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Innovation Failure: Which Capabilities Prevent It?

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Abstract

This paper investigates the contribution of a number of capabilities that prevent a firm from failing at innovation. We analyze the contribution of Knowledge Management, Technological, Cooperation and Marketing capabilities to the prevention of innovation failure. Analyzing a unique dataset of innovating firms in the Netherlands, we are able to determine that Knowledge Management capabilities only marginally contributes to the increase of turnover associated with newly developed goods and services. Technological, Marketing, and Cooperation capabilities, each, separately, do not help prevent abandoning innovation projects as a measure of failure, but do boost sales of newly developed goods. Effects of joint deployment of capabilities one would expect are largely absent. This paper contributes to understanding the intricacies of innovation processes at the firm level, thus substantially contributing to the knowledge needed for the implementation innovation activities.

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1. Introduction

Innovation is identified as one of the most important activities for firms since it contributes to their profitability: when a firm fails to innovate, growth and even survival can be in jeopardy (Baumol, 2002; Geroski *et al.,* 1993). From the perspective of the literature on strategic management, and particularly when building on a dynamic capabilities approach within that, one would expect that firms that have specific capabilities will be in a much better position not just to actively engage in innovative activities, but also to be successful or avoid failures (Mahoney and Pandian, 1992; Amit and Schoemaker, 1993; Teece *et al*., 1997). Which capabilities, we ask, help prevent innovation failure? We investigate key capabilities (1) in isolation, (2) in interaction with one another, as well as (3) orchestrated by management. Insights from the rich literature on dynamic capabilities and innovation have focused on the contribution that specific capabilities make to a firm's success. This paper investigates the contribution of a number of capabilities that prevent a firm from failing at innovation. Failure turns out to be a more powerful way for a firm to learn, and thus further develop capabilities, than success is (Madsen and Desai, 2010), making it perhaps a more important focus of attention from a strategic and organizational point of view. Innovation failure can show in starting inappropriate innovation projects that later need to be abandoned or by failing to introduce innovative products as well as services that generate sales on the market. These are more direct measure of the strength of a firm's capabilities relevant for innovation than e.g. profit is. By capabilities relevant for innovation we refer to capabilities involved in knowledge creation and used to produce new goods and bring these to a market. We analyze the contribution of Knowledge Management, Technological, Cooperation and Marketing capabilities to the prevention of innovation failure.

The Community Innovation Survey (CIS) is an extensively used database deployed every fourth year to determine what effects innovativeness at firm level (cf. Leiponen and Helfat, 2010). Analyzing this unique dataset of innovating firms in the Netherlands (n=2801), we are able to determine if and to what extent Knowledge Management, Marketing, Technological, as well as Cooperation capabilities, by themselves, in different combinations, as well as orchestrated, help prevent innovation failure. As a corollary, such insights help determine what makes a firm successful at innovation activities. In estimating a number of appropriate probit and tobit regression models, we look at innovation failure. Knowledge Management capabilities, surprisingly, do *not* help prevent innovation failure in terms of reducing the number of abandoned innovation projects and only marginally contributes to the increase of turnover associated with newly developed goods and services. Technological, Marketing, and Cooperation capabilities, each, separately, do *not* help prevent abandoning innovation projects as a measure of failure, but do boost sales of newly developed goods and services. Effects of joint deployment of capabilities one would expect are largely absent. Only combining Technological with Knowledge Management capabilities prevent innovation failure, but *not* in terms of preventing innovation project abandonment. This combination does help generate more sales from innovative goods. None of the capabilities benefit from orchestration by management. From an innovation failure perspective, orchestration seems to contribute in a general rather than in a specific sense.

By analyzing which capabilities prevent innovation failure, for which we use different measures, we provide evidence to suggest that a firm is well advised to develop specialized capabilities. We also find that a firm has a general ability to orchestrate or efficiently manage without much need for joint deployment. Implications for the RBV and capabilities views of firms are discussed.

2. Capabilities, and Innovation Failure

The literature on capabilities and dynamic capabilities is extensive. Winter (2003) states that dynamic capabilities are a collection of high-level routines that 'confers upon an organization's management a set of decisions options for producing significant outputs of a particular type'. Teece *et al*. (1997) distinguishes between the dynamic and the capability parts. Capabilities emphasize the key role of strategic management when it comes to adapting, integrating and reconfiguring 'internal and external organizational skills, resources and functional competences to match the requirements of the changing environment' (Teece *et al.*, 1997). Dynamic refers to the capacity to renew the competences of the business, in order to achieve congruence with the changing business environment (Teece *et al*., 1997). Dynamic capabilities allow companies to change, extend, protect or reject their asset base in order to sustain a competitive advantage (Helfat *et al*., 2007). As Eisenhardt and Martin (2000) put it: 'dynamic capabilities are the antecedent organizational and strategic routines by which managers alter their resource-base – acquire and shed resources, integrate them together and recombine them – to generate new value creating strategies'. Teece (2007) states that dynamic capabilities allow a company to: sense, shape, and seize opportunities; and, maintain competiveness through reconfiguring the business enterprises intangible and tangible assets (cf. Zott, 2003).

In line with the work of Teece and colleagues (1997, 2007), Helfat and Lieberman (2002) state that firms need complementary capabilities to profit from their core knowledge or technology capabilities (Winter and Zollo, 2002). Generalized capabilities are those capabilities that can be applied more broadly, general organizational resources and capabilities, such as skills for organizing multiple business units, and for transferring knowledge between units (Helfat and Lieberman, 2002). Specialized capabilities can be viewed as functional activities, such as R&D and marketing, which tend to be tailored to the technologies, operations and products of the business in which the firm participates. According to Helfat and Lieberman (2002), these two kinds of capabilities could lead to a range of capabilities that are different for every firm.

Teece *et al.* (1997) state that while the essence of capabilities is embedded in organizational processes, the content of these processes and the opportunities that accompany them are 'shaped significantly by the assets the firm possesses.' Eisenhardt and Martin (2000) claim, however, that while dynamic capabilities are idiosyncratic in their details, they display common features that are associated with effective processes across different firms. Competitive advantage is then created by companies that use dynamic capabilities 'sooner, more astutely or more fortuitously than that of the competition' (Eisenhardt and Martin, 2000).

Organizational processes and resources explain the essence of a firm's dynamic capabilities and its competitive advantage. Long-term advantage derives from the application of dynamic capabilities to the configuration of resources a firm possesses. While dynamic capabilities are necessary, without the proper resources and the proper organizational processes ('the way things are done in the firm, known as routines of current practice and learning', Teece *et al.*, 1997), companies will not create a competitive advantage. When looking at a dynamic capability of the firm, it is important to analyze both the complementary assets the firm has or wants access to and what routines are involved. Helfat and Lieberman (2002) talk about this in terms of core and complementary assets. Core assets refer to 'knowledge that fundamentally underlies and is required to create a product or service, including technical knowledge and knowledge of the customer needs'. Complementary assets are then required to profit from core knowledge. 'Successful commercialization can only occur when the required know-how in question is utilized in conjunction with other assets or capabilities' as Hill and Rothaermel (2005) observe.

There have been quite a few studies of how dynamic capabilities contribute to a firm's competitive position (Armstrong and Shimizu, 2007). Most of these have focused on a single capability, while some have focused on the combination of two capabilities. Prime among the latter are Hitt *et al*. (2001) who have shown how profit from a firm's innovation capacities can be expected to increase substantially if a firm has significant legal capabilities as well.

In this study we will both look at a number of single capabilities that the literature has linked with innovation. These are Knowledge Management, Technological, Marketing, and Cooperation capabilities. We significantly broaden extant literature on capabilities that allow a firm to thrive in a dynamic environment by including a number of key ones, doing justice to the social complexity of resources possibly at the disposal of firms. In addition, we determine how capabilities may in conjunction determine the innovativeness of firms. Analyzing capabilities co-determining the innovativeness for a firm is the second major contribution our paper offers. Pace Sirmon *et al*. (2007, 2008), we, thirdly, explicitly include and test the idea that single or combined capabilities at a firm's disposal may need to be actively orchestrated by a firm's management.

2.1 Single Capabilities

Of the capabilities that are predicted to determine innovative outcomes of firms, some are deemed more obviously involved than others. Technological capabilities and Knowledge Management Capabilities are among them. Marketing capabilities, too, are recognized as important, as they may provide input for the innovation process. The literature on lead users in manufacturing and customer co-development in services points at this. We will discuss a fourth one, Cooperation capabilities, increasingly recognized as an important capability for innovative firms. To the best of our knowledge there is no exhaustive listing of capabilities that would be important for firms to be successful at innovation, but the literature does suggest another capability, or rather its reverse a constraint, that affects a firm's innovativeness: financial constraint (Savignac, 2008). We have decided not to include this variable into our analysis as it relates more to an externally imposed constraint for the firm than to a central feature of theory aimed at developing an understanding of how resource and capabilities at the disposal of firms help it be competitive.

Cooperation Capabilities. An important trend in industrial organization is the growth of cooperation between companies, also in the domain of innovation (Hagedoorn, 2002; Heimeriks, 2008). Cooperation may be placed on a continuum ranging from ‘infrequent arms length transactions, to closer long-term relationships and to fully integrated relationships, involving mergers and acquisitions’ (Stattford, 1994). Cooperation between firms, including increasingly strategic alliances, is sometimes seen as a ‘critical element of a corporation’s business network’ or even as ‘the most important strategic weapon for competing with a firm for core markets and technologies’ (Insch and Steensma, 2006; cf Eisenhardt and Ozcan 2009). Strategic alliances ‘are geared towards realizing an improved product market combination for any of the firms involved’ (Heimeriks, 2008), to reach a common goal by pooling of resources and activities. Some strategic researchers look at the structure of alliances, the type of contract and the degree of partner-fit, while others emphasize the experience or knowledge companies get with alliances, the extent to which alliance knowledge is institutionalized to leverage these alliances, and the importance attributed by firms to cooperation activities (Doz, 1996; Heimeriks, 2008; Mowery *et al.*, 1996; de Faria *et al*., 2010).

Rothmaerl and Deeds (2006) stress that cooperation is of the utmost importance when a company or industry is in either: a. in the start-up phase of its existence, or b. is changing the way it is operating fundamentally. Both situations require new (complementary) assets in order to survive or facilitate a transformation. Therefore, an important reason for building and maintaining alliances is to gain access to the required complementary assets (Duysters *et al*., 2007; Mitchell *et al*., 2002). Cooperative strategies ‘offer significant advantages for companies that are lacking competencies or resources since cooperation allows them to link with others companies possessing complementary skills or assets’ (Child and Faulkner, 1998). Protection of the company’s own assets can also be a motive (Jorde and Teece, 1990). Alliances allow firms to ‘add and extract value from underutilized resources they posses, by more efficient use or by creating new resources’ (Mitchell *et al*., 2002). However, companies cannot provide iron-clad protection for these resources from appropriation by a partner, since the same processes that help leverage the company's resources also expose these resources to the partner (Mitchell *et al*., 2002). While companies rely more on alliances as a mean of enhancing their competitiveness and growth, at the same time they are vulnerable to opportunistic behavior (Kale and Singh, 2009; Rangan and Yoshino, 1996).

Having, thus, a well-developed capability to cooperate with other firms is an important source of competitive advantage (Gulati, 1998; Heimeriks and Duysters 2007). While experience is important in building alliances (Doz, 1996), the adoption of higher-order routines, as exemplified in "dedicated alliance function", may even be more critical (Kale and Singh, 2009; Parise and Casher, 2003; Eisenhardt and Schoonhoven, 1996). Establishing and maintaining cooperation with other firms can be viewed as a dynamic capability, as it allows firms to share, capture, disseminate, internalize and apply know-how (Eisenhardt and Martin, 2000). Therefore, we hypothesize:

Hyp 1a: Cooperation capabilities prevent innovation failure for a firm.

Technological Capabilities. Obviously, it would seem, strong technological capabilities will prevent innovation failure (cf. Kor and Mahoney, 2005). When a firm has strong research, it will be in a better position to embark on those innovation avenues that are more likely to be technologically feasible (Taylor and Lowe 1997). Especially the possibility to combine or recombine existing (mature) technological knowledge with emerging technological knowledge will make them more likely to be successful (Schoenmakers and Duysters, 2010). Abandoning innovation projects may be less common for a firm that has strong technological capabilities, as experience will allow for a better judgment about which projects to start, preventing having to abandon them. Building on such advanced knowledge it may be better able to meet the demands from parties in the market. The prowess accompanied by a strong technological capability may mean that the department or individuals involved may set high expectations both in terms of the technological standards to be met. At the same time, however, innovation projects may also be pursued, at least initially that are more promising from a technological than from a marketing point of view. Strong technological capabilities may prevent a proper consideration of what market developments, possibly over-designing new products developed. In addition, existing firms, with a fairly stable set of technological capabilities, may be less likely as well to develop new products that will sell in a market particularly when discontinuities emerge (Granstrand *et al*., 1997; Christensen, 1997). Yet, as the linear model of innovation has been abandoned long ago and firms are well aware of the need to incorporate information and feedback (Bogers *et al*., 2010), we believe that the former effects of technological capabilities to prevent innovation failure outweigh the latter effects. Thus:

Hyp 1b: Technological capabilities prevent innovation failure for a firm.

<u>Knowledge Management Capabilities</u>. Well-developed capabilities in Knowledge Management (KM) may be discernible from a routinized way in which to determine which knowledge is available within a company that may be relevant for parties elsewhere in the company. Knowledge management capabilities may strongly contribute to a firm innovative prowess (Argote *et al*., 2003), as knowledge transfer in a company is by no means unproblematic (Szulanski, 1996). Knowledge integration requires an active involvement of management in a company (Verona and Ravasi, 2003). Well-developed KM capabilities and infrastructure may also be evident from having in place procedures to stimulate new innovative projects as well as to evaluate existing ones (Powell and Dent-Micallef, 1997). The purpose of KM capabilities, of course, is to prevent committing resources to innovative projects that do not yield commercial or learning benefits. Developing new goods and services that do not reach a substantial market can be prevented by KM capabilities. KM capabilities should also be there to address and accommodate hampering factors. One could argue that abandoning innovation projects prematurely could be seen as a sign of a firm having proper KM capabilities. When, however, the chances for a project are low, KM capabilities should help it from continuing early on, before a project is actually recognized as such within a firm. When proper KM capabilities and procedures are in place innovation failure should be reduced, as we hypothesize:

Hyp 1c: Knowledge Management capabilities prevent innovation failure for a firm.

<u>Marketing Capabilities</u>. Marketing capabilities may be of different kind. These are capabilities that allow a firm to better market an existing good or service and positively impact its

performance (Ellis, 2006; Han *et al*., 1998). From the perspective of innovation, these may not be as relevant as the capabilities that allow a firm to connect to, learn from and then market newly developed goods and services (Gebhardt *et al*., 2006; Kor and Mahoney, 2005). There is an exponentially growing literature on this topic at the interface of marketing and innovation studies. Literature involving lead users in the actual development or design of a product is one (von Hippel, 2005). Another emphasis in the literature is on new ways to learn from consumers of newly developed goods *after* they have been introduced into a market, for instance by being able to rapidly introduce versions or extensions of a product (Leonard-Barton, 1995). The chances of newly developed goods to grab a market share soon after launch should increase when a firm has strong marketing capabilities since a better understanding of the market pervades the innovating firm informing it of which projects to chose, and since the products it will launch can be supported in the market better as well. Having extensively learnt from the market should help a marketing function to feed research with new ideas for goods that would find a market, and so to fewer abandoned projects. Alternatively, a focus on *extant* market conditions may shut a firm's eyes for truly innovative new goods and services – current players and consumers in the market may have a status-quo bias. This tendency is currently well understood in the literature (Christensen, 1997) as well as by management in highly competitive, global markets but, the literature suggests, seems to be outweighed by the earlier tendency of a firm with strong marketing capabilities learning from the market. Thus we hypothesize:

Hyp 1d: Marketing capabilities prevent innovation failure for a firm.

2.2 Capabilities Combined

The literature argues that capabilities need to be combined for a firm to have a competitive advantage: "doing more of one thing increases the return of doing another thing" (e.g. Sirmon *et al*., 2008). Inclusion of multiple capabilities in attempting to determine what explains firm performance is rarely undertaken, however (Ray *et al*., 2004). Just having R&D capabilities, for instance, is rarely sufficient to obtain a competitive position (Hill and Rothaermel 2005; Teece 1986, 2007). At the same time, lack of resources might also complement each other to form obstacles to innovation (Galia and Legros, 2004). In developing hypotheses about the effects of combinations of capabilities under investigation, theory does not seem to provide clues for all of the possible combinations. Rather than discussing each combination, at length, we focus on those combinations for which there is reason to believe that they are most pertinent.

Technological and KM capabilities. Strong research or technological capabilities combined with well-developed and organized KM capabilities should especially mean that fewer innovation projects will have to be abandoned after they have actually commenced. In the early stages of a project, or even before it is recognized as such, procedures and expertise in place will allow a firm to determine which projects to formally start. In addition, when an innovation project starts, research and KM capabilities will prevent failure by, for instance, promoting knowledge transfer in a firm (Aalbers *et al.*, 2010), by having senior staff commit to a project (Kijkuit and Van de Ende, 2007), and by signaling potential failure early so that measures to address it can be developed. We hypothesize that:

> *Hyp 2a: Combining Technological and Knowledge Management capabilities prevent innovation failure for a firm.*

Technological and Marketing capabilities. When the research efforts of a company are properly informed by the marketing functions, the firm may focus its efforts on developing those goods and services that are more likely to find a substantial market share (Kor and Mahoney, 2005). Such collaboration across functions may go both ways, however, as marketing may benefit from having a clear understanding of the features of a product so that it can inform the customer better if only as it has a better understanding of how a good compares with competing ones. When combining marketing and research capabilities, a proper (better) understanding of the firm's external environment and the uncertainties faced there could emerge, since knowledge about these two areas is key in being able to fathom future developments in a firm's environment. The input of research capabilities, through a focus on what is technically feasible, may offset input from marketing about what opportunities for new goods and services current market conditions allow for. We thus hypothesize:

Hyp 2b: Combining Technological and Marketing capabilities helps a firm prevent innovation failure for a firm.

Knowledge Management and Marketing Capabilities combined. Insights from marketing could be used as input for knowledge management by indicating which goods or services would find a market. The direction research takes can be altered (slightly), which would lead to fewer projects being abandoned. In addition, one would expect sales from newly developed products to increase. Insights from marketing could both be expected increase the perception of (external) hampering factors, but could equally decrease as more information becomes available that can be used from an earlier stage in the life of an innovation project.

Hyp 2c: Combining Knowledge Management and Marketing capabilities will prevent innovation failure for a firm.

2.3 Capabilities Orchestrated

Hitt, Sirmon and colleagues (Sirmon *et al*., 2007; Sirmon *et al*., 2008) in particular have argued that similar sets of capabilities of a specific quality can still be put to different use. In addition to developing specific single resources and combining resources with other ones, firms need to actively manage and leverage the resources at their disposal. Orchestration of capabilities is how management in actual fact uses the capabilities at its disposal. Orchestration of firm resources and capabilities involves mobilizing and coordinating them, as well as deploying them in light of a firm's strategy and the contingencies faced in the market (Sirmon *et al*., 2007).

Larger firms in particular will be able, it may be argued, to orchestrate capabilities. Larger firms are likely to have more capabilities to begin with (Leiponen and Helfat, 2010; Granstrand *et al*., 1997), increasing the need for orchestration. This observation is of particular importance as Sirmon *et al* (2007, p.284) observe that the active leveraging of capabilities across different markets will create value and allow for additional learning. To the extent that developing valuable capabilities needs a concerted effort, larger firms may be better able to do so given that they have more resources at their disposal and can pursue division of labor or specialization (Nooteboom, 1994; Vossen, 1998). One area in which specialization can take place for larger firms is that of developing management expertise, for instance to develop strategies about which capabilities to develop, how to combine them and how to leverage them. As "the set of explicit and tacit knowledge on which a firm relies to deploy its capabilities is often complex" (Sirmon *et al.*, 2007, p.286; Johnson, 2002) specialist managers are needed.

Such specialization giving rise to proper orchestration, including of capabilities, can only be expected after a certain size for a firm according to some (Garnsey, 1998). However, others argue in the context of innovation in particular that firm size comes at a cost because as firms grow larger the costs due to the increased need for alignment, coordination and communication might grow more than the benefit of specialization to develop and orchestrate capabilities (Nooteboom, 1994; Pugh and Hickson, 1969, Pugh *et al.*, 1969; Vossen, 1998). Beyond some point for a firm to grow larger may no longer help in leveraging capabilities, suggesting an inverted U-shaped relation between innovation failure and orchestration in general. We thus hypothesize that:

Hyp 3a: Orchestration of capabilities, allowed for by the specialization that comes with firm size, prevents innovation failure.
Hyp 3b: Capability orchestration in general, allowed for by the specialization that comes with firm size, prevents innovation failure; yet orchestration is related with innovation failure in an inverted-U fashion.

3. Data and Method

The Community Innovation Survey (CIS) is an extensively used database deployed every fourth year to determine what effects innovativeness at firm level in EU countries (cf. Leiponen and Helfat, 2010). Being originally developed in the Netherlands (Brouwer and Kleinknecht, 1995), the survey is highly standardized, promoting comparison across the different countries as well as between industries. In addition to the standard survey that is administered once every four years, the Netherlands statistical office (CBS) experiments with some the questions asked in in-between survey waves. For this study, we use such in-between data for a survey wave between the third and the fourth wave that collected information from the period 2000-2002. The survey collects data on the innovation activities of firms from both the manufacturing and the service sector. This data includes data about issues that capture the capabilities of innovative firms and is unique data in the sense that it is not available for any other country and has not been, to our knowledge, used in academic studies. While the data we use is from a one-off survey, the core questions in the survey are also included in the other survey waves. Statistics Netherlands undertakes reliability checks to compare data across waves. Reliability of data collected during the in-between wave is comparable to that of the ordinary waves because the methods employed are the same. Moreover, CIS surveys are subject to extensive pre-testing and piloting in various countries, industries and firms with regard to interpretability, reliability and validity (Laursen and Salter, 2006). Questionnaire and methodology are based on the Oslo Manual and harmonized across countries. This international application of CIS surveys indicates the quality and reliability of the data (Mairesse and Mohnen, 2010).

The CIS captures a larger variety of innovation activities rather than just R&D expenditures, e.g. personnel skills and training. Innovative output includes the introduction of innovative production processes and organizational changes. It contains also a wealth of information about the organization of innovation activities. Heads of R&D departments or innovation management are asked directly if and how they are able to generate innovations. This leads to the production of direct measures for innovation processes and outputs which can complement traditional measures of innovation activity such as patents (Laursen and Salter, 2006).

The survey was administered to more than 4000 firms, and completing the form was mandatory. Even though the Community Innovation Survey is administered every four years, no panel can be constructed because the survey is stratified (Mairesse and Mohnen, 2010; cf. Armstrong and Shimizu, 2007, p. 977). Firms included in the survey are larger than 10 employees, and are thus likely to have at least started organizing in separate functions and knowledge domains (Vossen, 1998). Since most of the questions in the survey have to be answered only by innovative firms, i.e. firms that introduced at least one product or process innovation between 2000 and 2002 or had ongoing or abandoned innovation activities, we only included in our analysis the 2801 firms that reported innovation activities.

3.1 Variables

Dependent Variables. As indicated above, our goal is to inquire into the relationship between firms' capabilities and innovation failure. The effect of capabilities hypothesized to relate to innovation failure or success should be visible in terms of different kinds of performance outcomes. Performance outcomes of firms can, however, be affected by other factors than its strength at innovation. Since we are interested in the factors most immediately related to innovation, we do not use financial data for instance. Rather, we use two different measures as our dependent variables of failure (lack of success) of innovation activities. The first variable is a binary variable that indicates if the firm had any abandoned innovation or R&D projects during the period 2000-2002. Abandoning innovation projects is a sign of failure because such project had erroneously started to begin with. The second measure is the percentage of turnover associated to technologically <u>not</u> significantly improved <u>nor</u> completely new products or services (reverse coded). This measure is an output measure of the failure of innovation activities.[1] It is important to take in consideration that the two variables are associated to negative performance. Accordingly, if an independent variable positively relates to a dependent variable, it promotes innovation failure, and if it negatively relates to a dependent variable, it prevents innovation failure.

Independent Variables. The focal point of our analysis is the effect of firm´s capabilities on the innovation success/failure. Consequently, we include four variables that measure four different kinds of capabilities and the interaction effects that measure the binary combined effect of these capabilities.

Knowledge management is defined as the capability to make knowledge available to people within the organization (Liebowitz, 1999). The CIS includes three questions that allow measuring this firm capability: if the firm has a clear policy or strategy with regard to applying knowledge management; if there is a person or department responsible for the knowledge management policy, and if the firm makes use of indicators to measure the success of knowledge management activities. This binary indicators are aggregated into a count variable

[1] A third measure, also related to the input stage of innovation processes, was used to check for the robustness of our findings. A count variable (0-3) indicates how many external hampering factors that led to seriously delayed, abandoned, not-started innovation projects were encountered by the firm. The hampering factors indicated in the survey are: economic risks, market uncertainties, and regulation. We restricted our investigation to external hampering factors since hampering factors related to internal aspects are closely related to the capabilities under analysis in this study, and their inclusion could bias our results. The results of this variable (not included in the results table, but presented in an appendix) are in line with our main findings.

that proxy the depth of the knowledge management capabilities of the firm. Technological capabilities are measured by the share of turnover that is invested in intramural R&D (cf. Raymond *et al*., 2006). To measure marketing capabilities we also aggregate two measures of marketing strategy. The survey inquires if the firm introduced significant improvements in traditional marketing strategies, and if the firm introduced radical changes in the way it contacts its customers and suppliers. By combining this information from these two questions we are able to construct a measure of marketing capabilities of the firm. The binary variable indicating if the firm had any innovation cooperation agreement was used to proxy the cooperation capabilities of the firm.

By introducing interaction terms, we can determine if combining capabilities prevents innovation failure. Orchestration of capabilities is, as argued, related with the size a firm; the extent to which capabilities are amenable to orchestration is visible in the interaction with firm size. We measure firm size as the number of employees, and include this term as well as its square as a general measures for degree to which orchestration of capabilities is important. We hypothesize that after a specific size a firm's knack at orchestration may deteriorate beyond a point (an inverted U-shaped relationship).

Controls. Sirmon and colleagues (2007, p.286; see also 2008) also emphasize that contingent factors may play an important role. They point in particular to the uncertainty such as "rapidly changing industry recipes, growing or fluctuating market demand, and a high probability of environmental shock" that firms may face when orchestrating or leveraging the capabilities that they have. In order for our analysis to have as clear an analysis as possible and as straightforward managerial implications as is feasible, we will filter out such contingencies. This research approach differs from the one which is mostly adopted in studies that are inspired by the resource or capabilities theories in management studies. Many cases studies restrict themselves to a single industry where all firms may be expected to be affected similarly, in line with the suggestion that "the value of a firm's resources must be understood in the specific context within which a firm is operating" (Barney, 2001, p. 52). While a firm differentiating its capabilities from others in an industry is likely to allow it to be successful (Shamsie *et al*., 2009), too much difference between the capabilities of firms in an industry will only hurt the firm unless properly orchestrated (Sirmon and Hitt, 2009). In their review, Armstrong and Shimizu (2007) sympathize with this argument, but also argue for the need to generalize and deepen our knowledge. We argue, pace Armstrong and Shimizu (2007), that controlling for relevant industry-wide contingencies in a cross-industry study allows for a much clearer understanding of how resources, their bundling, and their orchestration contribute to a firm's competitive position, thus addressing a major challenge that Armstrong and Shimizu (2007) identify. Innovation success/failure may also be influenced by other firm characteristics not directed related to the capabilities described above. We included control variables to exclude alternative explanations, based in contingency considerations, for the patterns found, also as a check about the robustness of our findings. Being part of a group may, independent of cooperation capabilities influence the levels of innovation success/failure since the firm can have access to additional resources and capabilities from partners helping it to deal with contingencies (binary variable). In line with this, we include a variable that distinguishes between national and foreign groups in order to take in consideration the internationalization of the firm (binary variable). This measure may also control for the extent to which an industry is globalized or research-driven, eliminating these as contingencies. The share of turnover invested on extramural R&D was also included to control for research resources not developed by making use of own capabilities. The extent to which firms actually use marketing or technological capabilities might be different in different phases of an industry or product life cycle (Dolfsma and Van der Panne, 2010; Jovanovich and MacDonald, 1994; Klepper, 1996; Klepper and Graddy, 1990). An economy typically consists of sectors that differ substantially in the phases in a cycle they are in. In order to control for this, we include a binary variable that indicates if the life cycle of the firm main product is less than two years. Finally, we include industry dummies to control for sector differences. Including firm-level dummy variables to control for even more heterogeneity (Armstrong and Shimizu 2007, p.975) is technically impossible for reasons of data-availability including as a result of privacy regulations, and may render results of an analysis theoretically difficult to interpret.

3.2 Methods

Since we include two different dependent variables with statistically different characteristics, we need to apply two different estimation models. To measure the effect of the different independent variables on the abandoned projects variable we used a Probit estimation. The share of turnover associated to non-innovative products varies between 0 and 1. Since it a left-censored variable, a Tobit regression model is used in the analysis.

4. Findings and Discussion

Table 1 presents the results from the probit and tobit regressions. Each model has two specifications: one without the interaction terms and one including this terms.[2] We also run some consistency checks in order to test the robustness of our findings. The results of the environmental hampering factors model, of the specification including the interaction effects of more than two capabilities combined and of the specifications only including services and only manufacturing firms show results in support of our findings in Table 1. The appendices provide these analyses.

The first result that can be highlighted is that knowledge management capabilities alone do not prevent innovation failure: the results are not significant regarding abandoned innovation and are only show a small effect on the share of turnover associated to non-innovative products. Single Technological, Marketing and Cooperation capabilities lead to more sales of innovative products, but also lead to more abandoned innovation projects. As expected they have a favorable effect (negative coefficient) on the percentage of turnover associated to innovative product, but an unfavourable effect (positive coefficient) for abandoned innovation projects. Our hypotheses 1a, 1b and 1d are thus partially accepted. These results do not support for hypothesis 1c. High level capabilities can, thus, not only raise the efficiency of innovation activities but also the probability of finding problems that lead a firm to abandon an innovation project only afterwards. For example, a firm with more capabilities may be involved in more projects and so, despite being more able to face adversity, will have a higher probability of having to abandon an innovation project.

Table 1: Innovation Failure and Capabilities – Regressions Results

		Abandoned Innovation (Probit Regression)			Share of Turnover associated to non-Innovative Products (Tobit Regression)		
Variable (type):	Model:	I	II	III	I	II	III
Single Capabilities:							

[2] The descriptive statistics are summarized in Table A1

	Abandoned Innovation			Share of Turnover associated to non-Innovative Products		
	(Probit Regression)			(Tobit Regression)		
Model:	I	II	III	I	II	III
Variable (type):						
Knowledge Man.(count)	-0.040	-0.033	-0.033	-0.009**	0.000	-0.001
	(0.028)	(0.044)	(0.046)	(0.004)	(0.006)	(0.006)
Technological (share)	1.071***	1.776***	1.967***	-0.442***	-0.256**	-0.262**
	(0.348)	(0.653)	(0.670)	(0.056)	(0.105)	(0.107)
Marketing (count)	0.167***	0.186***	0.158**	-0.029***	-0.023**	-0.022**
	(0.037)	(0.063)	(0.065)	(0.006)	(0.009)	(0.009)
Cooperation (d)	0.427***	0.383***	0.418***	-0.044***	-0.038***	-0.036**
	(0.058)	(0.091)	(0.094)	(0.009)	(0.014)	(0.014)
Capabilities Combined:						
KM * Technological		0.124	0.157		-0.125***	-0.124***
		(0.284)	(0.288)		(0.047)	(0.047)
KM * Marketing		-0.033	-0.038		-0.007	-0.007
		(0.036)	(0.036)		(0.005)	(0.005)
Technological * Marketing		-0.486	-0.462		0.053	0.051
		(0.394)	(0.396)		(0.065)	(0.065)
KM * Cooperation		0.024	0.023		-0.004	-0.004
		(0.056)	(0.057)		(0.008)	(0.008)
Technological * Cooperation		-0.736	-0.694		-0.109	-0.115
		(0.674)	(0.676)		(0.109)	(0.109)
Marketing * Cooperation		0.059	0.045		-0.000	0.001
		(0.074)	(0.075)		(0.011)	(0.011)
Capabilities Orchestrated:						
KM * Size			0.000			0.000
			(0.000)			(0.000)
Technological * Size			-0.002			0.000
			(0.001)			(0.000)
Marketing * Size			0.000**			-0.000
			(0.000)			(0.000)
Cooperation * Size			-0.000			-0.000
			(0.000)			(0.000)
Firm Size	0.000***	0.000***	0.000**	0.000**	0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm Size (sq)	-0.000***	-0.000***	-0.000**	-0.000*	-0.000*	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls:						
Part of a Group (d)	0.190***	0.185***	0.193***	-0.002	-0.003	-0.003
	(0.067)	(0.067)	(0.067)	(0.009)	(0.009)	(0.009)
Domestic group (d)	-0.072	-0.071	-0.074	0.009	0.011	0.011
	(0.069)	(0.070)	(0.070)	(0.011)	(0.011)	(0.011)
External R&D as share of turnover (ratio)	-0.711	-0.471	-0.314	0.356**	0.256*	0.254*
	(0.974)	(0.996)	(0.994)	(0.140)	(0.145)	(0.148)
Product Life Cycle less than 2 years (d)	0.167***	0.163**	0.160**	-0.155***	-0.155***	-0.155***
	(0.064)	(0.064)	(0.065)	(0.010)	(0.010)	(0.010)

Variable (type): Model:	Abandoned Innovation (Probit Regression) I	II	III	Share of Turnover associated to non-Innovative Products (Tobit Regression) I	II	III
Industry Controls (d)	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-1.155*** (0.205)	-1.160*** (0.209)	-1.153*** (0.210)	0.946. (0.031)	0.938*** (0.031)	0.938*** (0.031)
Sigma				0.215*** (0.003)	0.215*** (0.003)	0.215*** (0.003)
Pseudo R2[3]	0.107	0.109	0.111			
N	2801	2801	2801	2801	2801	2801
LR/Wald chi2	325.22	330.11	336.70	640.14	652.63	654.51
P-value	0.000	0.000	0.000	0.000	0.000	0.000

d: Dummy variable. Standard errors in parentheses. Significance levels: * p<0.10, ** p<0.05, *** p<0.01.

Knowledge Management capabilities do have a beneficial effect when combined with Technological capabilities, increasing the percentage of turnover associated to innovative products, rather than reducing the number of project failures. Combining these two capabilities does not have a direct influence in the evaluation of innovation projects but does have an impact on the share of revenues gained from innovation activities. This gives only partial support 2a.

Surprisingly, we do not find evidence for the importance of combining other capabilities to prevent innovation failure. Apparently, except for combining Knowledge Management and Technological capabilities, having *combined* strengths in sets of capabilities does not prevent innovation failure in addition to that associated with each capability in its own right. We thus cannot accept hypotheses 2b, 2c and 2d. This result stresses one of the main findings of this study: having capabilities in a specific area can be enough to be a more successful (less failure-prone) innovator: there is little evidence to suggest that several capabilities in different key areas are to be developed in conjunction.

Hypothesis 3, related to capabilities orchestration, is also only partially supported. None of the single capabilities seems to benefit from orchestration leading to lower innovation

[3] For continuous distributions, the log likelihood is the log of a density. Since density functions can be greater than 1 (cf. the normal density at 0), the log likelihood can be positive or negative. Similarly, mixed continuous/discrete likelihoods like tobit can also have a positive log likelihood. Hence, this formula for pseudo-R^2 can give answers > 1 or < 0 for continuous or mixed continuous/discrete likelihoods like tobit. So, the pseudo-R^2 has no real meaning for the tobit regression.

failure. Orchestration of marketing capabilities even leads to more innovation failure in terms of abandoned projects. This leads us to reject hypothesis 3a. Orchestration in general does affect innovation failure as expected. The relationship between the different measures of innovation failure and the size of the firm is inverted-U shaped, as predicted in hypothesis 3b.

We will briefly discuss significant effects of control variables although we did not develop a-priori hypotheses indicating what to expect. Being part of a group increases the probability of a firm having abandoned innovation project, yet does not lead to increased share of sales from new products. Being part of a domestic group does not prevent innovation failure: perhaps a firm learns little from this. The share of turnover invested in external R&D activities does not prevent abandoning innovation projects and actually unfavorably affects share of sales from new products. Outsourced innovation projects might be subject to less stringent controls and be more zealously promoted than internally executed ones. Finally, the variable related to the life cycle of the firm show that firms that are more pressured to redefine its product portfolio have a higher probability of having failed projects. To them the saying seems to apply ‘better save (to have tried different innovation projects) than sorry (to have neglected a possible chance)’. Pressure in the market will result in innovation projects that fail before they come to fruition, yet they do lead to higher shares of sales from new products afterwards.

5. Discussion, and Conclusions

Our findings indicate that the single capabilities are likely to prevent innovation failure. Combining specific capabilities or orchestrating them does not have the impact expected in the recent literature (Sirmon *et al.,* 2008; Sirmon and Hitt, 2009). The areas of expertise inherent in capabilities may be difficult, organizationally, to combine. Except in the case of combining Knowledge Management and Technological capabilities the effect is insignificant, which means that developing capabilities in parallel will not significantly affect firms’ innovation performance. Exchange of knowledge between individuals involved in different capabilities may also be too much of a challenge (Szulanski, 1996). Orchestration in a general sense does contribute to preventing innovation failure beyond a certain threshold size.

In our analysis we used two different measures for innovation failure: abandoned projects and failure to generate turnover from innovative products. We anticipated similar results for these, but found systematic differences that may be of interest for managers and that may also be suggestive of future research. A firm to have developed single capabilities has a higher chance of abandoning innovation projects, irrespective of its size, and yet has a larger share of turnover from innovative products. Abandoning projects mid-way is perhaps essential in the sense of unavoidable for effective learning, rather than a sign of failure. When developing Technological capabilities a firm needs to develop Knowledge Management capabilities as well. The latter without the former is not likely to benefit a firm, while the former without the latter does. Not just the combination is, however, a significant contribution to preventing innovation failure, but also increases the effect of Technological capabilities. Orchestration of Marketing capabilities leads to more chance of abandoning an innovation project, yet, surprisingly, does not lead to more turnover from innovative products.

One could argue that the larger a firm is, the more likely it is to have had to abandon a project, and so our findings are, in part, a result of the measures chosen. There is, however, consistency in the results we have, in particular for the relation between firm size as a measure for orchestration on the one hand and our two measures for innovation failure on the other hand. This is an indication that the measures used provide substantive insights.

Our analysis is at a high level of aggregation, which obviates differences between individual firms. The data available does not allow for micro-level analysis. In responding to the call by Armstrong and Shimizu (2007), we suggest findings that have significance beyond that of the single firm or single industry. Findings for individual firms may diverge from our analysis, but are less likely to diverge for industries: industry dummies were included yet did not have a significant effect on results. Our results pertain to the Netherlands. While it is known that management practices can differ across countries (Van Reenen and Bloom, 2010), the Netherlands is known as an economically developed country that is open to the vagaries of the global economy. In that respect, our findings are representative and indicative.

6. Conclusions

Drawing on insights from, a.o., strategic management literature, we expect core capabilities that innovating firms have to impact on their chances of success, or its corollary: failure. Innovation failures relates more directly to firm-internal capabilities than the success in the market of innovation. Looking at two different measures for innovation failure we use unique, Dutch data on innovating firms to find surprising results. Knowledge Management capabilities do *not* help to avoid innovation failure. Technological, Marketing and Cooperation capabilities each, separately also do help avoid failure, but only in terms of sales prospects for newly developed goods and services to generate sales in the market. Contrary to expectations, thus, each of these three capabilities, separately, increase the likelihood of failure in terms of innovation projects abandoned. Effects of joint deployment of capabilities one would expect to show up are surprisingly weak. Combining Technological with Knowledge Management capabilities, however, does prevent innovation failure, yet, and again surprisingly, *only* in terms of generating more sales from new goods.

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Appendices

Table A1: Descriptive Statistics

Variable	*Mean*	*SD*
Environmental Hampering Factors	0.232	0.422
Abandoned Innovation	0.226	0.573
Share of Turnover associated to non-Innovative Products	0.818	0.238
Knowledge Management Capabilities (count)	0.936	1.031
Technological Capabilities (share)	0.025	0.084
Marketing Capabilities (count)	0.569	0.753
Cooperation (d)	0.387	0.487
No of employees (log)	4.425	1.148
Part of a Group (d)	0.717	0.450
Domestic group (d)	0.784	0.412
External R&D as share of turnover (ratio)	0.005	0.33
Product Life Cycle less than 2 years (d)	0.248	0.432
No of observations	2801	

Table A2: Innovation Failure and Capabilities – Regressions Results (robustness checks – hampering factors; and with extra interactions)

	Environmental Hampering Factors	Abandoned Innovation	Share of Turnover associated to non-Innovative Products
	Negative binomial regression	Probit Regression	Tobit Regression
Model	I	II	III
Knowledge Management Capabilities (count)	-0.005 (0.089)	-0.022 (0.053)	-0.001 (0.007)
TECHNOLOGICAL Capabilities (share)	3.737*** (1.300)	2.591*** (0.910)	-0.156 (0.145)
Marketing Capabilities (count)	0.563*** (0.113)	0.148* (0.078)	-0.028** (0.011)
Cooperation (d)	0.866*** (0.174)	0.402*** (0.105)	-0.041*** (0.016)
Interaction: KM * TECHN	-0.173 (0.540)	-0.682 (0.721)	-0.303*** (0.108)
Interaction: KM * Marketing	-0.082 (0.063)	-0.034 (0.057)	-0.003 (0.008)
Interaction: TECHN * Marketing	-0.450 (0.740)	-0.779 (0.947)	0.071 (0.150)
Interaction: KM * Cooperation	0.048 (0.102)	0.030 (0.078)	-0.001 (0.011)
Interaction: TECHN * Cooperation	-2.371** (1.178)	-0.938 (1.244)	-0.204 (0.202)
Interaction: Marketing * Cooperation	-0.264** (0.128)	0.089 (0.108)	0.017 (0.017)
Interaction: KM * Size	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Interaction: TECHN * Size	-0.007** (0.004)	-0.002 (0.001)	0.000 (0.000)
Interaction: Marketing * Size	0.000 (0.000)	0.000** (0.000)	-0.000 (0.000)
Interaction: Cooperation * Size	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Interaction: KM * TECHN * Marketing	-0.173 (0.540)	0.472 (0.656)	0.071 (0.100)
Interaction: KM * TECHN * Cooperation	-0.173 (0.540)	0.627 (0.886)	0.197 (0.137)
Interaction: KM * Marketing * Cooperation	-0.173 (0.540)	-0.036 (0.077)	-0.012 (0.011)
Interaction: TECHNOLOGICAL * Marketing * Cooperation	-0.173 (0.540)	-0.263 (1.183)	-0.104 (0.189)
Interaction: KM * TECHN * Marketing * Cooperation	-0.173 (0.540)	-0.066 (0.774)	-0.035 (0.119)

Model	Environmental Hampering Factors Negative binomial regression I	Abandoned Innovation Probit Regression II	Share of Turnover associated to non-Innovative Products Tobit Regression III
No of employees	0.000	0.000**	0.000
	(0.000)	(0.000)	(0.000)
No of employees (sq)	-0.000	-0.000**	-0.000*
	(0.000)	(0.000)	(0.000)
Part of a Group (d)	0.099	0.195***	-0.002
	(0.119)	(0.067)	(0.009)
Domestic group (d)	0.096	-0.075	0.011
	(0.129)	(0.070)	(0.011)
External R&D as share of turnover (ratio)	-0.491	-0.262	0.248*
	(1.881)	(0.999)	(0.148)
Product Life Cycle less than 2 years (d)	0.363***	0.159**	-0.155***
	(0.111)	(0.065)	(0.010)
Industry Controls (d)	Yes	Yes	Yes
Constant	-2.395***	-1.165***	0.938***
	(0.390)	(0.211)	(0.032)
Sigma			0.214***
			(0.003)
Ln alpha	0.546***		
	(0.146)		
Pseudo R2	0.060	0.112	
N	2801	2801	2801
LR/Wald chi2	193.16	339.71	660.76
P-value	0.000	0.000	0.000

d: Dummy variable. Standard errors in parentheses. Significance levels: * p<0.10, ** p<0.05, *** p<0.01.

Table A3: Innovation Failure and Capabilities – Regressions Results (robustness checks – manufacturing; services)

	Abandoned Innovation		Share of Turnover associated to non-Innovative Products	
	Probit Regression		Tobit Regression	
Model	M	S	M	S
Knowledge Management Capabilities (count)	-0.071	-0.005	-0.009	-0.000
	(0.066)	(0.072)	(0.009)	(0.010)
Technological Capabilities (share)	3.420***	1.832*	-0.419**	-0.178
	(1.220)	(1.031)	(0.177)	(0.161)
Marketing Capabilities (count)	0.173*	0.114	-0.002	-0.044***
	(0.090)	(0.107)	(0.014)	(0.015)
Cooperation (d)	0.461***	0.500***	-0.059***	-0.002
	(0.131)	(0.161)	(0.020)	(0.024)
Interaction: KM * TECHN	-0.494	0.400	-0.129*	-0.078
	(0.519)	(0.464)	(0.077)	(0.075)
Interaction: KM * Marketing	-0.004	-0.045	-0.012	0.002
	(0.055)	(0.055)	(0.008)	(0.008)
Interaction: TECHN * Marketing	-1.079	-0.247	-0.037	0.069
	(0.672)	(0.673)	(0.101)	(0.107)
Interaction: KM * Cooperation	0.018	0.015	0.009	-0.018
	(0.083)	(0.088)	(0.012)	(0.013)
Interaction: TECHN * Cooperation	-1.878	-0.701	-0.014	-0.301
	(1.162)	(1.190)	(0.171)	(0.194)
Interaction: Marketing * Cooperation	0.117	-0.025	0.008	-0.001
	(0.108)	(0.117)	(0.017)	(0.018)
Interaction: KM * Size	0.000	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Interaction: TECHN * Size	0.001	-0.005	0.000	-0.000
	(0.002)	(0.004)	(0.000)	(0.000)
Interaction: Marketing * Size	0.000	0.000	-0.000**	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Interaction: Cooperation * Size	-0.001**	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
No of employees	0.001**	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
No of employees (sq)	-0.000	-0.000	0.000	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)
Part of a Group (d)	0.190**	0.198*	0.010	-0.018
	(0.095)	(0.105)	(0.014)	(0.015)
Domestic group (d)	-0.113	0.019	-0.004	0.028
	(0.091)	(0.117)	(0.014)	(0.018)
External R&D as share of turnover (ratio)	-0.637	-0.423	0.239	0.133
	(2.623)	(1.254)	(0.401)	(0.196)
Product Life Cycle less than 2 years (d)	0.126	0.223**	-0.129***	-0.194***
	(0.089)	(0.103)	(0.014)	(0.016)

	Abandoned Innovation		Share of Turnover associated to non-Innovative Products	
	Probit Regression		Tobit Regression	
Model	M	S	M	S
Industry Controls (d)	Yes	Yes	Yes	Yes
Constant	-0.654** (0.331)	-1.102*** (0.270)	0.908*** (0.052)	0.897*** (0.043)
Sigma			0.205*** (0.004)	0.230*** (0.005)
Ln alpha				
Pseudo R2	0.097	0.093		
N	1340	1219	1340	1219
LR/Wald chi2	158.12	100.51	275.11	339.21
P-value	0.000	0.000	0.000	0.000

d: Dummy variable. Standard errors in parentheses. Significance levels: * $p<0.10$, ** $p<0.05$, *** $p<0.01$.