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PUSH OR PULL?

AN EMPIRICAL ANALYSIS OF THE DEMAND FOR INDIVIDUAL PROJECT GRANTS FROM THE SWISS NATIONAL SCIENCE FOUNDATION

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Abstract

This study empirically analyses on the basis of a panel of grant requests to the Swiss National Science Foundation (SNSF. From the results it can be concluded, that the different scientific disciplines react in very different ways to the institutional and financial framework conditions set by the funding agency. Regarding the expansion of the tertiary educational system it can concluded that it has an impact on research funding in the form of two contrary influences. These two effects offset each other to the extent that they do not suffice to explain the rising trend in terms of the number of requests observable as from the year 2000.

JEL Code: C33, H52, I2.

Keywords: research funding, universities, panel estimations.

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1. Introduction – Current Situation

Research at universities is increasingly being financed through research funding agencies and, in a parallel development, increasingly less through the general funds appropriated to universities and, by extension, to professorial chairs. The financing of research through external agencies is said to contribute to an improvement in the quality of research output by virtue of the competitive components involved in the research grant process. Irrespective of the shifting significance of these two funding channels, research funding agencies in many countries are generally being showered with a practically exponentially growing number of research funding applications. The present study investigates, based on an analysis of the Swiss National Science Foundation (SNSF), to what extent the growth of the tertiary education system has contributed to the rapid rise in applications for research grants during the past several years and whether the given structures of research funding agencies and the funding possibilities they offer might also be a factor for the strong increase in grant applications.[1]

This investigation is in many ways explorative in nature because no similar studies, neither theoretical nor empirical, have - to our knowledge - been conducted in the past. The initial results of this investigation do reveal, however, that the differing behaviour and the differing response patterns of researchers in different scientific disciplines should, whenever the issue of demand for research project grants is under discussion, be an object of scientific investigation. Such investigation is likely to generate also new insights into the production of knowledge in the individual scientific disciplines.

2. Research questions and hypotheses

In this study two groups of hypotheses that are of relevance in a theoretical sense were investigated even though there actually is no real theory on the factors determining the number of research grant applications at national research funding agencies. These two groups of hypotheses differ in that the first group covers "push" factors, i.e., those factors that are defined by the environment in which the grant applicants work and conduct their research. These are factors that directly influence the likelihood that researchers will submit an application for a research grant. The second group, the "pull" factors, comprises those factors that are determined by the research funding agencies themselves, in this case the Swiss National Science Foundation, due to the various ways in which they are organized and operate; they have a direct and indirect influence on researcher demand for grants.

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[1] This report is based on a study conducted by the Centre for Research in Economics of Education at the University of Berne at the request of the Swiss National Science Foundation (SNSF). The responsibility for the contents of this essay resides solely with the authors and any views and opinions expressed herein may not necessarily reflect the views or opinions of the Swiss National Science Foundation or the institutions represented by the authors. The authors thank Hans Peter Hertig and Véronique Jost for this research assignment and their confidence and they are also grateful to numerous employees at the SNSF for their valuable assistance in obtaining information. Thanks also go to Petra Koller, Philipp Dubach and Philippe Jacobi at the Swiss Federal Statistical Office for their assistance in obtaining valuable data material and other additional information. The usual disclaimer holds.

2.1 Push factors

In this group, primary attention is focused on the employment relationship of the researchers and the influence this exerts on the number of research grant applications submitted. Within this group, a distinction can also be made between push factors that influence the number of funding applications submitted per researcher within a given research community and push factors that have an effect on the overall number of researchers who might submit an application for a research grant. The latter sub-group will alter the total number of applications submitted even if the number of applications submitted per researcher stays the same.

a) Expansion of the tertiary system

The increase in the number of people who can or, in fact, should submit grant applications is primarily dependent on the quantitative development of the university system because it is from this system where most of the applicants originate. Therefore, the number of people who conduct research in the university system is, ultimately, also influenced by the size of the student population at universities because one can assume that the number of non-professorial and professorial teaching staff will eventually be adjusted to the number of students attending universities (albeit after a certain delay and to a proportionally lesser extent). Since both parts of the system, i.e., the non-professorial and professorial faculty, are expected to conduct research in addition to their teaching responsibilities, the number of persons who could potentially submit applications for research grants from the SNSF should grow in tandem with the expansion of the tertiary system. Such a straightforward connection between the size of the student population and the number of researchers at universities cannot, however, be generalized nor can it be assumed that it is a constant. There are two main reasons for this. One is that research activities in certain disciplines may simply be increased due to a need for research knowledge, without being initially triggered by a change in student enrolment numbers.[2] In such cases the number of students enrolled may even display a delayed response to an increase in research activity. The other reason is that – as mentioned above – an increase in student enrolment can initially have an adverse effect on the ratio of students to teaching staff until, at a much later point in time, more university faculty staff are hired. If the number of faculty staff increases at a proportionally slower rate, it can be assumed that the professorial and non-professorial faculty will have to meet much greater teaching obligations and, as a result, the number of research grant applications per researcher is likely to decline. In this case an expansion of the tertiary system could even have a neutral, or indeed negative, impact. A decisive factor here is certainly the given situation in which the discipline or university finds itself.

b) Changes in the general conditions for research activities

It can also be presumed that there are factors within the university system that affect both the probability that researchers will submit grant applications and the frequency of such submissions. There are two main channels that qualify as possible influencing factors. It is quasi-inherent in the system that research activity has a positive impact on the market value of researchers. Therefore, every researcher has a fundamental interest in maintaining a high output of high-quality research. In this regard, funding possibilities via third-party agencies or

[2] For example in the field of environmental sciences at the ETH in the wake of the debate on dying forests.

offices, the SNSF, for example, are an opportunity for researchers to achieve these goals more quickly by obtaining more financial resources, to say nothing of the positive reputation value that is created whenever an application for research funding is accepted. In order for such a situation to actually increase the number of applications submitted per researcher, modifications to incentive systems making it more rewarding and more imperative for researchers to seek and obtain research funding at the universities (or in specific disciplines) would have to be observable. Looking at British and American universities as an example, it can be said that such incentive systems have certainly become more common and more effective at the international research level over the past several years.

Apart from the changes concerning the incentive structure of university research operations (as well as in non-university settings), there has been another development that actually should have a positive impact on the number of grant applications submitted. The overall funds available at most universities (ex third-party funding) have stagnated in inflation-adjusted terms during the past few years. Considering that the growing student population has indeed resulted in an increase in the overall number of staff at universities, this means that the amount of funding per professorship has declined. Therefore, since increasingly fewer funds are available per professorial chair, every professor should feel compelled to compensate for the decrease in funding by turning to third-party funding sources in order to maintain the same level of research output (not to mention the possible efficiency gains, which are probably more easily achieved when teaching than researching). Nevertheless, while one can certainly grasp that a reduction in funding per professorship would basically have a positive impact on the number of grant applications submitted, here, again, differing effects are conceivable depending on the actual circumstances at each university. For instance, in addition to a *compensatory effect* (when a lack of internal university funds is compensated for by seeking third-party funding), a *discouraging effect* might also be observable. This effect would be particularly noticeable once the financial funding per chair drops to such a low level that the "sunk costs" that are incurred during the grant application process can no longer be recouped and are no longer justifiable. Submitting applications for research grants would then no longer be worthwhile, regardless of the reduced availability of funds. And, of course, there are also interacting effects with other factors that would also have to be taken into consideration. For example, the lower the application acceptance rate at the SNSF, the sooner this discouraging effect is likely to set in. A discouraging effect could also be expected if the sunk costs of submitting an application are very high. Such a constellation would certainly appear plausible at Division I[3], for example. This is because, in addition to the unfavourable ratio of faculty to students in the corresponding disciplines at the universities and the low grant acceptance rates at the SNSF compared to other disciplines, the demands placed on the grant applicants have, according to expert opinions, also risen in recent years (leading to higher sunk costs as well).

To summarize, it can be said that hypotheses on the influence exerted on the number of grant applications submitted to the SNSF stemming from the research and employment environments at Swiss universities cannot be clearly and unequivocally formulated from a theoretical standpoint and such hypotheses must, therefore, be empirically investigated. On the other hand, it is somewhat unlikely that the aforementioned, possibly dampening, effects on the number of grant applications could be so strong that they would be capable of completely offsetting the amplification effects associated with the quantitative expansion of the tertiary system. It follows that not only the quantitative expansion of the tertiary system

[3] Individual disciplines are assigned to one of three Divisions at the Swiss National Science Foundation. An overview is given in the Appendix. Division I compromises mainly disciplines of the humanities and social sciences, Division II engineering, natural and exact sciences and Division III biology and the medical sciences.

but also the changes underway with regard to the incentive systems throughout the research landscape and, ultimately, the tighter budgets for basic funding of universities would tend to increase demand for external research funding sources and, therefore, have a positive impact on the number of funding requests submitted to the SNSF.

2.2. Pull factors

Turning to the factors attributable to operational and functional aspects of the Swiss National Science Foundation, a distinction can be made between three different kinds of pull factors. One comprises the other funding instruments of the SNSF (besides the normal individual project grants) that could have an interactive effect on the grants awarded for individual research projects in the Divisions I, II and III. Secondly, although the SNSF's capacity to promote research (defined by the total amount of financial resources available to it for grants) is determined by exogenous forces (i.e. in a political process), it does have some freedom (subject, of course, to substantial constraints) in appropriating these resources to the various Divisions and disciplinary groups, which, in turn, probably has an impact on the number of grant applications submitted by the individual disciplines. Thirdly, there are also certain dynamic elements to be considered because the initial processing of grant applications and the probability that an application will be accepted can, to a certain extent, be anticipated, as can the amount of funding that is likely to be awarded. Therefore, these dynamic elements also have an impact on the behaviour of potential grant applicants. However, since these elements, for example the probability that an application will be accepted, are, in turn, influenced by the total number of grant applications submitted (the financial resources of the SNSF are not limitless), there is a dynamic interactive effect that, ultimately, has a co-determining influence on the number of applications submitted in the following observation period.

a) Alternative research funding instruments

With regard to the alternative research funding instruments offered by the SNSF, the study focuses on the following three: (1) the targeted research programmes under the National Research Programme (NRP and SPP), (2) the National Centres of Competence in Research (NCCR) and (3) the SNSF Professorships. Theoretically, all three can influence the number of applications for individual project funding submitted in the Divisions I-III. The interactive effect between the funding instruments and the applications for grants is, once again, theoretically unclear and ambiguous. One could assume that fewer applications might be submitted because of the alternative funding instruments, since researchers will be able to obtain funding from these alternative sources. This hypothesis would be particularly plausible under the presumption that the alternative funding instruments, especially the National Research Programmes (NRP), have a certain *substitutive effect* on the grant applications submitted within the scope of normal project funding. Furthermore, this dampening effect will increase accordingly as researchers themselves discover that there are certain upper limits to the amount of research they can conduct, i.e. that they cannot simply increase their research activities at will. In such a situation research needs met through other sources would reduce the likelihood that "normal" requests for project funding would be submitted.

On the other hand one could also posit a certain *complementarity* of the funding instruments. As a result of this complementarity, researchers who were successful in receiving funding through one instrument would only then have access to resources enabling them to further increase their research capacity and also to generate new research ideas in the process. In such a situation one could imagine that researchers working on a project in a NRP are, by virtue of

this involvement, encouraged to present new funding requests for individual project funding and that they can do so much more easily. With this complementarity, the expansion of the alternative funding instruments would not lead to a decrease in the number of grant applications submitted, but rather a continued increase.

With regard to the alternative funding instruments, an empirical investigation was only possible with the NRPs, for various reasons. The SNF Professorships and the NCCR have not existed long enough to permit exogenous variables to be generated that allow for clear, unequivocal conclusions. The projects in the SPP programmes were not taken into consideration because the variance of this variable was too small to serve as an explanation for the fluctuations in the number of funding requests in the individual discipline groups.

b) Approved grant applications

Our second hypothesis pertains to the relation between the amount of grants awarded per discipline group in year t-1 and the number of requests submitted in year t. This relation should be positive under the assumption that the researchers will take note, either directly (through their own experiences) or indirectly (through other researchers or information from the SNSF), of any increase in the amount of funding available. In other words, an increase in funds earmarked for research grants serves as an incentive to submit more requests for grants in the subsequent period. The decisive point here is the hope that the greater amount of funds available will have increased the probability of having a grant application accepted. However, an increase in grant monies in the preceding period could just as well lead to a decline in the number of grant applications submitted in the subsequent period if a discipline is unable to quickly increase the number of funding applications it produces. This is because in the given situation an increase in research funding during the preceding period would have a saturation effect. A decline in grant monies in the preceding period could conceivably lead to either effect, depending on whether one postulates discouragement or compensation as the response from the researchers.

The changes in grant monies awarded is analyzed per discipline group since it can be assumed that, from a researchers' point of view, only the data on discipline group to which they belong is of relevance.

c) Dynamic feedback effects

The decision-making situation of a researcher contemplating whether to submit an application for a research grant can be briefly described as follows: An application will be submitted only if the net benefit of the research project is positive, i.e., if the benefit is greater than the cost associated with the process of applying for a research project grant. The latter includes the effort required to conceive and design a project, i.e., all resources that must be invested in the project grant application. The benefit will also depend on the probability that the application will be accepted and, in the event it is accepted, on the amount of funding that will be provided for the research project, while the costs of submitting the application are sunk costs, regardless of the presumed chances of acceptance.

Three different types of response patterns can be expected given the decision-making situation described above.

- A **Type 1** response pattern would be practically no reaction in the number of funding requests to changes in the expected acceptance rate and the degree of funding provided. This could be attributable to various reasons. One would have to assume, however, that the decision-making situation for Type 1 researchers is a 0-1 decision, meaning that the decision is whether to submit a project proposal or not and not whether to submit more or less proposals. The absence of any response can be expected if there is deterioration in the aforementioned acceptance and funding rates that does reduce the net benefit but this net benefit is, nevertheless, still clearly positive. Therefore, the likelihood of submitting an application does not change much because the 0-1 decision is still be in favor of submitting an application. The expected effect of changes in acceptance probability and the degree of financing provided is accordingly marginal and probably not statistically significant.
- A **Type 2** response pattern would be researchers who reap either a relatively small benefit from a research project and/or for whom the costs of submitting a grant application are relatively high. In the event the benefit was already close to nil prior to any deterioration in the acceptance probability and degree of funding provided, we would expect that a reduction in these rates would bring the net benefit into a negative range. We refer to this response type as a "case of discouragement." Any deterioration in the general funding conditions at the research promoting agencies would immediately discourage these researchers from submitting a funding request in the first place.
- **Type 3** has a similar starting situation as Type 1 above, i.e., the net benefit prior to any change in rates is clearly in positive territory. In addition to the assumptions made for the Type 1 model, however, we assume that Type 3 researchers are aware of not only the net benefit of an individual research project but also of their overall research output. If the net benefit of one single application declines due to the greater probability that the application will be rejected and because less funding per grant is offered, these researchers will feel compelled to compensate for the reduced benefit per application by submitting more applications. Only by doing so can they maintain the overall benefit of their aggregate research activity at the same level as before. This would be a "case of compensation", meaning that the reduced expected benefit of a single grant application will have to be compensated for by submitting more applications. This type of response is expected if, for example, existing research infrastructure can only be maintained by having a continual flow of research activity. Such situations can also arise if individual research projects are more or less follow-up projects within a broader, continuing research programme; a disruption in the research chain would have negative effects on the entire research output in the long term.

Our operationalization of the acceptance rates and funding rates is based on the assumption that researchers' expectations will be extrapolative or adaptive. This means that the behaviour of researchers at the point t in time will respond to the given rates at the point t-1 in time.

Type 3 is the most likely of the three aforementioned response patterns to trigger a dynamic response chain. Assuming the amount of funds appropriated to the SNSF remains practically unchanged, and the number of grant applications in year t increases due to an exogenous effect, then the acceptance and funding rates would recede in year t. This would compel researchers to submit more grant applications in year t+1 (compensation), which, *ceteris paribus*, would cause the rates in year t+1 to recede once again in comparison with year t. This, in turn, would lead to a further increase in grant applications in year t+2 and so on.

3. Experience abroad

As expected, a brief review of the literature confirms that there is virtually no research literature on this specific issue. No investigation of this subject matter has been documented in the theoretical or the empirical literature; so far only the effects of the general institutional environment and incentive systems on individual research activities have been investigated, and only in a few studies describing the research activities of individual researchers. These papers are of little interest with regard to the specific question as to why more grant applications might be submitted to a particular research funding agency. Inquiries addressed to foreign institutions that are comparable to the SNSF were answered in Germany and Austria. In Germany, the German Research Foundation (DFG) reported a growing number of funding requests in its individual grants programme. As a result of this increase, the DFG lowered its acceptance rate, which declined on average from 68.4% in 1995 to 46.3% in 2004. In Austria, the Austrian Science Fund (FWF) reported that the number of requests for individual grants had not risen very much but the amount of funding requested per proposal had. The FWF reacted to this development by turning down a greater percentage of the requests submitted and its acceptance rate consequently declined from approximately 60% to 36.2% during the 1995-2004 period.

In both cases, however, there had been no investigations made, in order to analyse the reasons for the increased funding requests or the amount of funding requested.

An interesting note in both of these cases is that the pressure on the two research promotion agencies stemming from the growing number of grant applications was met primarily by an increase in their refusal rates rather than a reduction in the amount of money provided per application (see also section 4). Due to the hypotheses formulated in section 2, one would have to presume that the constant reduction in the probability that an application will be accepted would still contribute to an increase in the number of applications submitted if the costs of submitting an application "sunk costs" were not prohibitively high.

4. Database, operationalizations and limitations

4.1. Data specification for the dependent variable

The variable to be explained in the following analyses is the total number of grant applications submitted to the SNSF Divisions I to III. The analysis is limited to project requests. It does not cover other types of requests, such as applications for personal grants or conference grants.

Request statistics are generated twice a year. A spring and an autumn figure hence exist for each year. These two figures were used to calculate an annual rate. It would be possible in theory to combine the autumn figure in the year t-1 with the spring figure in t, since these might be exposed to the same influences in terms of time. Another possibility would be to combine the spring and autumn values in year t to produce an annual figure. Both specifications were tested and yielded fairly similar trends in terms of the annual figures. Hence, we are opting for the specification which adds up the two values from the same year. This also facilitates interpretation of the coefficients of the independent variables.

A vigorous and unusually linear increase in grant applications as from 2001 can be observed, in particular with regard to Division I discipline groups. The SNSF has furnished us with explanations for this major trend, which, however, we were unable to test on a quantitative basis.[4] We therefore attempted to take this trend into account by means of a specific control variable. This variable explores whether there was a significant trend for the post-2000 period, with particular reference to grant applications from Division I, which both differs from the trend prevailing in the 1990s and is also stronger than the trend for Divisions II and III.

4.2 Grouping in terms of the dependent variable

Two specifications for dependent variables were set up for empirical analysis. The first specification is based on the discipline groups and the second is based on the inputting tertiary institutions (including the Swiss Federal Institutes of Technology in Zurich {ETH}, and Lausanne {EPFL}, respectively).

a) By discipline group

The first specification allows the broadest dataset and also takes account of the fact that the request figures in the individual disciplines may be subject to very different exogenous influences. This process enabled the creation of a panel covering 285 observations, at best. The panel is based on 19 discipline groups yielding a value in each case over a 15-year period. The basic criterion for setting up a panel with all discipline groups is the assumption that the request figures for the various discipline groups are not interlinked or correlated (although they may of course be subject to the same exogenous influences). Although this assumption might not apply one hundred percent, it is nevertheless appropriate because it is hard to assume that the number of requests in one particular discipline might influence the requests in another discipline. Naturally, due to the difficulty in drawing demarcation lines, there may be cases in which this assumption does not always apply – especially with regard to divisions II and III, for example when discipline groups are redefined and grant applications that were formerly in Group x now count as belonging to Group y. This would bring about a causal negative correlation between the two disciplines that would not be explainable by exogenous factors.

The hypotheses in section 2 showed that, based on theoretical reasoning, individual disciplines or discipline groups are likely to react very differently to exogenous effects, not only in extent but also in terms of the direction of response. Setting up panels for discipline groups is a suitable basis for estimating such effects separately for discipline groups (divisions).

[4] These explanations are mainly about the expiry of SPP projects and the initiation of the NCCR; none of the disciplines in Division I received funding during the first round of the NCCR's but the SPP covered well the humanities and social sciences. These two effects might naturally have resulted in more requests mounting up in Division I.

b) By tertiary education institution (i.e., conventional university and Swiss Federal Institutes of Technology

As well as classification on the basis of discipline groups, grant applications may of course also be categorized in terms of the institutions from which the applications come. The assumption of independence between the various groups in terms of the dependent variable is probably even more applicable when specifying in terms of educational facility rather than in terms of discipline groups, which makes specification unproblematic. The variable is made up of grant applications involving universities and the two ETHs. The new universities of Lucerne and Lugano have not been included among the universities because they were not yet a significant factor during the period of observation. This gives a panel of eight conventional universities and two Federal Institutes of Technology, and encompasses a period of 15 years, yielding a maximum N of 150 in terms of the dependent variables.

Basically, it would be reasonable to assume that, given the research setting, researchers in the same discipline would react identically or similarly to exogenous effects, and that affiliation to a particular institution would not necessarily be the crucial criterion. However, this assumption does not apply where university-specific incentive systems exist. As long as universities differ in this respect on a structural basis, these differences are taken into account by the dummy variables for the individual institutions (fixed effects) even if a discipline-based panel is set up. So why is it necessary to set up an institution-specific panel? There is one main reason, and it involves the difference in data structure for SNSF data and Swiss Federal Statistical Office (SFSO) data (see 4.4). Transfer of the SFSO's university-specific statistics to an SNSF nomenclature on a discipline basis gives a very imprecise picture, whereas classification by institution is naturally much easier. Therefore, factoring exogenous variables from the university domain into estimates for discipline groups runs the risk of generating results that do not reflect true-life correlations, but are merely a consequence of imprecise data matching.

The institution-specific analyses also go on to explore whether the conventional universities as a group show different trends and respond differently to exogenous variables than do the two federal institutions, the ETHs.

There are two main reasons for this approach. Firstly, it can be assumed that the research and research funding climate at the ETHs differs from the climate prevailing at the cantonal universities, which might result in a situation where the incentive for researchers to submit SNSF grant applications is much higher at ETHs than at cantonal universities. Secondly, an unusually high increase in the number of full-time professorships can be seen for the ETHs starting from 2000. Although this trend requires further explanation, it automatically has a major influence on all exogenous variables related to the number of professorships.

4.3. Exogenous variables from the SNSF area

With regard to the variables from the National Foundation's sphere of influence, three groups of exogenous variables were created for the analysis, after tests showed that these groups have a high explanatory value.

The simplest solution was to operationalise the variables emerging from the number of grant applications submitted and the level of funding applied for, and the number of applications actually approved and grant monies actually awarded.

a) Acceptance rates and degree of funding

In terms of the acceptance rate, a significantly negative trend over time in all three divisions is easy to detect by descriptive means alone. Thus, the acceptance rate is virtually a mirror image of the increasing numbers of applications. This is because there was an upper limit to the resources available to the SNSF, and the only response to an increasing number of requests was a higher refusal rate. Analysis of the degree of funding of the approved projects over time clearly shows that the limited resources were not simply distributed among a larger number of projects, which would have been possible but would not have been rational from a research policy point of view.

b) Total approved sums broken down by discipline group

This variable comprises the total approved amounts per discipline group. This variable was operationalised as the rate of change versus the previous year. Hence, the impact of this variable can be investigated without the impact of differences in the levels of approved amounts between the disciplines.

c) National research programmes (NRP)

It is more difficult to operationalise the exogenous variables, which are intended to reflect the alternative funding instruments of the SNSF. Various operationalization options are available, and various specifications were tested for that reason. The table below shows the version ultimately used in the empirical analyses. As far as operationalization is concerned, it is important to investigate the impact of NRPs on individual project funding such that the start, run time, and end of an NRP may produce a different effect on project requests. This is because a certain compensatory effect on other project requests is most likely to occur during an NRP, whereas at the start of an NRP, both a compensatory response and a stimulation of "normal" project submissions would be conceivable. Thus, it is conceivable that project submissions refused for an NRP, because they did not have exactly the right subject area, later re-appear via individual project submissions in the Divisions I-III. Upon completion of an NRP, two effects are possible. On the one hand, in the course of a project in an NRP, new project ideas might be generated which would boost the number of project requests at the end of the NRP. On the other hand, people completing an NRP project (for example as part of the doctoral programme of the persons concerned) might be more inclined to engage in evaluation work based on the completed paper and hence have fewer resources for starting other projects, which would tend to reduce the number of research funding applications.

Table 1: Operationalization of variables for an NRP

Duration of an NRP	-	x	x	x	x	-	-
Variable 1 (beginning)	1	0	0	0	0	0	0
Variable 2 (middle)	0	1	1	1	1	0	0
Variable 3 (end)	0	0	0	0	1	1	0

The variables were specified such that all discipline groups are each allocated three dummy variables if an NRP applied to the subjects covered by the discipline group. Two variants were tested for Variable 2. One variant always assumed a value of 1 when an NRP was in progress for the respective discipline. The other specification added up the NRPs of relevance to the discipline. In the empirical analyses, the first specification had the greatest explanatory value, which was why the first type of operationalization was used.

4.4. Exogenous variables from the tertiary institution area

a) Expansion of the tertiary education system

Operationalization of the variables from the tertiary institution area was associated with three major problems, the first of which put the greatest constraints on the analysis options. The table below shows that the Swiss Federal Statistical Office's system for classifying academic disciplines differs from that of the SNSF.

Table 2: Comparison of SNSF and SFSO systems for classifying academic disciplines

SNSF classification	SFSO classification
Philosophy, religious studies and educational sciences	Theology
Sociology, political sciences, business administration, economics and law	Social studies Law Business studies
History	Historical + cultural studies
Archaeology, ethnology, urban studies	Historical + cultural studies
Language and literature	Language + literature
Mathematics	Exact science
Astronomy	Exact science
Chemistry	Science
Physics	Exact science
Engineering	Construction + geodesy Mechanical and electrical engineering
Environmental studies	Science
Geography	Science
Basic biological science	Science
General biology	Science Agricultural science + forestry
Basic medical science	Medicine
Experimental medicine	Medicine
Clinical medicine	Medicine Veterinary medicine
Preventive medicine	Medicine
Social medicine	Medicine

The consequence of the nomenclatural incompatibility is that matching the SFSO figures to each of the 19 SNSF disciplines produces a fairly undifferentiated picture.

A second problem concerns the operationalization of the variable "finances per university." Since this data is available only for the period since 1995, analysis based on this variable can only extend back to 1995, strictly speaking. However, this would reduce the volume of data to an extent that would impact on the outcomes. Therefore, it was decided to use constructs as a basis for elaborating data for the pre-1995 period.

The third problem concerns the professorship statistics. As already mentioned, the ETHs saw an unusual increase in the number of professorships from 2000 onward. Further, the statistics of the Federal Statistical Office show that the professorships allocated to Division III were subject to structural disruption between 1995 and 1996. These ruptures indicate that the SFSO reshuffled professorships and classified them to different disciplines during this period.

Because this effect has an impact on all variables elaborated with the variable "professorships", a regrouping of these professorships was attempted, on the assumption that the post-1995 classification is the correct one. Pre-1995 trends in the individual discipline groups were therefore adjusted to the 1996 level in each case. This more or less precludes any structural rupture in the variables. Regrouping was not necessary for the analysis of request figures per tertiary institution because regrouping mainly pertains to discipline groups and has practically no influence on the analyses per tertiary institution.

b) Policy changes impacting on research activities

It was also intended to operationalise the possible changes in the framework conditions for research activities at universities (incentive systems, appointments policy, etc.). To this end, discussions took place with senior management personnel from almost all Swiss universities. These talks confirmed that there had certainly been changes in framework conditions during the period of observation, but it was not usually possible to date these changes to specific years. This information therefore produced no workable variables for the empirical part. Hence, although such policy changes may well affect the numbers of funding applications submitted, this association is impossible to pinpoint. Consequently, any growth triggered by such changes would manifest as a trend with no precise explanation.

5. Estimation methods

The statistical method employed here for empirical evaluation is panel estimation. The panel structure is composed of a cross section of 19 disciplines / 10 universities and a longitudinal section of 15 years.[5] Hetereoscedasticity was controlled for, which is an obvious step in view of the differently sized groups of applications in the individual disciplines and universities. An AR(1) term was used for correction of longitudinal autocorrelation.

In all our estimates, we use dummies for the individual years and individual discipline groups / individual tertiary education institutions. This approach allows us to correct for unobserved structural differences between the years, the disciplines and the tertiary institutions, and reduces the risk of misinterpreting outliers in the years, disciplines or tertiary institutions and misreading them as trends or other correlations.

6. Empirical evaluations

For the reasons mentioned above, empirical evaluation proceeds as follows: Wherever possible, estimates are made on the basis of the dataset of applications according to the individual discipline groups. This enables the use of the most extensive and differentiated dataset. However, it also means that, for this data, the exogenous variables from the tertiary institution area cannot be taken into account (because of the definition problems mentioned

[5] All estimates were done using the econometric program Stata 8.0.

above). The variables from the tertiary institution area (see 6.3.) are therefore only used for the analyses pertaining to request figures per tertiary institution. It is therefore impossible to present a combined explanatory model with data from the SNSF and tertiary institutions. For all calculations, the dependent variable (number of applications) was used in a logarithmized form. Accordingly, the coefficients of the independent variables are to be interpreted as percent changes in the number of applications.

6.1. Trend

The purpose of the first empirical test is to see if any statistically significant trend whatsoever can be identified for the observation period from 1990 to 2004. In this process, as mentioned above, fixed effects will be estimated for the individual discipline groups and for each year, i.e. a trend will be identified as significant only if the movements in the numbers of applications cannot be explained by individual discipline effects or year effects. The results, i.e. the coefficients, are read such that a change in the independent variable, i.e. in this case, the trend, of 1 (i.e., one year) changes the dependent variable (the grant applications per discipline group) by x percent.

Table 3: *Trend estimates (fixed effects for years and discipline groups); dependent variable: number of grant applications (logarithmized) by discipline group; coefficients x100*

Coefficients	Estimate 1	Estimate 2	Estimate 3
Trend 1990-2004	3.22***		
Trend 1990-2000		1.87***	
Trend 2001-2004		14.06***	
Trend 1990-2000 Division I			2.65***
Trend 1990-2000 Division II			1.67***
Trend 1990-2000 Division III			1.73***
Trend 2001-2004 Division I			22.26***
Trend 2001-2004 Division II			14.39***
Trend 2001-2004 Division III			9.45***
N	285	285	285
N groups	19	19	19
Time periods	15	15	15
Wald chi(.)	31567.7	31567.7	27104.47
Prob > chi2	0.000	0.000	0.000

*, **, *** stand for a 10%, 5% and 1% level of significance, respectively. The estimates are estimated for heteroscedastic panels with cross-sectional correlation. Autocorrelation is corrected with an AR(1) coefficient for all panels.

If one estimates a linear trend for the period of observation (Estimate 1), then the grant applications submitted to the SNSF rose an annual 3.2%. Analysis of the numbers of grant applications shows, however, that this trend was not linear because the strong growth in requests did not set in until after 2000, following a slight dip in 99/00. If one breaks the trend

down into the two periods 1990-2000 and 2001-2004, one will see (Estimate 2) that, though a statistically significant trend was already in place in the first period, it was no higher than approximately 1.9%. Starting from 2001, the trend indicates an annual increase of more than 14% in the number of requests. Basically, however, it is not easy to decide which of the two trend specifications is better, because the good fit of the linear trend could also be interpreted as indicating that the considerable increase in applications in the 2001 to 2004 period was simply a reaction to the decline seen in the previous two years.

If you break the two trend periods down even further into divisions (Estimate 3), it again becomes clear that growth was mainly engendered by the disciplines in Division I. The trends in Divisions 2 and 3 are statistically significantly lesser than the trend in Division I (for reasons of space, the tests are not shown here), but are also statistically significantly different from zero and in the positive range. The next step is therefore to explore whether these trends can be partly or wholly explained by other variables.

6.2. Connections between variables in the SNSF area

a) Acceptance rate

In Table 4 below, the first variable to be tested as an explanatory variable is the acceptance rate for applications per discipline.

Table 4: Application acceptance rate (+trends); Dependent variable: number of grant applications (logarithmized) by discipline groups; coefficients x 100

Coefficients	Estimate 1	Estimate 2
Acceptance rate (Year t-1)	-0.11	
Acceptance rate Division I (Year $_{t-1}$)		0.33***
Acceptance rate Division II (Year $_{t-1}$)		-0.52***
Acceptance rate Division III (Year $_{t-1}$)		-0.10
Trend 1990-2000 Division I	1.15**	2.03***
Trend 1990-2000 Division II	0.71**	0.50**
Trend 1990-2000 Division III	0.33	0.80
Trend 2001-2004 Division I	16.01***	20.15***
Trend 2001-2004 Division II	10.45***	7.42***
Trend 2001-2004 Division III	3.88***	3.59
N	266	266
N groups	19	19
Time periods	14	14
Wald chi(.)	10476.80	16888.10
Prob > chi2	0.000	0.000

*, **, *** stand for a 10%, 5% and 1% level of significance, respectively. The estimates are estimated for heteroscedastic panels with cross-sectional correlation. Autocorrelation is corrected with an AR(1) coefficient for all panels.

The acceptance rate is taken from the year t-1 and, pursuant to the hypothesis, should have an impact on the number of applications in year t. Estimate 1 shows no significant effect for the acceptance rate across all disciplines. However, if one breaks down the effect by divisions, significant effects are disclosed for Divisions I and II, the direction being inverse in either case. In contrast, the disciplines in Division III do not seem to react significantly to the rate of acceptance of applications.

Pursuant to the hypotheses in section 4, what one observes in Division I is an encouragement/discouragement effect, whereas the effect one observes in Division II is a compensatory effect. In other words, the number of applications in Division I declines in response to a declining acceptance rate (and rises in response to a rising acceptance rate), while, in Division II disciplines, a decline in the acceptance rate prompts an increase in the number of applications. Hence, Division II disciplines seek to offset a lower probability of having a request accepted by submitting more applications the following year.

b) Degree of funding

Similarly to the exploration of the impact of the acceptance rate, this section looks at how the degree of funding of prior grant applications affects the number of applications subsequently submitted.

Table 5: Degree of funding of grant applications (+trends); Dependent variable: number of grant applications (logarithmized) by discipline group; coefficients x 100

Coefficients	Estimate 1	Estimate 2
Degree of funding (Year t-1)	-0.74***	
Degree of funding Division I (Year $_{t-1}$)		-0.42***
Degree of funding Division II (Year $_{t-1}$)		-0.32
Degree of funding Division III (Year $_{t-1}$)		-0.61***
Trend 1990-2000 Division I	1.60***	1.50***
Trend 1990-2000 Division II	0.57**	0.60**
Trend 1990-2000 Division III	1.01***	1.20***
Trend 2001-2004 Division I	15.85***	15.91***
Trend 2001-2004 Division II	8.05***	8.07***
Trend 2001-2004 Division III	5.44***	6.15***
N	266	266
N groups	19	19
Time periods	14	14
Wald chi(.)	15806.35	16354.10
Prob > chi2	0.000	0.000

*, **, *** stand for a 10%, 5% and 1% level of significance, respectively. The estimates are estimated for heteroscedastic panels with cross-sectional correlation. Autocorrelation is corrected with an AR(1) coefficient for all panels.

Across all disciplines, an increase in the degree of funding (Estimate 1) has a significantly negative effect on the number of applications submitted in the subsequent year. In other words, all disciplines would react to a reduction in the degree of funding of their applications in year t-1 by increasing their applications in year t. Broken down by division, this effect is strongest in Division III. The discipline groups in Division II do not show a significant reaction to a change in the degree of funding.

c) Approved grant applications

The next exogenous variable to be investigated is the grant monies awarded per discipline group. This variable is defined as the percent change in approved amounts from t-2 to t-1 per discipline group.

Table 6: Approved amounts (x1000) for grant applications (+trends); Dependent variable: number of grant applications (logarithmized) by discipline groups; coefficients x 100

Coefficients	Estimate 1	Estimate 2
Approved amounts (Year $_{t-1/t-2}$)	-0.17***	
Approved amounts Division I (Year $_{t-1/t-2}$)		-1.30***
Approved amounts Division II (Year $_{t-1/t-2}$)		-0.63*
Approved amounts Division III (Year $_{t-1/t-2}$)		1.42***
Trend 1990-2000 Division I	1.60***	1.16***
Trend 1990-2000 Division II	0.74***	0.90***
Trend 1990-2000 Division III	0.43	-0.00
Trend 2001-2004 Division I	18.31***	17.04***
Trend 2001-2004 Division II	9.74***	11.32***
Trend 2001-2004 Division III	4.55**	2.73
N	247	247
N groups	19	19
Time periods	13	13
Wald chi(.)	128034.26	14273.41
Prob > chi2	0.000	0.000

*, **, *** stand for a 10%, 5% and 1% level of significance, respectively. The estimates are estimated for heteroscedastic panels with cross-sectional correlation. Autocorrelation is corrected with an AR(1) coefficient for all panels.

An increase in approved amounts has a negative effect on the number of grant applications across all discipline groups and in all departments, but, as already seen for the acceptance rate, the effects differ from one division to another. If there is an increase in the approved amounts in the Division I discipline groups, this lowers the number of applications submitted in the next period. In other words, a kind of short-term saturation effect is observed. This effect might be explained thus: when more applications have been approved, these need to be "researched" before new applications can be submitted. A similar but weaker reaction can be

observed for the discipline groups in Division II. In contrast, the Division III discipline groups display a contrary response in terms of this variable. If the approved amounts increase, the number of requests submitted in the next period also increases, i.e. positive growth in terms of the amounts approved "whets the appetite for more" among these discipline groups.

d) National Research Programmes (NRPs)

Various specifications were subjected to empirical testing for the exogenous variables that describe the funding instrument of the NRPs. A detailed description will be provided only of the particular model that proved to be significant. The table shows that, in a simple test of NRP variables, at least the two variables describing the run-time (middle) of an NRP and marking the end of an NRP are significant. The effects are negative throughout, i.e. you can assume that an NRP which covers one of the 19 discipline groups significantly lowers the number of grant applications in this discipline group. For reasons of comparison, the table again gives the outcome of the first trend estimate. This comparison is intended to show that, despite the subduing effect of NRPs on the number of applications, there is no major downturn in divisional trends.

Table 7: National Research Programmes (NRPs)(x100) (+Trends); Dependent variable: number of grant applications (logarithmized) by discipline groups; coefficients x100

Coefficients	Estimate 1	Estimate 2
NRP (start)	-2.77	
NRP (middle)	-3.87**	
NRP (end)	-3.23**	
Trend 1990-2000 Division I	2.90***	2.65***
Trend 1990-2000 Division II	1.70***	1.67***
Trend 1990-2000 Division III	1.83***	1.73***
Trend 2001-2004 Division I	22.79***	22.26***
Trend 2001-2004 Division II	14.00***	14.39***
Trend 2001-2004 Division III	9.79***	9.45***
N	285	285
N Groups	19	19
Time periods	15	15
Wald chi(.)	15399.84	27104.47
Prob > chi2	0.000	0.000

*, **, *** stand for a 10%, 5% and 1% level of significance, respectively. The estimates are estimated for heteroscedastic panels with cross-sectional correlation. Autocorrelation is corrected with an AR(1) coefficient for all panels.

e) Combined effects

Whereas exogenous variables were tested individually in the foregoing tables, it is always prudent to assume that the exogenous variables might also display intercorrelations; hence, a

model that tests all variables together need not always disclose the same effects. However, the collective model produces similar outcomes in almost all respects as compared with the individual tests of the exogenous variables, apart from minor differences in the significances.

Table 8: Exogenous variables from the SNSF area (+trends); Dependent variable: number of grant applications (logarithmized) by discipline groups; coefficients x100

Coefficients	Estimate 1	Estimate 2
NRP (Start)	-3.13**	
NRP (Middle)	-5.74***	
NRP (End)	-7.28***	
Approved amounts Division I (Year $_{t-1/t-2}$)	-1.93***	
Approved amounts Division II (Year $_{t-1/t-2}$)	0.13	
Approved amounts Division III (Year $_{t-1/t-2}$)	2.03***	
Degree of funding Division I (Year $_{t-1}$)	-0.58**	
Degree of funding Division II (Year $_{t-1}$)	-0.08	
Degree of funding Division III (Year $_{t-1}$)	-0.19	
Acceptance rate Division I (Year $_{t-1}$)	0.72***	
Acceptance rate Division II (Year $_{t-1}$)	-1.07***	
Acceptance rate Division III (Year $_{t-1}$)	-0.618**	
Trend 1990-2000 Division I	2.65***	2.65***
Trend 1990-2000 Division II	0.16	1.67***
Trend 1990-2000 Division III	0.44	1.73***
Trend 2001-2004 Division I	23.5***	22.26***
Trend 2001-2004 Division II	3.52	14.39***
Trend 2001-2004 Division III	3.09***	9.45***
N	247	285
N groups	19	19
Time periods	13	15
Wald chi(.)	6877.91	27104.47
Prob > chi2	0.000	0.000

*, **, *** stand for a 10%, 5% and 1% level of significance, respectively. The estimates are estimated for heteroscedastic panels with cross-sectional correlation. Autocorrelation is corrected with an AR(1) coefficient for all panels.

While the funding instrument of the National Research Programmes (NRP) generally has the effect of reducing the number of requests, differences can be observed in particular between the Division I discipline groups and the other two divisions in terms of the other variables. Deterioration in the likelihood of receiving SNSF funding (acceptance rate and degree of funding) has a discouraging effect in Division I and prompts a decline in the number of requests. Request levels in Divisions II and III do not react significantly to the degree of funding (which may be explained by the possibility of availing of alternative funding

options), but a compensatory effect can be observed in terms of the acceptance rate. If the probability of having a request accepted declines, the response is to increase the number of applications submitted. Division I responds to approvals of applications in preceding periods with a saturation reaction, while Division III responds by increasing the number of applications still further.

For comparison purposes, the trend estimate is again shown. The effects emerging from two different regressions are not directly comparable, but very marked changes can be seen with regard to the significance of the outcomes. If you take into consideration the framework conditions for approval of grant applications, for the available and allocated funds, and for the other SNSF funding instruments, it seems that all these factors have no influence whatsoever on the request trend in Division I, i.e. they do not explain the trend. In contrast, no further significant effects can be discerned for Divisions II and III in the 1990s.

Drawing an interim conclusion from analysis of the request figures by discipline group, it can be seen that the trend toward an increase in the number of grant applications is primarily determined by an unexplainable trend in terms of funding requests in Division I, while the increasing number of requests in Divisions II and III is a reaction to deteriorating SNSF acceptance rates.

6.3. Correlations between type of tertiary educational institution and funding requests

As stated, analysis of correlations between tertiary education institution variables and the number of applications for SNSF funding is based on a breakdown by institution. This analysis includes the two ETHs and the universities (unis). Since we have legitimate doubts as to whether the ETH data is truly comparable to the university data, especially due to the heavy increase in professorships from 2000 onward and because of the difference in the thrust of research between the ETHs and cantonal universities, the exogenous influences are estimated separately for the universities and the ETHs by using interaction variables.

a) Trend

Two things soon become apparent from the trend estimates: The first estimate shows that estimation of the trends in two periods with the request figures grouped according to university yields approximately the same figures as estimation by discipline group, which would suggest that the analyses are comparable. The second estimate shows that, as was to be expected, the marked trend in the second period is mainly due to Division I disciplines; this can be seen from the fact that the ETHs do not display any such trend, because they do virtually no research in these disciplines.

Table 9: Trends; dependent variable: number of grant applications (logarithmized) by tertiary education institution: coefficients x100

Coefficients	Estimate 1	Estimate 2
Trend 1990-2000	1.13***	
Trend 2001-2004	13.89***	
Trend 1990-2000 (unis)		1.07***
Trend 2001-2004 (unis)		13.21***
Trend 1990-2000 (ETHs)		1.18
Trend 2001-2004 (ETHs)		3.53**
N	140	140
N groups	10	10
Time periods	14	14
Wald chi(.)	23664.78	27527.13
Prob > chi2	0.000	0.000

*, **, *** stand for a 10%, 5% and 1% level of significance, respectively. The estimates are estimated for heteroscedastic panels with cross-sectional correlation. Autocorrelation is corrected with an AR(1) coefficient for all panels. Years and universities are controlled for using dummy variables.

b) Number of professors

The number of professors has a positive effect on the number of applications for research funding. The coefficient in estimate 1 is to be interpreted as indicating that adding one professor increases the number of requests by approximately 0.07%. Since the annual average number of applications in the observation period is slightly in excess of 1,000 applications, this means that one additional full professorship in the tertiary system would increase the number of applications submitted to the SNSF by 0.7. If the tertiary institutions are broken down into universities and ETHs, the significant effect for the ETHs is effaced, while the coefficient for the universities rises slightly. However, the former probably does not mean that the number of professorships is of no relevance to the submission of applications at the ETHs; rather, it is probably attributable to the fact that the number of ETH professorships is distorted because of special effects.

Due to limited space, the analyses of student numbers are not given here. The results show that there is a time lag before a change in the number of students impacts on the number of grant applications. This shows that quantitative expansion of the tertiary education system is reflected a short time later in more professorships and hence in a higher requirement for research funding. The effect size is such that adding 100 students results in 1.25 more research requests five years later. The effect for the ETHs is around 3.5 times higher than for the universities, because it takes considerably fewer additional students for an additional professorship to be installed at the ETHs than at cantonal universities (again with the necessary limitations in terms of data quality).

Table 10: Number of professors (+trends); dependent variable: number of grant Applications (logarithmized) by tertiary educational institution; coefficients x1000

Coefficients	Estimate 1	Estimate 2
Number of professors	0.72***	
Number of professors (unis)		0.84***
Number of professors (ETHs)		0.30
Trend 1990-2000	0.99***	0.93***
Trend 2001-2004	12.85***	12.5***
N	140	140
N Groups	10	10
Time periods	14	14
Wald chi(.)	15591.24	16887.29
Prob > chi2	0.000	0.000

*, **, *** stand for a 10%, 5% and 1% level of significance, respectively. The estimates are estimated for heteroscedastic panels with cross-sectional correlation. Autocorrelation is corrected with an AR(1) coefficient for all panels. Years and universities are controlled for using dummy variables.

c) Student-professor ratios

The next analysis looks at the impact of the student-professor ratio on the number of requests for funding. The specification of the student-professor ratio does not distinguish between cross-sectional and longitudinal effects.

Table 11: Student-professor ratios (+trends); dependent variable: Number of grant applications (logarithmized) by tertiary institution; coefficients x100

Coefficients	Estimate 1	Estimate 2
Student-professor ratio	-0.61**	
Student-professor ratio (unis)		-0.82***
Student-professor ratio (ETHs)		2.43**
Trend 1990-2000	1.30***	1.35***
Trend 2001-2004	15.28***	15.74***
N	140	140
N Groups	10	10
Time periods	14	14
Wald chi(.)	11258.74	9893.02
Prob > chi2	0.000	0.000

*, **, *** stand for a 10%, 5% and 1% level of significance, respectively. The estimates are estimated for heteroscedastic panels with cross-sectional correlation. Autocorrelation is corrected with an AR(1) coefficient for all panels. Years and universities are controlled for using dummy variables.

This means that a poor student-professor ratio at one university as compared with another university might equally be the cause of a significant coefficient as a change in the student-professor ratio over time. As might be expected, the effect is negative and significant. A deterioration in the student-professor ratio (more students per professorship) correlates with a decline in the number of requests. Because teaching takes up more time, less time remains to engage in research and submit research funding requests. The ETH coefficient should not be paid too much attention because it is likely to be heavily biased by the trends in the number of professorships as described above.

d) Funds per professorship

Since overall funding (not including third-party funding) at the universities remained virtually unchanged since the mid-1990s in real terms, while the number of professorships rose slightly in most cases, the available university resources per professorship declined steadily in real terms. Based on the assumption that you might expect professors to be tempted to alleviate this trend and offset it by seeking external funding, the logical expectation would be for the reduction in funding per professorship to result in an increase in the number of applications for funding submitted to external agencies. This effect can be discerned overall and also for the universities and ETHs separately.

Table 12: Funds per professorship (+trends); dependent variable: Number of requests (logarithmized) by tertiary education institution

Coefficients	Estimate 1	Estimate 2
Funds per professorship	-1.87e-07***	
Funds per professorship (unis)		-1.27e-07***
Funds per professorship (ETHs)		-6.12e-08***
Trend 1990-2000	0.91***	0.99***
Trend 2001-2004	12.58***	12.80***
N	140	140
N groups	10	10
Time periods	14	14
Wald chi(.)	28100.99	18697.27
Prob > chi2	0.000	0.000

*, **, *** stand for a 10%, 5% and 1% level of significance, respectively. The estimates are estimated for heteroscedastic panels with cross-sectional correlation. Autocorrelation is corrected with an AR(1) coefficient for all panels. Years and universities are controlled for using dummy variables.

e) Combined model

Having found significant effects for three groups of exogenous variables, what is of interest now is to explore whether these variables – which are inter-correlated – all remain significant in a collective model. It immediately becomes clear that the number of professors cannot be tested simultaneously with the other variables in a single model, because the other two variables themselves depend on trends in terms of the number of professorships. Moreover, the coefficients of the ETH variables cannot be included in the analysis because these

coefficients are unreliable owing to the aforementioned data trends in the ETH area, and, in point of fact, are no longer significant in the calculations.

It can be concluded from the combined model that expansion of the tertiary educational system impacts on research funding in the form of two contrary influences. On the one hand, the deterioration in the student-teacher ratios at the universities has subdued the submission of requests, while on the other hand the reduction in the funds available per professorship at the universities has raised the pressure to acquire third-party funding. These offset each other to the extent that they do not suffice to explain the rising trend in terms of the number of requests observable as from the year 2000. A genuine mass effect – where more grant applications are submitted because more researchers are active in the system – cannot be discerned, because a mass effect of this kind is counteracted by the trend apparent in terms of university finances and due to a time delay in the setting up of new professorships in the presence of a rising number of students.

Table 13: All exogenous variables (+trends); dependent variable: number of grant applications (logarithmized) by tertiary educational institution

Coefficients	Estimate
Student-professor ratio (unis) (x100)	-0.83***
Student-professor ratio (ETHs) (x100)	2.81
Funds per professorship (unis)	-1.49e-07***
Funds per professorship (ETHs)	-2.91e-08
Trend 1990-2000 (unis)	1.11***
Trend 2001-2004 (unis)	14.18***
Trend 1990-2000 (ETHs)	0.86
Trend 2001-2004 (ETHs)	2.67
N	140
N Groups	10
Time periods	14
Wald chi(.)	9104.29
Prob > chi2	0.000

*, **, *** stand for a 10%, 5% and 1% level of significance, respectively. The estimates are estimated for heteroscedastic panels with cross-sectional correlation. Autocorrelation is corrected with an AR(1) coefficient for all panels. Years and universities are controlled for using dummy variables.

7. Conclusions

The empirical analysis of the determinants of the factors influencing the demand for research grants shows that the institutional features and the funding mechanisms of the funding agencies play a prominent role as well as the expansion, the financing and governance of the tertiary system.

Concerning the funding agency, the "pull factors", it can be shown, that the financial resources at disposal, the institutional settings and the instruments for financing research can trigger new requests as well as put off new applicants. The most interesting result found so far is, that the different scientific disciplines react in a very different way to the same circumstances and incentive structures, which points to the fact that the knowledge production in the different scientific fields must be governed by quite different factors and rules. Whereas the humanities and social sciences seem to be easily saturated when the opportunities for more research grants are ameliorated, the same situation "wets the appetite" for more research money in the field of medical sciences. At the same time a reduced probability that a research proposal is accepted discourages the number of applicants in the humanities and social sciences, whereas in the natural, exact and medical sciences it triggers more proposals in order to compensate for the reduced probability of acceptance. Saturation and discouragement for the humanities and the social sciences could be an indication that rather high sunk costs are attached to research proposals. This leads to a situation where refused proposals cannot easily be replaced by new ones nor can accepted proposals be easily supplemented by additional ones. In the other scientific disciplines the different reaction to a change in the research funding framework shows that on the one hand that favourable conditions can be exploited rather easily and that because of the need for a constant flow of research money, deteriorating conditions have to be compensated by an increase in the requested grants. The fact that these disciplines can react and adapt the production of proposals in the short run also means that the cost of a single proposal and the possibility to replace refused proposals with new ones must be quite different than in the humanities and the social sciences.

As regards the expansion of the tertiary system, the "push factors", it can be noted that this has an impact on the number of requests for research grants but a net effect can only be expected in the long run. More professors – as expected – seek more research money and therefore push the number of proposals to the funding agencies. Due to the fact that the personnel and finance resources allocated to the universities only react sluggishly to the expansion in the number of students, the student/professor ratio and the finance per chair ratio deteriorate in the short term. Whereas the unfavourable student/professor ratio decreases the number of requests for grants because professors are tied up with teaching, the decrease in the financial resources per chair causes the opposite. Professors have to look for outside money if the resources at their university do not keep pace with the expansion. This provokes two counteracting factors, with the consequence that the expansion has no net effect in the short run.

The findings have to a certain extent pioneering and exploring character. Therefore future research should – to our view – analyse further whether the high degree of uniformity of the instruments of research funding agencies is equally suited to all scientific disciplines. The same holds for the effects periods of expansion and contraction of the tertiary system can have on the knowledge production in individual scientific disciplines.

Appendix

Division grouping of disciplines

Division	Disciplines
Division I	Philosophy, religious studies and educational sciences
	Sociology, political sciences, business administration, economics and law
	History
	Archaeology, ethnology, urban studies
	Language and literature
Division II	Mathematics
	Astronomy
	Chemistry
	Physics
	Engineering
	Environmental studies
	Geography
Division III	Basic biological science
	General biology
	Basic medical science
	Experimental medicine
	Clinical medicine
	Preventive medicine
	Social medicine

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