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CHARACTERISTICS AND DETERMINANTS OF EMINENT SCIENTISTS' PRODUCTIVITY

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The empirical research on the sample of 385 eminent Croatian scientists was carried out in order to explore the patterns and factors of their scientific productivity. The study design made it possible to compare the results with those obtained in the 1990 survey on a sample of the research population. The average scientific productivity of eminent researchers is not only several times larger but also shows a more intensive scientific collaboration and orientation towards the international scientific arena. The most important predictors of the elite's productivity are also qualificational and organizational variables but of a more selective nature. By including the eminent scientists' gatekeeping roles, the explanation of their total, co-authored and foreign publications can be improved.

Introduction

The scientific productivity of eminent and other (average) scientists is one of the crucial and still open research problems of science studies. The productivity, and its quality in the first place, is at the same time a starting point and the basis of studying the contribution of scientists to the scientific knowledge. The same tendency can be traced in the sociological science studies. The very character of sociological theorizing, being rather abstract and thus not easily tested,[1] is obviously advantageous to the reduction of scientific contributions to the publication productivity and the citatedness of scientists. A reinforcing element of this simplification may be the pluralism and even the divergence of sociological theories: the mertonian – classical and modernized,[2–3] constructivist[4–7] and the TSO (Theory of Scientific Organizations).[8–9]

The theoretical insufficiency in the research of scientific productivity is followed by a methodological one-sidedness. In spite of the greater flexibility of surveys in data collecting,[10] there is still an overemphasized preference of bibliometric databases and methods of analysis, to the detriment of the more diverse information gathered directly from scientists-respondents.

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The mentioned limitations of sociological research on the scientific contributions (productivity) of the scientific elite and the average emerge in the empirical tests of the Ortega hypotheses.[11-16] In a special discussion about that thesis,[17-30] some theoretical and methodological impoverishments of such a complex problem as the cognitive contribution of scientists have been criticized.[17,19,27] An answer to the mentioned research challenge requires much more than just analyses of the citation patterns within and among the groups of eminent and average scientists.

Namely, the scientific productivity studies, not mentioning the analyses of scientific contributions, insufficiently take into consideration the crucial social processes in the production of knowledge: the organizational variables, division of labour, distribution of influence and power. At the same time, some sociological empirical studies have shown that a (hierarchical) position of researchers in scientific insitutions and in project groups has a significant impact on their scientific work and productivity.[31-39] A questionnaire study of a sample of Croatian researchers has also shown that project and organizational roles are significant, although not the most powerful, predictors of respondents' five-year scientific productivity.[40-41]

However, the sociological importance of the discussion about the Ortega hypothesis exceeds its theoretical and methodological defects. It namely draws the attention to an average scientist, to the armies of researchers typical for a contemporary production of knowledge and mostly neglected in the scientific productivity analyses. Most sociological investigations focus on the productivity of the (most) eminent scientists, regardless of whether they are the most cited or the most productive ones, prestigious awards' winners, academicians, university professors or at least doctors of science.

In order to better understand the scientific productivity it is important, even crucial, to be familiar with a compare its characteristics and factors in the overall research population and in the group of first-class scientists. Unfortunately, more complete sociological comparisons of these two groups are extremely rare: the contrasting of their social background, education, career pattern, professional position and productivity. In that regard, the comparison of the American super-elite and a sample of average scientists still stands out with its systematicness.[42]

Since a fairly complete insight into the publication productivity of the Croatian research population has already been obtained, the eminent scientists' productivity was necessarily the next research problem. Also, this study's aim was not, and could not be, the establishing of contribution of eminent scientists as opposed to the average ones.

In the focus of this work is the social and professional profile, and above all, the patterns and factors of the eminent researchers' scientific productivity. In other words,

the answers to the following questions are looked for: who are the eminent scientists, what is their productivity like and how and with what factors is it explained, in contrast to the research population in which the average scientists are predominant?

Approach and research strategy

Although it is not a question of a comparative research strategy in the strict methodological sense, the study's design has still ensured a comparability of both investigations' data. What is even more important, the research design made it possible to test and further develop a complex hypothetical model of the scientific productivity determinants. The original model, already successfully tested on a sample of researchers, included four sub-categories of potential factors: socio-demographic, socializational, qualificational and organizational variables.[40-41]

The influence of the socio-demographic and socializational characteristics of scientists on their productivity has not been unambiguously established in numerous empirical studies.[43] It is therefore necessary to further test it in different socio-cultural settings and scientific sub-systems and on different sub-populations of researchers. It is particularly the case with the least examined productivity factors: scientific (as well as linguistic) qualifications of researchers and of their organizational roles, that is the roles that result from the hierarchically distributed tasks and the influence in projects and scientific institutions.

Naturally, the eminent scientists' publication productivity was expected to be less explained than in the case of the researchers' sample, and also that the patterns of predictors would be different. With regard to its scientific accomplishments and the hierarchical position, the elite group is far more homogenous than the research population because the processes of professional differentiation are much stronger across the entire research system than at its wider or narrower peak.

The position of the eminent is already very high and it implies a high level of professional reputation, authority, influence and power also in a disciplinary scientific community, as well as within the entire scientific system. Therefore, the so called cumulative advantage and the ratchet effect favour the maintenance of such a social position.[44]

Because of the expectation that the original set of the scientific productivity predictors will have a lesser explanatory strength with eminent scientists, it has been decided that after that set, an additional one ought to be tested. It would include some other scientists' roles - the gatekeeping in a broader sense from the one that was originally attributed to them.[45] These are the researchers' roles in a wider scientific

(local and international) community which significantly influence the development of each and every scientific field: the roles of editors, reviewers, mentors, examiners and the roles in scientific societies. These roles also undergo an assessment in the scientific performances' evaluation,[46] and serve as indicators of the researchers' eminence. That is how they were treated in the 1990 survey.[40]

The testing of such scientific productivity factors proceeds from the 'constant-probability-of-success model, which maintains that quality (or creative success) is a positive function of quantity (or productive fertility)'.[47] In some most recent scientific quality studies, it has been found that the publication quantity is the best predictor of the evaluated scientific quality.[48] However, it would be useful to examine the opposite: could not some dimensions of the scientific prominence or the gatekeeping roles of successful scientists help in explaining the variation in the quantity of their publications.

Methods

The comparison of this and the previous productivity research is possible thanks to the following: a) the same time span of the analyzed productivity (the number of publications during the whole career and in a five-year period before the research); b) the same categorization of the analyzed publications: scientific and professional; solo-authored and co-authored; publications abroad; c) the maximum similarity of the analyzed characteristics of researchers that are (theoretically and empirically) relevant factors of the respondents' scientific productivity.

The data were collected in the first two of six thematic blocks of a broader questionnaire. These two blocks were designed to collect the following information: concerning the demographic, socializational, qualificational and organizational characteristis of the respondents; concerning the characteristics of the scientific context (scientific institutions and fields); concerning productivity (publications); concerning the respondents' roles as editors, reviewers, mentors, examiners and their roles in scientific societies.

The research was done in the late spring of 1995 by a mail survey on the population of eminent scientists listed in the bibliographical directory *Tko je tko u Hrvatskoj = Who is Who in Croatia*.[49] Since the directory includes all the living scientists, even those who are not scientifically active any more, as well as those living abroad, it was necessary to narrowly define the eminent scientists' population. According to our definition, it consists of the professionally active scientists (not older than 70 years of age, when they, according to the law, are retired), who live in

Croatia, excluding the professors at Art Academies and Theological Faculties/ Institutes.

The population of eminent scientists defined in such a way included 769 persons. The questionnaire was sent to their addresses. After three reminders, 385 respondents or 50.1% of the total population responded by sending back the questionnaires. By the application of the chi square, it was found that the sample obtained in such a way does not significantly diverge from the known relevant characteristics of the population – gender, age and scientific field.[50] The respondents not only amounted to a half of the eminent Croatian scientists' population but also represented it in a very proper way.

Research results and discussion

Socio-professional profile of eminent scientists

The central topic of this paper – the eminent scientists' productivity – can be better understood if their basic social and professional characteristics are analysed, particularly if they are also compared with the entire research population (Table A in the *Appendix*).

Thus, the eminent Croatian scientist is a man, and so is predominantly also a representative of the entire research population. However, the proportion of women in the latter is twice as large as among the scientific elite. It is, on average, significantly older than the population (59 to 45 years of age). Suprisingly, according to the social background (education of fathers), these two groups are almost undistinguished: more often they come from the higher and middle strata rather than from the lower ones.[51]

Eminent scientists did not achieve a better school record in secondary school than the representatives of all researchers. However, they did better at the university. Even more indicative is the fact that the eminent more often participated in research along with their university obligations than it was the case with the members of the research population. Professional or/and scientific works were published during the undergraduate studies almost twice as many by the first ones than by the second. The average number of publications was also higher: 3.1 to 2.6 publications.

Prominent researchers, more often than other colleagues, have a continuous scientific carreer. If they did not start in science, they came into the field at an average age of 35 years. None of them is without a doctorate and they got it on the average at 36 years of age. On the other hand, there are far fewer doctoral degrees in the research population and they obtain them at an older age: 39 years of age. The successful scientists usually speak two foreign languages and have a passive knowledge of another

two languages. For the research population sample, the average is one foreign language in each category of knowledge.

A good proof that we are dealing with eminent scientists, is the distribution of their roles in the scientific community that are usually taken as indicators of successful scientific performance. These respondents more often perform the roles of editors and reviewers. They are, on the average, members of one domestic journal's editorial board and of 0.4 international scientific journals (for the sample of researchers, the average percentages were 0.3 and 0.03). On the average, the distinguished scientists in five years review a lot more domestic colleagues' papers (7.4) than the average for the research population's sample (2.2 works). The same is true for an average number of foreign colleagues' papers, which are reviewed during a period of five years (2.8 to 0.5).

The scientific elite also stands out from the research population by its engagement in forming the scientific personnel. It is obvious from the average number of M.A.'s (2.4 to 0.7) and Ph.D.'s (1.3 to 0.3), to whom they were both mentors over five years. It also stands out by the average number of memberships in the committees on M.A. (4.3 to 1.1) and Ph.D. dissertations (2.5 to 0.5) over the same period of time.

The differences between the eminent scientists and the research population can easily be noticed in the level of professional integration. The former are on the average members of two (2.3) national and more than one (1.5) international scientific societies, while an average procentage for the latter amounts to 1.0 national and 0.3 international associations. Even more selective is the participation in the scientific committees of national and international societies and the differences are to the advantage of prominent scientists. Moreover, among them, there are also more laureates of scientific awards, particularly the national ones.

The socio-professional profile of eminent scientists significantly diverges from the one typical for the research population. The differentiation of the (most) successful ones begins in the course of their university studies and increases from the time of their scientific employment. According to their scientific qualifications and the knowledge of foreign languages that is very important (even crucial) for small countries and nations, the eminent scientists are by far more successful that the research population they belong to. The important roles they have in the evaluation of the scientific work quality, in educating the new generations of scientists and in functioning of the scientific associations, are proof that it is really a question of the prominent scientists. Let us analyze what productivity these scientific accomplishment are based on.

Quantity and patterns of eminent scientists' productivity

The basic reason for observing the productivity of scientists throughout their carreers and during a period of five years is of a methodological nature: productivity's sensitivity to a cumulative effect.[52] Namely, the cumulation of researchers' publications with their age contaminates the comparison of the groups or populations of scientists with a different age structure. The cumulative impact of age on a scientist's productivity is necessarily smaller in shorter periods of time, so that the comparisons are much more correct. This has to be kept in mind in the analysis of the following results:

Table 1

A comparative overview of the average productivity of eminent scientists and the research population in Croatia

Publicatons	Eminent scientists (1995)	Sample of researchers (1990)
THROUGHOUT THE CAREER		
Scientific publications	68.3	17.8
Professional publications	50.4	18.2
Scientific and professional publications	118.7	36.0
DURING A FIVE-YEAR PERIOD		
Solo-authored scientific publications	7.1	4.8
Co-authored scientific publications	9.7	4.2
All scientific publications together	16.8	8.9
Foreign scientific publications	6.9	1.8

Already at first sight, these data show that a distinguished scientist, during his or her career, publishes approximately four times more scientific and three times more professional papers than what is the average for the research population sample. The ratio between the scientific and professional publications (57.5%:42.5% for the former, and 49.4%:50.6% for the latter) is an indicator of a relevant qualitative difference - the scientific work prevails over the professional in the group of eminent scientists. They are, as we have seen, on the average 14 years older and the time span of their career is therefore significantly longer and could contribute to a larger cumulated publication productivity of the elite research group.

Really, the differences in the scientific productivity, examined during a period of five years are smaller but still significant: eminent scientists produce almost twice as many scientific publications than an average representative of the entire research population. Moreover, the comparison concerns the period (1990–1995) when there was in Croatia an enormous decrease of investments in the total R & D expenditure which were per researcher lower than the African average.[53] Only within such a socio-economic context, is it clear that the average scientific productivity of prominent researchers is relatively even higher than the productivity of the population because the latter is shown here by the data from an economically more prosperous period (1985–1989).

The differences in the orientation to the international scientific scene and team work are sociologically even more significant and important. The eminent publish almost four times as many scientific works in international/foreign publications. These publications represent more than two fifths (41.1%) of the entire number of their five-year scientific works. This elite is not only far more internationally active and recognized but also more involved in teamwork and other forms of regular scientific cooperation.

Its members, on the average, publish more coauthored than single-authored publications while the members of the research population have an approximately equal number of both types of publications. Yet another datum is in favour of using co-authored publications as an indicator of the work segmentation's intensity in science. On the average, eminent respondents work on common investigations with 4.8 domestic researchers and an "average" researcher collaborates with 2.5 of their colleagues.

Large differences in productivity and their sensitivity to the time framework were established on the sample of the research population.[54] What are these differences like in the group of successful scientists and how do they respond to different time periods? If the scientific productivity is examined throughout the whole career, it turns out that 36.6% of the above-average productive respondents (those with 70 and more works) produced 64.6% of all the scientific publications. Each of them, on the average, published 116.5 scientific papers. As many as 32.8% of the above-average scientists as for their productivity, in a five-year period (with 17 and more publications), published 65.2% of all the scientific papers. Each of them, on the average, produced 33.4 scientific papers during the same period of time.

In brief, the differences in their productivity also follow the general trend: the minority (of eminent) scientists produces the majority (of their) published papers. However, that minority is almost twice as large as the one in the research population

sample, where the publication productivity behaves closer to the Lotka law. Moreover, the proportion of the most productive authors and their publications is far more stable, less sensitive to different time frameworks in the case of prominent scientists than in the case of the research population.

Bearing in mind the results obtained on the samples of Norwegian tenured faculty,[55] it is plausible to presume that the productivity differences and their sensitivity to the time framework could be smaller if the scientists are more successful.

Eminent scientists' productivity predictors

In order to determine the factors of the eminent scientists' publication productivity, multiple regression analyses (stepwise procedure) were carried out (SPSS for MS WINDOWS). In congruence with the initial theses, the first block of predictors used was the one composed of socio-demographic, socializational, qualificational and organizational variables.[56] The variables serving as criteria were the scientific works that had been published by eminent respondents in the course of their entire career and during the period of 1990/1995. The results of these regression analyses are presented in Table 2.

The significant predictors of all scientific publications in respondents' career are: younger age at obtaining a Ph.D., younger age at appointment to the present scientific rank, active knowledge of foreign languages, principal investigators' roles in foreign/international projects, present older age, collaborators' roles in foreign/international projects and passive knowledge of foreign languages. The most relevant productivity factor is an early acquisition of a Ph.D., explaining 10% of the total productivity variance.

Together, these significant predictors explain 30% of the variance in the career-long scientific productivity of eminent scientists. It is almost half as big as the quantity of the explained variation (58%) in the number of the scientific papers found in the sample of the entire research population.[57] In spite of that there are some fundamental similarities between these two predictor structures.

The most important one is the largest contribution of the qualificational factors to the scientific productivity explanation. In the sample of all the researchers, the most powerful predictors were the scientific ranks and degrees. The productivity of eminent scientists, who are all Ph.D.'s mostly of the highest academic rank, is best explained by an earlier acquisition of a doctorate. Its influence has been found in some other studies, as well.[58-61] The age at the time of appointment in the highest scientific rank and the linguistic qualification are among the most important predictors.

Table 2

Statistically significant socio-demographic, socializational, qualificational and organizational predictors of the publication productivity throughout the career of eminent scientists and in the period of 1990/95

	Scientific publications				
	In whole career	In 1990/95 period			
		All	Solo	Co-auth.	Foreign
	Beta	Beta	Beta	Beta	Beta
Gender	-	-	0.1001	-	-
Age	-0.2083	-	-	-	-
Career continuity	-	-	-	-0.1169	-
Age at obtaining Ph.D.	-0.3224	-	-	-	-0.2206
Age obtaining the highest rank	-0.2623	-0.1939	-	-0.1815	-0.1266
Foreign languages/active	0.2460	-	0.1360	-0.1088	-
Foreign languages/passive	0.1062	-	0.1639	-	-
Number of international projects	0.1573	-	-	-	-
Leading international projects	0.2098	0.1293	-	0.2306	0.3804
Number of domestic co-workers	-	-	-0.1000	-	-
Multiple R	0.5474	0.2317	0.2542	0.3294	0.4484
R square	0.2996	0.0537	0.0646	0.1085	0.2011
F-ratio	23.0373	10.8385	6.5634	11.5589	31.9648
Signif F	0.0000	0.0000	0.0000	0.0000	0.0000

Another important similarity is the effect of age on the publication quantity in a person's career. It means that when the influence of other relevant variables is excluded, there is a certain independent contribution of age to the number of scientific publications' number. Regardless of whether they are eminent or average, older respondents are more productive, if the total number of publications or the number over a longer period of time are observed. Therefore, the scientific productivity analyses in shorter time spans should not fail to be carried out.

Only two predictors have a low but significant contribution to the explanation of the five-year quantity of the scientific publications by eminent scientists. A younger age at the appointment into the highest scientific rank and the principal investigator's

role in international and foreign projects together explain only 5% of the variance. On the other hand, a lot more variability of the five-year long productivity was explained by significant predictors in the sample of all the researchers (39%).[62] Therefore, we cannot avoid the conclusion that a five-year scientific production of the eminent is obviously influenced by some scientific (disciplinary), social and socio-psychological factors that are not taken into account and that the used independent variables much better predict the total, rather than a short-term production of scientific publications.

However, significant predictors vary in kind and power, explaining the different types of the five-year scientific publications by respondents. Thus, a better passive or active knowledge of foreign languages, (male) gender and a (smaller) number of co-workers in research will explain only 6% of the variation in the number of solo-authored publications.

The co-authored publications by respondents are somewhat better explained (11% of the variance) by: the principal investigator's position in foreign projects, (younger) age at the appointment into the highest rank, a continuous scientific career and the knowledge of a fewer number of foreign languages! The foreign publications are the best explained kind of respondents' five-year productivity (20% of variance). Leadership of foreign projects explains 14.5% of the variance and much lower are the individual contributions of the other two important predictors: (younger) age at acquiring a Ph.D. and appointment into the highest degree.

In brief, the factors that have been taken into consideration better predict those kinds of five-year scientific publications that presuppose a higher degree of the scientific collaboration and international scientific activity of eminent scientists.

In order to improve the explanation of the distinguished scientists' productivity, additional multiple regressions were carried out, in which the predictors' set was broadened while the criteria remained the same. The roles of editors, reviewers, mentors and examiners, as well as the respondents' roles in scientific societies constituted twelve additional predictors.[63] The results of these regressions are presented in Table 3.

The percentage of the explained variance was significantly increased in the case of the career-long productivity of respondents (for 8 percentage points) and in the case of their co-authored and international works published in the last five years (for 10 of 12 structural points). The total five-year scientific publications (regardless of their subtype) and single-authored publications are slightly better explained by introducing new predictors into the existing group. However, the differences do not only lie in the explanation level of an individual type of productivity but in its strongest predictors.

Table 3

Statistically significant socio-demographic, socializational, qualificational, organizational and gatekeeping predictors of publication productivity throughout the career of eminent scientists and in the period of 1990/95

	Scientific publications				
	In whole career	In 1990/95 period			
		All	Solo	Co-auth.	Foreign
	Beta	Beta	Beta	Beta	Beta
Age	-0.2419	-	-	0.1643	-
Career continuity	-	-	-	-0.1159	-
Age at obtaining Ph.D.	-0.2464	-	-	-	-0.1885
Age at obtaining the highest rank	-0.2580	0.1373	-	-	-
Foreign languages/active	0.1202	-	0.1360	-0.1155	-
Foreign languages/passive	-	-	0.1639	-	-
Number of international projects	0.1760	-	-	-	-
Leading international projects	-	-	-	0.1249	0.3804
Number of domestic co-workers	-	-	-0.0996	-	-
Executive at institution	-0.0868	-	-	-	-
Member of national editorial boards	0.0924	-	0.1041	-	-
Reviewing domestic colleagues' papers	-	-	-	-	-0.1572
Reviewing foreign colleagues' papers	0.2364	-	-	0.1970	0.3176
Member of committees for M. A. degrees	0.0898	-	-	-	-
Member of international scientific societies	0.3601	0.2683	-	0.3278	0.1259
Member of international societies' committees	-	-	-	-	-0.1604
Multiple R	0.6162	0.2995	0.2553	0.4561	0.5695
R square	0.3797	0.0897	0.0652	0.2067	0.3243
F-ratio	22.8900	18.8247	6.6259	16.4118	30.2372
Signif F	0.0000	0.0000	0.0000	0.0000	0.0000

The largest individual contribution to the explanation of the career long productivity is now given by the membership in international/foreign scientific societies (13% of the variance) and only then other factors: (younger) age at obtaining a Ph.D. and being appointed to the highest scientific rank, older chronological age, reviewing the foreign colleagues' papers, collaboration in international projects, active

knowledge of foreign languages, membership in national editorial boards, memberships in committees for M.A. theses and nonperformance of an executive position in a scientific institution. Together, these predictors explain 38% of the variance of eminent respondents' total publications. To conclude, participation on the international scientific scene, an earlier scientific promotion and an older age are the best predictors of the scientific production in a person's career.

Two significant predictors – the membership in international scientific societies and a (younger) age at the appointment into the highest scientific rank – contribute to the explanation of a small portion of the variation in a five-year long scientific productivity (only 9%). Solo-authored publications by eminent scientists are even less explained (7% of the variance) by passive and active knowledge of foreign languages, by membership in national editorial boards and a smaller number of research co-workers. Such a set of predictors suggests that it might primarily be a question of researchers from social and humanistic sciences.

The most important predictor of the co-authored publications quantity is the respondents' membership in international scientific societies (11% of the variance). Other important factors whose contribution to the explanation of this type of production is significantly smaller are: reviewing the foreign colleagues' papers, younger age at present, leaders' roles in foreign projects, a continuous career and an active knowledge of a smaller number of foreign languages. All these predictors together explain one fifth (21%) of the criterion's variability and they undoubtedly suggest a connection between the quantity of co-authored publication and an orientation to the international scientific arena.

Such an orientation is naturally most expressed in the foreign publications by respondents. All the significant predictors together explain 32% of the variation in the number of these publications. Leaders' role in foreign projects and reviewing the foreign colleagues' papers are the strongest predictors of the foreign publications quantity in a five-year period of time. They alone contribute to the explanation of 15% and 10% of the variance. Other relevant predictors are: younger age at obtaining a Ph.D., reviewing a smaller number papers by domestic colleagues, nonparticipation in committees of international scientific societies and also membership in international scientific societies.

In short, publishing in other countries presupposes a firm researchers' integration in the international scientific community, mostly through projects and reviews, which probably requires an international scientific reputation. Without it, it is hardly possible to get either projects or evaluational roles on the international scientific scene.

Finally, it has been shown that by including the scientists' gatekeeping roles among the productivity factors, we can better explain their career-long scientific production and the more stimulated and appreciated forms of recent scientific production – the international and co-authored publications by eminent researchers.

Conclusions

When generalizing the findings of this study, one can say that a comparative approach to the research of distinguished scientists' productivity and their professional profile, contrasted with the research population, is analytically fruitful. As was expected, great differences among the observed groups have been found: in the socio-professional profile, in the average scientific productivity and its subtypes, as well as in the scientific productivity determinants.

A socio-demographic picture of the eminent scientists' group, with an even larger overrepresentation of men and the elderly than is the case of the research population, shows a socio-professional selectivity. Female researchers, as well as young researchers have much less chance of accomplishing important scientific achievements and a corresponding reputation. When the educational progress and the professional development of eminent scientists and representatives of the population is reconstructed, an increase of differences among them can be noticed. They can be traced from the research and publishing activity during the course of undergraduate study and until the acquisition of the highest scientific qualifications, to the supervisory positions in projects and in scientific institutions and to the influential gatekeeping roles in the local and international scientific community.

The scientific productivity of eminent scientists is generally much higher than the average for the sample of the entire research population. The one that is career-long is four times higher, and the five-year one is twice as high the average. The average number of foreign publications by outstanding scientists in five years is also four times bigger. They, different from their less successful colleagues, operate in the international scientific arena. They also gather a larger number of collaborators and it is reflected in their co-authored publications.

It is important to point out that the inequality of the eminent researchers' productivity is much lower than the one of the research population representatives. Also, it is not sensitive to different time frameworks. Such a finding supports the thesis that the validity of Lotka's law could depend on the definition of the population of scientists, that is scientific authors.[55]

The examination of the determinants of the eminent scientists' productivity has shown the following:

1. The eminent scientists' career publications are half as much explained by significant socio-demographic, socializational, qualificational and organizational variables than the same productivity type of the research population was explained by the same type of factors. On the other hand, the eminents' five-year scientific publications are many times less explained by the said factors than the same type of the research population's production was explained by similar predictors. However, even in the eminents' five-year publications there are some differences - their co-authored and in particular foreign publications are much better explained than their solo-authored publications.

2. Qualificational and organizational variables are here also the most important predictors of different forms of productivity but are intellectually and socially more exclusive: they are connected with the younger age of the acquisition of a Ph.D. and the highest scientific ranks and with leaders' roles in foreign projects. An older age is a significant predictor of the eminent scientists' publication quantity in their career, just as was the case with the sample of all researchers. These findings are at the same time an important methodological warning to those who research into productivity.

3. An expansion of the predictors' set, with the respondents' gatekeeping roles, contributed to a better explanation of the scientific productivity, particularly of those types that were better explained by a narrower set: career publications, co-authored and foreign five-year publications. The connection of these gatekeeping roles (the usual indicators of scientific quality) with productivity, can be explained with the constant-probability-of-success model. According to their predictive power, particularly important are the factors that show an integration into the international scientific community: membership in international scientific societies and reviewing foreign colleagues' papers.

In conclusion, we can say that a lesser but significant explanation of eminent researchers' scientific productivity or its systematically stimulated forms is not surprising. It is even expected. In this elite group, homogenity is larger and variability is smaller than in the entire research population. Smaller differences in scientific competence, the professional position and qualifications do not manage to sufficiently explain those in the quantity of productivity. For that reason, the following research step could be an analysis of the scientific (disciplinary) context as a determining framework of the distinguished scientists' knowledge and publications production.

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50. In the same sequence in which these variables are given, the obtained non-significant values of the chi-square are also given: 1.3241 (df=1; P=0.01); 3.2492 (df=6; P=0.01); 6.7264 (df=5; P=0.01).
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57. In the 1990 survey, the obtained significant predictors were: the scientific ranks and degrees, older age, a leadership role in regular projects, publications during the universities studies, a leadership role in regular subprojects, collaborative roles in the so called selective projects, active knowledge of foreign languages and scientific collaboration outside one's own scientific institution.
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63. These are: memberships in national and international editorial boards; reviewing domestic colleagues' papers but also those by foreign colleagues; the number of supervised M. A. theses but also those of Ph.D. candidates; memberships in committees for master's theses and doctoral dissertations; membership in national and international scientific societies and their committees.

Appendix

Table A

Socio-demographic, socializational, qualificational and some professional characteristics of eminent scientists (N = 385) and of the entire research population's sample (N = 921)

Respondents' characteristics	Structure (in %) 1995	1990
GENDER		
Male	83.1	65.8
Female	16.9	34.2
AGE		
Under 29 years of age	-	9.4
30-34	-	12.6
35-39	0.8	13.9
40-49	12.8	30.5
50-59	34.8	24.8
60 and over	51.6	8.8
FATHER'S EDUCATION		
Elementary school and lower	29.1	25.0
School for skilled workers	4.7	9.0
Secondary school	24.4	25.4
Two-year post-secondary school	9.6	11.9
University	32.2	28.7
TYPE OF COMPLETED SECONDARY SCHOOL		
Grammar school (gymnasium)	85.7	72.2
Other secondary school	14.3	27.8
FINAL SECONDARY SCHOOL GRADE		
Good (and sufficient)	8.1	9.0
Very good	36.4	35.3
Excellent	55.6	55.7
AVERAGE GRADE AT UNIVERSITY		
Good (and sufficient)	12.6	22.2
Very good	60.6	61.8
Excellent	26.8	16.1
RESEARCH OTHER THAN STUDY OBLIGATIONS		
Did not participate	57.0	74.3
Did participate	43.0	25.7

Table A - cont.

PUBLICATIONS DURING UNIVERSITY STUDIES		
Did not publish any papers	72.8	85.5
Did publish papers	27.2	14.5
PERMANENTLY EMPLOYED IN SCIENCE		
Was employed outside science	41.2	53.9
Employed in science from the beginning	58.8	46.1
SCIENTIFIC DEGREE		
No doctorate	-	61.6
Doctoral degree	100.0	38.4
ACTIVE KNOWLEDGE OF FOREIGN LANGUAGES		
None	4.9	13.1
One foreign language	38.7	48.3
Two foreign languages	37.9	28.9
Three foreign languages	12.5	6.5
Four or more foreign languages	6.0	3.2
PASSIVE KNOWLEDGE OF FOREIGN LANGUAGES		
None	8.8	24.5
One foreign language	22.3	39.3
Two foreign languages	44.2	26.1
Three foreuign languages	15.6	7.4
Four and more foreign languages	9.2	2.7
NATIONAL EDITORIAL BOARDS		
Is not a member of any	31.2	77.7
A member of one editorial board	38.3	15.6
A member of two editorial boards	18.1	5.2
A member of three or more editorial boards	12.4	1.4
INTERNATIONAL EDITORIAL BOARDS		
Is not a member of any	76.6	97.7
A member of one editorial board	18.1	1.8
A member of two or more editorial boards	5.4	0.4
REVIEWING DOMESTIC COLLEAGUES' PAPERS		
No paper in five years	11.7	63.8
One to two papers in five years	13.6	11.9
Three to four papers in five years	17.8	9.0
Five to six papers in five years	19.7	6.4
Seven or more papers in five years	37.2	8.9

Table A - cont.

REVIEWING FOREIGN COLLEAGUES' PAPERS		
No paper in five years	59.6	92.3
One to two papers in five years	17.6	3.8
Three to four papers in five years	8.5	1.6
Five or more papers in five years	14.3	2.3
SUPERVISING M. A. CANDIDATES		
Never in five years	25.6	78.7
Once in five years	21.9	6.2
Twice in five years	16.6	5.6
Three times in five years	15.0	2.9
Four or more times in five years	21.0	6.5
SUPERVISING Ph. D. CANDIDATES		
Never in five years	37.2	87.0
Once in five years	27.7	6.9
Twice in five years	21.1	3.3
Three or more times in five years	14.0	2.8
COMMITTEES ON MASTER'S THESES		
Never in five years	17.6	76.2
Once in five years	10.9	5.3
Twice in five years	10.7	4.2
Three times in five years	11.2	3.8
Four times or more	49.6	10.5
COMMITTEES ON DOCTOR'S DISSERTATIONS		
Never in five years	23.3	82.8
Once in five years	17.6	5.4
Twice in five years	20.3	3.9
Three times in five years	16.5	2.7
Four times and more	22.3	5.2
NATIONAL SCIENTIFIC SOCIETIES		
Not a member of any society	10.2	40.6
A member of one society	24.6	28.4
A member of two societies	25.9	20.6
A member of three societies	21.5	6.7
A member of four and more societies	17.8	3.7
INTERNATIONAL SCIENTIFIC SOCIETIES		
Not a member of any society	29.8	78.6
A member of one society	31.2	15.5
A member of two societies	22.8	3.6
A member of three or more societies	16.2	2.3

Table A - cont.

NATIONAL SOCIETIES' COMMITTEES		
Not a member of any committee	57.3	78.0
A member of one committee	28.9	17.2
A member of two committees	9.8	4.1
A member of three or more committees	4.0	0.7
INTERNATIONAL SOCIETIES' COMMITTEES		
Not a member of any committee	77.5	97.2
A member of one committee	17.0	2.3
A member of two or more committees	5.5	0.5
NATIONAL SCIENTIFIC AWORDS		
No award received	61.5	86.8
One award received	24.3	8.3
Two awards received	7.9	2.8
Three or more awards received	6.3	2.1
FOREIGN SCIENTIFIC AWARDS		
No award received	91.8	99.0
One award received	5.5	0.5
Two or more awards received	2.7	0.5