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Allocation of R&D Grants in the Business Sector

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Abstract

The aim of this paper is to provide new empirical evidence on the most crucial determinants of success for firms applying for public R&D grants. Previous studies have been limited to firm level data and mainly tested how firm characteristics affect the allocation of R&D grants. Thereby, they cannot differentiate between firms that have applied for grants but been rejected and firms that did not apply at all. Our contribution is that we use a detailed database of accepted and rejected R&D applications and also introduce several measures of quality indicators of R&D project applications. The estimates show that R&D projects that are assessed with good or very good ratings are significantly more likely to receive approval; particularly for innovative content and novelty as well as to expected additional impacts on R&D activities. In contrast to previous studies, most firm-level characteristics (R&D intensity, labor productivity, cash flow, industry affiliation) are not relevant, indicating that the R&D funding agency does not discriminate among different types of firms. Consequently, applicant firms should focus on radical, new and innovative ideas in their applications rather than on minor improvements.

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1 Introduction

Governments regularly subsidize R&D activities in the business sector. The main reason for these subsidies is that due to external spillover effects, R&D is expected to have higher social returns than private returns. Because firms only consider private returns when deciding about R&D investments, the actual level of R&D investments is below the socially optimal level in a free market (Arrow, 1962; Adams and Jaffe, 1996).[1] This market failure motivates governments to subsidize R&D investments in the business sector. These subsidies can be granted indirectly through tax incentives or directly through public R&D grants.

In the case of direct funding, firms must apply for R&D grants. The grant applications are usually evaluated by an audit committee of internal and external experts from industry and academia. Applications can be either accepted or rejected depending on how well the evaluation criteria are fulfilled. Knowing which criteria are crucial for R&D funding is important for both R&D managers of firms and managers of the funding agency. In general, little is known empirically about how R&D subsidies are allocated among firms and projects.

Previous studies find that larger firms, high R&D intensity or R&D expenditures, capital intensity, previous successful applications for R&D grants, and R&D projects with a high degree of novelty are more likely to receive a public R&D grant (Antonelli and Crespi, 2013; Aschhoff, 2010, Busom, Corchuelo and Martínez-Ros, 2017; Cantner and Kösters, 2012; Dumont, 2017; Duguet, 2004; Feldman and Kelley, 2006; Gonzalez, Jaumandreu and Pazo, 2005; Hussinger, 2008; Silva, Silva and Carneiro, 2017; Takalo, Tanayama and Toivanen, 2013). These studies have two drawbacks. First, they have mainly compared firms with public R&D-funds to those without such funding. In the latter group, there are both firms that have applied for grants but been rejected and firms that have not applied at all. Thus, biased samples have been used. Second, few studies have used project-level data and the quality of project applications to examine how R&D subsidies are allocated among firms, and this situation is due mainly to a lack of access to such data.

[1] Another reason to subsidize private R&D investments may be that a sector has a public-good character, such as the environment, water or defense sectors, where private markets do not exist. A last reason for the government to intervene is when the time horizon of R&D projects is extremely long.

The aim of this paper is to provide new empirical evidence on the determinants of receiving an R&D grant. By using a detailed database of both accepted and rejected project applications to the Austrian R&D funding agency (FFG), we can identify those firms that have applied for grants but been rejected. Furthermore, we explicitly focus on two groups of factors: quality indicators of the R&D project applications and firm characteristics. The main contributions of this paper to the literature are that we can handle the sample selection bias regarding non-funded firms and that we introduce quality indicators of the project applications into the R&D subsidy equation. The mixed-effects probit model is employed to analyze the factors that influence the likelihood of receiving R&D grants. The advantage of this estimation method is that the error term is allowed to vary across firms.

The main conclusions from the empirical estimates are that R&D projects that are assessed with good or very good ratings are significantly more likely to be approved. This finding particularly applies to project factors such as innovative content and novelty, expected additional impacts on R&D and qualifications of the staff. Good ratings in the area of environmental aspects and technical equipment are of no or minor importance. In contrast to previous studies, we find that most firm-level characteristics (R&D intensity, cash flow, industry affiliation) are not relevant except for size. These findings suggest that the R&D funding agency does not discriminate among different types of firms. As a consequence, applying firms should focus on radical new innovative ideas in their applications rather than on minor improvements. The paper is structured as follows. Section 2 introduces the theoretical background and reviews the literature. Section 3 presents the database, descriptive statistics and the econometric model. Section 4 presents the empirical results, and section 5 concludes.

2 Theoretical background and previous literature

2.1 Picking the winner strategy

One of the most popular hypotheses in analyses of how public R&D grants are allocated in the business sector is the ‘picking the winner’ strategy. According to Stiglitz and Wallsten (2000), funding agencies tend to pick projects with a high probability of success and low expected returns rather than risky projects with a lower probability of success but higher expected returns. There are several arguments behind this behavior (Cantner and Kösters, 2012; Antonelli and Crespi, 2013).

First, R&D projects are inherently risky and exhibit a high probability of failure. The public choice theory suggests that a strong political commitment is needed to justify subsidizing many failed projects. Second, R&D subsidies distort competition. Subsidized firms gain an advantage at the expense of non-subsidized firms. By subsidizing good (efficient) rather than bad (inefficient) firms, the negative effects of crowding out non-subsidized competitors are minimized (Shane, 2009). Third, by selecting good firms, authorities can directly finance future technologies, partly on the basis of considerations of public choice. However, this strategy requires complete information.

The selection of the winners can be measured in a number of ways, such as past performance, capital endowment or previous funding experience of the applicant. Other measures include the degree of novelty of the planned R&D project and the subjective assessment of the evaluation committee in terms of degree of commercialization and expected returns. The cash-flow ratio measured in the year of project application can also be used to measure firm performance.

2.2 Application experts

Firms that have had experience with government grants or applications in the past seem to have an advantage over inexperienced firms (Lerner, 2009). First, past grants − regardless of project outcome − help firms to legitimize themselves in a research area and to recruit the necessary equipment and personnel. These resources can later be used for future research. Second, with every proposal submitted, firms gain insights into the grant application process. Such experienced firms should have a higher probability than others of receiving grants. Finally, there is also a risk that a given funding agency will select firms that have received grants from other government resources, hoping of leverage their grant dollars. The result can be a stream of government subsidies to firms that are consistently underperforming. Therefore, Lerner (2009) emphasizes that government authorities should constantly assess both the winning firms and the entire programs to ensure that the objectives of the programs are achieved.

The "Matthew effect" is also helpful in motivating the high degree of persistence in the allocation of R&D subsidies (Merton, 1968; Antonelli and Crespi, 2013). According to the Matthew principle, distinguished scientists receive disproportionately abundant recognition for their contributions to science, which means that firms that have successfully received public support for R&D activities in the past are more likely to receive R&D grants in the current application process.

2.3 Previous studies

Many studies have evaluated the effectiveness of public R&D grant programs. The focus has been on whether R&D grants induce more R&D spending among recipients in the business sector (e.g., Almus and Czarnitzki, 2003; Duguet, 2004; Feldman and Kelley, 2006; Gonzalez *et al*., 2005; Takalo *et al*., 2007).

However, this paper focuses on the process of selecting firms that eventually receive R&D grants. Previous literature is limited to a few studies and confirms that firm characteristics are highly relevant in obtaining R&D funding. In particular, large firms, high R&D intensity, previous successful applications for R&D grants, and R&D projects with a high degree of novelty are more likely to receive a public R&D grant (Aschhoff, 2010, Blanes and Busom, 2004; Cantner and Kösters, 2012, Antonelli and Crespi, 2013: Silva, *et al*, 2017).

Using firm-level data, Blanes and Busom (2004) analyze which Spanish firms participate in R&D-grant funding programs. The authors find that large firms, firms that already have R&D activities and firms with previous funding from the program have a significant advantage in receiving R&D subsidies. Similarly, Aschoff (2010) uses firm-level data to analyze German firms' participation in R&D funding programs. The author finds that there is a high degree of persistence among firms participating in public R&D programs. Thus, firms with past funding are more likely to receive funding again. In addition, firm size, R&D capability and the human resources of the applicant also increase the probability of funding. Cantner and Kösters (2012) analyze R&D grants to German start-ups. The authors test the hypothesis that funding authorities follow a strategy of 'picking the winner'. The authors find some support for this hypothesis. R&D grants are given to start-ups that 1) are spin-offs from academia; 2) have innovative business ideas; and 3) have relatively high initial capital. However, the founders' previous experience and ambitions do not affect the probability of receiving R&D grants.

Antonelli and Crespi (2013) investigate the determinants of firms’ access to public R&D subsidies based on Italian firm-level data. Using probit models, the authors find that the probability of R&D subsidies in the current period is significantly positively related to obtaining R&D subsidies in the past. Furthermore, larger firms and firms with higher R&D capabilities are more likely to receive R&D subsidies. Using a dynamic random effects model, Busom *et al.* (2017) find that program participation in the past explains the majority of the likelihood of obtaining funding in the current period.

The studies mentioned above have two limitations. First, these studies have compared firms that received government grants with those who did not receive them. In the latter group, there are both firms that have applied for grants but been rejected and firms that have not applied at all. Thus, biased samples have been used. Second, the studies do not provide information on the features of the applications at the project level, which leads to problems with omitted explanatory variables. We will consider these two issues in the following empirical model.

3 Database, descriptive statistics and empirical model

3.1 Database and descriptive statistics

The database used in the present study is provided by the Austrian R&D funding agency (FFG).[2] FFG is the largest provider of public R&D grants to the business sector in Austria, with €300 million distributed in 2014. The database consists of two parts: a firm-level database with information on sales, employment and R&D activities of the applying firms and a project-level database consisting of the agency's ratings of the R&D project proposals. When submitting their applications for funding, firms must provide information on their basic characteristics for the past three years. The requested firm-level information is (i) total sales revenues (in thousand €), (ii) the share of exports in sales, (iii) the number of employees (full-time equivalents), (iv) the number of R&D employees (full-time equivalents), (v) expenses for R&D (in thousand €) and (vi) cash flow (in thousand €). In addition, there is information on industry affiliation.

[2] Die Österreichische Forschungsförderungsgesellschaft (FFG).

The project-level database contains information on the planned duration of the project, planned project costs, the decision of the funding agency (approval or rejection), share of funding, type of funding (grant or loan), and expert ratings on approximately 16 evaluation criteria, grouped into 4 broader categories of criteria (relevance of the project in relation to the program line, quality of the project, economic potential and utilization, suitability of the applicants). These criteria are outlined below:

Relevance of the project in relation to the program

- Additional effects on project R&D
- Additional effects on firm R&D
- Additional funding opportunities through the R&D grants
- Knowledge gains through new technologies
- Risk of not achieving economic goals

Quality of the project proposal

- Innovative content
- Development risk
- Novelty of the technology or methodology
- Complexity of the task
- Scope of technology
- Future potential of the technology
- Environmental aspects

Economic potential and utilization

- Market prospects
- Exploitation potential

Suitability of the applicants

- Qualification and motivation of the staff
- Level of technical equipment

FFG decides whether and how R&D subsidies will be granted. Each R&D project application is evaluated by experts, and the decision to provide a grant for an R&D project and the amount of funding depend on specific selection criteria. According to FFG's guidelines, the fund aims to promote R&D in small firms and in start-up firms. Furthermore, there are special grant programs called "start-up", which favor technology-oriented firms that have been established in the past 3 years and have fewer than 50 employees.

The evaluation criteria are measured on an ordinal, five-level scale (++ for very good, + for good, - for poor, -- for very poor and KO for unacceptable projects). We split the ratings of the evaluation criteria into a group of additive dummy variables that equal one if the ratings are positive (+) or very positive (++) and zero for the remaining ratings (KO, - or --). The two databases are linked to the firm-level characteristics dating back to one year before the start of the project.

Table 1. Distribution of the rating scores for different criteria (percent).

Category	Criteria	Exclusion KO	Strong negative --	Negative -	Positive +	Very positive ++
Sample 2005−2012 (# obs. 3217)						
Relevance	Additional effects on firm R&D	0.005	0.030	0.353	0.568	0.046
	Knowledge gains through new technologies	0.001	0.071	0.403	0.460	0.066
	Add. funding opportunities through the R&D grants	0.007	0.040	0.210	0.435	0.308
	Risk of not achieving economic goals	0.000	0.122	0.501	0.326	0.048
Quality of the project	Scope of technology	0.000	0.060	0.526	0.380	0.034
	Complexity of the task	0.003	0.104	0.447	0.400	0.047
	Future potential of the technology	0.001	0.022	0.269	0.603	0.105
	Environmental aspects	0.000	0.004	0.764	0.219	0.013
Economic potential	Market prospects	0.005	0.032	0.404	0.553	0.006
	Exploitation potential	0.009	0.045	0.289	0.566	0.091
Suitability of applicant	Qualifications and motivation of the staff	0.003	0.026	0.165	0.649	0.157
	Technical equipment	0.002	0.032	0.278	0.571	0.118
Sample 2008−2012 (# obs. 1553)						
Relevance	Additional effects on project R&D	0.028	0.021	0.261	0.565	0.125
Quality of the project	Development risk	0.006	0.091	0.432	0.421	0.051
	Innovative content	0.011	0.032	0.349	0.563	0.046
	Novelty of the technology or methodology	0.001	0.156	0.490	0.306	0.048

Source: R&D funding agency, own calculations.

Information is available for approximately 17000 R&D projects during the period 2005−2012. The number of firms applying for funding is approximately 1500, depending on the year, and the agency has many program lines. We select project applications in the largest program line, titled “Basic R&D grants”. Projects applications that are follow-up projects of previously accepted project applications are excluded. So-called successor projects are not comprehensively evaluated and therefore cannot be compared with initial applications. The estimation sample consists of approximately 3370 R&D project applications from 1915 firms, of which 68 percent are approved. This figure corresponds exactly to the acceptance rate (68 percent) of “Basic R&D grant programs” for the year 2016 as calculated by the funding agency (FFG/OÖ, 2017). After matching with the firm-level characteristics, information remains on 2490 projects from 1355 firms, of which 72 percent receive funding. The relatively high acceptance rate is likely because the basic R&D funding program is the largest funding line with the highest budget and because the Agency intends to expand the R&D base of the economy. As new criteria such as "innovative content of the project proposal" were introduced in 2008, two samples will be used: one for the overall sample from 2005 to 2012 and the other from 2008 to 2012. Note that a firm can submit multiple applications for funding within a given time period.

In Table 1, the level of rating scores differs across criteria. For instance, with respect to the criteria "additional effects on firm R&D", 61 percent of the R&D project applications receive a positive rating − either a plus (+) or two plus (++) − whereas for environmental aspects, few firms achieve a positive score. Positive scores are most common for the following criteria: additional effects on firm level, additional funding opportunities, exploitation potential, future potential, qualification of the staff, additional effects at project R&D and innovative content, with 60 percent or more. The firm characteristics differ between successful and unsuccessful applications. The t-test for the same mean and tests for the same median show that the companies that received an R&D grant differ significantly in terms of age and export share (Table 2). Based on the median test, which is less sensitive to influential observations and outliers, we find that company size is relevant as well. Labor productivity, R&D intensity and cash flow ratio do not differ between companies that do or do not receive an R&D grant.

Table 2. Firm characteristics of funded and non-funded applications (median).

	Non-funded Median	Funded Median	t-test (p-value)	Test on equal median (p-value)
R&D to sales ratio	0.067	0.070	0.055	0.664
No. of employees	55	89	0.315	0.055
Turnover per employee in Euro	160	165	0.992	0.486
Export share	0.560	0.700	0.000	0.003
Firm age in years	14	16	0.046	0.045
Cash-flow ratio	0.089	0.084	0.004	0.620

Note: Test on equal median is based on the least absolute deviation model with no control variables. Source: R&D funding agency, own calculations.

In Table 3, the acceptance ratio also differs across the evaluation criteria. As expected, highly scored research projects have significantly higher acceptance rates. These differences are significant for all 16 promotion criteria based on the Fisher exact test with a significance level of 1 percent. In particular, innovative content, additional effects on firm R&D, development risk, future potential, and qualifications and motivation of the staff seem to be the most important factors in obtaining funding. The proportion of approved projects is between 34 and

50 percentage points higher for those firms with good or very good ratings. In the case of market prospects, which are also among the most strongly weighted criteria according to the funding agencies' selection rule, the proportion of approved projects is 30 percentage points higher for firms with good or very good ratings. The other criteria (additional funding opportunities through R&D grants, additional effects on project R&D, complexity of the task, exploitation potential, knowledge gains through new technologies, novelty of the technology or methodology, and risk of not achieving economic goals, technical equipment) are also relevant, with differences in the acceptance rate between 20 and 34 percentage points. Less relevant are environmental aspects, with a difference in the rate of approved projects of 11 percentage points.

Table 3. Acceptance rate for different ratings across criteria, percent

Category	Criteria	negative rating -,--, KO	positive rating ++, +	Fisher exact test (p-value)
Sample 2005−2012 (# obs. 3273)				
Relevance	Additional effects on firm R&D	0.477	0.816	0.00
	Knowledge gains through new technologies	0.516	0.837	0.00
	Add. funding opportunities through the R&D grants	0.524	0.740	0.00
Quality of the project	Risk of not achieving economic goals	0.587	0.848	0.00
	Scope of technology	0.610	0.791	0.00
	Complexity of the task	0.560	0.840	0.00
	Future potential of the technology	0.422	0.793	0.00
	Environmental aspects	0.660	0.767	0.00
Economic potential	Market prospects	0.516	0.818	0.00
	Exploitation potential	0.500	0.781	0.00
Suitability of applicant	Qualification and motivation of the staff	0.376	0.759	0.00
	Technical equipment	0.527	0.756	0.00
Sample 2008−2012 (# obs. 1558)				
Relevance	Additional effects on project R&D	0.483	0.798	0.00
Quality of the project	Development risk	0.541	0.879	0.00
	Innovative content	0.398	0.895	0.00
	Novelty of the technology or methodology	0.593	0.897	0.00

Source: R&D funding agency, own calculations.

3.2 Empirical model

The empirical model can be derived from an individual utility maximization approach. We assume that the applicants for an R&D grant face two outcomes: i) approval or ii) rejection. These two alternatives provide the firm with a given utility. For each application for an R&D

grant, *i*, we observe the status *y* equal to 1 if the funding application is accepted and 0 if the application is rejected. The outcome is the funding agency's decision to select an R&D project, which is assumed to be an unobserved latent variable. The probit model links the observed outcome to the unobserved funding probability with the underlying characteristics *X* via a standard normal cumulative distribution function (ϕ) (the individual index *i* is suppressed for convenience):

$$Pr(Y = 1 \mid X) = \phi(X'\beta). \tag{1}$$

where the funding likelihood, Y^*, is a function of the observable characteristics *X*

$$Y^* = X' ß + \varepsilon . \tag{2}$$

The latent variable, Y^*, is observed as a binary variable *Y*, which is defined as follows:

$$Y = \begin{cases} 1 & if \quad Y^* > 0 \\ 0 & if \quad Y^* \leq 0 \end{cases} . \tag{3}$$

X is a vector of covariates containing project and firm-specific characteristics, and ß is the corresponding coefficient vector. Random factors and unobservable factors influencing the selection decision are captured by the error term, ε. The association can be estimated by the probit model using the maximum likelihood estimator. Alternatively, the logit model can be employed. Standard errors are clustered at the firm level because projects belonging to the same firm are not independent of each other.

Given the theoretical considerations outlined above, the selection of an R&D grant application *Y* is specified as a function of several factors:

$$\begin{aligned} Y_{ijt} = {} & ß_0 + \sum_{C=1}^{Z} ß_C CRITERIA_{ijtC} + \sum_{Y=1}^{Z} ß_Y YEAR_{ijty} + \alpha_1 YOUNG_{jt-1} \\ & + \sum_{S=1}^{4} \alpha_{2S} EMPCLASS_{ijtS} + \alpha_3 RDY_{jt-1} + \alpha_4 EXY_{jt-1} + \sum_{I=1}^{17} \alpha_{5I} SECTOR_{ijtI} + \sum_{R=1}^{8} \alpha_{6R} REGION_{ijtR} + \varepsilon_{ijt} \end{aligned} \tag{4}$$

where *i* denotes the planned R&D project for firm *j* at application year *t*. CRITERIA is a set of dummy variables consisting of expert ratings of several evaluation criteria (with a negative rating or knockout as the benchmark category). Yearly dummy variables, *YEAR,* measured as the start of the planned project control for aggregate time varying factors such as the business cycle and the inflation rate. *YOUNG* denotes a dummy variable for young firms (aged between zero and five years). *EMPCLASS* consists of a set of dummy variables measuring firm size based on the number of employees (1-9, 10-49, 50-249, 250+), with zero employees as the reference category. Other firm-specific variables include the ratio of R&D expenditures to turnover (*RDY*) and the ratio of exports to turnover (*EXY*). *SECTOR* is a set of dummy variables indicating industry affiliation, *REGION* denotes the federal state of the applying firm, and ε_{ijt} is the error term. The standard probit model with cluster-adjusted standard errors at the firm level is used to estimate the probability of obtaining an R&D grant. As an alternative to the standard probit model, the so-called mixed effects probit (or logit) model can be used (Skrondal and Rabe-Hesketh, 2004). This model makes it possible to account for parameter heterogeneity across firms. We use the random effects probit model, where the error term is allowed to vary across firms.

We expect that the selection of the R&D grant application depends on the expert ratings of the funding criteria, with innovative content and complexity of the planned R&D project being the most important. Firm-specific factors might also be important. According to the winner hypothesis, firms with a high cash flow are more likely to be awarded grants. Differences may also exist between large and small firms.

4 Empirical results

Table 4 shows, using different probit models, the marginal effects of the determinants on the acceptance rate of R&D funding applications.[3] Three different models are provided. In models 1 and 2, we use the standard probit model, with Model 1 containing only the rating criteria and the application year, while Model 2 adds firm characteristics, industry affiliation, and regional dummies. Model 3 contains the same explanatory variables as Model 2, but now the mixed-effect probit model is used where the constant is allowed to vary across applicants. The likelihood ratio (LR) test shows that the presence of random firm effects cannot be

[3] Z-values of the marginal effects of the standard probit model are based on clustered adjusted standard errors at the firm level.

Table 4. Probability of obtaining an R&D grant (total sample 2005−2012)

	Standard Probit estimations						Mixed effect Probit estimations		
	Project characteristics			Project and firm characteristics			Project and firm characteristics		
	Model 1			Model 2			Model 3		
Explanatory variables	dF/dx		z-stat	dF/dx		z-stat	dF/dx		z-stat
Additional effects on firm R&D + (ref -,--, KO)	0.189	***	9.98	0.189	***	9.24	0.134	***	9.62
Additional effects on firm R&D ++	0.210	***	5.60	0.182	***	5.73	0.229	***	4.98
Knowledge gains through new techn. + (ref -,--, KO)	0.189	***	10.42	0.172	***	8.63	0.133	***	8.95
Knowledge gains through new technologies ++	0.172	***	4.10	0.140	***	3.28	0.144	***	3.80
Add. funding opport. through R&D grants + (ref -,--, KO)	0.105		4.74	0.082	***	3.11	0.064	***	3.23
Add. funding opportunities through the R&D grants ++	-0.030		-1.08	-0.007		-0.21	-0.004		-0.16
Risk of not achieving the economic goals + (ref -,--, KO)	0.115	***	5.57	0.127	***	5.86	0.104	***	5.91
Risk of not achieving the economic goals ++	-0.057		-1.08	-0.016		-0.31	-0.009		-0.23
Scope of technology + (ref -,--, KO)	0.080	***	4.16	0.086	***	4.23	0.066	***	4.29
Scope of technology ++	-0.021		-0.33	0.004		0.06	0.000		0.00
Complexity of the task + (ref -,--, KO)	0.136	***	6.79	0.145	***	6.66	0.112	***	6.95
Complexity of the task ++	0.113	**	2.55	0.122	***	2.81	0.114	**	2.48
Future potential of the technology + (ref -,--, KO)	0.146	***	7.53	0.169	***	7.96	0.118	***	7.85
Future potential of the technology ++	0.144	***	4.18	0.150	***	4.56	0.149	***	4.66
Environmental aspects + (ref -,--, KO)	0.077	***	3.50	0.055	**	2.25	0.042	**	2.23
Environmental aspects ++	0.065		0.73	0.091		0.94	0.088		1.10
Market prospects + (ref -,--, KO)	0.180	***	9.49	0.156	***	7.67	0.109	***	7.84
Market prospects ++	0.103		1.03	0.003		0.03	-0.008		-0.08
Exploitation potential + (ref -,--, KO)	0.193	***	8.57	0.180	***	7.46	0.127	***	7.53
Exploitation potential ++	0.161	***	4.73	0.155	***	4.71	0.157	***	5.06
Qualification and motivation of the staff + (ref -,--, KO)	0.220	***	8.66	0.192	***	6.28	0.132	***	6.93
Qualification and motivation of the staff ++	0.168	***	5.92	0.140	***	4.62	0.127	***	4.62
Technical equipment + (ref -,--, KO)	0.045	**	2.06	0.060	**	2.45	0.040	**	2.26
Technical equipment ++	-0.077	**	-2.00	-0.011		-0.30	-0.002		-0.08
Firm size 1-9 (ref 0)				-0.070		-0.67	-0.057		-0.86
Frirm Size 10-49				-0.106		-1.02	-0.084		-1.27
Firm size 50-249				-0.143		-1.33	-0.109		-1.61
Firm size 250+				-0.262	**	-2.30	-0.180	***	-2.61
Young firm (0-5 years)				-0.041		-1.39	-0.029		-1.44
R&D to turnover t-1				-0.044		-1.45	-0.033		-1.61
ln Sales per employees t-1				-0.009		-0.64	-0.008		-0.75
Exports to turnover t-1				-0.055	*	-1.80	-0.036		-1.57
8 Regional dummy variables	No			Yes			Yes		
7 additive year dummies (reference 2005)	Yes			Yes			Yes		
15 additive sector dummies	No			Yes			Yes		
Number of observations	3271			2487			2487		
Pseudo R^2	0.35			0.404					
Correctly classified in per cent	82.6			84.4					
LR test vs. standard probit model (p-value)							0.030		

Notes: Asterisks ***, **, * denote significance at the 1%, 5% and 10% levels, respectively. This table reports the marginal effects, dF/dx, and the corresponding z values. Z-stat in the probit model is based on cluster-adjusted standard errors at the firm level. The mixed effect probit model is estimated using the me-probit procedure of Stata 14.1 with random effects. The share of accepted applications is 68.5 per cent in Model I (excluding firm characteristics). The corresponding share is 71.3 percent in Models 2 and 3 (including firm characteristics). Additive dummies for years and sectors are not shown but are available from the authors on request.

rejected at the 5 percent level. Therefore, the interpretation of the results focuses on the more general mixed-effect probit estimations (Model 3). Interestingly, the standard probit estimations tend to overestimate the impact and significance of positive ratings (+). The differences in the marginal effects between Models 2 and 3 are approximately 2 percentage points on average.

The probit estimates reveal that the acceptance rate of R&D grant applications significantly depends on the different assessment criteria. In contrast, firm-level characteristics do not have a significant impact on the acceptance rate. The only exception is that firms with more than 250 employees have a significantly lower acceptance rate. Among the project evaluation criteria, the qualifications and motivation of the staff, expected additional effects on firm R&D, exploitation potential, knowledge gains through new technologies, future potential and complexity of the task of the R&D project have the largest impact on the probability of being selected. Expected additional effects on firm R&D have the highest impact. For instance, in Model 3, the probability of receiving an R&D grant is 23 percentage points higher for firms with a very positive rating (++) than for firms with a negative rating (-.--, or ko). For applications with good ratings (+), the marginal effect is 13 percentage points. For knowledge gains of the R&D project, the difference between good and very good ratings and the reference category is 13 and 14 percentage points, respectively. Similarly, a good rating for future potential is associated with a 12- and 15- percentage-point-higher acceptance rate. Technical equipment and environmental aspects are less relevant, as indicated by the marginal effects.

Firm-level characteristics are generally not relevant for the selection of R&D grant applications. For instance, R&D intensity measured as the R&D-to-sales ratio is not significant at conventional significance levels. Similarly, labor productivity and export ratio are not significant at conventional significance levels. This indicates that independently of their level of labor productivity, R&D intensity and export performance, firms have equal chances of obtaining a grant. Unreported results show that the cash-flow ratio is not significant, indicating that R&D funding is neutral to internal financing possibilities. However, cash flow is not included in the final specification because of the large number of missing values. An exception is firm size, where the largest firms (> 250 employees) have a significantly lower probability of receiving funding. Based on the multi-level probit model, such firms have an 18-percentage-point lower probability of receiving funding. If random firm-level effects are not considered, then the firm-size effect is overestimated (+28 percentage points). The reason for the higher rejection rate might be that large firms submit multiple applications at the same time, which diminishes the probability of obtaining funding.

Table 5. Probability of obtaining an R&D grant (sub sample 2008−2012)

	Standard probit estimations			Mixed effects probit estimations		
	Model 4			Model 5		
Explanatory variables	dy/dx		z-stat	dy/dx		z-stat
Additionality at project level + (ref -,--, KO)	0.222	***	8.86	0.149	***	8.89
Additionality at project level ++	0.118	***	5.12	0.141	***	4.98
Additionality effects on firm R&D + (ref -,--, KO)	0.142	***	5.28	0.096	***	5.84
Additionality effects on firm R&D ++	0.115	***	3.81	0.178	***	3.82
Knowledge gains through new technologies + (ref -,--, KO)	0.074	***	3.12	0.056	***	3.18
Knowledge gains through new technologies ++	0.017		0.33	0.016		0.36
Add. funding opport. through R&D grants + (ref -,--, KO)	0.103	***	3.44	0.078	***	3.31
Add. funding opportunities through the R&D grants ++	0.070	*	1.91	0.055	*	1.87
Risk of not achieving the economic goals + (ref -,--, KO)	0.119	***	4.73	0.093	***	4.83
Risk of not achieving the economic goals ++	-0.126		-1.58	-0.068	*	-1.68
Development risk + (ref -,--, KO)	0.107	***	4.45	0.084	***	4.32
Development risk ++	-0.058		-0.79	-0.037		-0.79
Innovative content + (ref -,--, KO)	0.285	***	9.54	0.182	***	10.01
Innovative content ++	0.135	***	5.16	0.375	***	3.90
Novelty of the technology or methodology + (ref -,--, KO)	-0.020		-0.60	-0.013		-0.54
Novelty of the technology or methodology ++	-0.284	**	-2.49	-0.130	***	-2.57
Scope of technology + (ref -,--, KO)	0.061	***	2.89	0.048	***	2.82
Scope of technology ++	0.031		0.45	0.025		0.55
Complexity of the task + (ref -,--, KO)	0.099	***	4.22	0.074	***	4.09
Complexity of the task ++	0.089	*	1.79	0.101	*	1.90
Future potential of the technology + (ref -,--, KO)	0.031		1.32	0.020		1.06
Future potential of the technology ++	-0.010		-0.18	-0.007		-0.19
Environmental aspects + (ref -,--, KO)	0.060	**	2.55	0.049	**	2.42
Environmental aspects ++	-0.085		-0.65	-0.052		-0.77
Market prospects + (ref -,--, KO)	0.117	***	4.56	0.076	***	4.64
Market prospects ++	-0.355	*	-1.78	-0.161		-1.49
Exploitation potential + (ref -,--, KO)	0.244	***	6.24	0.146	***	6.66
Exploitation potential ++	0.139	***	4.93	0.156	***	4.74
Qualification and motivation of the staff + (ref -,--, KO)	0.109	***	2.62	0.080	***	3.50
Qualification and motivation of the staff ++	0.071	*	1.77	0.068	**	2.21
Technical equipment + (ref -,--, KO)	0.073	**	2.26	0.045	**	1.99
Technical equipment ++	-0.007		-0.18	-0.007		-0.21
Firm size 1-9 (ref 0)	-0.314	*	-1.97	-0.159	**	-2.14
Frirm Size 10-49	-0.309	**	-2.23	-0.174	**	-2.36
Firm size 50-249	-0.375	***	-2.60	-0.203	***	-2.71
Firm size 250+	-0.374	***	-2.67	-0.214	***	-2.79
Young firm (0-5 years)	-0.011		-0.31	-0.009		-0.36
R&D to turnover t-1	-0.020		-0.64	-0.017		-0.67
ln Sales per employees t-1	0.004		0.22	0.000		-0.02
Exports to turnover t-1	-0.032		-0.87	-0.021		-0.82
8 Regional dummy variables	Yes			Yes		
4 additive year dummies (reference 2008)	Yes			Yes		
15 additive sector dummies	Yes			Yes		
No. of observations	1334			1334		
Pseudo R^2	0.59					
Correctly classified in per cent	89.3					
LR test vs. standard probit model (p-value)				0.05		

Notes: Asterisks ***, **, * denote significance at the 1%, 5% and 10% levels, respectively. This table reports the marginal effects, dF/dx, and the corresponding z values. Z-stat in the probit model is based on cluster-adjusted standard errors at the firm level. The mixed effect probit model is estimated using the me-probit procedure of Stata 14.1 with random effects. The share of accepted applications is 68.5 per cent in Model I (excluding firm characteristics). The corresponding share is 71.3 percent in Models 2 and 3 (including firm characteristics). Additive dummies for years and sectors are not shown but are available from the authors on request.

The probability of receiving an R&D grant also does not vary much across industries.[4] The finding that the majority of company characteristics are irrelevant for determining the probability of acceptance stands in contrast to the previous literature.

Table 5 shows the probit estimates for the small sample, where four more evaluation criteria are available. Again, the assessment ratings for the different evaluation criteria are highly significant, while firm characteristics are not related to the acceptance rate. Innovative content stands out with very positive ratings, increasing the probability of acceptance by 37 percentage points. Expected additionality effects – either on firm-level R&D or project-level R&D – are also highly relevant. Assessment ratings related to scope of technology, risk of not achieving economic goals, development risk, additional funding opportunities through R&D grants, complexity of the task, market prospects, and qualifications and motivation of the staff are also significant, with marginal effects in the moderate range. Firm size is the only firm-level characteristic that is significantly related to the acceptance rate. For the small sample, we find that acceptance is monotonously negatively related to firm size. The largest firms (> 250 employees) have a 21-percentage-point lower acceptance rate.

Several robustness checks are conducted. First, estimations conducted for firms with high and low R&D intensity are conducted. The results show that the importance of the different criteria does not differ much between firms with low and high R&D intensity. The results might also be different between SMEs and large firms. Unreported results show that firm size does not play a significant role in the sign and significance of the assessment criteria.

5 Conclusions

This study provides the first empirical evidence on the determinants of the probability that firms will receive public R&D funding at the individual project level. Previous studies were limited to the analysis of firm-level characteristics. Our study uses a database of accepted and rejected R&D grant proposals and employs unique information derived from a detailed project-level assessment rating system linked to firm-level characteristics of the applicants. This database makes it possible to differentiate between companies that have applied for, but

[4] Specifically, applicants from the pharmaceutical sector (NACE rev 21) and business services (NACE rev 2 63 to 96) have lower probabilities of receiving funding, whereas firms in the metal sector (NACE rev 2 24 to 25) and other manufacturing sectors have significantly higher probability (NACE rev 2 31 to 33).

been rejected, public funding for their R&D projects and companies that have not applied at all. Mixed effects probit estimates show that the likelihood of obtaining an R&D grant depends mainly on assessment ratings of the evaluation criteria on the project level, with good reviews in innovative content and expected additional effects on firm-level or project-level R&D, exploitation potential and qualification and motivation of staff of the R&D project being most important. Good and very good assessment ratings in innovative content raise the acceptance probability by 18 and 37 percentage points, respectively, compared to low ratings. Furthermore, small and micro firms, firms with low R&D expenditures (as a percentage of turnover) or low levels of labor productivity do not have a disadvantage in receiving R&D grants. This finding indicates that the R&D funding agency does not discriminate between firms with high or low labor productivity or among micro, small or large firms. However, the largest firms – those with more than 250 employees – have a significantly lower acceptance probability.

The result that the quality of the project application is more important than firm characteristics is a new finding in the literature. These results have several implications for R&D managers of the companies and for executives of R&D funding agencies. Successful R&D managers should focus on radical, new and innovative ideas rather than on minor improvements. Accordingly, research and development projects that involve minor technological changes to existing products or imitation of existing solutions, as well those that lack technological novelty, should not be submitted for funding. Given these results, R&D managers should not hesitate to apply for funding for very difficult projects. Additionally, very small firms and loss-making firms or firms with low labor productivity should be encouraged to apply for R&D grants.

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