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Research grants

The top eight percent: development of approved and rejected applicants for a prestigious grant in Sweden

Göran Melin and Rickard Danell

In the final round of a call for applications for one of Sweden's most prestigious research grants, 40 relatively young and potentially promising researchers remained. Half were eventually approved; the other half were rejected. The differences between them in terms scientific merit were investigated. No particular differences were found. How did these two groups differ in terms of scientific development a few years later, with respect to publications, international co-authorships, further funding and spin-offs? Results show that the approved group has been more successful in many ways. A discussion is held regarding the effects of providing young promising researchers with sufficient funding, and the cost of failing to do so.

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FOR A YOUNG AND PROMISING researcher in his/her formative years, after the PhD exam and a subsequent post-doc period but before obtaining a permanent research position and becoming an established research leader, life is often a hard fight for financial resources (Horton, 1996; Nerad and Cerny, 1999; Dillon, 2003). The approval of a research proposal can mean the difference between a continued academic career and the end of it. Those who can attract grants have relatively good possibilities of forming a research group or developing a line of research of their own.

This phase of the academic career is a period of particular relevance to anyone who is interested in socialisation processes in academia, formation of scientific networks, factors at play in the establishment of research groups or knowledge transfer from established disciplines to new fields of study (Abbot and Stiegler, 1996; Parker, 2002; Burris, 2004). It is not unusual during this phase for new branches to grow out from existing fields or disciplines and with time to develop into new fields.

In many European countries, there has been an increase in the number of students who receive a PhD degree. Naturally, attention is paid to the preconditions for continuing with scientific work for the young researchers, in academia or elsewhere — what employment opportunities there are and what funding possibilities exist (Melin, 2004; Musselin, 2004; 2005).

It is important that good talents are located and provided with reasonable resources to develop their ideas and, in the long run, contribute back to society.

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Göran Melin has since early 1990s been oriented towards the study of research collaboration, especially the international aspects. He has also been working with international collaboration matters in practice in the position of director at The Swedish Foundation for International Cooperation in Research and Higher Education (STINT). During the most recent years as senior researcher at The Swedish Institute for Studies in Education and Research (SISTER), the focus has partly shifted towards the study of young researchers and their situation. The often critical phase at the end of graduate studies and the subsequent postdoc period has been investigated in several studies.

Rickard Danell completed his PhD in the spring of 2001 and has been a member of the information science research group (Inforsk) at Umeå University since 1995. His dissertation focused on the effects of internationalisation and the principles of stratification in science. His subsequent research has continued within areas related to sociology of science and scholarly communication. He is currently studying mobility patterns among scientists, and the changing position of Sweden and Swedish research in the international research community.

The functionality of funding schemes, evaluation procedures and selection processes is crucial in this context (Langfeldt, 2001). It is important that the most talented students are picked for graduate studies; it is important that the most talented PhDs are picked for post-doc positions; it is important that the most talented young researchers are provided with research money and decent working conditions — not only for them, but for the grant-giving organisations as well, no matter whether it is private or public money they distribute.

This study focuses on a group of highly talented young scientists in the natural, medical and technological areas. They all sent in applications to one of Sweden's largest research foundations, which had announced a very prestigious funding programme with 20 research grants of a scale and scope that is unique for Swedish circumstances: each over 1 million Euro during six years. For young and relatively non-established researchers, this may be the largest and most attractive research grant there is in Sweden. This group made it all the way to the final round in a careful selection process with full applications and also an interview by a panel of appointed evaluators. It contained the last 40 applicants from originally over 500; this means that 20 of them received a grant and 20 did not.

This also means that there were probably very small differences between them in terms of merit, qualifications and future potential. Was it even possible to distinguish any differences among the last 40 applicants? In general, where is it reasonable to draw the rejection line? Where is it optimal to draw it? Can any evaluation process however careful distinguish the best four or five percent, and not just five percent of the best ones more broadly? Such questions form the starting point for this study.

However, this funding programme had other criteria attached to it, which we will describe. Our point is not one of suspicion towards those ones selected or criticism of the evaluation process as such. Rather, our curiosity is oriented towards the very selection of some before others as the result of a careful but still common evaluation process, and the implications this may have for the future research career, both for those approved and for those rejected.

A less good performance at the interview could have meant the difference between approval and rejection. Were there any distinguishable and measurable differences between those who got the grant and those who did not, and how did it go afterwards? What did it mean to get such a grant early in a career? What did it mean to be rejected? As an attempt to approach these and the previous questions, a couple more specific questions will be investigated empirically:

- What scientific merits did the applicants have?
- How have the scientific merits developed after the decision to fund/reject?

Before describing the methods used, the features of the specific programme will be presented in brief.

INGVAR funding programme

Early in 2000, the Swedish Foundation for Strategic Research (SSF) announced a call for tenders within a new funding programme called Individual Grant for the Advancement of Research Leaders (INGVAR). SSF is one of Sweden's largest foundations with an annual expenditure of roughly 100 million Euro. The sum fluctuates year by year depending on the initiatives that the foundation decides to be involve in, and the growth of the invested capital.

It is an endowed foundation and, in juridical terms, a private one. However, the endowment was made by the Government in 1993, and the Government appoints the members of the board. In reality, it is thus a semi-private–public body of a rather unusual kind. It may be noted that Sweden has several foundations of the same character. SSF supports research within medicine, science and technology through a range of activities. The supported research should have potential for development of industrial applications, widely defined.

The INGVAR programme was born as a result of a perceived lack of significant and stable funding possibilities for young researchers in, or right after, the so called post-doc phase. The research councils did not provide big enough grants, SSF decided, and did not target the critical period between the PhD degree and a tenured assignment. SSF wanted to select the future research leaders and provide them with a significant long-term grant, almost without restrictions on its use.

The call was announced internationally and anyone was welcome to apply. The research should be carried out at a Swedish university though. A

completed post-doc period abroad was one requirement for eligibility. The grant was specified as SEK 10 million, which in 2000 was equivalent to approximately €1.2 million and US$1.1 million; in 2005 (January to October) to €1.1 million and US$1.4 million. The grant was paid out over a period of six years, starting in mid-2001. Thus, it is still ongoing.

A particular detail with INGVAR is that it targets future research leaders. One consequence is that the grantees should not be too established already. There are examples of applicants who were rejected because they had come too far in their career. There was no specified age limit but 'about 40' was in reality considered a maximum age.

The most striking detail is, however, that the grant included a leadership training programme. Participation was mandatory for the grantees. It included a ten-day trip to Japan with frequent visits to universities and companies, a series of thematic two-day workshops and a psychological test of each person's personal profile. Each grantee was also provided with a mentor, in many cases very prominent people from the top layer of Swedish industry or academia.

No doubt, the leadership programme has received much attention in Sweden and must be regarded as a very successful initiative with a high profile. It has contributed significantly to the debate about academic leadership. The innovative and, in some aspects, unusual construction of INGVAR has shown the Swedish scientific community that research grants can be distributed in a way that is different from that of the traditional research council, without giving up selection criteria that target scientific excellence.

The selection process did include, for instance, a pre-proposal, letters of recommendation, international evaluation by three field experts, evaluation of the strategic value of the proposals, full application and finally an interview. During this process, which lasted more than a year, 504 applicants were step by step reduced to 20. In fact, one additional individual was included among those approved, but this person already had funding within another scheme at the foundation and the foundation thought that the leadership programme was especially suitable for him to participate in. Thus, there were 21 individuals in the successful group.

Although there has been occasional critical voices, not many have questioned that the successful grantees all fall within the absolute élite layer of young scientists at Swedish universities. Actually, many have pointed out that some of the rejected applicants were just as talented, and especially in the final group of 40, 20 (plus one) of which were accepted for the grant and 20 were rejected.

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Method

The aim of the data collection was to reconstruct the publication histories of the 40 applicants for the period 1997 to 2004. The database used for this purpose was Web of Science (WoS) (SCI-EXPANDED, SSCI, A&HCI). Publications that are not listed in WoS have not been counted; however, in a few cases we did check the authors' curriculum vitae (CVs) (see more below). Only rarely do they publish in anything but WoS-listed journals but a complete investigation has not been undertaken as to why publication-related results in this study bear this limitation.

In order to retrieve each individual's publications from the database, we used a search strategy consisting of several steps. In the first one we used a query containing the name of the individual in combination with their known affiliation (both current and previous), for instance, AU=(nilsson h*) AND AD=(phys* SAME lund SAME sweden). In the next step, we searched the database for AU=(nilsson h*) AND AD=(phys* SAME sweden NOT lund), to see whether there was another individual at a physics department named Nilsson H*. If so, we used the description of the individual and made a free internet search to investigate whether this was the same person.

Since we are dealing with an internationally mobile population, we also searched for individuals with the same name outside Sweden, for instance, AU=(nilsson h*) AND AD=(phys* NOT sweden). In those cases where we could detect possible mobility, we checked the articles against information in the individuals' CV and against data retrieved through the internet searches. Overall, the search process resulted in 581 articles for the individuals in the INGVAR-group and 625 for the comparison group.

Two aspects of the applicants' publication behaviour were analysed with bibliometric indicators. First we looked at the changes in productivity of the applicants. As a result of intra-field variation and co-authorship, both whole counts and fractional counts were calculated in order to measure the groups' average productivity. Whole counts mean that an individual is attributed one whole publication if he or she is one of the authors.

This measurement is problematic for two reasons. First, both groups contain individuals from different scientific fields in which the practice of co-authoring articles is more or less common. Second, some of the applicants have co-authored articles with each other, which means that, when using whole counts, an article may be counted several times. We therefore normalise the individual productivity using fractional counts. When calculating fractional counts an author is attributed a fraction of an article, and the size of the fraction depends on the number of authors in the author field; for instance, if an article has three authors, then each author is given one third of the article's authorship.

The second aspect of the publication behaviour that is analysed is whether the individuals publish in high-ranked journals. We use the journal impact factor (JIF) as an indicator of the standing of the journals. The JIF is calculated as the number of citations to articles published in a particular journal during a two-year period, divided by the number of articles published in the journal during the same period. This means that the JIF is the average number of citations that articles in a journal have received during a two-year period.

To make this indicator comparable among scientific fields we use a normalised JIF. This procedure is very important as the citation behaviour differs greatly depending on the field (Podlubny, 2005). For instance, articles published in some medical journals receive on average far more citations than articles published in, for instance, engineering journals. The normalised indicator is calculated for each article by dividing the JIF for the journal in which the article is published by the median JIF for the journal category. This operation neutralises substantial intra-field variation concerning the size of the JIF and makes comparisons among different fields meaningful.

We also conducted a small email survey. Both the approved and the rejected applicants were asked to answer a few questions regarding their research group, their funding, patents and eventual spin-offs from the group into new groups. In total, 37 responses were returned after one reminder: 20 from the approved group (of 21) and 17 from the rejected group (of 20).

Publication results

Both the approved group and the rejected group consist of highly productive individuals. Both groups also increase their productivity in the latter part of the investigated period: 2001–2004. On average, the approved group increase their productivity by 4.4 articles in period 2. The rejected group increase their productivity by 3.2 articles, but starts from a slightly higher average level in period 1 than does the approved group does. The standard deviation is relatively high; this is because some in each group are very productive while others have only written a few articles. In the rejected group, there are a few who have not published articles at all in period 2. They may have published results through other channels than scientific journals, or they may have worked with industrial applications and patents rather than journal articles.

It is interesting to note that the variation decreases in the approved group, while it increases in the rejected group. Partly, this can be explained by the different fields of study they work in. The use of fractions when counting authorships will to some extent compensate for the tradition of higher article production in certain fields than others. Table 1 presents the figures for the approved group and Table 2 for the rejected group.

Other comparisons are of interest as well. Before the grant, the approved group had published slightly less than the rejected group. Was there a difference in the journals in which they published? We assume that the market of scientific journals is separated in layers, where journals of different status are placed in different layers, for each field. The measure often used to indicate the layer of a journal is the normalised JIF, which can be retrieved from the Journal Citation Report, published by Thomson Scientific (formerly Thomson ISI).

Table 1. Publication productivity for the approved group
(number of journal articles)

	Period 1 (1997–2000)	Period 2 (2001–2004)	Sum articles
Average number of articles per applicant (whole counts)	11.4	15.8	581
Standard deviation (whole counts)	8.8	8.1	
Average number of articles per applicant (fractions)	2.5	3.9	136
Standard deviation (fractions)	2.1	2.4	

Table 2. Publication productivity for the rejected group
(number of journal articles)

	Period 1 (1997–2000)	Period 2 (2001–2004)	Sum articles
Average number of articles per applicant (whole counts)	12.6	15.8	625
Standard deviation (whole counts)	11.2	15.3	
Average number of articles per applicant (fractions)	3.3	3.9	160
Standard deviation (fractions)	2.0	3.3	

Table 3. Changes in publication pattern regarding choice of journal[a]

		Period 1 (1997–2000)	Period 2 (2001–2004)
INGVAR approvals	Average deviation from journal category (JIF/JIF-median)	3.4	3.8
	Standard deviation	2.5	1.8
INGVAR rejections	Average deviation from journal category (JIF/JIF-median)	2.4	2.4
	Standard deviation	0.9	1.1

Note: [a] The journals *Nature* and *Science* are not included in the analysis, both of which are classified as multidisciplinary and are extremes in their category in terms of JIF; if they are included, the ratio JIF/JIF-median changes significantly for both investigated groups: *Nature* has a JIF of 32.2 citations per article and belongs to a journal category where the JIF-median is 0.5, meaning that a publication in *Nature* weighs 67 times higher than the median for its journal category

The normalisation measure indicates to what extent the JIF of the journal where the article is published deviates from the median of the journal category. If the rate is larger than 1, then the article is published in higher layers of the given category. For each of the individuals in the two groups we can calculate which layer they have published in all together. Each individual may have published in both high and low layers over the years, but the normalised measure in Table 3 is a ratio, thus each individual's total article production, as listed in WoS, is weighted together.

Both groups tend to publish in the high layers of the respective journal category. However, the approved researchers publish in journals with slightly higher JIF within that category, than the rejected researchers. The approved researches show a slight positive development from 2000 onwards, while the rejected group remain much the same. The variance is higher for the approved group though, but decreasing, which means that the positive development is relatively comprehensive for the group.

Each dot in Figures 1 and 2 represents an individual. If the individuals appear on the diagonal line, nothing has changed between the two periods. The diagonal represents a steady-state in terms of publication pattern with respect to JIF. The conclusion is that most of the approved researchers are close to the line, or deviate positively from it. The same is true of the rejected researchers. Some of those with extremely high scores during the first period get a lower ratio during the second period, however.

To what extent do the groups differ when it comes to international co-operation? Has the degree changed between the two periods? We use co-authored journal articles as an indicator of international collaboration, something which is generally accepted but still not without reservation (Melin and Persson, 1996). The share of internationally co-authored articles is very high for both the groups (Table 4). Approximately every second article is written in collaboration with foreign colleagues. The approved group has a slightly higher share than the rejected group. The variance decreases for both groups, with respect to co-authored articles. The difference between the groups is smaller during period 2 than during period 1.

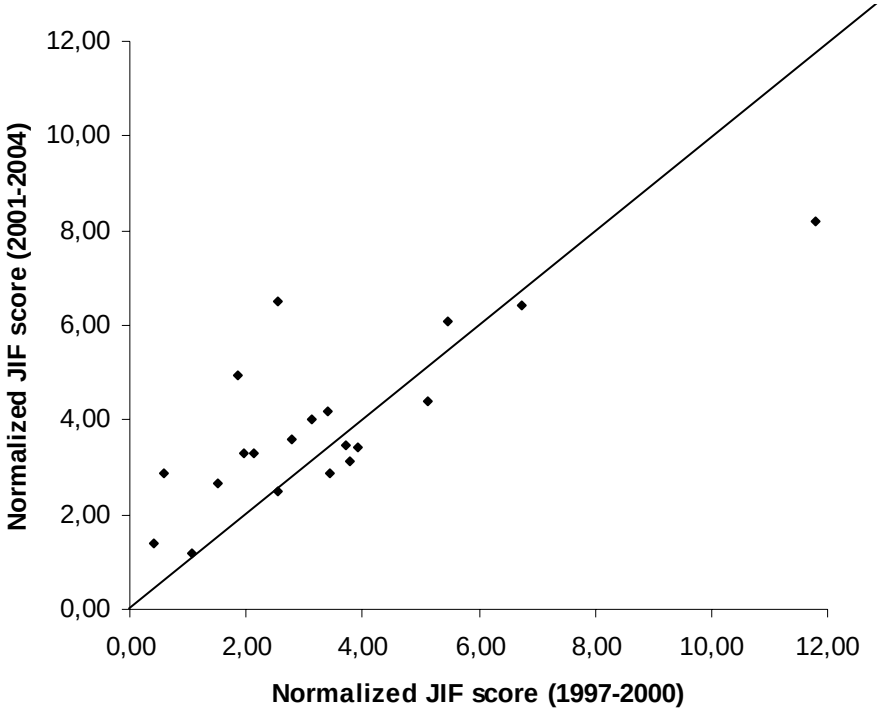

Figure 1. Changes in publication pattern for the approved group

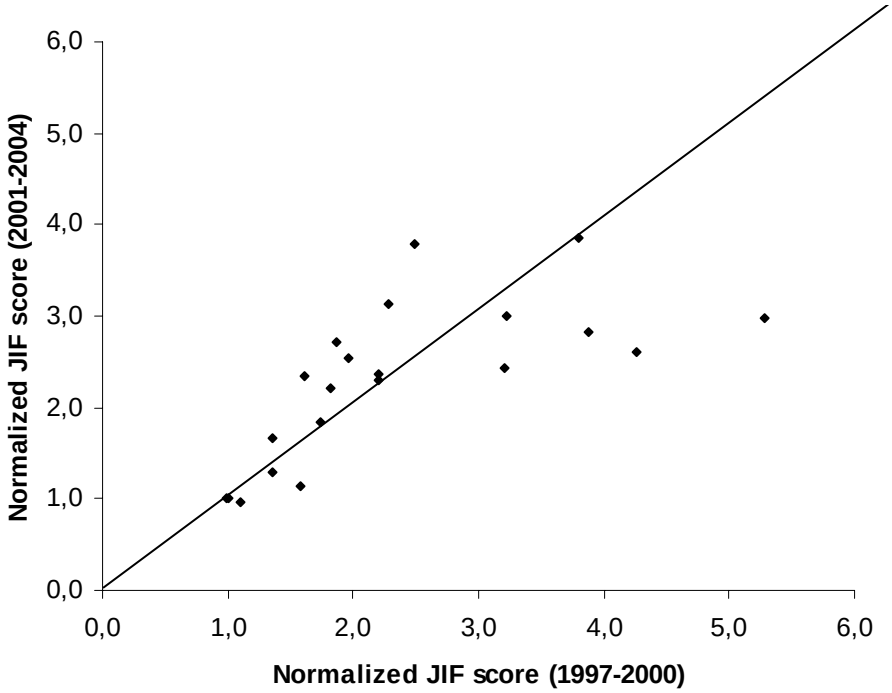

Figure 2. Changes in publication pattern for the rejected group

Questionnaire results

Through an email questionnaire sent out to both the approved and the rejected applicants, a few questions were asked with reference to the development from the time before the application up until today. All recipients were asked to provide the following information:

- number of people in the applicant's research group including the applicant at the time of the application (year 2000);
- number of people in the applicant's research group including the applicant today (year 2005);
- total amount of annual research money that the applicant and his/her group had at the time of the application (year 2000);
- total amount of annual research money that the applicant and his/her group has today (year 2005);
- number of patents that the applicant and his/her group has generated from 2001 up until today;
- number of spin-offs from the research group in terms of firms or new research groups since 2001;
- an overall estimation of how the approval/rejection has affected the research conditions.

Table 4. Average share of internationally co-authored articles

		Period 1 (1997–2000)	Period 2 (2001–2004)
INGVAR approvals	Internationally co-authored articles (mean)	54.3%	52.8%
	Standard deviation	29.3	25.7
INGVAR rejections	No of countries per article	2.0	2.0
	Internationally co-authored articles (mean)	42.4%	48.4%
	Standard deviation	28.8	23.6
	No of countries per article	1.5	1.6

The questions are not always very precise, and it is possible that one respondent includes some money, for instance, that someone else has not included. It is also possible that someone makes mistakes when trying to remember and count from a few years back. No figures coming out of the questionnaire have been checked with registers of any kind. They must be viewed as self-reported approximations with all potential deficiencies such data might have. Consequently, the results are indications, and not much heed should be paid to small differences. Big differences in the questionnaire results are, however, likely to reflect real circumstances. We have made efforts to give the data a plausible interpretation.

Figure 3 shows the average size of they research groups for the approved and rejected in 2000 and 2005. The sole noteworthy result is that there is no difference between the two groups; they have developed and grown similarly during the measured period. They both have approximately five group members in 2000; in 2005 they have about ten. The small size of the sample means that a more precise interpretation would be risky. Both groups have thus been successful in recruiting new personnel.

Is there no difference between the approved and the rejected applicants when it comes to their research budgets either? The answer is yes, there is a

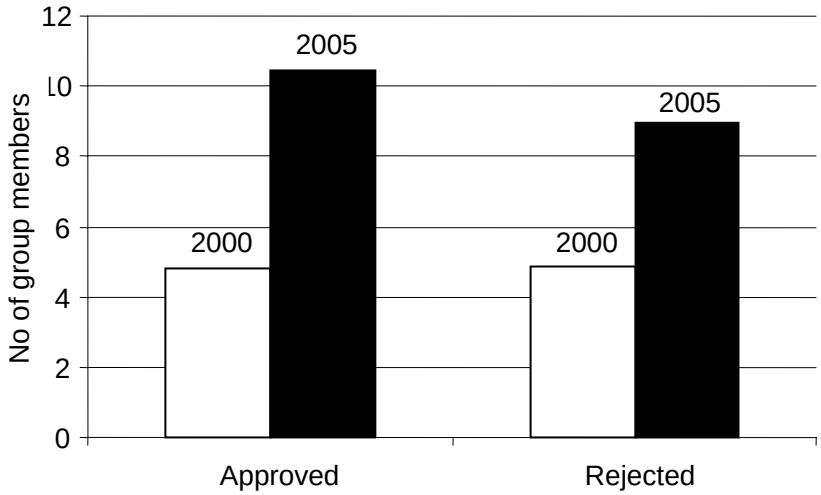

Figure 3. Development of research group size

clear difference (Figure 4). In 2000, the two groups had essentially the same economic resources but, in 2005, it is clear that the approved group has been significantly more successful in attracting financial support to their research group. The INGVAR grant in itself is one such source of money, but as the grant approximates to 1.7 million SEK per year, that grant does not explain the whole difference. In 2005, the rejected group had some 4.2 million SEK on average, while the approved had over 8 million SEK.

If the rejected group has on average less research money, could it be that they to a larger extent have chosen to leave the academic sector and move into industrial research? The next question in the questionnaire concerns the number of patents that the research group has generated since 2001. The purpose of the question is to find out whether there is a difference between the approved and rejected applicants and their research groups after the INGVAR grant was approved. If they have moved into industrial research, it could be that the research group has less money for its use but that it survives on industrial co-operation and instead generates patents.

This seems not to be the case. The approved group reports that, on average, they have over four patents while the rejected groups reports less than one patent on average. The standard deviation is relatively high and figures are generally low, so the result should be regarded with caution. Still, the approved group clearly generated significantly more patents than the rejected group.

The approved group has been significantly more successful than the rejected group in attracting financial support, registering patents and creating spin-offs: both groups publish in good journals, have international contacts and have grown to twice their original size

Obviously, spin-off firms are in various ways related to patent figures. It is also a sign of how the research activities expand in different directions. How do the groups differ when it comes to spin-off firms and new research groups? Clearly, the group of approved applicants has generated more spin-offs than the rejected group, both in terms of new research groups and companies. Figure 5 displays the summarised number of each group.

The approved group contains 20 individuals and the rejected one 17 individuals; thus the difference in spin-offs is much larger than the difference in size between the groups. On average, each approved applicant has generated 0.65 spin-off research groups and 0.70 spin-off firms; each rejected applicant has generated 0.47 spin-off research groups and 0.41 spin-off firms. It can be concluded that the approved group has been far more successful in terms of generating spin-off groups and firms.

The questionnaire also included a question where the respondent could give a free comment regarding what the approved/rejected grant had meant for his/her research situation. Generally, the approved applicants are very optimistic and think that the grant has provided an unusually good base for their work. Some of their remarks are overwhelmingly positive even. A few examples follow:

> The INGVAR grant plays a very important role in my research and career. It allows me to carry out an independent research programme, of real interest for me. It allows me to do basic research and it stimulates me to searching for new collaborations where I can apply the basic knowledge. The INGVAR grant for a very long time was the primary source of financial support for my group, and it still plays a most essential role, being my largest external grant. I would like to say, that I had a small group

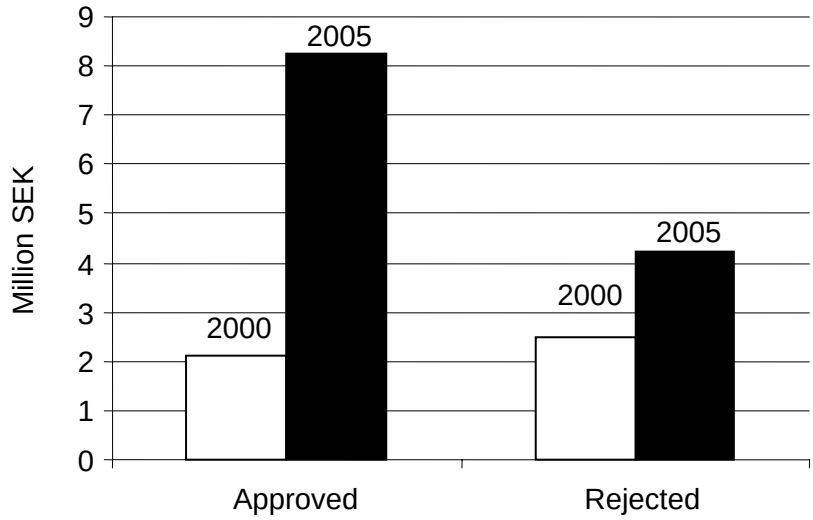

Figure 4. Development of research group budget
Note: 1 Euro=9.45 SEK in December 2005

> before I received the INGVAR grant. The INGVAR allowed me to keep the group, and to expand it. The grant had a big influence on my work situation.
>
> The impact of the INGVAR grant has been huge since it has allowed me to develop long-term projects, recruit new scientists and it has had a knock-on effect on my academic career.
>
> The grant has been absolutely crucial for my career. Through it I have been able to run long-term projects, which are now starting to pay off in terms of high ranked publications. A more limited grant would have meant that I had to produce less comprehensive and less qualitative publications.

The rejected applicants are correspondingly negative, even bitter. The grant would have meant a lot to them, we understand, and even though they often have managed to get other grants instead, their situation would have been much better if they had got the INGVAR grant. A few quotations may illustrate this feeling:

> I cannot afford to employ post-docs (but have still been successful in recruiting very talented post-docs who come to my group with their own funding). We cannot afford to undertake relatively costly high-risk/high-impact projects, which we might have done if we had the additional INGVAR funding. I am constantly looking for additional funding, which takes a fair amount of time, and thus I have much less 'peace and quiet' to focus on research than I imagine would have been the case if I had been awarded the INGVAR grant. For example, my current situation is that I don't have the funds to cover my own salary for the next year (since there is no university/faculty funding available).

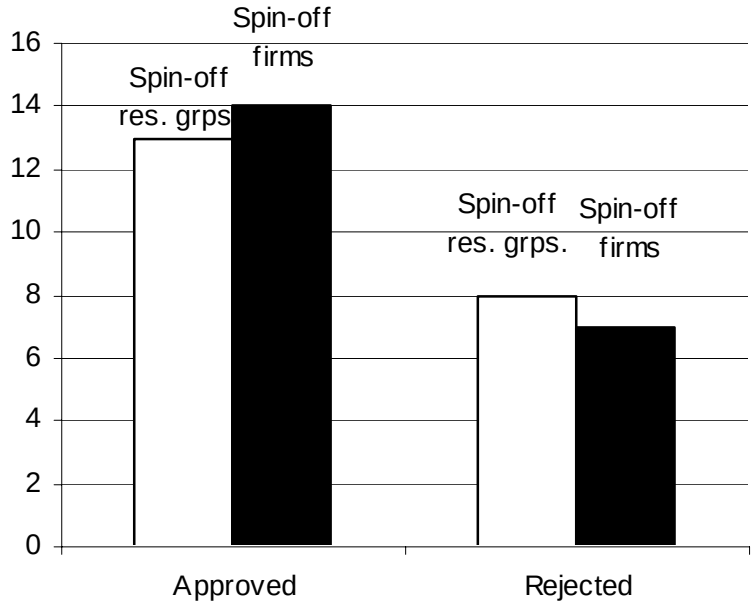

Figure 5. Number of spin-off research groups and firms

> It meant that I had to look for financing from several small sources. The funding I did obtain elsewhere was diverse and the focus was lost.
>
> After failing to secure an INGVAR grant in 2000, I decided that my long-term future was not going to be in Sweden. I therefore looked elsewhere and found better opportunities for developing my research in Australia.
>
> My view on it seems very clear. Had I received an INGVAR grant I would have the possibility for leading-edge research and deep science, including more freedom and creativity (thus more following my passion). The research group would perhaps have moved more towards scientific rather than industrial research.

A few report that their group no longer exists. A few have moved to other countries and established there. The last quotation above indicates one interesting thing: that more applied and industrially oriented research was chosen instead of 'scientific' (within academia). There is a logic to this but at the same time we have seen that the approved group has been more successful in terms of spin-off firms, possibly indicating a closer relationship with science parks, incubators and industrial funds. The mechanisms behind this require a more thorough investigation.

Conclusions and discussion

This study targets the consequences for relatively young and potentially promising researchers of receiving a major research grant on the one hand, versus being rejected on the other. Out of over 500 applicants, 40 individuals submitted full applications and participated in an interview session. This means eight percent of all applicants. Twenty of them received the grant.

The key assumption is that there were probably no significant differences among the last 40 applicants, in terms of scientific merits and potential of the planned research ideas. It can be questioned whether it is actually possible to separate the best four percent from the second best four percent in a set of applicants like the one at hand. Sometimes an organisation has to, and probably tries its best to, apply selection criteria that hold for evaluation and seem reasonable and functional.

Still, the underlying assumption in this study is that there cannot have been any clear differences, if any at all, between the approved and the rejected candidates in the final round. Some were approved because of their performance at the interview or because the design of the project happened to seem more interesting to the final evaluators, or because of other intuitive reasons rather than quality-related ones. With different people in the panel or a different order of the interviews, the outcome could very well have been different. In the end, a little bit of luck went a long way.

This implies no criticism of the grant-giving organisation. Even though SSF and many other organisations make real attempts to find distinguishable selection criteria, it is in the end very difficult to distinguish among the last candidates in an application round. To find the best 50 or 25 percent is not so hard, but to find the best four percent is indeed very difficult. Given that the scientific potential and the merits of the approved and the rejected applicants in the final round are similar, it is interesting to investigate what has happened after the grant was approved/rejected.

We have made attempts to find out how the approved group and the rejected group of applicants differed at the time of the application, in 2000, and a few years later, in 2005. Were there any visible differences then, and are there any differences today?

A few conclusions can be drawn from the empirical results:

1. There is no difference between the approved and the rejected groups in terms of number of articles in scientific journals, either during the period before the grant (1997–2000) or after (2001–2004). They publish significantly and they increase their publication activity in the second period. The minor differences that can be seen actually favour the rejected group; still, such nuances in the figures should be treated with great caution as the sample is very small.
2. Both groups publish in perceived good journals, that is, journals with high impact factor. However, the approved group publish in slightly better journals than the rejected group. The approved group furthermore improve their publication record in the second period by publishing in better journals than in the first period, while the rejected group remains on the same level.
3. The approved group seems slightly better connected internationally. This is indicated by the higher share of internationally co-authored journal articles. The difference is more emphasised during the first period than during the second, when the approved group and the rejected group converge. The number of nationalities involved in the co-authorships are higher for the approved group than for the rejected, and this difference remains in the second period.
4. From the time of handing in the application in 2000 until 2005, the research groups that the applicants direct have grown to approximately twice the size in terms of individuals. At the same time, the approved applicants have been significantly more successful in securing funding for their groups. In 2005, the approved group has approximately four times the research budget it had in 2000, while the rejected group has less than twice the budget. This is a remarkable difference given the range of similarities in so many other ways.

5. The approved group has on average generated over four patents, while the rejected group has on average generated less than one. The number of spin-off firms is significantly higher for the approved groups as is the number of spin-off research groups — almost double. This can be interpreted as a higher interest in industrial applications, and possibly better industrial connections.

All this taken together, there is evidence to state that there were no major differences among the 40 applicants in terms of scientific performance during the years before the application (1997–2000), but that there have been some significant differences in their development after the grant was given to half of them. This raises questions of a policy-related nature.

The first point refers to the size of the funding that young researchers are provided with in Sweden. A grant of the size of the INGVAR is unusual — about 1 million Euro during six years. Most grants are much smaller. To develop and explore a line of research, or build a research group, funding at the million-Euro level over a number of years is necessary. Such sums of money are more frequently available in the USA than in Sweden, and we do see a migration of scientists from Europe to the USA.

Sweden is not unique when it comes to insufficient and unsustainable research grants; similar insufficiencies can be found in many other countries. The consequence of systematically approving (too) small research grants is a system where it is almost impossible to engage in projects that require a little longer time-span: this greatly limits the possibility of growth by recruiting post-docs and PhD students, even for project leaders who are proven successful.

The character of the funding — whether it is free or bound with respect to its usage — is of vast importance. The INGVAR grant was completely free and the importance of this is underlined in many of the responses that the grantees have given. They could recruit new staff or undertake costly experiments, or establish contacts with colleagues in other countries. They could be involved in international co-operation and participate in industrial joint ventures or buy equipment. They could do what the research leader considered best to do to advance the research the most. Such freedom is rare and cannot be considered at all if the grants are so small that they only cover the salary of the grantee for one or two years.

The consequence of small research grants is a system where it is almost impossible to engage in projects that require a little longer time-span: this greatly limits the possibility of growth by recruiting post-docs and PhD students, even for successful project leaders

The issue of where to draw the line between approval and rejection of applications has been touched on through the study. It ought to be clear that separating small percentages of applicants within an application round is very difficult. Traditional evaluation methods, such as expert evaluations and peer review, even in several stages, can certainly distinguish poor from good from excellent, but when the target is not only the excellent but an élite layer of the excellent, such evaluation methods start to become less suitable. Formal and certified selection criteria are complemented with intuitive and informal ones. Normally, efforts are made to minimise other than formal, measurable and concrete parameters when evaluating applications; attempts are made to quantitatively grade what are really qualitative judgements in a project plan, for instance.

When the outcome of an evaluation must contain only a small share of the applications, coincidental selection criteria play a larger role. This is unfortunate and the only plausible conclusion is that grant-giving organisations should not announce calls where only very few can be approved. Where the exact line should be drawn will most likely differ from call to call and between areas of science. Further studies are necessary to gain a deeper understanding of the mechanisms behind this.

Finally, the INGVAR grant has generated great scientific activity for those who obtained approval. The grant has in turn generated further funding for them. Their colleagues, who by all measurable aspects were just as promising young scientists but were rejected, could only generate half as much funding in the four years that followed. In the case of this study, the granting of highly potential individuals was thus beneficial and led to added value beyond the initial input. A kind of 'Mathew effect' (Merton, 1973) seems to be at play: other organisations have been prone to grant the successful ones with further funding. The grant has led to frequent spin-offs in terms of private firms and new research groups. It is highly likely that this could have been the case for the rejected group as well, if they had been provided with the same resources.

It is crucial for a relatively small country such as Sweden to develop systems for attracting and distinguishing the most talented researchers and provide them with enough resources to advance their ideas. The return is apparently significant, both in scientific achievement and in creation of private firms. This means that we seem to have disclosed mechanisms at work of both an economic return on the investment, which justifies an expansion of the approvals beyond four percent, and also a return on scientific achievements, which may not have an immediate economic angle. Perhaps an accurate calculation of all ingoing and outgoing financial flows

over quite some time ought to be made to back up such a conclusion; still we believe that the findings show signs that cannot easily be neglected.

Whether the scientific achievements that this study revealed do justify the approval of twice as many applicants the next time there is an INGVAR call, is really a matter of available resources on that occasion. In general, though, this study gives support to the funding of more than four percent in any call, because there is not a legitimate evaluation system in place to distinguish such a low number of applicants, and secondly, it is beneficial for a society to finance talented young scientists whenever they can be located.

The cost of not having provided the 20 rejected applicants in this study probably exceeds the cost of 20 additional INGVAR grants substantially. 'Good practice' in research policy would locate the point of break-even in any application round, where the quality of the applications and the potential of the applicants are good enough for a grant to be beneficial. It would also include considering how large a grant ought to be to achieve optimal effect, given the available resources. These recommendations might hold for other countries that are in a similar situation to Sweden.

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