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When Research Meets Development: Antecedents and Implications of Transfer Speed

Jingshu Du, Bart Leten, Wim Vanhaverbeke and Henry Lopez-Vega

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**When Research Meets Development:
Antecedents and Implications of Transfer Speed**

Abstract

In this paper, we focus on the organization of new product development in large, R&D-intensive firms. In these firms, research is often conducted in dedicated projects at specialized research labs. Once research results are achieved by project teams, they are transferred to business units for further development and commercialization. We investigate the speed whereby research projects transfer their first research results to business units (hereafter: *transfer speed*). In particular, we analyze the antecedents and performance implications of transfer speed. Based on data of 503 research projects from a European R&D intensive manufacturing firm, our results suggest that a fast transfer speed (as measured by the time it takes for a research project to develop and transfer first research results to business units) is associated with a better research performance (as measured by the total number of transfers the research project generates). Moreover, we find that different types of external R&D partners— science-based and market-based partners— play distinct roles speeding up first research transfers. While market-based partnerships (customers and suppliers) generally contribute to a faster transfer of research results, science-based partnerships (universities and research institutions) only speed up research transfers of technologically very complex projects. Our results also show that early patent filings by research projects accelerate first research transfers.

Keywords:

Transfer speed, R&D partnerships, Open innovation, Patent applications, New product development

Introduction

New product development (NPD) is at the heart of corporations' survival and renewal in today's competitive industrial landscape. In many industries, new products account for more than 50 percent of firms' annual sales (Schilling and Hill, 1998) and NPD is perceived as a key management imperative (Cooper and Edgett, 2009). However, new product development is challenging and suffers from high failure rates (Castellion and Markham, 2013). The highest attrition rate occurs in the pre-development (research) phase (Cooper and Edgett, 2009) which features great risks and uncertainties. For instance, in the pharmaceutical industry, more than half of the research projects fail (Paul et al., 2010). Despite the high fall-off rate in the research phase, research activities strongly determine future product success (Markham, 2013) and greatly differentiate winners from losers on the market (de Brentani and Reid, 2012). Therefore, carefully managing the research phase is of paramount importance to improving the overall success of NPD activities.

In large R&D-intensive companies, research efforts are often separated from development activities (von Zedtwitz and Gassmann, 2002). By centralizing research in research labs, firms can benefit from economies of scale, reduce transaction costs associated with internal coordination, and generate more impactful research findings (Argyres and Silverman, 2004). Product development, on the other hand, is usually conducted by business units to create new product offerings to satisfy specific market needs. Once a tangible research result is achieved in research labs, this result will be transferred to business unit(s) which are interested in the further development and commercialization. As such, transfers symbolize successful research outcomes, and serve as the single most important input for business units in their development and commercialization activities (Chesbrough, 2006). Only transferred research results have the chance to be commercialized and launched in the marketplace, which makes

the transfer of results from research to development a crucial step for the overall success of new product development.

Despite its importance, the transfer of research results from research labs to business units remains an area which has not yet received scholarly attention in the NPD literature (Markham, 2013). While there are many aspects that relate to research transfers, in this paper we focus on the *speed* of the first research transfers from research labs to business units (hereafter: *transfer speed*). In the existing literature, speed (or ‘cycle time’) is pointed out as one of the most critical factors in the overall success of new product development (e.g. Cankurtaran et al., 2013), but speed of intra-firm transfers from research labs to development units has not yet been studied¹. Moreover, as increasingly more companies and their projects open up and collaborate with external partners (Chesbrough, 2003, Du et al., 2014), there is also a burning need in the open innovation literature to examine the effect of open innovation strategies on the speed aspects. In this paper, we therefore study the antecedents and implications of *transfer speed*. More specifically, we investigate the effect of having a fast (or slow) first transfer on the performance of research projects. Further, we examine the effects of (early) patent filings and two types of open innovation partnerships – market-based and science-based R&D partnerships – on transfer speed, taking into account the moderating effect of the technological complexity of the research project.

To investigate the antecedents and performance implications of transfer speed, we rely on a unique dataset of 503 research projects from a large European R&D-intensive manufacturing firm. This company has an annual R&D budget above 1 billion euros during the entire observation period (2003-2010) and its activities span a variety of industries. Our findings show that research projects that generate fast first transfers are associated with a better

¹ Transfer speed is different from the concept “fuzzy front end cycle time” (e.g. in Eling et al, 2013), with the latter referring to the time it takes a project to complete the fuzzy front end activities such as opportunity identification, idea generation and screening, concept development, project planning, etc.

research performance. Fast transfers enable research projects to collect early feedback from business units and help to secure further research funding by sending a positive signal to the research sponsors on the qualities of the research project. Moreover, we find that while market-based partnerships speed up research transfers in general, science-based partnerships are only linked to the acceleration of research transfers of technologically (very) complex projects. Finally, research projects that apply for patents early on in the research process are more likely to generate fast first transfers to business units.

The remainder of the paper is structured as follows: The next section provides the theoretical background of the paper. The subsequent section presents our five hypotheses. This is followed by a description of the data and research methods used in this paper. The paper concludes with a discussion of the theoretical and empirical implications, the limitations and avenues for further research.

Theoretical Background

A theory that underlies the mechanism of transfers and transfer speed from research labs to business units is the *intra-firm transaction theory* (Rotemberg, 1991). In intra-firm transactions, intermediate goods are produced and transferred between agents of the same firm (Kotabe, 1992). In the intra-firm transfer process, it is often difficult for the ‘buyer’ agent to assess upfront the quality of the intermediate goods (potentially) transferred from the ‘supplier’ unit, particularly when the goods are still in their early phase of development which is characterized by technological and market uncertainty. An important indicator for the ‘buyer’ to signal the quality of the intermediate goods is *the time or speed by which the intermediate goods are delivered* (Rotemberg, 1991). Delivery time can be influenced by two factors: First, the supplier’s choice of delivery. For instance, the supplier of intermediate goods may act cautiously and wait purposively until the goods are perfected before

transferring it to the buyer agent. Second, the supplier is genuinely incompetent to deliver high-quality goods in time (Allen and Faulhaber, 1988, Rotemberg, 1991). When the delivery of intermediate goods takes a long time, it is hard for an interested buyer to ascertain which of the two aforementioned situations (e.g.: prudence or incompetence) holds true (Rotemberg, 1991). Fearing the second possibility, the potential buyer may decide not to accept the intermediate good when it takes a long time for a supplier to deliver that good (Rotemberg, 1991). It follows that a competent supplier needs to show its competence early on to potential buyers in order to rule out a perception of being incompetent in the eyes of the latter. In other words, if the supplier is sound and capable of delivering high-quality goods, the time frame in which he/ she delivers these goods (*transfer speed*) can be of particular importance to its success in transfers.

In large, R&D-intensive firms, pre-development (research) and development activities are often conducted in different organizational units (von Zedtwitz and Gassman, 2002). Research projects are typically conducted in research laboratories to benefit from economies of scale and scope and reduced transaction costs (Argyres and Silverman, 2004, Belderbos et al., 2013), while the subsequent development of these projects usually takes place in business units that have a better understanding of market needs and can build on their experience to launch new products. Research projects produce research results — usually in the form of intermediate goods (e.g. prototypes, algorithms, models) — and transfer these intermediate goods to business units for further development and commercialization.

In this transfer process, research projects operate as a cost center and function as the internal suppliers of intermediate goods (research output) to business units. Business units, by contrast, act as a profit center and represent the internal buyers of the research results of research projects (Chesbrough, 2006). Business units have limited budgets to spend, and the profits they make on the market depend on the business success of the research outputs they

transfer in from research projects. As a result, business units have to constantly screen the quality of research outputs of research projects and select the most promising ones (Chesbrough, 2006). The ability of business units to make the right transfer decisions— to evaluate and select the most promising research projects (and the intermediate goods they provide) in the early research phase when little information is known— is essential (Cooper and Edgett, 2009).

An important element in the intra-firm transfer process from research projects to business units is the speed of the first transfer. Fast first transfers have a signaling function and may increase the confidence of business units in the capabilities of the research project. In the existing NPD literature, product development speed or NPD cycle time has been pointed as one of the most critical factors in the success of new product development (e.g. Brown and Eisenhardt, 1995, Cankurtaran, et al., 2013, Schilling and Hill, 1998). Numerous studies have elaborated on the importance of NPD speed, as it helps the firm to establish technology standards, jump ahead on the learning curve, respond rapidly to customer needs, and enjoy more alternatives than slower innovators (Cankurtaran, et al., 2013, Chen et al., 2010, Langerak and Hultink, 2006). However, little is known about the speed of intra-firm research transfers by which research results are transferred from research projects to business units, and to what extent research transfer speed may be linked to the performance of research projects.

In the intra-firm transfer process, research projects can adopt different strategies which may influence the transfer speed of research results. One strategy might be to open up and collaborate with external partners (Chesbrough, 2003, Grant and Baden-Fuller, 2004, Hagedoorn, 1993). The open innovation literature distinguishes between two important types of external R&D partnerships: science-based and market-based partnerships (Danneels, 2002, Du, et al., 2014, Faems et al., 2005). Science-based partnerships are collaborations with

universities and research institutes. These partnerships provide research projects access to scientific knowledge (Cockburn and Henderson, 1998, Fabrizio, 2009). Market-based partnerships consist of players with a close link to the market, such as suppliers and customers (Danneels, 2002, Faems, et al., 2005). Relationships with market-based players provide research projects with the latest technologies that are available on the market and first-hand information on market needs (Von Hippel and Katz, 2002). Research projects that combine multiple knowledge sources and leverage the best available expertise from both within and outside the firm are better positioned to make progress in research and to achieve faster research transfers. Besides access to unique knowledge, R&D partnerships can also improve the efficiency with which research projects conduct research (Grant and Baden-Fuller, 2004). Access to external knowledge may be especially important for research projects that are conducted in “complex” technology fields in which the new product consists of multiple components (Cohen et al., 2000, Harhoff and Reitzig, 2004) and in-house knowledge on some components may be missing. A second strategy for research projects to speed up the transfer of research results to interested business units may be filing early on for patent protection of their research results. Research projects with early patent filings are attractive to business units since research findings are (partly) codified and, if granted, patents offer exclusive monopoly rights (Arora and Ceccagnoli, 2006, Hall et al., 2005).

Hypotheses

In this section, we develop hypotheses on the antecedents and performance implications of transfer speed. We first investigate the relationship between transfer speed and the performance of research projects (H1). Next, we examine three potentially influential factors of transfer speed: market-based partnerships (H2) and science-based partnerships (H3)—

with the moderating effect of technological complexity (H4), and early patent applications (H5). Figure 1 provides a schematic overview of the research framework.

Insert Figure 1 about here

Transfer Speed and the Performance of Research Projects

We expect that the speed at which a research project transfers its first research result to business units (transfer speed) is an important driver of the success of the research project, for the following three reasons:

First, a fast transfer speed may positively signal the research capabilities of the research team. Research is characterized by high risks and great uncertainties. As a result, many research projects fail to reach satisfying research results. These ‘hanging’ projects consume valuable resources. Therefore, ‘detect and kill the failing projects early in the NPD process’ (Cooper, 2008) is oftentimes put forward as a golden rule – which prompts for the efficient use of valuable resources and cost savings by unplugging bad projects early on and redirecting resources to the more promising ones. Financial sponsors of research projects (often business units) therefore constantly screen the progress of their project portfolio, and are ready to stop the further financing of under-performing projects. Research projects that manage to quickly generate and transfer their first research results give a strong signal to their sponsors about their capabilities to successfully tackle their research tasks, which, in turn, may help them secure further financing, rather than being filtered out early in the research process.

Second, fast first transfers enable research projects to collect early feedback from recipient business units. The early feedback may serve as valuable input for the on-going research of the research projects, and may help them improve the quality of their work (Von Hippel,

1986). Third, research projects that have first transfers early on also allow the recipient business units to seek a sharp product definition (Cooper and Edgett, 2012, Cooper et al., 2004) and to learn beforehand about the value creation possibilities of the technologies under research (Chesbrough, 2003). Fast first transfers may therefore help to increase the attractiveness of the research result to potential recipient business units. In sum, we hypothesize that:

H1: Research projects with a fast transfer of first research results (transfer speed) are linked to a better research performance.

Market-Based Partnerships and Transfer Speed

Market-based partnerships consist of players with a close link to the market, such as suppliers and customers (Danneels, 2002, Du, et al., 2014, Faems, et al., 2005). We expect that market-based partners help research projects to speed up the transfer of first research results, because of the following reasons:

First, in research projects, defining and clarifying a specific research question as well as setting clear-cut research goals (Griffin, 1993) may take considerable time if the project team is working on its own without a clear view on what the market wants. When partnering with market-based partners, the project team gets equipped with up-to-date market information and timely adjustments of such information (Ulwick, 2002, Woodruff, 1997), which may enable the project team to detect and respond faster to market needs, and to speed up the development and transfer of their first research results to business units.

Second, market-based partners, and especially lead customers, tend to be concerned with the timely execution of research projects as this reduces the time to deliver new solutions to serve their needs (von Hippel, 1986). Such market-pull factors (Chidamber and Kon, 1994) may

give additional momentum to the research team to speed up the development and transfer of first research results to business units. Research projects that are conducted in collaboration with market-based partners may also be more appealing to potential recipient business units, as these projects are geared towards solving an (unmet) market need which is verified by their market-based partners.

Third, market-based partners provide market insights to the research project, which enable early testing and fast failing in the research process, what reduces the possibilities of rework and mistakes. A large portion of prolonged research activities in the NPD process stem from rework and mistakes (Kahn et al., 2005). As research is highly risky and uncertain, timely feedback is necessary because it points out ways for improvement and adjustment before substantial rework is needed (Harrison and Waluszewski, 2008), which reduces the time that is needed to develop and transfer first research results. Taken together, we hypothesize:

H2: Market-based partnerships enable research projects to speed up the transfer of first research results.

Science-Based Partnerships and Transfer Speed

Next to market-based partners, research projects may also involve science-based partners (i.e. universities and research institutions) in the research process (Du, et al., 2014, Rosenberg, 1990). We expect that science-based partnerships enable research projects to speed up their first research transfers, because of the following reasons:

First, science-based partners bring the research project specific resources and scientific knowledge, which may help to fill in the research gaps the project is facing. Research projects may experience delays in execution because key elements for the desired solution are missing. As research becomes increasingly complex and multi-disciplinary (Brusoni et al.,

2001, Rycroft and Kash, 1999), it is likely that firms do not possess all the necessary capacities in-house (Narula and Hagedoorn, 1999). As a result, working together with science-based partners may help to speed up the research transfer process by leveraging ready-to-use knowledge and technology from experienced scientific partners (Grant and Baden-Fuller, 2004). Slow innovators ‘reinvent the wheel’, instead of actively building on knowledge that already exists (Chesbrough, 2003, Tao and Magnotta, 2006).

Second, collaborating with science-based partners may enable research projects to benefit from a ‘division of labor’, i.e. the partitioning of research tasks among partners. Conducting research in parallel on different tasks may reduce the time to generate transferable research outcomes. Constrained by resource limitations (Barczak et al., 2009, Griffin, 1997), it may be challenging for research projects to simultaneously work on all research tasks. By collaborating with science-based partners, a project team may leverage the resources and expertise of its partners by working in parallel with them, which may shorten the time needed in research, and consequently, accelerate the first transfer of research outcomes to business units.

Third, science-based partners who possess profound scientific knowledge, may accelerate the speed of the first research transfers of by quickly spotting flaws in the research process and solving technical problems that research projects are facing. Science-based partners can also accelerate the generation and transfer of research outcomes by providing research projects with access to advanced scientific equipment and research facilities (Du, et al., 2014, Leten et al., 2013). Taking together, we hypothesize:

H3: Science-based partnerships enable research projects to speed up the transfer of first research results.

R&D Partnerships and Technological Complexity

Because of the distinctive nature of research projects adopting a universal research approach might not be effective (Clift and Vandenbosch, 1999, Kessler and Chakrabarti, 1999). One important dimension of differentiation is technological complexity of the research project. Cohen et al. (2000) distinguish between “complex” and “discrete” technologies. The key difference between both types of technologies is whether inventions are, respectively, comprised of multiple or relatively few patentable elements (Cohen et al., 2000). Research projects in complex technology fields focus on inventions consisting of having multiple functionalities (Griffin, 1997), and for which the overall understanding of all the encompassing components is typically low (Carbonell and Rodriguez, 2006).

Research projects in complex technology fields are expected to benefit more from R&D partnerships. Both types of R&D partnerships may help project teams to develop a better understanding of the large number of components of the new product in complex technology fields (Griffin, 1997; Carbonell and Rodriguez, 2006). It's likely that knowledge on some components is lacking in the firm. External R&D partners may not only provide the research team expert knowledge on specific components, they may also equip the research project with a better overall understanding of the technological and market space in which they search for solutions for the problems they are addressing. As a result, research projects in complex technological fields may benefit more from collaboration with external R&D partnerships, in terms of speeding up their research transfers.

Moreover, in complex technology fields, multiple components interact with each other in determining the functionality of products (Henderson and Clark, 1990). Any single mistake or misfit of one technology component may affect the overall success of the whole invention, resulting in unnecessary delays in product development. Collaborating with external partners

helps the research project access multi-disciplinary scientific and market knowledge, and develop a ‘helicopter view’ on different components and their interfaces in the knowledge architecture (Henderson and Clark, 1990). As a result, it may speed up the development of (first) transferable research outcomes. In sum, we hypothesize:

H4: Science-based and market-based partnerships have a larger impact on the transfer speed of first research results of technologically complex projects.

Patent Filings and Transfer Speed

Besides engaging in R&D partnerships, another important decision for a research project to make is whether and when to file for patents to legally protect its research outcomes. We expect that early patent filings accelerate the speed of first research transfers, for the following three reasons:

First, research projects that apply for patents on newly developed technologies may – if the patents get granted – improve the possibilities of the recipient business unit to appropriate economic value from the transferred technologies, by offering them a temporary monopoly on the use of the technologies (Arora and Ceccagnoli, 2006, Kultti et al., 2007). Patent protection increases the economic value of innovations, which is referred to as the patent premium (Arora et al., 2008, Hall, et al., 2005). Research projects which have already filed for patent applications may be considered as more attractive to business units and the early filings of patents may therefore lead to faster first research transfers.

Second, patent applications imply that research projects have achieved tangible research results. As mentioned before, in intra-firm transactions, business units encounter difficulties in assessing the quality of the research that is executed in projects that they sponsor (Rotemberg, 1991). Patent applications may serve as a signal of the status and quality of the

research activities that are undertaken by research projects, and as such, stimulate fast first research transfers.

Third, research results are a combination of both tacit and codified knowledge (Kogut and Zander, 1993, Nonaka, 1994). To further develop and commercialize research results, the recipient business unit has to develop a deep understanding of the transferred technologies. While codified knowledge can be easily transferred from one unit to another, tacit knowledge prevents efficient sharing between different units (Almeida et al., 2002, Grant and Baden-Fuller, 2004) especially when these units are of distinct nature and are featured with a large cognitive distance (Huber, 2012). This is particularly true for knowledge transfers from research projects to business units. When a research project files for patent applications, it engages in efforts to (at least partly) codify tacit research results by providing detailed descriptions of the functions and mechanisms of the underlying technologies in the patent application file. These detailed descriptions, in turn, may help the potential recipient business unit to better understand the transferred research results. Hence, early patent applications are expected to lead to faster first research transfers. This leads to the following hypothesis:

H5: Research projects can speed up the transfer of first research results by filing (early on) for patent applications.

Methodology

Sample and Data Collection

In this study we use detailed information on research projects from one large European-based R&D-intensive firm. This firm invests heavily in R&D, with an annual R&D budget of more than one billion euro consecutively during all our sample years (2003-2010). There are several reasons as to why we choose a single firm as our sample in this paper: First, in multiple firm studies, each of the firms may develop (slightly) different understanding of the

research phase, transfer speed, and research performance. Given these differences, combining various data sources to form an unified multi-firm dataset is not only challenging but may also engender less accurate results. Second, as we focus primarily on intra-firm transfers of intermediate goods (research outputs), a single firm study enables us to better focus on our major variables of interest, filtering out possible confounding effects at the ‘macro-level’ (e.g. firm level), such as innovation policy, corporate culture. Third, a single firm study also allows us to dig deeper into the phenomenon itself and get fine-grained data, making it possible to collect data on a large set of project-level control variables. This would be much more difficult in multi-firm studies.

Our dataset contains detailed information on 503 research projects that were initiated and executed in the different research labs of the company during the 2003-2010 period². Instead of relying on subjective and retrospective evaluations of managers, this study relies on objective information that is collected from existing internal databases of the sample firm that contain information on project staffing, project management and research outcomes (i.e.: research transfers). Our dataset includes both data on successful and failed research projects (i.e. projects that are exited without proceeding onto the next stage of development). These research projects span many different technological fields. They cover all eight main International Patent Classification (IPC)³ 1-digit technology fields and 44 more detailed IPC 3-digit technology fields. The five top-ranked technological fields in our sample of projects are: G06 (computing, calculating, and counting), A61 (medical science), H04 (electric communication), G01 (measuring and testing), and H01 (basic electrical elements).

² The same data structure has been adopted in prior own research (Du, Leten and Vanhaverbeke, 2014).

³ IPC is a hierarchical technology classification that follows a tiered structure to classify inventions into technology fields. At the most detailed level (represented by a 8-digit code), IPC differentiates between 70,000 technologies. These technologies are aggregated into subclasses (4-digit code), classes (3-digit code) and sections (1-digit code).

The starting date and ending date (in the case of projects ended before 2010) of each research project is recorded in our dataset. A research project can end either because it was terminated, i.e. if it achieved its research goal, or simply because of a lack of research funding, regardless of whether the research was finished or still in progress. During the execution of a research project, research results can be achieved at any point of time. If perceived as valuable by business units, they are transferred to interested business units who are willing to commit resources (time, money, people) to further develop and commercialize these research results into new products and services. As a result, a research project may generate multiple transfers during its lifetime. A transfer implies that a research result is taken over by a business unit, and for which there is documented evidence of its use by this respective recipient. More specifically, a 'transfer' has to fulfill the following criteria:

- A transfer involves a written transfer plan agreed between the research project and the business unit;
- A transfer coincides with a wrap-up of activity in the business unit that aims to utilize the knowledge being transferred from the research project;
- A transfer must conclude with an agreement from the receiving business unit that the transfer has taken place and that the transfer is complete

While there are differences across transfers in the type of research outcomes that are transferred (prototypes, algorithms etc.), the above criteria ensure that transfers are comparable and can be used as indicator of the performance of research projects. This was confirmed in interviews with managers of our sample company, as it uses the number of transfers as key performance indicator of research projects and research labs.

Research projects are initiated by either one of the Business Units of the firm or by Corporate Research. Business Units earn their profits from product sales, and mostly sponsor research that is geared towards clear market needs. Corporate Research is the central research lab and

has an annual R&D budget to sponsor research projects that are of strategic importance to the firm, and which tend to be more general purpose in nature (e.g.: platform technologies which do not cater to the specific needs of any business unit). About half of the research projects are sponsored by Business Units, and the rest are sponsored by Corporate Research. Both sets of projects are executed in the same set of research labs.

There are various types of business units within the firm that can act as recipients of research transfers. Most business units are organized around specific product groups. Besides the main business units which deal with the core business of the firm, the New Business Development (NBD) department explores the internal use of technologies that fall outside the scope of the firm's existing business fields. The Incubator department incubates early-stage technologies that can grow into a new business later on. The business departments— IP & Standards and Licensing— deal with external third parties and are responsible for licensing out or selling technologies that result from research projects for which there is no direct interest by the internal business units in commercializing them.

Insert Figure 2 about here

Business units that received research transfers are often the sponsors of the transferring research projects, but other business units can also ask for a transfer of research results. We have illustrated the transfer process for one hypothetical research project in Figure 2. This research project was initiated by Business Unit 1 and has generated three research transfers. The first two transfers were requested by Business Unit 1 (the sponsor) while the third transfer was requested by Business Unit 2. The project also filed for two patents, one

preceding the first research transfer, and one application that took place between the first and the second research transfer.

Methodology

To test the antecedents and performance implications of transfer speed, we have conducted two different types of empirical analyses.

Transfer speed and project research performance

First, to investigate the relationship between the speed of first research transfer and project research performance we used the Heckman two-step selection model. Since transfer speed can only be measured for research projects that generate at least one transfer, the performance analysis is limited to the subset of projects ($n=170$) with research transfers. The Heckman two-step selection model controls for possible selection effects, due to the non-random nature of the subset of projects with transfers.

We first estimated the probability that research projects generated at least one research transfer – and for whom transfer speed could be calculated – using data on the full sample of 503 projects. We used the dummy variable ‘sponsor department’ as selection variable. This variable takes the value of 1 if a research project was sponsored by Corporate Research, and a value of 0 when one of the firm’s Business Units sponsored the research. We expect that projects which are sponsored by Business Units are more likely to generate a research transfer than projects sponsored by Corporate Research since the former focus on technologies that are directly relevant to at least one business unit, being the sponsor.

This is not the case for projects sponsored by Corporate Research, as they focus more on technologies that are general purpose in nature, but which not directly linked to the needs of a specific business unit. However, despite the expected higher likelihood for Business Units’ sponsored projects to generate one transfer, there are no clear theoretical reasons to expect

systematic differences in the overall performance (total number of transfers) of research projects that have different types of corporate sponsors⁴. As a result, the variable ‘Sponsor department’ qualifies as a selection variable. In the second step, we estimated the relationship between transfer speed and research project performance for the subset of 170 research projects, controlling for possible selection effects by including the inverse mills ratio from the selection equation.

Data on project transfers is used to measure the performance of research projects. A transfer signals a commitment of the recipient business unit and a willingness to invest (time, money, people) to further develop and commercialize the research output. Hence, transfers can be considered as a positive evaluation of the value creation potential of the specific research output by individual business units. In this way, project transfers serve as a valuable indicator of project research performance. The higher the number of research transfers the research project delivers to business units, the better the (perceived) performance of the research project. To control for the skewed nature of this variable, we used the logarithmic transformation of the number of research transfers as our dependent variable.

Antecedents of transfer speed

To explore factors that may affect the (first) transfer speed of research projects, we used event history analysis, also known as survival analysis. Event history analysis has been frequently used in prior studies where ‘speed’ and ‘time’ were focal variable of interest (e.g. Schoonhoven et al., 1990, Zander and Kogut, 1995). Event history analysis has several advantages: First, it takes account both the occurrence and timing of an event while estimating the effects of explanatory variables. Second, it takes care of right-hand censoring problems.

⁴ We have empirically tested this assumption. The dummy variable “sponsor department” turns out to be insignificant when included in the performance equation, using data of the subset of 170 research projects.

The dependent variable measures *how fast* a research project generates a first transfer (the hazard that a project reaches an event—a transfer). We opted for the Cox proportional hazard model (Cox, 1972), since this model requires no upfront assumption concerning the distribution of the hazard rate of project transfers. The Cox model allows the baseline hazard to be fitted from the data. The Cox model specifies the hazard that a project results in a research transfer as the product of a baseline hazard $h(t)$ and a project-specific hazard, with the latter modeled as an exponential function of the model parameters β_x and regressors x_{ij} :

$$h(t|x_{ij}) = h(t) \cdot \exp(x_{ij} \cdot \beta_x)$$

We augmented the Cox model with a stochastic project-level component α_i that controls for unobserved project-specific effects such as differences in project tasks, management styles, and team capabilities (Blossfeld et al., 2007). This project-level component, or shared frailty' term, enters the hazard function in a multiplicative manner and has a mean of 1 and a variance of θ . As we have detailed information about the start and transfer date of each transfer, we detailed our analysis at the monthly level. We also specified the exit time of those projects that stopped before the end of our observation window.

Variables

Transfer speed

We measure transfer speed in the Heckman selection model as the time from the start of a research project to its first transfer of research results, at the monthly level. By the end of our observation period in 2010, 170 of the 503 research projects did already generate research transfers. The remaining research projects were either still on-going or ended already without generating research transfers. The average speed of first research results for the 170 research projects is 1.35 years.

Table 1 gives a brief description of the variables we used in this study. Appendix A and Appendix B show the descriptive statistics and correlations for the dependent and explanatory variables in the event history analysis and in the Heckman two-step estimations, respectively.

Science-based and Market-based partnerships

We have annual information on the involvement of external partners in research projects. More specifically, we know -for each project and year- whether they collaborated with a science-based and/or market-based partner. Science-based partnerships are defined as collaborations with universities and research institutions. Market-based partnerships refer to collaborations with customers and suppliers. Science-based and market-based partnerships are both binary variables that take a value “1” if collaboration with a specific type of partner took place in the research project up to the observation year, and “0” otherwise. In our sample of 503 projects, 286 projects (56,9%) collaborated with both types of partners, 78 projects (15.5%) only with science-based partners, 68 projects (13.5%) only with market-based partners, and the remaining 71 projects (14.1%) had no external R&D partnerships.

Project patent application

Project patent application is a variable indicating the number of patent filings by research projects. The variable is measured annually and indicates the number of patents applied for by the research project at the European Patent Office (EPO) up to the observation year. We focus on EPO patent applications because our sample firm is headquartered in Europe and follows the EPO system for most of its patent applications.

Technological complexity

Technological complexity measures the average complexity of the technologies that are under development in a research project. Technologies are considered complex when they focus on inventions that comprise multiple functionalities (Griffin, 1997) and patentable

elements (Cohen et al., 2000). Prior literature has measured the complexity of technology fields by the average number of patent claims⁵ in patents of that field (Harhoff and Reitzig, 2004; Cohen et al., 2000). To construct our complexity measure, we first calculate the average number of patent claims in each different IPC 4-digit technology field, using data on all EPO patents filed in that technology field worldwide during the period 2000-2010⁶. Second, our measure of the technological complexity of a particular research project is calculated as the average complexity of the different technologies that are under development in that research project. More details on the assignment of research projects to technology fields can be found in the section on control variables. In this paper, we experiment with two different cut-off values to differentiate between less and more complex projects: the 50th and 75th percentile of the complexity values in our sample.

Control Variables

We added the following set of control variables to our analyses:

Project Resources. Project resources have been pointed out as a critical factor determining project success or failure (Barczak, et al., 2009, Carbonell and Rodriguez, 2006). We use the (log-transformed) number of full time equivalent researchers (FTE) working on a research project as proxy of the size and the resource endowments of this research project. This variable is recorded on a yearly basis and calculated in a cumulative way by adding FTEs over the research project's lifetime up to the observation year.

Project Technological Fields. We use a set of dummy variables to denote the technological fields in which the research projects are executed. Research projects that are conducted in different technological fields may face different challenges and generate distinct outcomes (Hall et al., 2003). We have followed a two-step approach to classify projects to technology

⁵ Patent claims provide clear and concise definitions of what the patent legally protects (OECD report, 2009).

⁶ There are approximately 640 different IPC 4-digit technology fields.

fields: First, for projects that have applied for patents, the technology class (IPC) information on their patent applications is used. If a patent contains multiple technology classes, a project is assigned to multiple technological fields. Second, the remaining projects that have not (yet) applied for a patent are manually assigned to technology fields by using information on the project's content from the project titles, abstracts, and descriptions. Technology fields with a low number of projects are grouped together into a rest category in the analyses.

Length of the Research Project. Project duration is another important factor that may affect the performance of research projects. For instance, projects that last longer may enjoy more time for research, and thus have a higher possibility to generate (more) transfers. In this paper, we use the number of years a research project lasts as measure for the project duration. This variable has been called research cycle time in prior research (e.g. Eling et al., 2013).

Firm Patent Stock. This variable represents the technical strength of the firm in the technological field(s) to which a research project belongs. Technical competences of the firm in the field under research are expected to be (at least partly) accessible to the project team. We take the 5-year prior patent stock of the sample firm to measure the technical strength of the firm in the relevant technological fields of the research project (Du, et al., 2014). We have collected EPO patent data for the sample firm at the consolidated level, including patents that were assigned to the parent company or to its majority-owned subsidiaries. The consolidation was done on a yearly basis (2003-2010) to take into account changes in the firm group structure. Patents of subsidiaries that are acquired and divested are, respectively, added and removed from the patent stock from the year of acquisition or divestment. Due to the long time-windows of patent granting decisions at the EPO⁷, we use patent application data to construct the patent stocks.

⁷ Patent granting decisions at the EPO take on average more than 5 years Harhoff, D., and S. Wagner. 2009. The duration of patent examination at the European patent office. *Management Science* 55 (12): 1969–1984.

Project Management Formality. Following prior research (e.g. Cooper, et al., 2004, Du, et al., 2014), we control for the extent to which research projects have followed a formalized management process, that is, the research project was planned, monitored and controlled in a formal way by the project management team. The management process of each project is evaluated annually by the project manager. In line with prior work (Du, et al., 2014), scores from 0 to 5 (a score of '0' means that the activity is not performed; a score of '5' indicates that great importance is given to the activity) are provided for each of the following three project management activities: 1) regular review of the project process, involving management, project owner and project sponsors; 2) during project reviews, corrective actions are identified, documented, and tracked through to project completion; 3) progress reports are made available at the project level on a regular basis, including information on project termination and transferred results. The project management formality score is, in line with Du et al. (2014), calculated as the average score on these three questions. For projects that last longer than one year, the average score over time is used. A higher average score implies that the project is managed in a more formal way by the project management team.

Number of Projects Under Management. The more projects a project leader is actively managing, the less time he/ she may devote to each individual project, which may negatively affect project outcome (Geanakoplos and Milgrom, 1991). Projects that receive more attention from their project manager may enjoy timely feedback, and generate faster research transfers. We use the number of projects that a project leader is managing concurrently in a certain year as a proxy for the managerial attention of individual research projects.

Sponsor Department. In our data, research projects can be initiated from two types of sponsor units, i.e. a central research unit - Corporate Research (51% of sample projects), or

any of the Business Units of the firm (49% of sample projects).⁸ The variable sponsor department is a dummy variable, taking the variable 1 if a project is initiated by Corporate Research, and 0 otherwise. As explained in detail in the methodology section, this variable functions as selection variable in the two-step Heckman procedure.

Project Initiating Year. Next, we also control for the year in which a research project started. This variable may signal the macroeconomic situations at a particular point in time, but it may also embody the effects of changes in corporate level strategy on research projects. We include a range of dummy variables to control for the project initiating years.

Empirical Results

Transfer Speed and the Performance of Research Projects

We first analyze the relationship between transfer speed and the performance of research projects⁹. Table 2 reports the regression results of Heckman two-step regression model. Model 1 shows the selection result for the first step: whether a project generates a transfer or not. It includes the control variables and the selection variable (Sponsor Department). The coefficient of the selection variable is negative and significant as expected, confirming that research sponsored by Corporate Research has a lower probability to generate at least one transfer. Projects that have more resources and that can build on a large firm-level patent stock have a higher probability to generate a research transfer. The results further show that research projects that are managed in a more formal way are more likely to generate transfers to business units.

⁸ Models with separate dummies for the 10 business units give very similar results.

⁹ We used the number of research transfers after the first delivery” as alternative dependent variable; this specification gave qualitatively the same results.

Insert Table 2 about here

Model 2 is the second step of the Heckman model where we regress the performance of research projects on transfer speed (as measured by the number of months a project takes to generate a transfer). We control for a possible selection bias by including the Heckman correction term in the equation. The inverse mills ratio is significant, showing that without controlling for this variable our performance equation would suffer from a sample selection bias. We also control for the length of the research project, referred to as research cycle time in prior research (Eling, et al., 2013). The coefficient of the transfer speed variable is negative and significant. This finding confirms Hypothesis 1: Research projects with a fast first transfer speed (less months needed to generate a first transfer) to business units are associated with better research performance¹⁰. Model 2 also showed that projects with a longer research cycle time perform, on average, better than their counterparts with a shorter research cycle time.

Antecedents of Transfer Speed

Table 3 reports the regression results of the Cox shared frailty analysis in which we analyzed the impact of market-based partnerships, science-based partners and (early) patent filings on the transfer speed of first research results. As the Cox model measures the rate at which a first transfer is delivered, a positive (negative) coefficient indicates that a variable accelerates (decelerates) transfer speed. Model 1 is the baseline model with only control variables. We find that projects that have resources and are managed by project leaders who simultaneously manage multiple projects are able to faster transfer first research results. Further, we find that

¹⁰ We also tested the possibility of a non-linear relationship between transfer speed and project performance. However, no evidence of such a relationship was found.

project that are sponsored by Corporate Research take a longer time to transfer their first research findings (have a slower transfer speed).

Insert Table 3 about here

The market-based and science-based partnership variables are added to Model 2. A positive and significant effect is found for market-based partnerships on project transfer speed. This confirms Hypothesis 2: Market-based partnerships accelerate the transfer speed of first research results. The results show that market-based partnerships accelerate transfer speed by 69.55% ($= \exp(0.528) - 1$). However, we do not find a significant effect for science-based partnerships on project transfer speed, thus, we do not find empirical support for Hypothesis 3, that science-based partnerships universally speed up first research transfers.

Further, we add the patent application variable to our specifications (Model 3 + Model 4). The coefficient of this variable is positive and significant in both models. This confirms Hypothesis 4 that early patent filings in research projects accelerate the transfer speed of first research results to business units. The coefficient shows that each additional patent application accelerates research transfer speed by 4.3% ($= \exp(0.042) - 1$). The inclusion of the patent variable has no material effect on the R&D partnership variables.

Finally, we include technological complexity as moderating variable of market-based and science-based partnerships in Model 5 and Model 6. In Model 5, we use the medium sample value of complexity as dummy for technological complexity. In Model 6, we raise the bar of technological complexity to the 75 percentile to differentiate between very complex projects and the rest. The complexity variable is negative and significant in both models, indicating

that research projects that focus on complex technologies, in general, take more time to transfer research results. The results further show that collaborations with market-based partners in general speed up the transfer process. Interestingly, while science-based partnerships do not speed up the transfer process of research projects in general, they have an acceleration effect on projects that deal with very complex technologies (as indicated by the positive interaction effect in Model 6). Thus, Hypothesis 5 is only partly supported: technological complexity only moderates the relationship between science-based partnerships and transfer speed.

Conclusion and Discussions

In this paper, we focused on the organization of R&D activities in large, R&D-intensive firms. In these firms, research is typically conducted in research projects within research labs. Product development, on the other hand, is executed by business units. Once research results are achieved, they are transferred from research projects to business units for further development and commercialization. We investigated the antecedents of transfer speed (the time a research project takes to deliver its first research result to a business unit) and the relationship between transfer speed and the performance of research projects (measured by the number of transfers a project generates). More specifically, we examined the effect of early patent filings, and two types of open innovation partnerships — science-based and market-based partnerships as the antecedents of first transfer speed, and the effect of having a fast first transfer on the performance of research projects.

Our findings show that research projects that generate a fast first transfer to business units are linked to better research performance. Fast first transfers give a strong positive signal to the financial sponsors of a research project about the capabilities of the research team. This increases their confidence in the research team, and increases the willingness to further fund

the on-going research. Moreover, a fast first transfer enables research projects to collect early feedback from business units, which can be used to improve the on-going research. R&D partnerships are found to be useful – under some conditions – to speed up research transfers. While market-based partnerships have a positive effect on transfer speed, the speeding-up effect of science-based partners is limited to projects in fields characterized by a high technological complexity. Furthermore, our study provides evidence that filing for patents early on in research projects accelerates the transfer of first research results to business units.

Somewhat surprisingly, we did not find an universal acceleration effect of science-based partnerships on the transfer of first research results. This finding deserves further considerations. In R&D partnerships, coordination may take substantial time when partners have diverse goals (Lorange et al., 1992), different working habits (Bstieler and Hemmert, 2010) and distinct organizational cultures and thought worlds (Dougherty, 1992). In such situations, coordination and communication complexities (Gulati, 1998, Rothaermel and Deeds, 2006) may offset the potential benefits of partnerships on transfer speed, or even extend the time to research transfers. These factors are likely to differ according to the type of R&D partners involved. For science-based partners, bureaucratic hierarchy, inflexibility, and different rewarding systems (Mowery, 1998) are expected to hinder their efficiency in quicken research transfers. Frictions may also arise resulting from different organizational cultures and perceptions (Bstieler and Hemmert, 2010). Furthermore, science-based partners are often involved in government-funded projects (e.g.: European FP-7 projects) which have complex administrations and reporting formalities (quarterly or yearly). As a result, the firm and its science-based partners involved in such projects are constrained in the transfer process, as the structure and process are predetermined by the government. These above-mentioned factors, may jointly offer an explanation to why we did not find a general positive effect of science-based partnerships on research speed. However, we find an accelerating effect of

science-based partnerships for a specific set of research projects, namely those that focus on (very) complex technologies. Drawing from their expertise in scientific research, science-based partners are well positioned to develop a ‘helicopter view’ on complex technologies that consist of multiple components in complex product architectures (Fleming and Sorenson, 2004, Rosenberg, 1990). This enables them to sort out the intricate relations between technology components and speed up the development of transferable research outcomes. However, the situated effect of science-based partnerships should be interpreted with caution. It might be that, although science-based partners do not (universally) accelerate research transfers, the research results of projects they are involved are more innovative and/ or of greater impact. In other words, the benefits of science-based partners might be materialized in a different way, i.e. via more impactful innovations or higher financial returns (see in this respect: Du et al., 2014).

In addition to the aforementioned results, we found that the number of projects supervised by the same project leader were associated with a faster transfer of first research results. This seemingly unexpected result may be interpreted as follows: the variable ‘number of projects at hand’ may signal the attention each research project gets from its manager; but at the same time, it may also signal the importance of the research project. Projects that are running simultaneously with many other projects and that are handled by the same project manager may be relatively less important to the firm. By contrast, those large, resource-intensive and strategically-important projects may need very dedicated and sophisticated project management, and are thus managed by one (dedicated) project manager who has a smaller number of projects at hand. These latter set of projects, although getting the most managerial attention (as they are handled by dedicated project managers who have limited number of projects at hand), may take longer to transfer their first research results.

Theoretical Implications

This paper contributes to the NPD literature, in particular the research on NPD cycle time, in several ways. First, we introduce a new concept of speed – the speed of intra-firm research transfers from research projects to business units. Prior research on cycle time predominantly took a monolithic view on cycle time by studying the speed of the entire NPD process from ideation all the way down to product market launch (e.g.: Cankurtaran et al., 2013; Chen et al., 2010). Consequently, “little is known about the specific effect of the cycle times of the different NPD stages on NPD performance” which “emphasizes the need to conduct performance effect studies of NPD cycle time at the stage level rather than at the monolithic process level” (Eling et al., 2013, p 626). We responded to this call by focusing on the research phase of NPD and more specifically, the speed whereby research projects generate and transfer a first set of research results to business units. As such, this paper contributes to the development of a better and more nuanced understanding of NPD cycle time.

Second, our paper contributes to the debate in recent cycle time studies whether having a shorter cycle time is beneficial or disadvantageous to NPD performance (Swink et al., 2006). We find that, at least for the speed of first research transfers, there is a positive relationship with performance. Third, this paper contributed to the NPD literature by introducing a new conceptual lens— the speed of research transfers— to make early assessments of NPD performance. In doing so, this paper also adds to the intra-firm transaction theory by emphasizing the importance of a fast delivery of intermediate goods in intra-firm transactions.

Besides adding to the NPD literature, this paper also contributes to the open innovation literature by showing hard evidence of the effect of R&D partnerships on the transfer speed of research projects. Responding to the call of Chesbrough et al. (2006) that “neither the practice of nor research on open innovation are limited to the level of the firm” (p 287), in this paper we analyzed open innovation at a more refined level, being the project level. Moreover, we added to the existing open innovation literature by investigating the ‘time’

aspect—the effect on transfer speed— of different open innovation partnerships. Despite the burgeoning studies on the effects of open innovation on a wide range of performance dimensions, such as financials (Du, Leten and Vanhaverbeke, 2014), cost savings (Knudsen and Mortensen, 2011), number and share of innovative products (Faems, et al., 2005, Laursen and Salter, 2006), whether open innovation increases the time efficiency, of the NPD process, remained an open question. In this paper, we made a first contribution to these lines of research by empirically studying the effect of different types of open innovation partnerships (market-based and science-based partnerships) on the speed of first research transfers, which helps to develop a better and more holistic understanding about the effects of open innovation.

Managerial Implications

Several managerial lessons can be learned from this study. We show that to improve the performance of research projects and to assess their potential when little information is available in the early research phase, having an early first transfer is crucial. Our results suggest that, instead of being prudent in keeping refining initial research results, the research project may actually be better off if presenting initial research results to business units early on in the research process. A fast first transfer can improve the confidence of the project sponsor on the capabilities of the research team, which, in turn, gives the team a better position to negotiate more substantial research funding to sustain its further research.

Next, regarding the strategic choices of a research project to speed up its transfer of research outcomes, our findings suggest that collaboration with external R&D partners is no panacea to speed up research transfers under all circumstances. Instead, the effect of R&D partnerships on the transfer speed of research projects depends on the type of partners involved in the collaboration process and the technological complexity of the project. Market-based partnerships in general contribute to fast first research transfers, while science-based partnerships seem to be only beneficial in accelerating first research transfers of

technologically very complex projects. As a result, R&D managers in large, R&D-intensive firms need to choose the type of partners based on the objectives and the characteristics of the research project. Other factors hold equal, for projects in less complex technology fields, if there is time pressure to quickly transfer research results, teaming up with market-based partners may be a better strategy than collaborating with science-based partners, while for technologically very complex projects, both types of external partnerships are helpful to speed up first research transfers.

Last but not the least, our research results suggest that it is beneficial for a research project to file patents early on in the research process, as early patent filings are instrumental in speeding up first research transfers. Early patent applications help to codify research results, and facilitate knowledge flows between the research team and the potential business recipients. Moreover, early patent applications also provide an option to legally protect technologies under research, improving the attractiveness to business units.

Limitations and Future Research

Although we handled our research with great care, this study has several limitations. First, there may however be other factors that determine the speed of first research transfers beyond those that we included in our conceptual model. We encourage scholars to further enrich our conceptual framework by studying additional determinants of transfer speed, such as for example the potential role of internal partnerships between research projects and business units. Research projects that have strong internal links to (multiple) business units may be better positioned to find recipients for their research results and therefore to speed up research transfers.

Second, our dataset does not allow us to gain insights on the identity of the external partners of research projects. This limitation prevent us from performing a more fine-grained analysis

of the role of R&D partnerships in speeding up transfers and including measures on the quality of partner involvement. Our data allows for only two broad categories of R&D partnerships: science-based and market-based. We believe that splitting R&D partnerships into more finely grained categories will help to further improve our understanding on the role of R&D partnerships. For the same reason, we have no information on R&D partnerships with competitors, and therefore we are unable to analyze the individual effect of competitors on transfer speed. Further, we encourage future studies to explore the interplay of market-based and science-based partnerships with respect to transfer speed. Of special interest is the question whether both types of R&D partnerships act as complements or substitutes to each other. Finally, it may be interesting to check to what extent our results hold across different firms and industries that are involved in other technologies than our sample firm.

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Figure 1 Conceptual Model

Figure 2 Transfer Flow and Research Flow of a Research Project

Table 1 Variable definitions, measures, and categories

Variable name	Measure	Type
Performance of Research Projects	The number of transfers the research project generates	Count (log transformed)
Research Transfer Speed	The speed of the first transfer from research project to business unit	Continuous
Science-based Partnerships	Collaboration with science-based partners	Binary
Market-based Partnerships	Collaboration with market-based partners	Binary
Project Patent Application	Number of patent applications at EPO	Count
Technological Complexity	Technological complexity of the technology field to which the research project belong	Binary
Project Resources	Full Time Equivalent (FTE) researchers work on a project	Count (log transformed)
Project Technological Fields	The technological fields the project is active in	Dummy
Length of the Research Project	The number of years a research project lasts	Count
Firm Patent Stock	Previous 5-year patent stock of the firm in the technological field to which the project belong	Continuous (log transformed)
Project Management Formality	Average score of project management proficiency on 1) regular review of the project process; 2) corrective actions during project reviews; 3) progress reports	0-5 Likert scale
Number of Projects Under Management	Number of projects a project leader is actively managing	Count (log transformed)
Sponsor Department	The sponsor of the project: <i>Corporate Research</i> or one of the <i>Business Units</i>	Binary
Project Initiating Year	The year in which the research project is initiated	Dummy

Table 2 Heckman Two-Step Regressions on Transfer Speed and Performance of Research Projects

VARIABLES	Model	
	<i>Coefficient</i>	<i>Standard Error</i>
Selection equation: Model 1		
— Heckman Stage 1 (Dependent variable= Transfer Yes/ No)		
Sponsor Department	-0.460***	(0.135)
Project Management Formality	0.154*	(0.085)
Firm Patent Stock	0.0937*	(0.0534)
Project Resources	0.721***	(0.182)
# Projects Under Management	0.123	(0.1018)
Constant	2.653	(1.994)
Performance equation: Model 2		
— Heckman Stage 2 (Dependent variable= (log) # of Transfers)		
Transfer Speed	-0.0308***	(0.0062)
Length of the Project	0.0211***	(0.0038)
Project Management Formality	-0.0382	(0.117)
Firm Patent Stock	0.0094	(0.0649)
Project Resources	-0.1581	(0.254)
# Projects Under Management	-0.0176	(0.1313)
Technology Fields	<i>Included</i>	<i>Included</i>
Initiating Year Dummies	<i>Included</i>	<i>Included</i>
Constant	-4.375***	(0.772)
Mills ratio	-0.892**	(0.435)
Number of observations	503	
Number of censored observations	333	
Number of uncensored observations	170	
Wald test: χ^2	88.79***	

Robust standard errors in parentheses:

*** p<0.01, ** p<0.05, * p<0.1

**Table 3 Cox Shared Frailty Regressions on
Market-based & Science-based Partnerships, Technology Complexity and Project Transfer Speed**

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Market-based Partnership (MB)		0.528*** (0.201)		0.549*** (0.205)	0.591** (0.302)	0.567** (0.232)
Science-based Partnership (SB)		0.0391 (0.197)		0.0490 (0.201)	0.078 (0.295)	-0.139 (0.225)
Project Patent Applications			0.0423** (0.0183)	0.0449** (0.0187)	0.048** (0.019)	0.0470** (0.0192)
Complexity (50 percentile)					-0.885* (0.464)	
MB * Complexity (50 percentile)					0.029 (0.418)	
SB * Complexity (50 percentile)					0.007 (0.415)	
Complexity (75 percentile)						-1.468** (0.614)
MB * Complexity (75 percentile)						-0.0457 (0.518)
SB * Complexity (75 percentile)						0.983* (0.549)
Project Management Formality	0.185 (0.114)	0.173 (0.119)	0.194 (0.120)	0.169 (0.122)	0.156 (0.127)	0.150 (0.129)
Sponsoring Department	-0.742*** (0.166)	-0.734*** (0.180)	-0.782*** (0.179)	-0.732*** (0.184)	-0.789*** (0.191)	-0.768*** (0.189)
Firm Patent Stock	0.110 (0.075)	0.143* (0.0792)	0.119 (0.0791)	0.138* (0.0811)	0.159* (0.086)	0.130 (0.0845)
Project Resources	0.630*** (0.175)	0.644*** (0.210)	0.616*** (0.214)	0.545** (0.223)	0.666*** (0.235)	0.602*** (0.232)
# Projects Under Management	0.734*** (0.171)	0.824*** (0.190)	0.831*** (0.190)	0.849*** (0.196)	0.929*** (0.202)	0.900*** (0.202)
Project Technological Fields	<i>Included</i>	<i>Included</i>	<i>Included</i>	<i>Included</i>	<i>Included</i>	<i>Included</i>
Project Initiating Year	<i>Included</i>	<i>Included</i>	<i>Included</i>	<i>Included</i>	<i>Included</i>	<i>Included</i>
Observations	13,308	13,308	13,308	13,308	13,308	13,308
Number of groups	503	503	503	503	503	503
Number of events	170	170	170	170	170	170
Log Likelihood	-911.7	-907.7	-909.0	-905.0	-901.06	-900.6

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Appendix A. Descriptive Statistics and Correlations (Cox Regressions: Monthly records)

	Mean	S.D.	1	2	3	4	5	6	7	8	9
1. Market-based Partners	0,608	0,488	1,000								
2. Science-based Partners	0,693	0,461	0,245	1,000							
3. Technological Complexity (75 percentile)	0,219	0,414	-0,036	0,068	1,000						
4. Sponsor Department	0,582	0,493	-0,155	0,053	0,016	1,000					
5. Number of Patent Applications	0,890	4,738	0,040	0,058	0,007	-0,042	1,000				
6. Firm Patent Stock	5,771	2,120	0,026	-0,075	-0,145	-0,010	0,008	1,000			
7. Project Resources	1,892	0,595	0,243	0,282	0,034	0,020	0,230	0,017	1,000		
8. Project Management Formality	3,956	0,824	0,146	-0,016	0,001	-0,200	0,028	-0,013	0,068	1,000	
9. # Projects Under Management	3,298	0,804	0,050	0,142	0,013	-0,036	0,013	-0,207	0,223	-0,053	1,000

(n= 13308)

Appendix B. Descriptive Statistics and Correlations (Heckman Two-step: Transferred projects)

	Mean	S.D.	1	2	3	4	5	6	7
1. Total # of Transfers	3,594	4,074	1,000						
2. # Months to Transfer	16,19	10,52	-0,215	1,000					
3. Length of the Project	44,95	20,01	0,297	0,311	1,000				
4. Project Management Formality	4,087	0,740	0,156	0,168	0,127	1,000			
5. Firm Patent Stock	6,260	1,934	0,162	-0,098	0,082	0,075	1,000		
6. Project Resources	1,451	0,392	0,154	-0,030	-0,087	0,125	0,078	1,000	
7. # Projects Under Management	3,307	0,742	-0,235	0,210	-0,370	0,066	-0,167	0,130	1,000
(n= 170)									