices, cognitive styles and the epistemic concepts of the scientists can also be different (Whitley 1984; Fuchs 1992). Becher's typology (Becher and Towler, 2001) also acknowledges these characteristics in principle. However, even organisational theories result in limiting typologies that draw a rather firm line between individual natural and social sciences.

Just as general claims on the positivism of practising scientists, regardless of their scientific area or field, unify sciences despite their mutual differences, typologies also result in excessive fragmentation of sciences and constrain certain types of social and intellectual organisation within individual (sub)disciplines. Instead of a uniform science or fragmented scientific disciplines, one complex structure of science seems more convincing. This structure shows both a common socio-cognitive nucleus of all sciences and recognisable patterns of individual scientific areas, fields and (sub)disciplines (Prpić, 1997).

Thus, professional values, perceptions of science or epistemic concepts of scientists from different scientific fields or organisations cannot be expected to be either uniform or completely disparate. After all, as we have already shown, this is corroborated by the similarities and differences in scientists' concepts of research quality (Hemlin and Montgomery, 1990; Hemlin, 1993; Gulbrandsen, 2000; Prpić and Šuljok, 2009), studies of scientists' professional ethos (Swazey, 1993; Anderson, 2000; Prpić, 1998, 2005b) and surveys of scientists' views of science (Andersen, 2001; Prpić, 2005c).

This analysis and the cited comparative studies of the epistemic views of scientists reveal that the structure of the concepts of science and scientific objectivity is also complex. It does not strictly adhere to the boundaries between disciplines; it produces different combinations of values, attitudes and opinions, revealing also a nucleus of common epistemic concepts, but also peculiarities of the cognitive styles of the natural and social sciences.

Which perceptions of natural and social scientists present a common view of objectivity, and which indicate the peculiarities of each of the two areas? Objectivity is the crucial value for both natural and social scientists. Both mostly believe that it is attainable; both are least prone to define it as the correspondence of knowledge and reality; both stress the importance of research procedures, primarily verification and evidence in science, and non-subjectivity and impartiality. At least two or even three epistemic concepts are discernable in both. However, a type of epistemological realism in the sense of the importance of evidence and reason seems to prevail in both scientific areas.

Peculiarities of the cognitive style of the natural and social sciences follow the sociological typologies of scientific fields. Natural scientists show greater conviction in the attainment and attainability of objectivity, generally greater confidence in the power and efficiency of scientific methods and procedures, and they also accentuate replicability and measurement. Their greater inclination towards positivism is obvious. Relativism is, naturally, more frequent in social scientists. They put greater emphasis on the inevitability of subjectiveness and external influences in their field. They express greater doubt in the omnipotence of research methods and procedures, and more often either question the possibility of achieving objectivity or reject it in principle.

These findings also have some practical implications since they allow natural scientists and social scientists to gain insight into the peculiarities of the other scientific area, so as not to observe and evaluate it from the standpoint of the cognitive practice and style of their own field. The so-called science wars do not even have to be mentioned as an extreme form of the unwanted gap between the two scientific fields. It will be sufficient to bring to mind the examples closest to Croatian (and probably wider) everyday life in science – the criteria of the academic promotion of scientists that has caused resentment among the natural scientists on account of the "privileged" appointments of social scientists that "are not based on WoS publications", and the irritation of the latter due to the attempts to automatically expand the research productivity criteria of the natural sciences to the social sciences.

The theoretical implications of the analysed results are twofold. Firstly, they warn that even the social theories that explain the social and intellectual organisation of science better than others still offer an oversimplified picture. And the simplicity and/or elegance of the theoretical models that the natural scientists admire are not necessarily also successful in the social sciences. Here, the simplest, bipolar models of science(s) receive the lowest empirical support. We are still waiting for a complex and explanatorily (more) powerful social theory of science.

The second remark concerns the scientific importance of understanding scientists' epistemic views. If we follow the logic of social constructivism, such knowledge would be of no importance due to the discrepancy between everyday scientific practice and the scientists' values which are their ideology or the ideological front of science. The discrepancy, and often the rift, between the values and life of science is not manifested only in the studies of scientific practice and in knowledge production. It is also revealed by our respondents who warn of unprofessional and unethical actions in their own scientific organisations and communities as a hurdle to greater objectivity. Despite the various opinions, objectivity, as a socio-cognitive value or norm, is an important landmark or ideal for scientists. If only for that, objectivity has an important role in the production and evaluation of knowledge, regardless of its realisation in scientific practice. Put briefly, sociological theories should consider more seriously the role of objectivity in order to reach a deeper understanding of scientific practice and its (un) attainable value landmarks.

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Bridging the gap between the two scientific areas

Before returning to the initial question of this book and drawing conclusions about the gap between the natural and social sciences based on the conducted theoretical and empirical analyses, it might be important to recapitulate the findings obtained in our research. Here, it is necessary to take into account the selectiveness of the samples whose influence we have tried to control by comparing our results with the findings of other studies and then also with the results of the bibliometric studies of scientific productivity of all doctors of natural and social sciences when analysing the research productivity of our respondents.

The social and professional profile of natural and social scientists (Golub, 2009) showed no significant differences in the two groups regarding their socio-demographic and socialisational background. Thus, we can conclude that they were mostly recruited from the same social groups. That is why there are relatively more men than women, middle-aged and older rather than younger researchers, offspring of a narrow group of highly educated parents than scientists of a lower educational background, more scientists who graduated as very successful students than those who were outstanding. An elite social background, not necessarily accompanied by early elite educational achievements, characterises both groups of scientists.

On the other hand, significant differences are seen in the professional aspects of these groups which also indicate a differentiation of the social and cognitive organisation of the two areas. While an academic institutional structure prevails in the social sciences, the natural sciences are marked by a high proportion of public institutes, mostly thanks to the biggest scientific institute in Croatia – the Ruđer Bošković Institute. Basic research prevails in the latter scientific area, while the social sciences include a greater proportion of applied research, development and mixed-type research, as artificial as this distinction and as heterogeneous as the concept of basic research may be (Calvert, 2006). Bibliometric indicators (Nederhof, 2006), as well as self-reported research productivity (Prpić and Brajdić Vuković, 2009), also provide evidence of the relatively high proportion of applied social studies. Croatian (post)socialist economic and techno-scientific development must certainly have influenced this institutional and cognitive structure, so there are some national specificities of the science model alongside its resemblances to international trends.

The career patterns in the compared areas also manifest great differences. Thus, an average natural scientist obtains a doctorate at a younger age than the social scientist. His career is more focused on regular research cooperation with international colleagues, and his high integration in the international scientific community is confirmed by the high rate of his reviewing of papers by international colleagues. He dominates the local scientific scene with extensive team work and engagement in scientific and professional associations. In contrast to the Croatian natural scientist, the Croatian social scientist works on more local projects and reviews more papers by local authors. He is also more often a member of the editorial boards of local journals. In brief, the natural scientists' international orientation and the local national focus of social scientists are empirically corroborated here.

The research productivity of natural and social scientists was investigated in a questionnaire survey (Prpić and Brajdić Vuković, 2009) and by using biblometric parameters (Jokić and Šuljok, 2009). In terms of *self-reported* productivity, it has been empirically proven that the natural and social sciences have developed different publication patterns. The social area is characterised by twice the number of professional publications and by the preponderance of mono-authored publications among scientific works, whereas natural scientists produce twice as many papers indexed in WoS databases, and predominantly co-authored papers. A significant differentiation of research productivity is noticed in both areas because individual sciences show recognisable patterns of career and five-year productivity. The disciplinary specificities of research production patterns can be ascribed to differences in the intellectual and social organisation, mode of knowledge production and cognitive styles of scientific areas and fields.

The composition of significant predictors and their contribution to explaining the analysed types of research productivity also differ. The best predictors of production in the natural sciences are the researcher's international cooperation and networking, whereas the social sciences show the greater impact of the scientist's national or local orientation, i.e. focus on the local scientific community. However, a predictor that at the same time accounts for a significant portion of publication productivity in both areas and indicates the scientist's social capital has been identified. It is the variable of invited stays abroad that would be impossible without the scientist's international collegial networking.

Longitudinal data from Croatian and foreign studies (Kyvik, 1988, 2003) identify deep structural changes in the main forms of research productivity in both areas, especially in the social sciences, and chiefly in the number of authors and international availability of scientific results. Our findings, however, lead to the tentative conclusion that the levelling out or reduction of differences between the social and natural sciences takes place in productivity patterns, but to all appearances also in productivity predictors.

Due to selectiveness, and particularly due to the orientation towards scientific periodicals and the English language, scientific output indexed in *WoS and Scopus databases* favours hard science publications, and consequently manifests even greater differences among the observed domains. To be more precise, the natural sciences greatly surpass the social sciences in terms of productivity, citation rate and the h-index. According to WoS, the average number of papers per natural scientist was ten times the number of papers per social scientist. Practically three quarters of the social scientists did not publish a single paper referenced in these databases over a period of ten years, compared to slightly over one tenth of the natural scientists. The average citation rate of a natural science paper was almost three times the citation rate per paper from the social sciences. In contrast to the social sciences that still lag behind the world average for its area, the natural sciences in general are less far behind, while some of the disciplines are on a par with their international counterparts. The defects in the international bibliometric and citation databases and the mentioned differences in patterns of scientific communication strongly suggest that the bibliometric monitoring of publications in the social sciences and humanities should not rest on the same methodological assumptions that apply to the hard sciences (Nederhof, 2006).

In addition, significant disciplinary oscillations were determined in the natural and social sciences. Scientific fields show specific publication practices, making the levelling of criteria in any of the two observed scientific areas utterly questionable. Since this is the first comprehensive bibliometric study, it is unfortunately impossible to make any comparisons with earlier periods. It is nevertheless certain that the differences between the publication productivity of the social and natural sciences had to be even greater in the past due to the earlier even greater provinciality of the former.

Perceptions of scientific excellence and objectivity were investigated using a qualitative research method – open-ended questions (Prpić and Šuljok, 2009; Prpić, 2009). Regarding *scientific quality,* our respondents proved to understand it in a way similar to the understanding of Swedish scientists (Hemlin, 1993). This confirms the claim of the author of the theoretical review that scientists from different countries basically develop similar concepts of scientific quality (Hemlin, 2009). The smaller scientific community of post-socialist types of societies complements the social and scientific context of Nordic countries and the USA, on which the hypothesis/conclusion was founded.

Differentiation between natural and social scientists in giving prominence to individual aspects or parts of the research process and the quality attributes ascribed to them is statistically relevant, but the similarities of their concepts of scientific quality are also indubitable. In both scientific areas, quality is most often mentioned in regard to scientific results and/or cognitions (knowledge), and the research problem is ranked third. However, methods are the second most frequently mentioned aspect in the social sciences, while scientific production has the same position in the natural sciences. Despite the same rating of attributes of scientific excellence, social scientists tend to highlight solidity of research more often than natural scientists.

The perceptions of the measurability of scientific quality are structured similarly in both fields and no significant differences have been determined among them. Those convinced in the measurability of quality are relatively the most numerous, but while natural scientists more often tend to see bibliometric and scientometric methods as relatively reliable, social scientists do not consider them as the most suitable for measuring excellence. It is important to point out that natural scientists also do not agree about the dominant role of these methods of evaluating scientific research and published papers, since almost one half of respondents express scepticism about the (reliable) measurability of quality. If the natural sciences are not as hard as presumed, it seems that the social sciences are also not as soft as they are usually believed to be – one half of social scientists believe that scientific quality is measurable in their field as well.

The structure of respondents' opinions of science and *scientific objectivity* proved more complex than theoreticians and philosophers believe, since it is formed by different mixtures of values and opinions, manifesting some shared epistemic convictions, as well as peculiarities of the cognitive styles of the scientists' scientific fields.

To be more precise, objectivity is the key value for both natural scientists and social scientists. The majority believe that it is attainable, both groups perceive it in the context of the correspondence thesis least often, and they both emphasise the importance of research procedures and non-subjectivity and impartiality. At least two cognitive orientations can be identified in both, with epistemological realism prevailing in the broader sense of the weight of arguments and evidence. These similarities in understanding objectivity underpin the basic thesis expressed in the theoretical paper – epistemic differences between the social and natural sciences are not insurmountable (Mali, 2009).

The specificities of the cognitive style of the natural and social sciences depicted by our findings also corroborate the propositions of the sociological distinctions (theories) of the scientific fields. Natural scientists manifest firmer belief in the objectivity of their disciplines and area, and they express confidence in the efficiency of scientific methods and procedures, especially stressing replicability and measuring. They show greater commitment to positivism than social scientists do. In contrast, relativism is more common to social scientists who tend to stress that subjectivity is unavoidable (to a certain extent) in their domain.,Social scientists are also more sceptical of the omnipotence of research rules and methods, and more often tend to doubt or even deny the attainability of objectivity. Despite the differences, objectivity is an important scientific benchmark, ideal or mode of communication (Fuchs, 1997, 2002).

In conclusion, we should ask how the outlined principal findings of our studies answer the question from the beginning of the book and what their theoretical and practical implications are. Let us start from the hypothesis/claim about the insurmountable differences between the natural and social sciences as perceived by Snow, and advocated by numerous researchers of science, especially social constructivists.

Judging from the recruitment of research personnel, scientists' organisational and cognitive context and career patterns, their output and cognitive convictions, the natural and social sciences show both similarities and significant differences. However, we cannot talk of any insurmountable hiatus in the light of our results. Differentiation in the social organisation of science seems even greater than the differences in the cognitive dimension, at least that made up of scientists' cognitive convictions. In other words, even greater differences were identified in the organisation and mode of knowledge production reflected in career patterns, in professional differentiation and stratification in scientific organisations and communities, and in research productivity than in scientists' perceptions of scientific quality and objectivity. At first sight, at least.

Although the differences between the two areas seem great, as in the dichotomy of the orientation towards international and national research, or team and individual work, and even appear enormous at times, as in the scientific production indexed in WoS and similar bibliographic databases, there are also similarities, even tendencies for cognitive practices to converge. Thus, the growing orientation towards team work, cooperation, and the international scientific scene can also be identified in social scientists, just as the lessening of those differences can be noticed over a relatively short period of time. Differences in publication practices in journals indexed in the most eminent bibliographic and citation databases are also expected to decline. The process must have already started, but it has not been monitored analytically.

Significant differences found in the cognitive convictions of researchers in the two scientific areas do not seem that great considering the theoretical expectations or the described cognitive styles of the natural and social sciences (Biglan, 1973a, 1973b; Becher 1994; Becher and Towler, 2001). Naturally, typologies can always be defended by the necessary divergence of different varieties and transitional forms. However, there are too many of them in both areas when one area is pronounced hard, and the other one soft, as happens in many uses of this bipolar classification in literature.

If the obtained cognitive differences are slighter than theoretically assumed, this suggests that they do not have to completely reflect scientific practice, which again indicates a certain autonomy of the cognitive sphere of science which is often questioned by sociologists of science, even when they call scientists' professional standards a professional ideology or façade which never corresponds to the professional practice of science. The discrepancy between scientists' everyday research activity and what they profess as their values, convictions or norms is indubitable. The only question is whether a sociologist can neglect scientists' opinions if he or she wants to *explain* and *understand* science as a social and cognitive activity in the best manner of the Weberian epistemological and methodological credo.

For this reason, the claim of the unbridgeable gap between the natural and social sciences seems more of a myth when viewed through our empirical results than as a well-founded presupposition. What, then, are the theoretical implications of the data and analyses presented here?

The theories of scientific fields or organisations (Whitley, 1984; Fuchs, 1992) are superior to the unitary concept of science in their explanation of the differences in the social and intellectual organisation of scientific fields. Yet, it is impossible to explain the common features of scientific fields within an area, or the similarities among wider scientific areas, without conceptually demarcating science and other knowledge and belief producers, and consequently the changes in the theses of these theories. When such a modification is made (Prpić, 1997), these theories (as shown by our findings) can successfully interpret both the similarities and specificities in the social and cognitive sphere of the natural and social sciences: the common and the specific in the social organisation, professional and career patterns, research production and in the scientists' cognitive convictions.

The practical implications of our research relate to the possibility for the two great scientific communities to establish bridges for better communication which can then be the basis for the development of the transdisciplinarity predicted by some sociological models of the development of science (Gibbons et al., 1997). Being better informed and having a deeper understanding of the mutual similarities and differences may be the first step in this direction. We therefore hope that our book will be interesting not only to the narrow circles of analysts of science from different disciplines, creators of science policy, but also to practising scientists interested in this topic. We hope it will reach the broadest scientific public, especially the majority of natural and social scientists, and encourage them to (re)consider their own understanding of the other scientific area. However, we do not believe that this scientific insight can itself bridge the gaps in their beliefs or bring down the myths of the natural and social sciences.

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