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by

Florian Umlauf

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Network Determinants of a Collaborative Funding System: The Case of the German Innovation Policy

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Abstract

The granting of publicly subsidized joint projects has become a popular policy instrument in Germany and other developed countries. However, little is known about how an emerging subsidization network affects the overall allocation process of further project grants. Employing a database that contains all funded R&D projects of the German federal government, this paper analyzes the extent to which the funding network tends to reproduce itself. The results of an empirical model show that participation within a collaborative project does not raise, per se, the chance of an enterprise obtaining another project grant. Rather, it is important to hold central positions within the network or have access to a diverse external knowledge base to receive anew project grant.

Keywords: R&D subsidies, project allocation, network determinants, cooperation

JEL classification: H32 L53 L60 O38

1 Introduction

During recent decades, innovation policies of Germany and other developed countries evolved towards an increased importance of collaborative research within government-funded R&D projects (Fier and Harhoff, 2002; Eickelpasch and Fritsch, 2005). Due to the growing awareness of the innovation-stimulating nature of collaborative research efforts – because of, for example, knowledge exchange, resource pooling or risk sharing – most of the publicly sponsored R&D projects in Germany inherently integrate cooperative elements. What is new about this policy is that only consortiums, rather than individual organizations, can apply for such a joint project. In the case of a cooperative project grant, organizations have to collaborate within the scope of the project, as well as to share their knowledge and the results at the end of the project (Broekel and Graf, 2012). Due to of the overall large number of joint projects and intertwined organizations, a complex network evolves, that is determined by policy-driven rules and organizational behavior. There is a rich source of literature regarding the internal dynamics (Broekel and Graf, 2012; Balland, 2012) and external-policy influences (Aschhoff, 2009) that drive the evolution of such a complex system, but interestingly less is known about the way both sources of change are related to one another.

This is even more evident since the government has had to comply with regulatory standards - preventing distortions to the market (such as reducing incentives to innovate), promoting existing market power or guaranteeing the survival of poorly performing enterprises. To some extent, the direct-funding system of the federal government anticipates the possibility of failure, since financial support is only granted for a certain period of time (BMBF, 2012) in order to prevent it giving an extraordinary amount of support to private organizations. But the idea of clear regulation is misleading, since there are no upper bounds of projects an organization can have subsequently or in parallel. There is no doubt that governmental policy shapes the funding system to a high degree, but there are some concerns that policies are highly affected by the self-reinforcing tendencies of the system, which could lead to unexpected feedbacks and distortions to the market.

This paper is intended to analyze the extent to which the dynamic of the system is influenced by its structural patterns. Therefore, the second section gives a systematic overview of the allocation process of a project grant, complemented by some hypotheses, exploring the dependency of the funding system on some network-related effects. The third section presents the empirical background of the paper. The fourth section introduces the model and the employed data in order to check whether the hypotheses are valid or not. Section five presents and discusses the results of the estimated model. The final section summarizes the results and gives an outlook on further research questions.

2 Theory

2.1 Decision-making process of a project grant

Since the allocation of project grants is a long-term process, it is necessary to analyze the overall decision process in detail (Figure 1). The process starts with the initiation phases

of a new project, which transits into an application phase and possibly ends up with a successful project completion. The initiation and execution phases touch an enormous number of interests of various stake-holders coming from politics, public administrations and the industry; all of them can be responsible for the acceptance or refusal of the project grant. For the following analysis, it is useful to split the overall decision process into the single steps of the 'Eligibility', 'Awareness', 'Application', 'Acceptance' and 'Execution' of a project grant (Tanayama, 2007; Keese et al., 2012). While politicians and administrations make decisions regarding the eligibility of an organization, the organization decides to seek a contribution and, moreover, to apply for the project grant. The granting of the funding lies in the responsibility of the public administration. In a final step, the organization checks whether to start the project or not. Within these steps, a lot of factors come into question affecting the decision-making process.

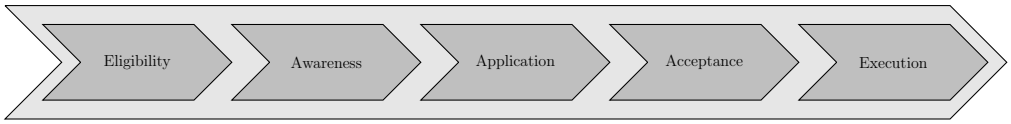


Figure 1: Decision-making process

2.1.1 Eligibility of the organization

The administration checks the eligibility of an organization on the basis of a criteria catalog, containing the funding conditions. On this account, it may be necessary to belong to a specific target group in order to fall within the group of addressed organizations. Some of these criteria are dominant enough to shape the overall composition of the funding regime. The ZIM program, for example, explicitly aims a large amount of financial resources at small- and medium-sized enterprises (SMEs), and such SMEs may therefore be overrepresented within the funding system. The InnoRegio program was specifically designed for the eastern states of Germany (Eickelpasch and Fritsch, 2005), so it is possible that organizations of eastern Germany have a higher chance of being represented within the system. Even the sectoral affiliation of an organization can play a role, since some program grants are related to specific technologies or industries. The importance of these factors has already been demonstrated by other authors. Keese et al. (2012) highlighted the significance of the sectoral affiliation, whereas Aschhoff (2009) found evidence of preferential treatment for organizations located within the eastern states. An additional factor comes into question as joint projects have evolved into a well-established policy instrument in Germany. New to this approach is the process whereby a consortium of organizations applies jointly for a project grant, with several groups of initiatives competing with each other for the project grant (Eickelpasch and Fritsch, 2005). So, without being a member of a consortium, an organization has no chance of appling for any joint project. Because of this, organizations can benefit from preexisting collaborations, if seeking partners who are willing to join the project, as they are already aware of the skills, the research questions and the interests of potential

project partners.

2.1.2 Awareness of the funding programs

Without the awareness of a funding opportunity, not a single organization would apply for a project grant. The decision to seek funding can only be taken by the organization itself, but several additional factors play a role within this context. First of all, the government could support this process by providing easily accessible communication platforms for organizations, informing them about current funding programs. Secondly, an organization can benefit from earlier project applications, since market monitoring is a costly process, which becomes more efficient if information channels between the applicant, the administration or other applying organizations already exist. Additionally, former projects promote both the prominence of the organization within administrative circles as well as familiarity with administrative processes. Prior collaborations with other particularly organizations support this process (Levinthal and Fichman, 1988; Mora-Valentin et al., 2004). Organizations connecting with each other, which entails the possibility of building up a recommendation network, leads to better information channels between the organizations and, thus, more opportunities to collaborate. The greater the quantity and quality of available information channels, the more central the organization becomes within the network (Freeman, 1978; Gould and Fernandez, 1989; Burt, 2000). This is even more relevant as most of the subsidized projects are joint projects.

2.1.3 Project application

Trust can be seen as the most important currency within the project, due to the problem of incomplete contracts, which entails the opportunity of opportunistic behavior between the project partners (Granovetter, 1985; Uzzi, 1996; Mora-Valentin et al., 2004). Scarcely anything is as valuable for cooperation as organizations that are known to be trustworthy partners. Previous collaboration experiences are manifested in networks (Ahuja et al., 2012), so the degree of embeddedness, or just being within the network, can enhance the credibility of a potential partner. The decision of the organization to apply for a project grant is made on the basis of a calculation, which takes into account the expected costs and benefits of the potential project. Therefore, the organization not only has to consider the financial aspects of the project grant, but also the additional value of collaborative projects increasing the likelihood to innovate (Czarnitzki and Fier, 2003; Tanayama, 2007; Blanes and Busom, 2004; Keese et al., 2012) due to, for example, knowledge spillover, risk sharing or economies of scale. The more the expected profits exceed the expected costs, the more likely the project application becomes, although the profit, as well as the cost of the project, cannot be completely specified before the project has ended. This is even more evident for joint projects, since incomplete contracts entail the possibility of opportunistic behavior of the partners (Eickelpasch and Fritsch, 2005). The application requires the formulation of a proposal, for which the necessary information must be compiled, and each organization has to justify whether

their expenditures are within the scope of the project (Tanayama, 2007; Eickelpasch and Fritsch, 2005). Additionally, detailed reports have to be delivered during and at the end of, the funded project. Aschhoff (2009) has shown that earlier applications lead to the development of routines for project applications. By utilizing the recovered project know-how, organizations can assess if the application could be promising. Such preexisting experiences and organizational processes ease organizational efforts and reduce the costs of further applications (Aschhoff, 2009; Tanayama, 2007). For the risk assessment of a project application, the organizational size has to be taken into account (Blanes and Busom, 2004; Aschhoff, 2009; Tanayama, 2007). Fixed costs diminish with the increasing size of the organization, thus potential sunk costs play only a tangential role. If a smaller organization cannot afford the expenses of a possibly unsuccessful application, the application will be canceled due to the limited resources of the organization. In case of a cooperation project, additional factors must be taken into account. First of all, the organization should be able to absorb circulating knowledge flows gained from internal R&D processes and external accessible knowledge gained from potential collaboration partners. The less knowledge an organization has accumulated in the past, the less developed is its absorptive capacity, thus the identification and enhancement of relevant new knowledge become more challenging (Cohen and Levinthal, 1990). Within a complex economy, knowledge is dispersed among different organizations (Brusoni et al., 2001), thus it becomes urgent to bring these different skills together, since innovations strongly depend on the recombination of diverse and complementary capabilities (Boschma, 2005; Nooteboom, 2000). Therefore, a diversified knowledge base within the project should be an incentive for an organization to join the cooperative project, since knowledge heterogeneity is known to be a promising driver of innovation (Mowery et al., 1998; Boschma and Frenken, 2009; Fornahl, Broekel, et al., 2011). If the cognitive proximity between the partners is too close, organizations may exchange too much redundant information, harming the initiation of the learning processes, whereas too little cognitive proximity complicates the exchange of knowledge within the group (Nooteboom et al., 2007). Mowery et al. (1998) found evidence for an inverted U-shaped interrelation between the likelihood to cooperate and the cognitive proximity, so that a pair of organizations is more likely to cooperate due to their promising heterogeneous knowledge structure.

2.1.4 Project acceptance

A jury of experts, consisting of administrative members or other external professionals, has to confirm the project application of the organization, so additional effects come into account within the decision-making process. The legitimacy of R&D subsidies is always in question, since governmental interventions could lead to government failure. This entails a certain pressure to succeed, because if too many projects fail, the impression of government failure could arise. Since projects always run the risk of failure, the expert group could systematically tend to select an previously successful organizations or a group of organizations which is known as a productive group, aiming to minimize the likelihood of an abandonment - known as the 'picking-the-winner' strategy (Blanes and Busom, 2004; Cantner and Kösters, 2009; Aschhoff, 2009). Another positive attribute

of an organization can be an earlier investment in R&D processes, which demonstrates a pending successful innovation process, if the organization has invested their own money. Further distortions could arise due to the attempt to minimize the market distortion by selecting previously successful companies, since subsidies to poorly performing organizations may affect the market equilibrium. Aschhoff (2009) and Keese et al. (2012) found that prior R&D expenditures and corporate growth enhance the likelihood of a project grant. Moreover, Aschhoff (2009) found an increased likelihood of younger organizations receiving a project grant. She attributes this to the fact that smaller organizations have certain difficulties if, for example R&D investments have a long-term horizon, high budget requirements or a high technical risk, when compared to other organizations. In addition, Blanes and Busom (2004) suggests that favoritism may exist for younger organizations in order to reduce the amount of free-riding by mature organizations.

2.1.5 Project execution

The beginning of the project execution phase marks the end of the decision-making process. By the initiation of the project, the expectations of the organization become concrete, while the portfolio of experiences continuously grows due to the research activities within the organization and the spillover effects gained from collaborative research projects. The completion of a successful project, which ideally implies the genesis of an innovation, helps to establish mutual trust between the project participants.

2.2 Hypotheses

The previous section has discussed the theory of how the allocation process is affected by internal and external determinants. Due to this, several network-related effects have been identified, affecting most of the stages of the overall decision-making process. Based on these preliminary considerations, some hypotheses are formulated to identify the particular importance of network relationships within the direct-funding system.

The first hypothesis is based on all stages of the decision-making process, except the last one. It is the simplest of the hypotheses, asking if a new project grant if more likely to be received due to the participation within a joint project.

> ***H1:*** The participation of an organization in a joint project raises the probability of the organization receiving a new project grant.

The second hypothesis is quite similar to the first, but it goes into a bit more in detail by asking if the position of the organization within the network positively affects the chance of obtaining an additional project grant.

> ***H2:*** The better the position of an organization within the network, the more likely an organization is to receive a new project grant.

The last hypothesis concentrates on the argument that the heterogeneity of knowledge within an organizational group stimulates the output of a research project, since

innovations depend greatly on the recombination of diverse and complementary capabilities (Boschma, 2005; Nooteboom, 2000). This should motivate the expert group, as well as the application group, to initiate a project only if it includes a certain degree of knowledge heterogeneity within the group of project participants. Therefore, the third hypothesis asks if an organization has a higher probability of obtaining another project grant when this organization has a certain degree of heterogeneity within their relations.

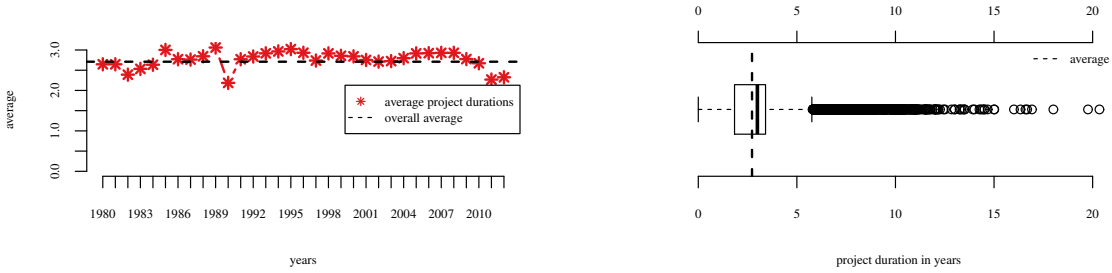
> ***H3:*** The better the access to heterogeneous knowledge, the more likely an organization is to receive a new project grant.

3 Empirical Background

3.1 Individual Approach

The empirical analysis of the German direct-funding system employes a publicly available database which contains all funded projects of the federal government. Reporting ministries are: the Federal Ministry of Education and Research (BMBF); the Federal Ministry of Economics and Technology (BMWi); the Federal Ministry of Transport, Building and Urban Development (BMVBS); and the Federal Ministry for the Environment (BMU). The so called 'Foerderkatalog' goes back to the late 1960s and includes more than 152,000 projects until the end of 2012. Each entry reports which organization received the funding, co-funded organizations, the location of the organization, the amount of funding, the funding period, the project theme and a classification number concerning the technology. In line with Broekel and Graf (2012), we assume an intensive knowledge exchange through the collaborative research effort between participants of those 'joint projects'. Those organizations that obtain a public grant accept the requirement of allowing every partner unrestricted access to the project's results and fee-free usage of their know-how and intellectual property rights. The selected data are restricted to those projects dealing with 'technology and innovations,' 'research and development' and 'basic research,' so that irrelevant projects such as 'non R&D related expenditures on education' are excluded.

Although there are no official regulations regarding the limit of the project durations or how many projects are allowed in parallel, or subsequently, there are some informal patterns within the governmental funding regime that can be identified. Therefore, we analyzed the average timespan between the beginning and end of each project since 1980 (Figure 2(a)). The time span varies around the overall mean value of 2.7 years. The relative constant level of variation over recent decades indicates the absence of major structural shifts between the years, but the imagination of an approximately constant project duration is misleading, as shown by Figure 2(b). The percentile values of $p_{0.25} = 1,838$ and $p_{0.75} = 3,411$ indicate some variance behind the mean value of 2.7, which signals remarkable inequalities in the treatment of projects. Both the overall constant average and the remarkable diversity of project durations us to consider if we can also find differences between the treatment of organizations.



(a) Average duration of projects

(b) Boxplot of project durations

Figure 2: Project durations since 1980

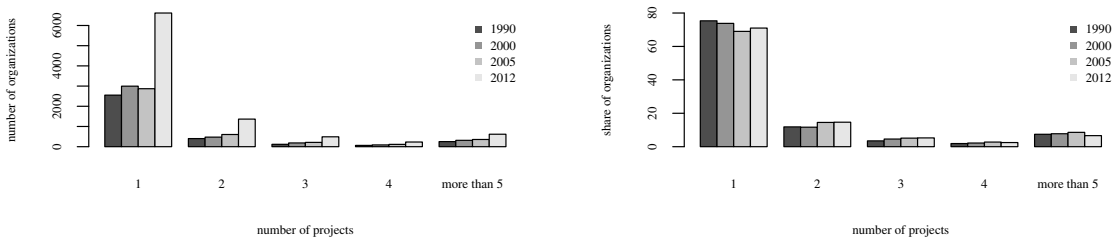
Figure 3(a) addresses this question by controlling for the number of projects per organization for several distinct years (1990, 2000, 2005 and 2012). While it seems normal that organizations are subsidized for just a single project, there are some organizations running two or even more subsidized projects at the same time. Moreover, Figure 3(a) indicates a growing number of subsidized projects and organizations every year, with a tremendous increase of 4,100 funded projects between the years 2005 and 2012. At the same time, the relative share of organizations that have received grants for one, two, three, four or even more projects are nearly constant (Figure 3(b)). If an organization obtains a contribution, the probability of being funded with exactly one single project equals 70%. The rest of the subsidized organizations are supported with more than one project, whereas less than 10% of all organizations have more than four projects in parallel. Between the years, there is a slight tendency towards more projects per organization, as the share of organizations with a single project decreases over time. Even this perspective hints at structural differences in the treatment of organizations within the funding regime.

3.2 Aggregated approach

Table 1: Stock changes within the funding system between 2005 and 2012

flow/years	2005	2006	2007	2008	2009	2010	2011	2012
+ entry	882	901	961	1,217	1,862	1,322	2,489	2,323
+ stay	3,278	3,414	3,550	3,896	4,457	5,474	5,734	7,000
- exit	973	746	765	615	656	845	1,062	1,223
= stock	4,160	4,315	4,511	5,113	6,319	6,796	8,223	9,323

This section abstracts from the individual boundaries of a single organization and shifts



(a) Number of projects

(b) Relative share

Figure 3: Projects per organization

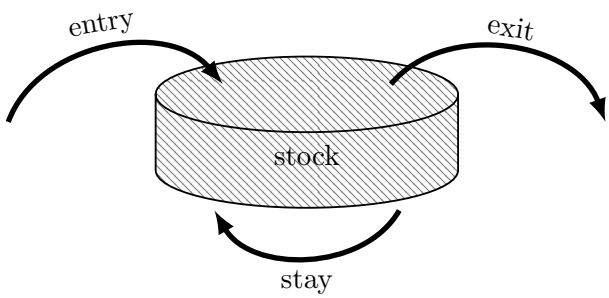
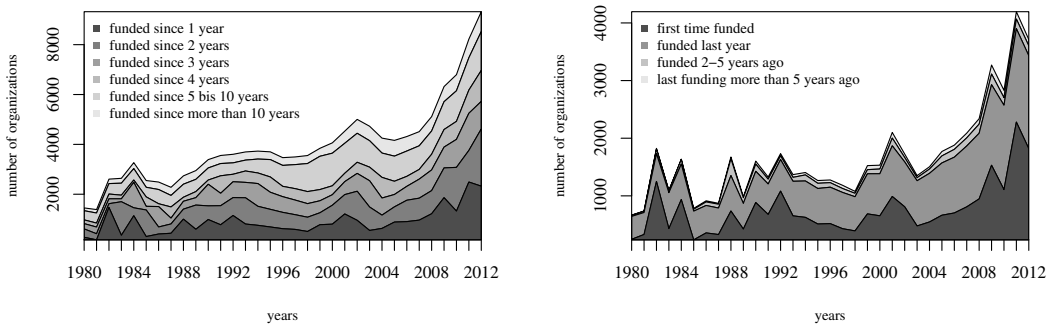


Figure 4: Dynamics within the funding regime



(a) Length of stay

(b) Duration since last funding

Figure 5: Persistence of organizations within the funding system

the focal point of interest towards an aggregated perspective of the direct-funding system in Germany, understanding the sum of actual projects as a complex and involving system shaped by the organizations that enter, stay in or quit the system. Those organizations staying in the system can be seen as the stock of organizations being active within the funding regime. The overall system grows or shrinks due to the continuous entering or quitting of organizations (Figure 4). If an organization successfully applies for a governmental contribution, the organization enters the funding system, whereas another organization leaves the system if the funding comes to an end and if there are no other ongoing projects. The number of organizations that enter, quit or stay within the system (Table 1) can be seen as the flows that shape the overall structure of the funding system. If the number of entering organizations exceeds the number of quitting ones, the whole system is expanding, whereas, in the reverse case, the system is shrinking. As can be found in Table 1, there was a major dynamic shift of entering organizations during, the recent years. Between 2005 and 2008 ,the number of organizations within the system more than doubled, from 4,160 in 2005 to 9,323 in 2012, since the share of the entering organizations exceeds the share of the leaving organizations in every year since 2006 (Table 1). Because of the rising divergence of both flows, the stock of organizations grew by about 5,163 until 2012.

The large share of organizations staying within the system indicates a strong persistence of organizations that have already entered the regime. Accordingly, Figure 5(a) presents, for every year, the length of stay of each organization within the system since 1980. In 2010, for example, there were 5,474 organizations within the regime, and, of those, approximately 2,000 organizations had been active for more than 5 years. Organizations with a newly funded project are mostly organizations which had previously received funding (Figure 5(b)). In 2010, exactly 2,831 organizations obtained at least one additional project, and, of those, 61% (1,723) had an earlier contribution, while only 39% (1,108) of the organizations received their first funding. Hence, if an organization

is already present within the system, the probability of obtaining additional funding increases significantly.

4 Model

4.1 Methodology

The analysis employs a model which was published for the first time by Gourieroux (2000). Nguyen Van et al. (2004), Fryges (2007) and Aschhoff (2009) applied this kind of model under comparable circumstances, whereas this paper aims to estimate the effect of organizational characteristics influencing the dynamic of the overall funding system. The model describes the dynamic by a series of Markov chains, where each transition probability depends on organizational characteristics. Through the application of the maximum-likelihood method, it is possible to estimate the significance of organizational characteristics changing the actual status of an organization.

Some definitions have to be made for the model. An organization $i = \{1, .., N\}$ at time point t can have the status $Y_{it} = \{0, 1\}$, whereas $Y_{it} = 1$ describes the status in which the organization i receives a new project grant in t . Correspondingly, $Y_{it} = 0$ describes the situation in which the organization i remains without a newly funded project in time point t (Gourieroux, 2000; Aschhoff, 2009), thus the occurrence of $Y_{it} = 1$ depends on how often an organization acquires a new project over time $t = \{0, ..., T\}$. The reason to consider only the time point t is that the decision to grant a funded project is taken only once by the expert group and not continuously. From of the two states, four possible combinations of transitions can be derived. If an organization changes its actual status, the organization switches either from unsubsidized to subsidized ($0 \rightarrow 1$) or from subsidized to unsubsidized ($1 \rightarrow 0$). If the current status remains, the organization preserves its unsubsidized ($0 \rightarrow 0$) status or receives a further promotion ($1 \rightarrow 1$). Therefore, it is necessary to know the transition matrix M_i for each organization i, where each value reflects the likelihood of an organization changing its present status into the next state. The transition probability of an organization from the status j in t into state $j^{'}$ in $t + 1$ is explained by the probability $P_{ijj'}$. Since the Markov process has no memory of prior stages, actual change only depends on current time (Chiang and Wainwright, 2005).

$$\mathbf{M}_i = \begin{bmatrix} P_{i00} & P_{i01} \\ P_{i10} & P_{i11} \end{bmatrix} \tag{1}$$

The columns of a transition matrix add up to 1, so $P_{i00} + P_{i01} = 1$ and $P_{i10} + P_{i11} = 1$. By simple transformations these formulas can be written as shown in Equation 2.

$$\mathbf{M}_i = \begin{bmatrix} 1 - P_{i01} & P_{i01} \\ 1 - P_{i11} & P_{i11} \end{bmatrix} \tag{2}$$

The substitution reduces the number of unknowns within the transition matrix to the variables P_{i01} and P_{i11}, with the variables describing the likelihood of an organization changing its actual status from $0 \rightarrow 1$ and $1 \rightarrow 1$, respectively. The model assumes that these probabilities are determined by organizational characteristics, explaining the elements of the transition matrix. This is possible due to the estimation of the transition probabilities using logistic regression techniques, similar to those used within discrete choice models (Gourieroux, 2000).

$$P_{ijj'}(t+1) \equiv P(Y_{it+1} = j^{'}|Y_{it} = j) = \frac{\exp\left(\mathbf{x}_{it+1}\boldsymbol{\beta}_{jj'}\right)}{\sum_{j'=0}^{1}\exp\left(\mathbf{x}_{it+1}\boldsymbol{\beta}_{jj'}\right)} \tag{3}$$

Therefore, it is possible to implement the probability $P_{ijj'}$ into a logit model (Stock and Watson, 2007; Greene, 2002). The vector $\mathbf{x}_{it} = (1, x_{it_1}, x_{it_2}, \ldots, x_{it_p})$ contains the regression constant and several specific characteristics of the organization i. Their impact on the transition probability $P_{ijj'}$ is explained through the vector $\boldsymbol{\beta} = (\beta_0, \beta_1, \ldots, \beta_p)$. Inserting $\beta_{j0} = 0$ and $j^{'} = 0, 1$ into Equation (3) leads to:

$$P_{ij1}(t+1) = \frac{\exp\left(\mathbf{x}_{it+1}\boldsymbol{\beta}_{j1}\right)}{1+\exp\left(\mathbf{x}_{it+1}\boldsymbol{\beta}_{j1}\right)}. \tag{4}$$

Substituting Equation (4) into $P_{ij0} = 1 - P_{ij1}$ constitutes, after several transformations:

$$P_{ij0}(t+1) = \frac{1}{1+\exp\left(\mathbf{x}_{it+1}\boldsymbol{\beta}_{j1}\right)}. \tag{5}$$

Inserting Equations (4) and (5) into the transition matrix leads to:

$$\mathbf{M}_i = \begin{bmatrix} \frac{1}{1+\exp\left(\mathbf{x}_{it+1}\boldsymbol{\beta}_{01}\right)} & \frac{\exp\left(\mathbf{x}_{it+1}\boldsymbol{\beta}_{01}\right)}{1+\exp\left(\mathbf{x}_{it+1}\boldsymbol{\beta}_{01}\right)} \\ \\ \frac{1}{1+\exp\left(\mathbf{x}_{it+1}\boldsymbol{\beta}_{11}\right)} & \frac{\exp\left(\mathbf{x}_{it+1}\boldsymbol{\beta}_{11}\right)}{1+\exp\left(\mathbf{x}_{it+1}\boldsymbol{\beta}_{11}\right)} \end{bmatrix} \tag{6}$$

The regressors $\boldsymbol{\beta}_{11}$ and $\boldsymbol{\beta}_{01}$ can be estimated by the application of the maximum-likelihood method. Using the distribution function (Gourieroux, 2000), it is possible to formulate the likelihood function (see Equation 7). Each organization i can choose one of four status changes between time points t and $t+1$. Therefore $n_{i,t,t+1}(jj^{'})$ delivers for organization i a value of 1, if an organization changes its status from j to $j^{'}$ between t and $t+1$ and 0 otherwise.

$$\ln L = \sum_{j=0}^{1}\sum_{j'=0}^{1}\ln L_{jj'} \text{mit} \ln L_{jj'} = \sum_{i=0}^{N}\sum_{t=0}^{T} n_{i,t,t+1}(jj^{'})\ln Pij^{'}(t+1). \tag{7}$$

Variables $\boldsymbol{\beta}_{01}$ and $\boldsymbol{\beta}_{11}$ are the only endogenous variables within the log-likelihood function. Their choice determines the values $\sum_{j'=0}^{1} \ln L_{0j'}$ and $\sum_{j'=0}^{1} \ln L_{1j'}$. Since both depend on the choice of $\boldsymbol{\beta}_{01}$ and $\boldsymbol{\beta}_{11}$, respectively, the log-likelihood function can be split into two partitions (see Equation 8), such that if $\sum_{j'=0}^{1} \ln L_{0j'}$ and $\sum_{j'=0}^{1} \ln L_{1j'}$ reach their individual maximums, the log-likelihood function is also maximized. The maximization of the log-likelihood function is done by the Broyden–Fletcher–Goldfarb–Shanno (BFGS) algorithm.

$$\ln L = \sum_{j'=0}^{1} \ln L_{0j'} + \sum_{j'=0}^{1} \ln L_{1j'} \tag{8}$$

4.2 Employed data

Within the empirical model, exogenous variables are used to explain the dynamic of the funding system. The estimation employs a database containing 88,758 firms within of the manufacturing sector, which can be identified by the German classification scheme of economic activities.[1] In addition to the names of the companies and the industry sector, the database includes the annual turnover, the number of employees, the founding year and the geographical location of the headquarters in Germany. A group of 5,966 organizations have been excluded as their entries were incomplete. A matching procedure identified 2,954 firms that have been mentioned jointly within the firm database and the project grant database.[2] Using these data, the model estimates how organizational characteristics influence the movement patterns of firms. The model includes 248,376 movement profiles of firms between the years 2009 and 2012, of which 244,176 belong to organizations which have never received a project grant (*event I*, $0 \rightarrow 0$).[3] Firms without previous project grant funding were newly funded in 1,727 situations (*event II*, $0 \rightarrow 1$), while in 1,873 cases firms did not obtain a further funding (*event III*, $1 \rightarrow 0$). A further grant was awarded in two consecutive years exactly 600 times (*event IV*, $1 \rightarrow 1$). On the basis of these occurrences, it is possible to calculate the probabilities of the events in order to construct the transition matrix (Equation 9).[4]

[1] Section C of the WZ-2008, see Destatis (2008).

[2] In the case of the 'Förderkatalog', the entry 'Zuwendungsempfänger' is used, naming the organization which receives the project grant.

[3] King and Zeng, 2001 warns of possible errors within the parameters if one of the events occurs quite seldom. Since the event of no change ($0 \rightarrow 0$) occurs more frequently than all the other cases, this could lead to distortions of the estimated parameters $\hat{\beta}_{11}$ and $\hat{\beta}_{01}$. To exclude this failure, the models were estimated by once again applying an alternative method, using the method proposed by King and Zeng (2001). Since the results of both estimation procedures are very close, it does not matter, for the interpretation of the results, if the standard model is used in the following. The estimation algorithm of the alternative model is published by Imai et al. (2008) and included in the *Zelig* package for the statistical software package R.

[4] Alternatively, a model specification was considered, in which not only the receipt of a new funding project causes a status change. Within the alternative model, a firm also stays within the funded status (*event IV*) if the duration of the project funding was granted for more than one year, so that *event III* only occurs when all projects of a company have expired. Since the results of the alternative

Table 2: Organizational collaboration within the networks

	2005	2006	2007	2008	2009	2010	2011	2012
collaborations (C)	14,448	16,285	17,915	21,492	26,220	28,891	30,799	32,505
organizations (N)	4,160	4,315	4,511	5,113	6,319	6,796	8,223	9,323
avg. degree (C/N)	3.5	3.8	4.0	4.2	4.1	4.3	3.7	3.5
max. intensity	8.8	13.3	9.9	10.3	10.5	11.2	9.9	10.3

$$\mathbf{M}_{Dynamik} = \begin{bmatrix} 244,176 & 1,727 \\ 1,873 & 600 \end{bmatrix} = \begin{bmatrix} 0.993 & 0.007 \\ 0.757 & 0.243 \end{bmatrix} = \begin{bmatrix} event\ I & event\ II \\ event\ III & event\ IV \end{bmatrix} \tag{9}$$

4.3 Network construction

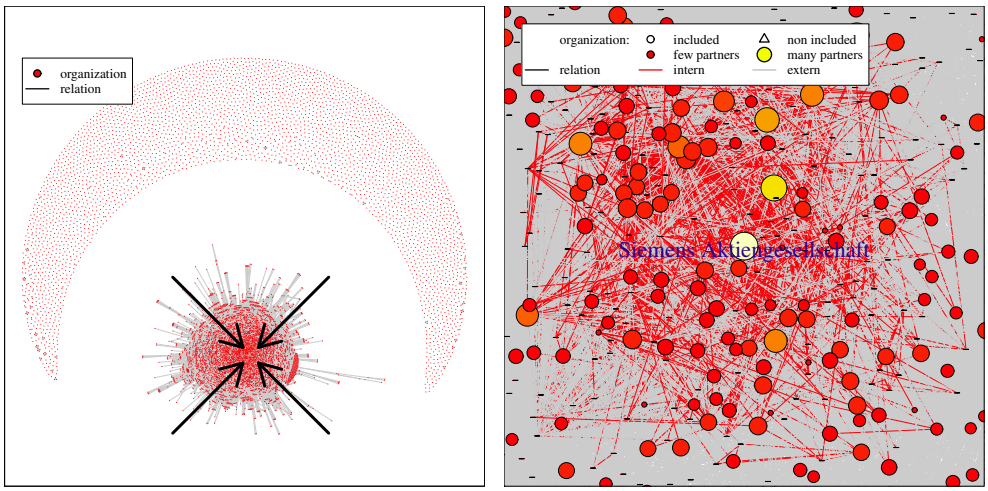
The networks are constructed on the basis of the project grant database. In contrast to the model, the networks integrate all organizations within the funding system, such that even research centers and universities are represented. The network of year t includes newly funded projects as well as ongoing projects from previous years. Collaborative funded projects can be identified due to a common identifier within the database.[5] The interlinkages of the collaborative projects construct the overall network. Since there is no certainty concerning the cooperation intensity between the organizations, this paper assumes that the intensity of the relations diminishes by a growing number of project participants. The more organizations participate within a project, the less likely it is that all partners will cooperate intensively together (Newman, 2001), so the intensity of a relationship can be estimated by the reciprocal number of combinations among the partners (Equation 10).

$$w_{ik} = \binom{n}{k}^{-1} = \left(\frac{n!}{2!(n-2)!}\right)^{-1} = \frac{1}{n*(n-1)*2} \tag{10}$$

Table 2 us of the structural patterns of the networks which have been observed between 2005 and 2012. The number of collaborations within the network continuously grows up to 32,505 in 2012, whereas the number of organizations is the same as in Table 1. The average degree fluctuates within the interval of 3.5 and 4.3. The last row of the table shows the strongest relationship measured during the year. Figure 6(a) gives an

model neither reject nor support the hypotheses, the estimated model results are omitted within the scope of this paper.

[5] In order to distinguish collaborations between companies and departments of the Fraunhofer Society, the Leibniz Association, the Helmholtz Association or Max Planck Society, the departments are differentiated due to their geographical location. Further problems could arise if organizations change their names. To minimize these distortions, some corrections within the database were made and the model was limited to a reasonable time horizon.



(a) Overall network (b) Center of the network

Figure 6: Subsidization network in 2012

overview of the observed network in 2012. The overall network consists of 9,323 organizations (nodes) and 32,505 collaborations (edges), which are shown as circles and lines, respectively. On the one hand, it can be seen that the network is broken into a lot of components (N = 3710), while on the other hand, a large component of 5,475 organizations has developed. Figure 6(b) focuses on the center of this main component. Inside this section, the relations of the visible organizations are displayed in black, otherwise they are shown in gray. In 2012, the network contains 2,227 organizations which have received funding during that time. Organizations belonging to that group are shown as circles and triangles. The latter will only be used for the model to calculate the cooperative determinants. The intensity of the color and size of the circle corresponds to the number of partners.

4.4 Variables

4.4.1 Hypotheses variables

Previous sections have shown, theoretically and empirically, that behind the dynamic of the funding system lies more than just a stochastic process. Based upon the empirical model, it is now possible to evaluate whether the determinants affect the allocation process or not. Therefore, this section describes all the explanatory variables which are relevant to the hypotheses, whereby the following section informs about the remaining ones. Table 3 allows some preliminary insights into the influence of the explanatory variables, since the table distinguishes between the average values for the four possible transition states.

Table 3: Variable statistics

	event			event		
	I $0 \rightarrow 0$	II $0 \rightarrow 1$	t-test	III $1 \rightarrow 0$	IV $1 \rightarrow 1$	t-test
log age$_t$	3.46	3.33	***	3.34	3.45	*
log employees$_t$	3.22	4.62	***	4.71	6.04	***
log turnover$_t$	1.40	2.93	***	3.04	4.56	***
small enterprise$_{bool\ t}$	0.69	0.35	***	0.32	0.18	***
east$_t$	0.15	0.23	***	0.24	0.18	**
project$_{bool\ t}$	0.01	0.36	***	1.00	1.00	***
project$_{count\ t}$	0.02	0.66	***	1.83	7.57	***
publication$_{bool\ t}$	0.02	0.14	***	0.16	0.35	***
publication$_{count\ t}$	0.01	0.15	***	0.19	0.74	***
cooperation$_{bool\ t}$	0.01	0.34	***	0.93	0.98	***
cooperation$_{count\ t}$	0.02	0.60	***	1.65	6.62	***
degree$_{avg\ t}$	0.08	2.95	***	4.19	21.60	***
betweenness$_{avg}$	8.91	783.95	***	842.76	16,916.69	***
eigenvector$_{avg\ t}$	0.00	0.01	***	0.01	0.05	***
knowledge heterogeneity$_t$	0.01	0.19	***	0.55	0.55	
food industry$_{bool\ t}$	0.07	0.02	***	0.02	0.01	**
textile industry$_{bool\ t}$	0.05	0.02	***	0.02	0.01	**
wood industry$_{bool\ t}$	0.15	0.04	***	0.04	0.01	***
chemical industry$_{bool\ t}$	0.20	0.21		0.23	0.20	
metal industry$_{bool\ t}$	0.29	0.21	***	0.21	0.15	***
machinery industry$_{bool\ t}$	0.43	0.67	***	0.67	0.79	***
others$_{bool\ t}$	0.10	0.11		0.10	0.09	
number of obervations	244,248	1,693		1,846	595	

comment: significances of a t-Test compairing the average values of the events I & II and of the events III & IV: *** 0.1%, ** 1%, * 5%, . 10%

For the confirmation of hypothesis ***H1***, two variables *cooperation*$_{bool\ t}$ and *cooperation*$_{count\ t}$ were constructed, evaluating if the participation of an organization within a joint project raises the probability of obtaining a further project grant. The first variable contains the value of 1 in time t for those organizations, which have participated in a collaborative project within the preceding three years, and 0 otherwise. This indicates whether an organization has participated in a prior joint project or not. In the case of the variable *cooperation*$_{bool\ t}$, the average value of 0.34 for organizations which switch into the funding system (*event II*) implies that 34% of all organizations have previously participated in a collaborative project. In contrast, only 1% of all organizations that remain outside the funding system (*event I*) have participated in a collaborative project. Even firms that obtain a further funding (*event IV*) have a higher average value compared to those firms that do not obtain additional funding (*event III*). Even more obvious are the differences regarding the number of joint projects, as indicated by the variable *cooperation*$_{count\ t}$. An organization that receives additional funding (*event IV*) has an average of 6.62 funded projects within the preceding three years, which lies four times above the average of an organization which does not obtain a further project grant

(*event III*). Since the situation for the other events does not differ from the former ones, it is assumed that previous experience with a collaborative project stimulates the chance of an organization to obtaining an additional project grant.

Hypothesis *H2* predicts that the centrality of an organization within the funding network has a positive impact on the likelihood of obtaining a further project grant. To analyze the extent to which the allocation process is influenced by the centrality of an organization, three different concepts of centrality come into question: (1) the degree centrality, (2) the betweenness centrality and (3) the eigenvector centrality. Firstly, the degree centrality informs us of the number of interconnections of a firm with other organizations (Wasserman and Faust, 1994; Jackson, 2008). The more neighbors, the more opportunities arise for an organization to initiate further collaborations with these partners, due to the reliable experiences and preexisting trust between those organizational pairings. Since the partners normally maintain their relations on an informal basis (Ter Wal, 2013; Fleming et al., 2007), it makes sense to average the centrality variable ($degree_{avg\ t}$) of an organization for the several years, of which it is necessary to exclude the current year due to the possibility of a causality problem, as the effect of a change cannot explain the change itself. For this purpose, the past three years are considered, in order to calculate the centrality measures for the model. Secondly, the betweenness centrality ($betweenness_{avg\ t}$) measures how often a firm is located within the shortest paths of all indirectly connected organizations. In the case of a high betweenness centrality, the company owns the function of a broker within the network who plays an important role for an efficient transfer of information between the organizations. The brokerage is an information advantage for these firms (Gould and Fernandez, 1989), since they are better informed about, for example, new funding offerings, technologies or collaboration opportunities within the funding system. The betweenness centrality is measured by the proposed method of Freeman (1978), which calculates the shortest paths on the basis of the weighted funding network. It is assumed that a high betweenness centrality increases the chance of a firm receiving an additional project grant. Finally, the eigenvector centrality is used to indicate the importance of an organization. As in the previous case, the centrality is calculated on the basis of the weighted funding network. The eigenvector centrality measures the importance of a firm, based upon the importance of its neighbors, which entails a self-referential problem that can be solved due to the eigenvector of the funding network (Jackson, 2008; Bonacich, 1987). Therefore, the eigenvector centrality indicates the interconnectedness of an organization within the overall network, which leads to the assumption that a high eigenvector centrality entails a higher chance of obtaining a further project grant. It is worth mentioning that all the average values of the variables during the possible events are highly different from each other (Table 3).

The third hypothesis, ***H3***, assumes that the chance of receiving an additional project grant depends on the diversity of knowledge within the neighborhood of an organization. Therefore, the heterogeneity of the external knowledge base is measured by the variable $knowledge\ heterogeneity_t$, ranging between the two extrema 0 and 1, indicating the complete divergence and complete congruence of the knowledge base, respectively. Since there is a need for a certain degree of heterogeneity to stimulate the gain of new knowledge, it is expected that both extremes are the least productive situations, because

the genesis of innovations performs best among actors with complementary capabilities. In accordance with Nooteboom (2007) and Mowery (1998), it is assumed that the relation between the heterogeneity and the productivity follows an inverted U-shape, so the optimal value lies somewhere between 0 and 1. Thus, it becomes necessary to implement an additional squared term of the variable to the model. The external knowledge base of a firm i can be explained as the sum of the weighted (w) cognitive proximities among the firm and all its neighbors (K) (Equation (11)). The cognitive proximity is calculated on the basis of the cosine similarity between two vectors (v_i, v_k), with the vectors containing the capabilities of the firm i and the neighbor k, respectively. Again, the values of the current year are excluded due to the possibility of a causality problem.

$$\textit{knowledge heterogeneity}_{it} = \frac{\sum_{k=1}^{K} \textit{cos-sim}_{ikt_{-1}} * w_{ikt_{-1}}}{\sum_{k=1}^{K} w_{ikt_{-1}}} \qquad (11)$$
$$\text{with} \qquad \textit{cos-sim}_{ikt} = \frac{v_{it} * v_{kt}}{\|v_{it}\| \, \|v_{kt}\|}$$

The capabilities of an organization are manifested in the technological knowledge of an organization, thus it is assumed that the capability vector v can be described as the number of R&D projects of an organization in different technological fields (Equation (12)). Since each funded project is assigned to a certain category of 24 technological areas (Broekel and Graf, 2012), it is possible to construct the vector using the funding history of an organization by just adding up the number of previous projects of an organization. Each year, 20% of the capabilities of an organization are subtracted, as it is assumed that the organization loses some of its capabilities over time due to, for example, organizational oblivion or labor mobility.

$$v_{it} = p_{it} + v_{it_{-1}} * 0,8 \qquad (12)$$

4.4.2 Other variables

This section is going to introduce the rest of the variables, since the theoretical discussion has shown that other determinants still come into question, affecting the overall allocation process of a project grant.

As previously discussed, it is assumed that the size of a firm matters, due, for example, the economies of scale, the sunk costs or the *'picking-the-winner'* strategy. Therefore, the model includes two different variables indicating the size of an organization, the number of employees (*log employees*$_t$) as well as the annual turnover (*log turnover*$_t$). It is expected that the influence of the two variables is not linear, but behaves digressively, so that the values of the variables are logarithmized. To observe as many firms as possible, some single missing values were interpolated to fill the gaps of the time series. Additionally, a variable is implemented to indicate if the organization is an SME or not, since several subsidy programs are especially designed for those enterprises which have less than 250 employees and no more than 50 million euro of annual turnover (EU, 2006).

The variable *small enterprise*$_{bool\ t}$ is set to 1 if an organization fulfills the condition and to 0 otherwise. Surprisingly, Table 3 gives an unexpected outlook on the opportunities of an SME, since the differences predict a lower chance of an SME obtaining a new project grant.

Another determinant that plays a role is the age of the firm. Similar to smaller firms, younger firms normally have scarce resources in combination with limited access to the financial market. This entails a kind of disadvantage for younger firms, which should be compensated for by the governmental innovation policy. The variable *log age*$_t$ is also logarithmized, as it is assumed that each additional year counts less to receive a new project grant. Table 3 does not clearly support this trend, since both T-tests are significant, but predicts contrary results for a new and an additional project.

As mentioned earlier, it is possible for organizations to gain experiences through participation in former project. Due to the routine of these practices, further applications become easier and the probability of receiving a project grant increases, since preexisting information channels enable an information advantage compared to other organizations. To measure the effect, two variables are included in the model. The first variable *project*$_{bool\ t}$ explains if an organization has received a project funding within the preceding three years, using the values of 0 and 1, with the current year being excluded due to the already mentioned causality problems. The same is true for the second variable *project*$_{count\ t}$, with the difference being that the variable counts the number of projects of the last three years. For both variables, Table 3 indicates a positive influence of the former project experiences.

Former R&D expenditures are advantageous for an organization, since the investment of scarce resources sends a positive signal to the expert group or possible partners, implying that the firm believes in its own success. Because the database contains no information about the internal R&D investments of a firm, it is necessary to approximate this information. Therefore, the R&D expenditures are estimated by the number of scientific publications, as it is assumed that an organization which invests in research and the development of new products is also willing to inform the public about its research results, which can also be seen as a kind of product marketing. Two variables were constructed on the basis of the '*Web of Science*' database. The first variable (*publication*$_{bool\ t}$) indicates whether an organization has published a scientific publication since 1990 or not, whereas the second variable (*log publication*$_{count\ t}$) counts the number of publications during that period. It is assumed that each additional publication is less important, thus the number of publications is logarithmized. Due to the mean values of the variables in Table 3, it is expected that having one or more publications positively affects the likelihood of receiving a new project grant.

Moreover, the sectoral affiliation of a firm should increase the chance of obtaining project funding, since some branches are more R&D related than others (Broekel and Graf, 2012) or specific subsidization programs were designed to support a specific industry sector (Eickelpasch and Fritsch, 2005). Because of this, a set of variables is included to capture the industry effect, with each variable indicating whether an organization belongs to a sector or not. The sectoral distinction is possible due to the German classification scheme of economic activities. Seven variables were included to indicate whether

a firm belongs to the food, textile, wood, chemical, machinery industry or another category. Table 3 supports this, since sectors with a higher tendency to invest in R&D, such as the machinery and chemical industries, are more likely obtain a new project funding compared to the rest.

The intensity of public subsidies differs among the regions in Germany (Fornahl and Umlauf, 2014), especially because funding programs are sometimes intended for the development of regions (Eickelpasch and Fritsch, 2005). One special event was the German reunification (Aschhoff, 2009), which led several promotion programs for eastern states of Germany, thus it is assumed that the location of the firm's headquarters in one of the new states of Germany increases the likelihood of a company receiving a new project fund. To capture this effect, the variable $east_{bool\ t}$ includes the value 1 if the firm's headquarters lie in the eastern states, or 0 otherwise.

The Condition Index (CI) was calculated for all explanatory variables in order to analyze whether the estimation process could be affected by collinearity problems or not (Belsey et al., 1980; Greene, 2002). The index rejects the possibility of collinearity within the explanatory data, since the calculated CI-value 29.79 does not exceed the conservative upper bound of 30.

5 Results

For the verification of the hypotheses, three different models were estimated. Since no variables were deleted from each subsequent model, it is possible to observe which variables lose their explanatory power due to the inclusion of network-related determinants. The model results of the maximum-likelihood estimation are presented in Tables 4, 5 and 6, including the parameters, t-values and the significance of the exogenous determinants. Due to the Akaike information criterion (AIC), it is possible to compare the quality of the estimated models.

The formulated hypotheses aim to prove the importance of network-related determinants for the overall allocation process of a project grant. The variables $cooperation_{bool\ t}$ and $cooperation_{count\ t}$ were included in order to check hypothesis ***H1***, which argues that the participation of an organization in a joint project raises the probability of the organization receiving a further project grant. Interestingly, both variables remain insignificant within the first model, but, even more surprisingly, the variable $cooperation_{count\ t}$ becomes significantly negative in the second and third models for a new project funding (event II). This is contradictory to hypothesis ***H1*** and the theoretical approach, since the reverse seems to be true. The explanation for this empirical finding is based on a trend which dates back to the 1990s. The year 1999 was the first year in which the number of joint projects exceeded the number of funded projects single (Figure 7). The trend continued until the year 2012, so that the number of joint projects exceeds the funded projects single by 38.3%. This ratio is low compared to the ratio within the model data (Figure 7), since the number of funded joint projects, exceeds the number of single projects in 2012 by approximately 681%. Induced by the switch in 1999, receiving a plain project grant has become something exclusive. Because of this, the second and

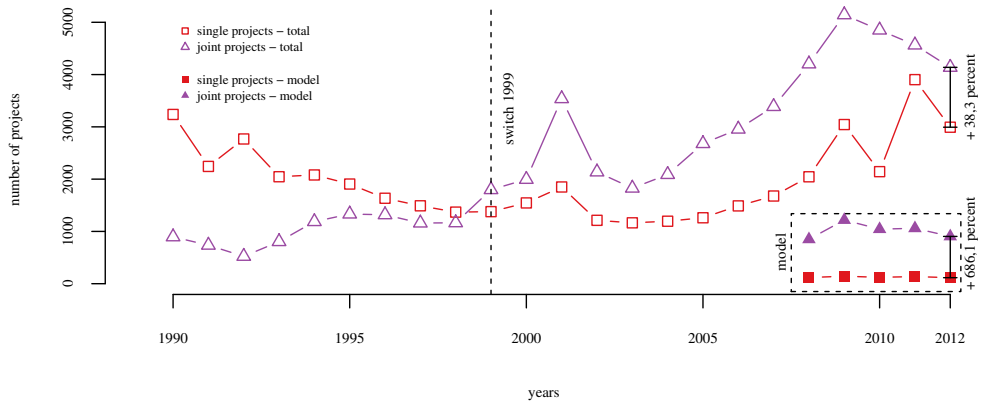


Figure 7: Number of projects per year

third models are right - if they indicate a higher chance of organizations with less cooperative projects but therefore more single project grants - since the difference between the estimated variables $project_{count\ t}$ and $cooperation_{count\ t}$ is still positive.

The second hypothesis, ***H2***, goes into more detail, asking whether the centrality of an organization increases the likelihood of receiving a new project grant. The centrality of an organization was operationalized through the degree, the betweenness and the eigenvector centrality within the funding network. The centrality variables were implemented within the second and third models. The expectations are basically confirmed, since the degree and the eigenvector centrality are significantly positive in the second model. Interestingly, the betweenness centrality ($betweenness_{avg\ t}$) does not reach any significance for either the *event II* or the *event IV*, which leads to the result that the ownership of a broker position within the network neither stimulates nor diminishes the chance of an organization obtaining a project grant. This could be an indication that organizations refuse to participate in communication over long network distances. In contrast, the degree centrality ($degree_{avg\ t}$) is positive and highly significant for both events, so the more connected an organization is to other organizations, the higher the likelihood of an organization to obtain a new project grant. How sociable a company is thus play a central role within the funding regime. The more contacts an organization has, the more potential partners the organization has gained for further collaborations. Interestingly, the strength of the degree parameter for the *event II* is twice as high as the degree parameter for the *event IV*, which could indicate that other factors play a role if the organizations want to obtain a further project grant. The eigenvector centrality seems to fill this gap, since the variable $eigenvector_{avg\ t}$ behaves contrarily to the degree centrality. Both estimated parameters are positive and significant within the second model, but the explanatory power and the impact of the estimator is higher in the case of the *event VI*

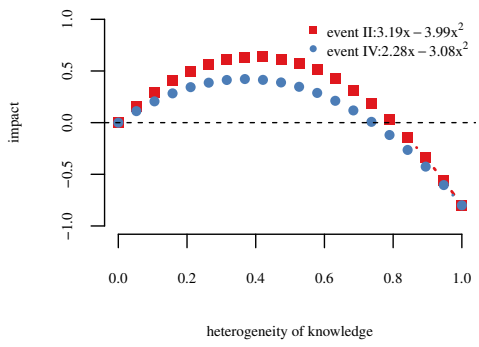


Figure 8: Effect of knowledge heterogeneity

and thus more relevant in obtaining an additional project grant. To receive an additional R&D project grant (*event VI*) it is even more relevant to whom an organization is connected, whereas it is more important to have a lot of connections within the network if an organization seeks a project grant without having ongoing funding (*event II*). Therefore, the overall network position of an organization is the second-most important network determinant, which shapes the allocation process of a project grant. Hypotheses ***H3*** assumes that a specific mixture of heterogeneity within the neighborhood of an organization has a positive impact on the likelihood of an organization obtaining a new project grant. In contrast to the previous hypothesis, which concentrates on the centrality of an organization, this hypothesis seeks a balance within the relationships of an organization. To estimate this effect, the variables $knowledge\ heterogeneity_t$ and $knowledge\ heterogeneity_{square\ t}$ were added to the third model, whereby the quadratic variable is necessary to analyze whether the relation follows an inverted U-shape or not. The estimated model parameters support hypothesis ***H3***, even if the significance of the parameter for the *event IV* lies a bit below their counterparts. It is most satisfying that the value of the first variable is always positive and the squared variable is always negative, which supports the parabolic relationship between the variable and the chance of a new project grant. This shows that organizations seek a certain ratio of familiar and new knowledge, so that it is possible for a company to acquire new capabilities during the project duration. For a closer look Figure 8 presents the estimated curves for the inverted U-shaped relationships. Both curves reach their maximum close to 0.4. If the similarity of the knowledge within the neighborhood reaches an index value of 0.8, the effect becomes negative, thus the likelihood obtaining a new project grant is deceased.

The remaining variables are used to calibrate the model. All of them are in line with the theory or previous studies so that they do not question the importance of the network determinants. The results of the three models are almost identical concerning the estimated parameters, since the observed small deviations do not affect the overall

significance of the results. Therefore, the variables will be presented on the basis of the first model.

The constant defines, somewhat, the baseline probability of an organization obtaining a new or further project grant. Irrespective of the other determinants, it depends on the present funding status of a firm as to whether the chance of a company receiving a new project grant is 0.2% or 4.7%. Therefore, it seems to be the normal case that a company does not receive subsidization. Moreover, the model proved the preferential treatment of younger companies ($log\ age_t$) within the funding system, since older firms are less likely to get a further project grant, possibly is to mitigate the high risk of an R&D investment or to reduce the free-rider effect. The size of the company is represented within the model by the number of employees ($log\ employees_t$) and the annual turnover ($log\ turnover_t$). The assumption that the size of the firm positively affects the likelihood of an organization obtaining a new project grant is broadly supported, since only the $log\ turnover_t$ variable is insignificant in obtaining of a further project grant. All estimated values are positive without exception. The size of the firm has a higher relevance to those firms that have not received a previous project grant, as the overall significances and parameter values are higher for the *event II*. Due to their size, larger firms are less affected by fixed costs or other risks in comparison to SMEs, since the variable $small\ enterprise_{bool\ t}$ is insignificant. Not even special programs for SMEs seem to drastically change their chances of obtaining a project grant. Another possible explanation for this could be, that the expert group favors already established enterprises, in order to reduce the chance of a project aborted (*'picking-the-winner'*).

It was assumed that the location of the firm's headquarters within the eastern states of Germany has a positive impact. Therefore, the variable $east_{bool\ t}$ was constructed to capture whether the location of the headquarters has an impact or not. The expectation is validated for the *event II*, since the estimated parameter is positive and strongly significant, but not for the *event IV*.

There can be no doubt that previous project experiences stimulate the chances of an organization obtaining a new project grant. Both variables $project_{bool\ t}$ and $project_{count\ t}$ were found to be positive and highly significant. The $publication_{bool\ t}$ variable was excluded from the estimation process for the *event IV*, since the variable is identical to the regression constant. The findings proved that companies can benefit from their former experiences, which leads to a reduction of the information asymmetry between the firm and other stakeholders in the allocation process.

The extent of former R&D investments was approximated by the scientific engagement of a firm within the academic discussion. Two variables, $publication_{bool\ t}$ and $publication_{count\ t}$, were included in the model to capture this effect. Interestingly, only the variable $publication_{bool\ t}$ has a positive effect for the case of new funding. All the other cases remain insignificant. Maybe these variables are outperformed by the previous project experiences, since both indicators refer to experiences in R&D investments.

Interestingly, most of the sectoral parameters are negativly significant for those companies, that receive a new project without having a previous one. This can be observed for the food, textile, wood and metal industries. Only firms within the machinery industry, and those firms who fall within the 'others' category, have a higher chance of receiving

a new project. For the case of an additional project (*event IV*), only the parameter of the machinery industry remains significant. This means that firms that have previously gained a project are relatively equal, except those firms from the machinery sector.

Table 4: results model 1

	unsubsidized → subsidized				subsidized → newly subsidized			
variable	parameter	s.d.	t-value	sign.	parameter	s.d.	t-value	sign.
constant	-6.12	0.17	-35.78	***	-3.10	0.45	-6.89	***
log age_t	-0.28	0.03	-9.50	***	-0.11	0.07	-1.68	.
log $employees_t$	0.35	0.04	8.84	***	0.02	0.08	0.31	
log $turnover_t$	0.11	0.03	3.56	***	0.14	0.06	2.11	*
small $enterprise_{bool\ t}$	-0.01	0.08	-0.07		0.19	0.18	1.10	
$east_t$	0.43	0.07	6.32	***	-0.11	0.16	-0.71	
$project_{bool\ t}$	2.50	0.26	9.80	***				
$project_{count\ t}$	0.40	0.15	2.59	**	0.29	0.07	4.07	***
$publication_{bool\ t}$	0.76	0.11	7.19	***	0.26	0.17	1.54	
log $publication_{count\ t}$	-0.01	0.06	-0.24		0.05	0.08	0.62	
$cooperation_{bool\ t}$	-0.27	0.26	-1.01		0.14	0.32	0.45	
$cooperation_{count\ t}$	-0.07	0.16	-0.43		0.11	0.08	1.43	
food $industry_{bool\ t}$	-1.06	0.19	-5.47	***	-0.62	0.65	-0.96	
textile $industry_{bool\ t}$	-0.52	0.18	-2.80	**	-0.24	0.55	-0.44	
wood $industry_{bool\ t}$	-0.75	0.13	-5.79	***	-0.61	0.45	-1.37	
chemical $industry_{bool\ t}$	0.07	0.07	1.04		0.00	0.16	0.01	
metal $industry_{bool\ t}$	-0.26	0.06	-4.09	***	-0.07	0.15	-0.48	
machinery $industry_{bool\ t}$	0.53	0.07	7.92	***	0.51	0.16	3.24	**
$others_{bool\ t}$	0.32	0.08	3.79	***	0.20	0.19	1.06	
log-likelihood	-7937.0				-1046.9			
AIC	15915.9				2129.7			

comment: significances of the parameter: *** 0.1%, ** 1%, * 5%, . 10%

6 Conclusion

The aim of the paper was to analyze whether the network-related determinants are relevant in obtaining a project grant or not. The preceding theoretical and empirical investigation of the funding system has shown that the allocation process is more than just a stochastic process, since some organizations seem to remain permanently within the funding system, while other organizations leave the system sooner or later. Some determinants were previously identified by other authors, but, interestingly, none of them have taken network effects into account, which appears even more dubious since joint projects have become a popular policy instrument in Germany. Therefore, three theoretical hypotheses, coming from distinctive network perspectives, were presented and estimated within an empirical model. Firstly, the hypothesis that the participation of an organization in a joint project raises the probability of the organization receiving a new project grant, was rejected. This was surprising and counterintuitive, but explainable due to the large amount of single projects for a relatively exclusive group of firms. The government has to be aware of this effect, which results from current R&D policy, since this indicates the privilege of a small group, which could ultimately lead to government failure. Secondly, the hypothesis that the centrality of an organization stimulates the chance of a new project grant, was broadly supported. Three measures were employed to test the most well-knows centrality measures of networks. The degree was found to be the most important one, indicating the high significance of preexisting information

Table 5: results model 2

	unsubsidized → subsidized				subsidized → newly subsidized			
variable	parameter	s.d.	t-value	sign.	parameter	s.d.	t-value	sign.
constant	-6.05	0.17	-35.28	***	-2.92	0.45	-6.44	***
log age_t	-0.28	0.03	-9.51	***	-0.12	0.07	-1.81	.
log $employees_t$	0.33	0.04	8.48	***	-0.01	0.08	-0.07	
log $turnover_t$	0.12	0.03	3.59	***	0.13	0.06	2.02	*
small $enterprise_{bool\ t}$	-0.02	0.08	-0.30		0.13	0.18	0.73	
$east_t$	0.43	0.07	6.27	***	-0.15	0.16	-0.93	
$project_{bool\ t}$	2.37	0.25	9.30	***				
$project_{count\ t}$	0.40	0.15	2.63	**	0.29	0.07	4.16	***
$publication_{bool\ t}$	0.71	0.11	6.62	***	0.21	0.17	1.22	
log $publication_{count\ t}$	-0.01	0.06	-0.16		0.09	0.08	1.08	
$cooperation_{bool\ t}$	-0.19	0.27	-0.71		0.24	0.32	0.77	
$cooperation_{count\ t}$	-0.38	0.17	-2.26	*	-0.06	0.08	-0.78	
$degree_{avg\ t}$	0.08	0.01	6.74	***	0.04	0.01	3.70	***
$betweenness_{avg}$	-5.1E-07	9.5E-06	-0.05		3.7E-06	4.6E-06	0.79	
$eigenvector_{avg\ t}$	2.76	1.63	1.70	.	4.00	1.47	2.72	**
food $industry_{bool\ t}$	-1.05	0.19	-5.39	***	-0.50	0.65	-0.76	
textile $industry_{bool\ t}$	-0.52	0.19	-2.79	**	-0.29	0.57	-0.52	
wood $industry_{bool\ t}$	-0.75	0.13	-5.78	***	-0.65	0.46	-1.42	
chemical $industry_{bool\ t}$	0.09	0.07	1.22		0.04	0.16	0.27	
metal $industry_{bool\ t}$	-0.27	0.06	-4.13	***	-0.10	0.15	-0.63	
machinery $industry_{bool\ t}$	0.51	0.07	7.60	***	0.48	0.16	3.01	**
$others_{bool\ t}$	0.31	0.08	3.69	***	0.14	0.20	0.71	
Log-Likelihood	-7908.6				-1033.1			
AIC	15861.21				2108.3			

comment: significances of the parameter: *** 0.1%, ** 1%, * 5%, . 10%

Table 6: results model 3

	unsubsidized → subsidized				subsidized → newly subsidized			
variable	parameter	s.d.	t-value	sign.	parameter	s.d.	t-value	sign.
constant	-6.04	0.17	-35.23	***	-2.84	0.46	-6.22	***
log age_t	-0.29	0.03	-9.58	***	-0.12	0.07	-1.82	.
log $employees_t$	0.33	0.04	8.45	***	-0.01	0.08	-0.11	
log $turnover_t$	0.12	0.03	3.65	***	0.13	0.07	1.96	*
small $enterprise_{bool\ t}$	-0.03	0.08	-0.32		0.11	0.18	0.62	
$east_t$	0.44	0.07	6.39	***	-0.13	0.16	-0.82	
$project_{bool\ t}$	2.38	0.26	9.33	***				
$project_{count\ t}$	0.41	0.15	2.65	**	0.28	0.07	4.00	***
$publication_{bool\ t}$	0.71	0.11	6.54	***	0.19	0.17	1.12	
log $publication_{count\ t}$	-0.03	0.06	-0.45		0.08	0.08	0.96	
$cooperation_{bool\ t}$	-0.45	0.32	-1.41		0.10	0.39	0.26	
$cooperation_{count\ t}$	-0.36	0.17	-2.11	*	-0.06	0.08	-0.72	
$degree_{avg\ t}$	0.07	0.01	6.05	***	0.04	0.01	3.38	***
$betweenness_{avg}$	4.8E-07	9.6E-06	0.05		3.4E-06	4.6E-06	0.73	
$eigenvector_{avg\ t}$	-0.09	0.11	-0.80		3.48	1.45	2.41	*
knowledge $heterogeneity_t$	3.22	0.88	3.67	***	2.34	1.02	2.29	*
knowledge $heterogeneity_{squared\ t}$	-4.04	0.88	-4.60	***	-3.14	0.99	-3.17	**
food $industry_{bool\ t}$	-1.05	0.20	-5.36	***	-0.45	0.66	-0.68	
textile $industry_{bool\ t}$	-0.51	0.19	-2.76	**	-0.27	0.57	-0.48	
wood $industry_{bool\ t}$	-0.75	0.13	-5.78	***	-0.63	0.46	-1.36	
chemical $industry_{bool\ t}$	0.08	0.07	1.12		-0.02	0.16	-0.14	
metal $industry_{bool\ t}$	-0.26	0.06	-4.03	***	-0.08	0.15	-0.50	
machinery $industry_{bool\ t}$	0.51	0.07	7.58	***	0.46	0.16	2.82	**
$others_{bool\ t}$	0.30	0.09	3.53	***	0.12	0.20	0.63	
Log-Likelihood	-7893.6				-1024.1			
AIC	15835.3				2094.1			

comment: significances of the parameter: *** 0.1%, ** 1%, * 5%, . 10%

channels, and trustworthy relations with other organizations, for securing new funding opportunities. No other network effect was similarly significant, but the variable loses some of its explanatory power if an organization obtains additional funding. This gap was closed by the eigenvector centrality, so that both centrality parameters seem to complement one another. This entails that the obtaining of an additional project grant requires a central position within the overall network, whereas an organization without a prior funded project needs to have a high degree centrality. Surprisingly, brokers do not own a privileged position within the funding system, since the parameters of the betweenness centrality were insignificant. Firms seem to prefer to communicate within their direct neighborhood, thus bridging links are less necessary for the communication patterns within the funding system. Overall, it seems necessary to keep a useful scope of centrality on the one hand and enough openness for new competitors within the funding system on the other hand, since the high impact of the network effects signals a tendency of the funding regime to reproduce itself. Finally, a diverse external knowledge base is significant for an organization to obtain a new funding project. Since this finding was important for both situations, for a new as well as for an ongoing project grant, all involved stakeholders in the allocation process seem to acknowledge the high importance of a certain extent of heterogeneous capabilities within an R&D project in order to stimulate the innovational outcome. Further research questions arise, due to the limitation of this paper, in that only successful project applications have been taken into account. To conclude whether the funding regime is systematically reproducing itself or not, it is necessary to also include the rejected project proposals within the analysis. Without these observations there can be no final certainty, as to whether the patterns evolve because of the strong network effects or due to a low number of applicants.

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