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Scientific Excellence and Extramural Research Grants: Beggars Can't Be Choosers?

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Non-technical summary

In the 1980s, the European Union (EU) started to develop its own technology policy independent from the member states. Since then the Framework Programme for Research and Technological Development (FP) has become the major funding scheme in this policy field. With a budget of around 17 billion Euros, the Sixth Framework Programme (FP6) provided funding for R&D projects in the years 2002 to 2006. Several attempts have been made recently to assess the impact of FP6 projects. A key interest of these reviews has been to analyse the structure of participation, i.e. who chose to participate and what these participants did achieve. One result is that FP6 projects involved the contribution of excellent scientists, measured in terms of publications and received citations. Another result is that participation seems to be widely regarded as a “quality seal” for the researchers involved.

This paper focuses on public science and the role that FP6 played for financing research in relation to other grant sources available to the scientists. In fact, university scientists may typically consider four types of extramural funding schemes. Besides the FP, national governments, foundations, and – not least – industry grants can be significant sources. Although all funding bodies typically apply competitive, merit-based selection procedures, there may be different priorities and success criteria to award a grant. Hence, scientists can be assumed to select the funding source for which they expect the highest “return”. More specifically, this paper investigates whether FP6 actually succeeded in attracting the scientific “A Team” given the variety of funding opportunities available to public science, and whether an FP6 participation complements or substitutes other types of grants. Based on a random sample of German scientists at universities and public research institutes, the paper links the scientist’s excellence and productivity in terms of publication and patenting activities to the choice of a particular grant.

The results indicate that highly credentialed scientists in fact prefer government, foundation and industry grants over FP6. Moreover, FP6 participation seems to substitute for other types of grants. These findings suggest that the FP is in fact the funding instrument for the scientific “B Team” which is in stark contrast to prior reviews of the FP. There seems to be a “division of labour” between the FP, which focuses on rather application-oriented research by mediocre scientists, and the other grant programmes, which clearly focus on scientific excellence. If this is intended to be changed other funding priorities will be required, for example smaller team sizes, no pre-definition of research topics by the European Commission, and a higher quality of the peer review system. However, application-oriented research needs funding too, and the FP seems to be the instrument through which such objectives can be accomplished.

Das Wichtigste in Kürze

Mit einem Budget von rund 17 Mrd. Euro bildete das sechste Forschungsrahmenprogramm (FP6) der Europäischen Kommission die Grundlage für die Förderung von FuE-Projekten in den Jahren 2002 bis 2006. In letzter Zeit wurden mehrere Studien vorgelegt, die sich mit der Wirkung des FP6 befassen. Im Mittelpunkt vieler Studien stand dabei die Analyse der Teilnahmestrukturen, d.h. wer die Teilnehmer waren und was sie erreichten. So wurde festgestellt, dass herausragende Wissenschaftler, gemessen an Publikationen und Zitationen, am FP6 teilnahmen. Ein anderes Ergebnis war, dass die Teilnahme am FP6 von vielen als „Qualitätssiegel" betrachtet wird.

Dieser Beitrag beschränkt sich auf Wissenschaftler an Universitäten und anderen öffentlichen Forschungseinrichtungen und deren Wahl für ein bestimmtes Förderprogramm. Neben dem FP auf europäischer Ebene stellen Fördermittel von Bundes- und Länderregierungen, Stiftungen und nicht zuletzt von der Industrie wichtige Quellen dar. Obwohl alle Förderer normalerweise wettbewerbs- und leistungsbasierte Auswahlkriterien anwenden, unterscheiden sie sich oft im Hinblick auf Prioritäten und Erfolgskriterien für die Gewährung von Zuschüssen. Man kann somit annehmen, dass sich Wissenschaftler die Forschungsförderung aussuchen, von der sie sich den höchsten „Ertrag" erwarten. Gegenstand dieser Arbeit ist daher die vergleichende Untersuchung der Entscheidungen von Wissenschaftlern für externe Forschungsförderung. Im Besonderen wird betrachtet, ob es dem FP6 in Anbetracht der Vielfalt an Fördermöglichkeiten, die der öffentlichen Forschung zur Verfügung stehen, gelungen ist, das wissenschaftliche „A-Team" anzusprechen und ob die Teilnahme an FP6 andere Fördertypen ergänzt oder ausschließt.

Auf Grundlage einer Stichprobe von deutschen Wissenschaftlern an Universitäten und anderen öffentlichen Forschungseinrichtungen untersucht diese Arbeit die Rolle von Exzellenz und Produktivität von Wissenschaftlern, gemessen an Veröffentlichungen und Patenten, bei der Entscheidung für ein bestimmtes Förderprogramm. Die Ergebnisse zeigen, dass hochproduktive Wissenschaftler Regierungs-, Stiftungs- und Industrieförderung dem FP6 vorziehen. In dieser Hinsicht scheint eine sinnvolle Arbeitsteilung zwischen dem FP, das eher auf anwendungs- bzw. beratungsorientierte Forschung von mittelmäßigen Wissenschaftlern fokussiert, und anderen Förderprogrammen, deren Ziel die wissenschaftliche Exzellenz ist, zu bestehen. Soll allerdings das FP kompatibler zu bestehenden Förderalternativen werden, so sind deutliche Veränderungen notwendig. Hierzu zählen beispielsweise kleinere Projektgrößen, eine thematisch offene Ausschreibung, geringerer Antrags- und Verwaltungsaufwand und einer Verbesserung des Begutachtungssystems.

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Abstract

Several reviews and impact assessment studies have concluded that the Sixth Framework Programme for Research and Technological Development (FP6) succeeded in fostering scientific excellence and attracting the "A Team" in public science. However, these studies typically fail to contrast their findings with the variety of funding opportunities available to public science. Based on a sample of more than 1,000 scientists at universities and public research institutes in Germany, this paper finds that highly credentialed faculty typically chose other funding opportunities than FP6, for example grants from science foundations or industry. In fact, FP6 only seems to be attractive for the scientific "B Team" that works rather application oriented. The findings further indicate that an FP6 participation substitutes for other grant programmes while the latter are complementary to each other. If this is intended to be changed other funding priorities will be required, for example smaller team sizes, less pre-defined research topics, a reduced administrative burden, and a higher quality of the peer review system.

Keywords: Research funding, scientist productivity, Sixth Framework Programme

JEL classification: L13, O31

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1 Introduction

In the 1980s, the European Union (EU) started to develop its own science, technology and innovation (STI) policy independent from the member states. Since then the Framework Programme for Research and Technological Development (FP) has become the major funding scheme in this policy field (Marin and Siotis, 2008). With a budget of almost 17 billion Euros, the Sixth Framework Programme (FP6) provided funding for R&D projects in the years 2002 to 2006. Several attempts have been made recently to assess the impact of FP6 projects (e.g., Arnold et al., 2008; Technopolis, 2008; BMBF, 2009; Rietschel, 2009). A key interest of these reviews has been to analyse the structure of participation, i.e. who chose to participate and what these participants did achieve. One result is that FP6 projects involved the contribution of excellent scientists, measured in terms of publications and received citations (Technopolis, 2008). Another result is that participation seems to be widely regarded as a "quality seal" for the researchers involved (Rietschel, 2009).

Although these results are undisputed, FP6 participation has typically been evaluated without considering alternative funding schemes available to scientists. While the FP and many other public funding schemes are open to industry and public science alike, this paper focuses on scientists at universities and other public research organisations (PRO) and their choice for a particular funding scheme. In fact, public scientists may typically consider four types of extramural funding schemes. Besides the FP, national government, foundation, and – not least – industry grants can be significant sources. Scientists, like all economic agents, can be assumed to select those grants for which they anticipate the highest "return". In this respect, return refers to the balance between the effort to walk through the application process, to manage the projects and cope with the administrative burden (in case that funding is received), and the amount of the funding itself, weighted by the probability of receiving the grant. As all funding bodies claim to apply competitive, merit-based selection procedures, the probability of receiving the grant is dependent on the scientist's excellence and research productivity.

The objective of this paper is therefore to provide a comparative analysis of scientists' choices for extramural research grants. More specifically, this paper investigates whether FP6 actually succeeded in attracting the scientific "A Team" (Rietschel, 2009) given the variety of funding opportunities available to public science, and whether an FP6 participation complements or substitutes other types of grants. Moreover, this paper not only sheds light on the choice but also on the actual scale to which the four types of grants contribute to the scientist's total research budget. The setting for this study is Germany which is particularly suitable since it took the lion's share of funding in FP6 and at the same time features a highly developed research funding infrastructure (BMBF, 2009). Based on a sample of German scientists at universities and public research institutes, the paper links the scientist's excellence and productivity in terms of publication and patenting activities to the choice for a particular grant, while controlling for individual and institutional characteristics.

The remainder of the paper is organised as follows. Section 2 provides a review of the policy context and rationale for research funding and sheds light on the different types of grants and their characteristics. Section 3 elucidates the role of scientific excellence played for the choice of a particular type of grant. Section 4 focuses on data and methods chosen while the results are presented in section 5. The paper concludes in section 6 with a discussion of the results as well as implications for STI policy and further research opportunities.

2 Policy context and rationale

The funding of public science can typically be characterised as a mix of institutional ("lump sum") and project-based funding (Schmoch and Schubert, 2009). While the institutional funding is determined by the state authorities, there are various sources for project-based funding, which can be public or private and on different levels (regional, national, and international). In fact, most European countries exhibit a well-developed funding infrastructure available to public science. In addition to that, the European Union started to develop its own STI policy in the 1980s, leading to the availability of funding schemes at the supra-national level, most importantly through the Framework Programme. In the following, a rather broad distinction is drawn between four different types of funding schemes that public scientists typically consider as relevant: grants within the FP, grants from national governments, grants from science foundations, and grants from industry.

Endowed with a substantial budget, the FPs provide funding typically for technology-oriented research joint ventures that comprise partners from various countries (Marin and Siotis, 2008). FP funding is awarded subject to several conditions that the prospective consortia have to meet. First, the projects need to be pre-competitive such that a conflict with EU competition law is prevented. At the same time, however, they are expected to strengthen the competitiveness of EU firms, either through having them participate directly in projects or through deliberate knowledge and technology transfer (KTT) and broad dissemination of the project outcomes. They should also demonstrate their usefulness for policy making. Second, in order to increase the chance of funding, consortia need to exhibit a fair representation of partners from "peripheral" countries, including for example the new member states from Central and Eastern Europe (Marin and Siotis, 2008). A major drawback of participation in the FPs from the scientists' perspective has been the substantial administrative burden associated with the application for and management of projects which has frequently been described as very costly and time consuming (Luukkonen, 2002). Moreover, scientists have criticised the requirement to form unsuitably large consortia, particularly for the social sciences and humanities, as well as a rather narrow definition of research topics (BMBF, 2009).

As its predecessors, FP6, which ran from 2002 to 2006, did not cover all areas of science and technology but instead focused on a limited number of thematic priorities in which projects were carried out. Nevertheless, the FP's scope has become broader over time, meanwhile covering a wide range of themes and funding instruments that include also the mobility of researchers (European Commission, 2002). Similarly, the economic and political justification for the FPs has become more elaborate. While the FPs up to FP4 declared added value through networking, cohesion and scale benefits to be a sufficient justification, FP5 shifted the focus towards socio-economic benefits in general. The launch of FP6 corresponded to the implementation of the European Research Area (ERA) which aims at bundling resources for research to create a system of scientific excellence that could readily compete with those of the U.S. and Japan. In order to build scale, FP6 therefore featured larger funding instruments with the objective to bring together the scientific elite from various countries (Marin and Siotis, 2008). In fact, over the recent years, the FPs have become a widely used instrument as Table 1 shows.

Table 1: Overview of FP5 and FP6 participation

	FP6	**FP6 excluding mobility actions**	**FP5**	**FP5 excluding mobility actions**
Total no of contracts	10,058	5,485	16,553	12,391
Total no of participants	74,400	65,960	84,267	75,046
Average no of participants per contract	7.4	12.0	5.1	6.1
Total EC financial contribution €m	16,669	14,952	13,065	11,808
Average EC financial contribution €m	1.66	2.73	0.79	0.95
Average EC contribution/participant €m	0.22	0.23	0.16	0.16

Source: European Commission (2008).
Excludes EURATOM fusion, which is contracted via contracts of association with national fusion associations.

Besides the sizable amount available through the FP, university scientists may rely on several other sources in order to finance their research, including the government, science foundations or industry. Bozeman and Gaughan (2007) show for the U.S. that federal government grants constitute by far the most important funding source for academic research. This situation is similar to large European economies like Germany where the annual expenditures for public science (around 32 billion Euros per year during 2002 to 2005) are more than twice as high as the total budget available through FP6 over a period of five years (BMBF, 2008).[2] The government typically also provides the majority of funds to science foundations, like the National Science Foundation in the U.S. or similar organisations in European countries to finance research. Furthermore, there are foundations which may be endowed by firms, like the Volkswagen Foundation, or other patrons. Both public and private foundations are usually rather important funding sources, not particularly in terms of the total budget available for grants but instead because of their high scientific reputation. The German Science Foundation, for example, annually awards the “Leibniz Prize” to ten distinguished scientists who receive “honour, prize money and idyllic freedom” (DFG, 2009), based on a highly competitive selection procedure.

Compared with grants from the government and science foundations, industry grants have contributed a relatively small share of funding, especially in the social sciences and humanities (Bozeman and Gaughan, 2007). In fact, the lion’s share of industrial research is

[2] The figure for Germany also includes the institutional financing of universities and public research centers which does not comprise grants-related research.

carried out in-house. The small contribution of industry is, however, in stark contrast to the alleged social and economical importance (e.g., Hall et al., 2003; Mansfield, 1995). Consequently, numerous efforts have been made in order to increase industry-science linkages, including R&D tax credits for industry funding of academic research (Bozeman and Gaughan, 2007) or research and technology partnerships (e.g., Audretsch et al., 2002; Link and Scott, 2005). Probably most important for establishing grants-related contacts between academia and industry has been the enactment of the Bayh-Dole Act in the U.S. in 1980 and its equivalents about 20 years later in European countries (Mowery et al., 2001). Facilitating the transfer of intellectual property rights, this regulation smoothed the way for universities to engage in grants-related research projects with industry.

Behind these four different types of funding schemes is a bewildering variety of grants and programmes. There is, however, ample empirical evidence suggesting that STI policy should be concerned with the provision of adequate funding of public science. Research grants are found to increase individual productivity (Stephan, 1996; Lee and Bozeman, 2005) although this relationship is moderated by the scientist’s career stage (Arora and Gambardella, 2006) and the size of the grant (Godin, 2003). Moreover, most research grants are intended to stimulate collaborative behaviour among scientists (Defazio et al., 2009). Collaboration has in fact been a cornerstone of all FPs and particularly in FP6 which featured also a new funding instrument specifically for that purpose (“networks of excellence”). While funding oriented towards teams of scientists has been shown to increase collaborative behaviour (Arora et al., 1998; Adams, 2005), the effect of collaboration on research productivity is less clear. Arora et al. (1998) find that, despite a negative effect of funding on team productivity, scientists would not have collaborated without funding. Lee and Bozeman (2005) show that funding is positively linked with collaboration and productivity even though they do not investigate the effect of funded collaboration on productivity. Evaluating these inconclusive results, Defazio et al. (2009) argue that funding cannot necessarily be regarded as productivity enhancing although it may allow scientists to move on along existing collaboration otherwise being more difficult to realise. Based on a panel of 294 scientists in collaborative projects financed through the FP, they distinguish between pre-, during- and post-funding periods and show that collaborations specifically formed to benefit from funding opportunities do not stimulate productivity in the short run but serve as effective instruments to enhance productivity in the longer run.

In sum, university scientists are confronted with a large variety of funding opportunities. While all funding schemes and grants employ different award criteria, a common feature is their focus on the excellence and productivity of the applying scientist. The following section will therefore explore the role of scientific excellence for attaining a research grant.

3 The role of scientific excellence

A common notion in the evaluation of FP6 and the participation of scientists is that FP6 included projects in which excellent scientists collaborated. Competitive and merit-based selection procedures have been described as a cornerstone of FP6, and the research conducted in the thematic areas has been evaluated as being of international standard (Rietschel, 2009). Principal investigators in FP6-funded projects have been found to excel their peers in terms of publications and citation performance (Technopolis, 2008). Moreover, participation in the FP is regarded as a "seal of quality" in many countries and an indicator for the scientific quality of the projects and the scientists involved (Rietschel, 2009). Some institutions like the University of Copenhagen even offer additional research money conditional upon being granted an FP project.

The strong emphasis on quality is motivated by the premise that public funds should not be wasted on less promising projects and their applicants. In this context it has been frequently recognised that academic research can be characterised by a "winner-takes-it-all" reward system in which the first to contribute a discovery in a peer-reviewed domain receives indirect and direct rewards, including citations, prizes, research grants or endowed chairs (Dasgupta and David, 1994; Sorensen and Fleming, 2004; Mudambi and Swift, 2009). At the same time, competition for research funding has increased considerably over the past decades as most scientists are to an increasing extent dependent on the acquisition of external grants in order to conduct research (Viner et al., 2004). In order to demonstrate legitimacy of the funding allocation, a key tenet of virtually all funding processes is that outcomes should be meritocratic. Although Viner et al. (2004) find that decisions by funding agencies cannot be fully explained by a scientist's reputation for excellence, scientists typically succeed in a competitive funding allocation process because of their past performance. In this respect, past performance may have an effect on current performance because of a "cumulative advantage". Such an advantage basically reflects both past recognition and the stock of past knowledge accumulated by the scientist (Defazio et al., 2009). In other words, past performance is associated with the level of reputation necessary to attract research funding and to clear the hurdle of peer-review.

Basically the same mechanism applies to industry grants. Academic reputation serves as a signal to potential commercialisation partners in industry (Murray, 2004). Grimpe and Fier (2010) show that higher scientific productivity, along with other quality indicators such as tenure, increase the likelihood that academics will transfer technology or applied research results to industry, co-author a paper with industry personnel, or serve as a formal paid consultant to an industrial firm. Besides highly-ranked publications, industry is therefore presumably also interested in patents that scientists might have generated. Patents may serve as a mechanism to appropriate the returns from inventive activity and thus open up commercialisation opportunities for firms. In fact, recent studies for the U.S. and Germany show that publications and university patenting are positively linked (e.g., Agrawal and Henderson, 2002; Stephan et al., 2006; Czarnitzki et al., 2009). As a consequence, as long as funding agencies and industry base their grant decisions on past performance, highly credentialed scientists will presumably seek funding from those sources where the expected benefits clearly outweigh the costs of applying for and managing a project.

The following section will hence explore the determinants of the choices for a particular grant, i.e. FP6, the national government, foundations, and industry. Particular attention is paid to the role of scientific excellence in order to evaluate whether FP6 actually is a premier funding instrument for highly credentialed scientists. Moreover, it is of interest to elucidate whether scientists tend to choose a particular combination of different types of grants. In other words, the analysis will focus on the question whether a choice for an FP6 funded project coincided with the choice for another grant from a different source.

4 Empirical approach

4.1 Data

The data used in the empirical analysis result from a survey among German scientists and was carried out within an evaluation project of FP6 on behalf of the German Federal Ministry of Education and Research. The survey was designed to yield an overview of university scientist's efforts to acquire research funding from several different sources. Data collection took place in 2008 and was implemented using an online questionnaire. Contacting respondents via e-mail involves the risk of outdated or misspelled e-mail addresses. Nevertheless, online surveys serve as quick and efficient instruments in order to reach a large number of persons.

The sampling procedure involved two major data sources. First, German university professors and academic personnel with a PhD are listed in the "Hochschullehrerverzeichnis" with their names, degrees and contact information.[3] As a substantial share of public R&D in Germany is performed in public research organisations, scientists at the four large German PROs – Max Planck Society, Fraunhofer Society, Leibniz Association and Helmholtz Association – holding a PhD were identified via an internet search of the institutes' websites. These two data sources yielded a population of 20,519 scientists with an available and not obviously wrong e-mail address. For 4,250 scientists, delivery of the message failed. We obtained 2,797 responses, a response rate on the net sample of 17.2 percent which can be regarded as satisfactory for such a large-scale online survey. Due to missing values for some variables the actual number of observations available for analysis is, however, lower.

4.2 Measures

The measures for the use of grants are based on faculty responses. Scientists were asked whether they were awarded[4] one of the four different types of research grants: FP6, the German government (including both federal and state funding), foundations, and industry. If yes, they were asked to indicate the share that this particular grant contributed to their overall

[3] This excludes the so-called "universities of applied sciences" whose major task is teaching and not research.

[4] This includes participation in a research consortium that jointly applied for a grant.

budget. The time frame the scientists should refer to was from 2002 to 2006 which corresponds to the duration of FP6.

Our main explanatory variables reflect the scientist's research productivity which is represented by the number of publications in refereed scientific journals and the number of patent applications they were involved with.[5] The time frame the scientists should refer to was also from 2002 to 2006 which could raise concerns regarding potential endogeneity. Moreover, reversed causality could be an issue in that an early participation in a grant programme led to publications and patents in later years.[6] An argument to combat these endogeneity concerns are the time lags in academic publishing and patenting. Before a paper is accepted for publication in a refereed journal or a patent application is drafted, significant research efforts have to be made which usually take place several years prior to publication or patenting. In this respect, we can assume that research output assigned to the years 2002 through 2006 is in fact a result of research productivity in prior years.

The analysis includes a number of explanatory variables to control for the individual characteristics and the institutional environment of the scientist. Dummy variables are included for the scientist's gender, whether the scientist is tenured, leader of a research group and whether a grant was received within at least one of the previous FPs. Moreover, the scientist's age as a linear and squared term, the institutional affiliation (dummy variables for Fraunhofer Society, Max Planck Society, Leibniz and Helmholtz Association, with university affiliation being the reference category) as well as the scientific field (dummy variables for life sciences; chemistry, physics, mathematics, and computer sciences; engineering sciences; with social sciences and humanities being the reference category) are included. These control variables have frequently been employed in studies focusing on the behaviour of university scientists and are also causally relevant to this research (e.g., Gaughan and Bozeman, 2002; Bozeman and Corley, 2004; Bozeman and Gaughan, 2007). The reasoning is that more productive scientists are more likely to be senior, tenured, leading a research group and, therefore, are more likely to receive a grant. Similarly, patterns of grant activity may vary according to the scientist's gender, particularly when it comes to industry support (e.g., Corley and Gaughan, 2005). In addition, disciplinary field effects are widely acknowledged as important in a range of faculty activities (e.g., Edler et al., 2008).

[5] The questionnaire did not specify a certain patent office but instead referred to the concept of a patent family representing a single invention that could have however led to patent applications at several patent offices. Although there may be differences in the technological and economic importance of patent applications, for example between the European Patent Office and national patent offices, this research is primarily interested in whether scientists consider the commercialisation of their research results and not in potential differences between the institutional loci of patent application.

[6] Assigning research results like publications or patents immediately to the participation in a grant programme is, however, challenging due to the cumulative nature and indivisibilities of knowledge. While grants might contribute a great deal towards the achievement of a research result, scientists will virtually always build upon prior knowledge and complementary knowledge from other sources.

4.3 Model

The choice of the dependent variables is reflected by the estimation strategy which involves two steps. First, a multivariate probit model for the scientist's choice of the four different types of grants is estimated: FP6, the German government, foundations, and industry. The multivariate probit model does not only explore the effects of the explanatory variables outlined above but also provides a test of the correlation of the error terms for the four types of grants conditional on the vector of covariates (Athey and Stern, 1998; Cassiman and Veugelers, 2006). A positive and significant correlation coefficient *rho* between two grants suggests that these two grants are complementary, i.e. scientists make use of both funding sources to secure their budget. If the coefficient is negative, both grants can be regarded as substitutive, i.e. scientists tend to focus on either one of the grants. Second, tobit models for the share of funding that stems from one of the four funding sources are estimated.

In both the probit and the tobit model there is a potential selection effect in that a scientist who did not get funding through a particular funding scheme either could have not applied for the grant at all or could have been unsuccessful with her or his application. Thus, ideally a selection model is required to estimate the likelihood of filing an application for a particular grant and to yield an efficient estimate for the likelihood of being funded through a particular grant. In the following, the models are estimated without such a selection step for two reasons. First, this research is interested in the outcome – which is the likelihood of obtaining funding from a specific source – and not in the determinants of filing an application. Second, and more importantly, while FP6 was a single programme it featured a multitude of calls during the period from 2002 to 2006 for which scientists could apply, Moreover, there is a bewildering variety of different grants and funding instruments available from the three other sources of financing. An appropriate selection model would thus need to consider potential applications to all the different calls and grants available from the four sources. Nevertheless, in order to increase confidence into the results, a robustness check is performed using additional information available from the questionnaire. Scientists were asked to indicate on a Likert scale from 1 (not important at all) to 5 (very important) how important the acquisition of extramural research grants is for a continuation of their research activities. If scientists face a high pressure to acquire grants (indicated by a value of 4 or 5 on the Likert scale) it can be assumed that they actually had to file a grant application during the years 2002 to 2006. Consequently, for the robustness check the sample is restricted to those scientists indicating high pressure to acquire grants. Results will be described in the next section while the estimation tables can be found in the appendix.

5 Results

5.1 Descriptive statistics

Table 2 shows the descriptive statistics of the dependent as well as our main explanatory and control variables. A correlation table for the explanatory variables can be found in the appendix. There is no indication for collinearity in the data as evidenced by an average variance inflation factor (VIF) of 1.41 (Belsley et al., 1980).

Table 2: Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Dependent variables					
Grant from FP6 (d)	1004	0.56	0.50	0	1
Grant from national government (d)	1004	0.40	0.49	0	1
Grant from foundations (d)	1004	0.51	0.50	0	1
Grant from industry (d)	1004	0.30	0.46	0	1
Budget share from FP6	755	0.24	0.30	0	1
Budget share from nat. government	726	0.21	0.27	0	1
Budget share from foundations	726	0.36	0.36	0	1
Budget share from industry	726	0.11	0.21	0	1
Explanatory variables					
No. of publications	1004	21.10	27.14	0	178
No. of patent applications	1004	0.84	2.03	0	20
Gender (d, 1 = female)	1004	0.16	0.36	0	1
Age (years)	1004	49.10	8.40	28	74
Tenured (d)	1004	0.82	0.38	0	1
Research group leader (d)	1004	0.71	0.45	0	1
Grant received from FP1-5 (d)	1004	0.40	0.49	0	1
University (d)	1004	0.58	0.49	0	1
Fraunhofer Society (d)	1004	0.07	0.25	0	1
Max Planck Society (d)	1004	0.08	0.28	0	1
Helmholtz / Leibniz Association (d)	1004	0.31	0.46	0	1
Social sciences and humanities (d)	1004	0.20	0.49	0	1
Life sciences (d)	1004	0.29	0.45	0	1
Chemistry, physics, mathematics (d)	1004	0.31	0.46	0	1
Engineering sciences (d)	1004	0.20	0.40	0	1

(d): dummy variable

Table 2 shows that the scientists in the sample have frequently received grants from the various sources. More than half of the scientists were involved in an FP6 sponsored research project, followed by grants from foundations, the government, and industry. On average, scientists received more than one third of their funds from foundations, followed by 24 percent coming from FP6, 21 percent from the government and 11 percent from industry. This indicates that foundations are by far the most important source for financing.

Regarding the explanatory variables, scientists have achieved on average 21 publications in the 5-year period from 2002 to 2006 and almost one patent application. They have an average

age of 49 years, and most of them are tenured and lead a research group. Only 16 percent of the scientists in the sample are female. 40 percent of the scientists reported experiences with one of the previous FPs. Most of them are university scientists[7], followed by scientists at one of the Helmholtz or Leibniz Association research centres (31 percent), at the Max Planck Society (8 percent) and at the Fraunhofer Society (7 percent). Finally, most scientists are in chemistry, physics, mathematics and computer sciences, followed by the life sciences, social sciences and humanities, and engineering sciences.

5.2 Multivariate analysis

Table 3 presents the results from the multivariate probit models on the choice for the four different means of financing.

[7] The means for the variables on the institutional affiliation of the scientist do not add up to 1 because scientists may be affiliated with both a university and a PRO. This overlap, however, is relatively small (60 scientists in the sample) which is why the variable for university is excluded from the regressions as a base category.

Table 3: Multivariate probit model

		Research grant received from		
	FP6	**government**	**foundations**	**industry**
No. of publications	0.000	0.003*	0.011***	0.005***
	(0.002)	(0.002)	(0.003)	(0.002)
No. of patent applications	-0.002	0.073***	0.043*	0.115***
	(0.025)	(0.026)	(0.025)	(0.027)
Gender (d, 1 = female)	-0.011	-0.123	0.078	-0.224
	(0.123)	(0.123)	(0.119)	(0.142)
Age (years)	-0.046	0.138**	0.108*	0.047
	(0.058)	(0.061)	(0.057)	(0.061)
Age (years)^2	0.000	-0.001**	-0.001*	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Tenured (d)	0.011	0.129	0.003	0.069
	(0.140)	(0.138)	(0.137)	(0.153)
Research group leader (d)	0.378***	0.630***	0.412***	0.559***
	(0.107)	(0.108)	(0.103)	(0.127)
Grant received from FP1-5 (d)	1.034***	0.304***	0.016	0.092
	(0.095)	(0.090)	(0.092)	(0.097)
Fraunhofer Society (d)	0.114	0.321	-0.737***	0.266
	(0.212)	(0.196)	(0.198)	(0.206)
Max Planck Society (d)	-0.07	-0.514***	-0.317*	-0.551***
	(0.163)	(0.182)	(0.162)	(0.209)
Helmholtz / Leibniz Association (d)	0.229**	-0.025	-0.624***	-0.360***
	(0.109)	(0.104)	(0.102)	(0.113)
Life sciences (d)	0.303**	0.131	0.006	0.016
	(0.131)	(0.134)	(0.128)	(0.142)
Chemistry, physics, mathematics (d)	0.531***	0.058	-0.032	-0.133
	(0.131)	(0.133)	(0.130)	(0.151)
Engineering sciences (d)	1.071***	0.247*	-0.363**	0.903***
	(0.153)	(0.150)	(0.141)	(0.155)
Constant	0.676	-4.387***	-2.960**	-2.556*
	(1.410)	(1.502)	(1.383)	(1.498)
rho (FP6 and (2), (3), (4))		0.062	0.009	-0.012
rho (government and (3), (4))			0.257***	0.440***
rho (foundations and (4))				0.279***
N	1004			
LR Chi2	738.732			
P-value	0.000			

(d): dummy variable; standard errors in parentheses.
*,**,*** indicate statistical significance at the 10%, 5% and 1% level
Reference categories: university affiliation; social sciences and humanities

Regarding the scientist's past productivity measured in terms of publications and patent applications the estimation results show that funding from all sources except for the FP6 is positively influenced by higher research productivity. Interestingly, productivity does not matter for funding through FP6 which is in stark contrast to the initial assumption that the scientists attracted to FP6 are among the most credentialed. Apparently, highly productive scientists prefer other funding sources. Regarding funding from the government, it turns out that more patents applied for by the scientist increase the likelihood of obtaining funding from this source while funding from foundations seems to be predominantly based on publications.

Moreover, scientists who are able to attract industry funding succeed primarily if they show both a high number of publications as well as patent applications. With respect to industry funding, this finding is somewhat in contrast to prior research on star scientist's involvement in biotechnological research (Zucker and Darby, 1996; Zucker et al., 2002), where particularly high publication activities qualify scientists as attractive research partners.

Regarding the control variables it turns out that there is no gender effect in the grant decision. Moreover, there is an inversely U-shaped effect from age for funding from government as well as foundations. No significant age effects can be detected for funding from FP6 and industry. As existing literature has suggested, research productivity should increase initially with increasing age up to a certain age from which scientists become less productive. Apparently, this seems to hold also for certain types of grants. No effect can be observed from being tenured or not. Instead, strong positive effects can be found from being a research group leader which is not surprising since these scientists have to support and finance a group of more junior researchers. Hence, their propensity to take advantage of the various types of grants should be higher. Having prior experience with one of the FPs only helps for receiving a grant in FP6 and from the government. While it is almost obvious that prior experience in an FP should help scientists in FP6, it is interesting to note that this also holds true for a government grant. There is no effect from experience on receiving a grant from foundations or industry, indicating a different orientation of the scientists.

Coming to the institutional affiliation of the scientist, some selective effects can be identified. Scientists at the Fraunhofer Society exhibit a significantly lower propensity to be funded by foundations compared to university scientists which is the reference category. As Fraunhofer scientists typically work strongly application-oriented this negative effect does not come with surprise. However, a positive effect could have been expected for industry funding as all Fraunhofer institutes maintain close contacts with industry. Apparently, although the respective coefficient is positive, it is not significant. In contrast to this, scientists from any of the Max Planck Society's institutes clearly have no need to acquire external grants. This is substantiated by the negative and significant coefficient for all grants but FP6 where the coefficient is insignificant. Finally, scientists at institutes of the Helmholtz or Leibniz Association are the only group that is significantly interested in FP6 funding. On the contrary, these scientists are much less likely to receive a grant from foundations or industry.

With respect to the scientist's discipline, being in life sciences, chemistry/physics/mathematics, and engineering sciences propels the chances to receive funding from FP6 in comparison to social sciences and humanities. This finding substantiates that FP6 held few opportunities for scientists in these disciplines. Engineering scientists also have higher chances to receive funding from government and industry. There is however a negative effect of engineering sciences on the probability of receiving a grant from foundations. Social sciences and humanities as the reference category thus seem to be more prominently present in these grant programmes.

Finally, the multivariate probit model allows testing for correlation of the error terms *rho* between the four equations. It turns out that there is no significant correlation for the FP6 equation's error term with any other grant equation. Instead, all other error terms are significantly positively correlated with each other. This finding suggests that scientists will typically consider applying either for an FP6 grant or any of the other grants. In other words, FP6 is not complementary to any of the other grant programmes but instead substitutive.

Table 4 reports the results for the tobit models for the share of the scientist's budget stemming from one of the four grants. Most of the results found in the multivariate probit model can be confirmed. Most interestingly, the scientist's productivity in terms of publications and patents is negatively associated with the budget share from FP6 participation. This result goes even beyond the finding from the probit model and shows that FP6 apparently attracted scientists with lower research productivity. Those with higher productivity aim at funding a larger share of their budget through foundations or industry. All other significant effects from the probit model for the productivity variables as well as for the scientist's age and position have disappeared in the tobit. Regarding the prior experience with an FP, there is – as expected – a positive and significant effect for the budget share coming from FP6. The effect is even negative for foundations.

The variables for the scientist's affiliation make clear that Fraunhofer scientists raise a higher share of their budget from government grants or industry and a lower share from foundations. This finding confirms the effects of these scientists' application-oriented research activities and qualifies the insignificant result from the multivariate probit model. Max Planck scientists have fewer incentives to acquire research grants as evidenced by the insignificant or negative coefficients. FP6 seems to be a predominant source of funding for scientists from the Helmholtz or Leibniz institutes. They also finance their activities to a larger extent through government grants but significantly less through foundations. Regarding the scientific disciplines, it turns out that scientists from all disciplines except the social sciences and humanities use FP6 grants to finance their budget, confirming the results from the multivariate probit model. Moreover, as expected, engineers raise a lower share from foundations but are significantly more engaged with industry.

Table 4: Tobit models

	Share of research budget that stems from			
	FP6	**government**	**foundations**	**industry**
No. of publications	-0.001**	0.001	0.002**	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
No. of patent applications	-0.014*	0.012	-0.007	0.023***
	(0.008)	(0.008)	(0.009)	(0.007)
Gender (d, 1 = female)	-0.010	-0.018	0.049	-0.071
	(0.050)	(0.054)	(0.056)	(0.052)
Age (years)	-0.027	0.022	0.003	0.006
	(0.024)	(0.027)	(0.029)	(0.024)
Age (years)^2	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Tenured (d)	-0.032	0.050	0.001	0.027
	(0.057)	(0.064)	(0.066)	(0.059)
Research group leader (d)	-0.025	0.060	-0.047	0.068
	(0.045)	(0.051)	(0.053)	(0.047)
Grant received from FP1-5 (d)	0.311***	0.044	-0.148***	-0.032
	(0.036)	(0.039)	(0.041)	(0.035)
Fraunhofer Society (d)	-0.092	0.211***	-0.448***	0.306***
	(0.077)	(0.080)	(0.100)	(0.067)
Max Planck Society (d)	-0.032	-0.119	0.034	-0.134*
	(0.071)	(0.081)	(0.078)	(0.078)
Helmholtz / Leibniz Association (d)	0.161***	0.120***	-0.301***	-0.055
	(0.041)	(0.045)	(0.049)	(0.042)
Life sciences (d)	0.139**	0.101*	-0.048	0.011
	(0.055)	(0.057)	(0.058)	(0.052)
Chemistry, physics, mathematics (d)	0.199***	0.074	0.008	-0.049
	(0.056)	(0.059)	(0.060)	(0.055)
Engineering sciences (d)	0.311***	0.092	-0.337***	0.303***
	(0.060)	(0.064)	(0.068)	(0.056)
Constant	0.619	-0.667	0.377	-0.454
	(0.599)	(0.676)	(0.717)	(0.593)
R2	0.160	0.041	0.128	0.201
N	755	726	726	726
Wald Chi2	181.597	41.977	163.66	174.392
P-value	0.000	0.000	0.000	0.000

(d): dummy variable; standard errors in parentheses.
*,**,*** indicate statistical significance at the 10%, 5% and 1% level
Reference categories: university affiliation; social sciences and humanities

As outlined above, robustness checks of the results are performed using information on whether scientists perceive a high pressure for acquiring extramural research grants for continuing their research activities. It turns out that this holds true for 67 percent of the scientists. Table 6 and Table 7 in the appendix therefore show the robustness checks for the reduced sample of scientists. The results confirm the findings of the main models in that the productivity variables show similar effects.

6 Conclusion

While the finding from previous studies that FP6 projects involved leading scientists remains certainly undisputed, evidence reported here suggests important qualifications to this statement. FP6 apparently did not succeed in becoming a premier source of funding as more productive scientists prefer grants from foundations or industry. Another important finding from this research is that scientists who chose FP6 are typically not the same who succeeded in attracting grants from other sources. In contrast to this, there is a positive correlation between government, foundation and industry grants. This suggests significant differences in the award criteria of the funding schemes and in the type of research that is funded by the different sources. FP6 obviously provided funding to very different scientists who rarely make use of other funding instruments.

This research has demonstrated that the FP is in fact attractive and valuable to a certain group of scientists, i.e. those scientists whose work is application or consulting oriented. These scientists typically do not work at a university but at a PRO which depends to a large extent on third-party funding, e.g. an institute of the Helmholtz or Leibniz Associations. The reward criteria of scientists in these institutes are not exclusively based on academic merit but also consider the successful acquisition of extramural research grants. For this group of scientists, having experience with the FP generates a huge pay-off. They have developed a cumulative advantage on how to draft applications and how to structure consortia that have a high chance of obtaining funding.

The policy lesson from this research is not unambiguous. On the one hand, the European Commission has left no doubt that the FPs are intended to complement national research funding by a supra-national instrument that seeks to facilitate collaboration among excellent scientists across Europe in order to create an integrated European Research Area supporting innovation, economic growth and prosperity. If we accept this policy rationale then there is a considerable need for adjusting the FP towards higher compatibility with the existing grant infrastructure of the EU member states. This adjustment should primarily involve changes to the types of grants awarded which aim at making the FP attractive for more productive scientists. Most funding instruments within the FP have frequently been criticised as being too inflexible and too much pre-determined with respect to a number of features, including for example the size and the structure of the consortia, the thematic orientation, the application procedure, or the requirements for project management (e.g., Rietschel, 2009).

On the other hand, this research has demonstrated that there seems to be a functional “division of labour” between the FP and the other funding schemes. The FP finances research that is rather close to application which is typically not the field where scientists gain academic merit. However, scientists who conduct this type of research activities require funding too. As a consequence, there seems to be little need for changes to the programme itself but instead to the communication about and assessment of the FP. Such change is both timely and pivotal given that the recent budget increase from FP6 to FP7 by around 40 percent also raises a higher need for accountability. With the start of FP7 in 2008, it is also the increased complexity of the FPs that poses challenges. The management of FP7 involves new agencies – for example the European Research Council (ERC) –, new grant agreements and new operating practices. At the same time, the efficiency of the European STI system in general will become under scrutiny to achieve the goals set out by the EU 2020 strategy. The mid-term review of FP7 which is planned for 2010 may in this respect serve as one element in this process.

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Appendix

Table 5: Correlation table

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
No. of publications	1.00												
No. of patent applications	0.15	1.00											
Gender (d, 1 = female)	-0.11	-0.07	1.00										
Age (years)	0.09	0.04	-0.12	1.00									
Tenured (d)	0.11	0.06	-0.18	0.43	1.00								
Research group leader (d)	0.27	0.10	-0.08	0.12	0.22	1.00							
Grant received from FP1-5 (d)	0.07	0.08	-0.05	0.10	0.14	0.02	1.00						
Fraunhofer Society (d)	-0.15	0.20	-0.03	-0.06	0.02	-0.08	0.08	1.00					
Max Planck Society (d)	0.09	-0.04	0.00	-0.09	-0.24	-0.09	-0.05	-0.08	1.00				
Helmholtz / Leibniz Association (d)	-0.11	0.00	0.04	-0.06	-0.01	-0.25	0.16	-0.18	-0.20	1.00			
Life sciences (d)	0.19	0.01	0.09	0.02	-0.09	0.10	-0.06	-0.12	0.07	0.01	1.00		
Chemistry, physics, mathematics (d)	0.13	-0.03	-0.08	-0.06	-0.01	-0.07	0.08	-0.06	0.09	0.15	-0.43	1.00	
Engineering sciences (d)	-0.15	0.20	-0.13	0.01	0.12	0.01	0.18	0.31	-0.15	-0.03	-0.33	-0.34	1.00

(d): dummy variable

Table 6: Multivariate probit model (robustness check)

	Research grant received from			
	FP6	**government**	**foundations**	**industry**
No. of publications	-0.002	0.002	0.015***	0.005***
	(0.002)	(0.002)	(0.004)	(0.002)
No. of patent applications	-0.046	0.064**	0.029	0.137***
	(0.028)	(0.032)	(0.029)	(0.038)
Gender (d, 1 = female)	-0.024	-0.236*	0.096	-0.307*
	(0.154)	(0.143)	(0.149)	(0.163)
Age (years)	-0.115	0.124*	0.057	-0.008
	(0.080)	(0.073)	(0.074)	(0.073)
Age (years)^2	0.001	-0.001*	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Tenured (d)	-0.052	0.252	-0.029	0.164
	(0.173)	(0.162)	(0.169)	(0.180)
Research group leader (d)	0.387***	0.556***	0.095	0.291*
	(0.149)	(0.139)	(0.136)	(0.159)
Grant received from FP1-5 (d)	1.028***	0.193*	-0.227**	-0.028
	(0.117)	(0.106)	(0.114)	(0.111)
Fraunhofer Society (d)	0.049	0.851***	-0.654***	0.836***
	(0.259)	(0.251)	(0.226)	(0.262)
Max Planck Society (d)	-0.208	-0.328	-0.092	-0.434*
	(0.216)	(0.230)	(0.247)	(0.259)
Helmholtz / Leibniz Association (d)	0.302**	0.156	-0.672***	-0.282**
	(0.141)	(0.126)	(0.129)	(0.135)
Life sciences (d)	0.174	-0.137	0.050	-0.032
	(0.160)	(0.162)	(0.178)	(0.172)
Chemistry, physics, mathematics (d)	0.362**	-0.243	-0.024	-0.221
	(0.168)	(0.167)	(0.182)	(0.185)
Engineering sciences (d)	1.023***	0.016	-0.491***	0.950***
	(0.192)	(0.180)	(0.187)	(0.193)
Constant	2.528	-3.612**	-1.288	-0.930
	(1.950)	(1.805)	(1.807)	(1.779)
rho (FP6 and (2), (3), (4))		-0.134**	-0.146**	-0.080
rho (government and (3), (4))			-0.131*	0.268***
rho (foundations and (4))				-0.018
N	675			
LR Chi2	469.515			
P-value	0.000			

(d): dummy variable; standard errors in parentheses.
*,**,*** indicate statistical significance at the 10%, 5% and 1% level
Reference categories: university affiliation; social sciences and humanities

Table 7: Tobit models (robustness checks)

	Share of research budget that stems from			
	FP6	**government**	**foundations**	**industry**
No. of publications	-0.002**	0.000	0.002**	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
No. of patent applications	-0.016*	0.011	-0.003	0.028***
	(0.008)	(0.008)	(0.009)	(0.007)
Gender (d, 1 = female)	-0.025	-0.022	0.036	-0.078
	(0.048)	(0.052)	(0.054)	(0.049)
Age (years)	-0.034	0.028	0.021	0.001
	(0.024)	(0.027)	(0.029)	(0.023)
Age $(years)^2$	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Tenured (d)	-0.009	0.055	-0.012	0.035
	(0.056)	(0.062)	(0.064)	(0.056)
Research group leader (d)	-0.035	0.088*	-0.092*	0.002
	(0.046)	(0.052)	(0.055)	(0.046)
Grant received from FP1-5 (d)	0.268***	0.033	-0.152***	-0.031
	(0.035)	(0.038)	(0.040)	(0.033)
Fraunhofer Society (d)	-0.104	0.223***	-0.449***	0.249***
	(0.074)	(0.077)	(0.096)	(0.063)
Max Planck Society (d)	-0.048	-0.049	-0.013	-0.089
	(0.075)	(0.084)	(0.081)	(0.078)
Helmholtz / Leibniz Association (d)	0.133***	0.100**	-0.299***	-0.058
	(0.041)	(0.045)	(0.048)	(0.041)
Life sciences (d)	0.105*	-0.012	0.017	0.034
	(0.057)	(0.058)	(0.060)	(0.053)
Chemistry, physics, mathematics (d)	0.163***	-0.027	0.046	-0.011
	(0.058)	(0.061)	(0.063)	(0.056)
Engineering sciences (d)	0.285***	-0.004	-0.284***	0.296***
	(0.061)	(0.064)	(0.069)	(0.057)
Constant	0.394***	0.415***	0.445***	0.334***
	(0.015)	(0.017)	(0.017)	(0.016)
R2	0.159	0.034	0.149	0.224
N	651	628	628	628
Wald Chi2	147.29	28.716	155.267	158.336
P-value	0.000	0.011	0.000	0.000

(d): dummy variable; standard errors in parentheses.
*,**,*** indicate statistical significance at the 10%, 5% and 1% level
Reference categories: university affiliation; social sciences and humanities