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An Empirical Study at Siemens**

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Abstract

It is becoming increasingly common to involve external technology providers in developing new technologies and new products. Two important phases in working with technology vendors are vendor selection and vendor management. For both steps, theory development of key decision guidelines is still immature. Therefore, we use detailed case studies of 31 innovation outsourcing projects at Siemens to develop grounded theory on provider selection criteria and on project management success drivers.

A selection criterion commonly associated with successful outsourcing is the provider's "track record" of previous experience. Our cases suggest that there is no generic "success track record", but that a predictor of project success is a *match* between the client firm's outsourcing motivation and the provider's strengths. A match appears to be a necessary condition for a successful outsourcing collaboration.

As to the second phase of managing the vendor, we identify operational project success drivers. There seems to be no "universal list" of essential success drivers, but the most important drivers seem to be contingent on the *type* of vendor chosen and on the technology maturity: we compare five provider types, universities, competitors, customers, start-up companies and component suppliers. Some success drivers are common across providers, but others are relevant only for certain provider types; moreover, drivers for a mature technology are more focused on successful transfer into manufacturing than development itself. Our findings offer guidelines for innovation managers on how to select innovation providers and how to manage them during the project.

Key words: innovation outsourcing, collaborative R&D, categorical data, field research, contingency analysis

1. Introduction

The last 20 years have seen a trend among the world's largest research and development (R&D) spenders to increasingly rely on external sources of technology. For example, the average growth rate of outsourced R&D between 1993 and 2003 was twice the growth rate of in-house R&D (Robert 2001; NSF 2008). The trend toward shifting innovation activities outside seems to be continuing, driven by a combination of more complex technologies, globalizing markets, more dispersed expertise, and the accelerating pace of technology evolution (Dyer 2000; Eppinger and Chitkara 2006).

Despite this innovation outsourcing trend and a growing body of academic literature on this issue (Chesbrough 2006; De Meyer and Loch 2007; Terwiesch and Ulrich 2008), many R&D organizations and creative companies struggle with the strategic challenges of deciding what innovation activities to outsource, where to source them, and how to make the cross-organizational knowledge transfer work. Specifically, we find from our interviews that managers lack guidelines on how to *select* external innovation providers to work with, and how to *manage* the outsourced projects.

We generate managerial guidelines on both of these questions, based on detailed case studies of 31 outsourced innovation projects at the global technology firm Siemens. First, we add to the traditional importance attached to track record in the choice of technology providers by demonstrating the importance of specific provider strengths that *match the outsourcing firm's needs*, a point often overlooked by managers, who tend to favor partners with *general* expertise. We categorize the outsourcer's needs according to six previously established outsourcing motivations: cost, market, technology, manufacturing, strategic, and organizational.

Second, we identify "operational success drivers" that guide the management of outsourced projects. However, we are not able to find a generic "universal" list; instead, we demonstrate that the key project success drivers are contingent on the *type* of provider, at least considering the five types of universities, customers, competitors, technology startups, and suppliers of manufactured goods, and on the maturity of the technology. Some drivers are relevant across all innovation providers (namely trust and communication, organizational stability, defined goals, and incentive alignment), and some are provider specific. For example, the transfer of project-specific knowledge will be critical in a

collaboration with a university, while the protection of intellectual property (IP) will have greater importance in collaborations with start-up companies and competitors.

In light of the immature state of existing theory (Edmondson and McManus 2007), we combine two research methods: grounded theory development based on multiple case comparisons, and some statistical analysis to ensure robustness of the findings. This method combination is common when some theory is available but it is immature (Strauss and Corbin 1998; Edmondson and McManus 2007).

2. Review of Previous Work

2.1 The Selection of Innovation Providers

For most technology outsourcing projects, companies choose one of several potential external innovation providers: before the outsourcing of R&D can begin, the question of how to select a technology provider must be resolved by management. Project management literature typically laments that price is too often used as the dominant selection criterion, rather than “track record”, to the detriment of later project success (Branconi and Loch 2004; Pinto 2006). The strategy and innovation literature identifies a number of useful criteria that capture the provider’s track record, including collaboration history (Kale and Zollo 2006), geographical proximity (Schidle 2006), and technology capabilities (Ruckman 2005; Schidle 2006). Other studies have examined the benefits of collaborating with different types of innovation provider (Belderbos et al. 2004a; Von Hippel 2005; Terwiesch and Ulrich 2008). For example, collaborating with a competitor may offer the advantage of established market share and new knowledge about products close to one’s own, but at the risk of leaking knowledge to “the enemy”.

These studies implicitly assume that there are “absolute” track record criteria associated with provider selection, irrespective of the specific needs of the client. However, it quickly emerged in our interviews that our interviewees did not think this way—they mentioned, for example, that a provider “did (or did not) have to offer what we needed.” Such statements suggest that track record is a requirement only in as much as it matches the client’s needs. Such a proposition has not been made explicitly in previous work: although Doz (1996) found in a study of alliances that mutual process

compatibility of the two organizations and mutually adjusted expectations increased the success probability, this notion of mutual compatibility is different from provider capabilities that match the client's needs.

However, there is related literature relevant to our question, namely studies of R&D outsourcing motivations (which correspond to the outsourcer's needs) across various research fields (Hagedoorn 1993; Ulrich and Ellison 2005; Holcomb and Hitt 2007; Terwiesch and Ulrich 2008). The reasons for deciding to outsource will differ from one R&D collaboration to another (Belderbos et al. 2004a), and several reasons may co-exist for any single project (Hagedoorn 1993). In summary, six innovation outsourcing motivations have emerged, as described in the following paragraphs and summarized in Table 1.

Motivation	Advantages
Cost	<ul style="list-style-type: none"> • Reduce investment by R&D cost and risk sharing • Partner's low development cost (better process, cheap labor, competitive provider market, larger scale, etc.)
Market	<ul style="list-style-type: none"> • Understand current market needs • Gain access to potential new market
Manufacturing	<ul style="list-style-type: none"> • Shorten time-to-market cycle • Obtain lower manufacturing cost or total cost of ownership
Technology	<ul style="list-style-type: none"> • Obtain access to technology and general expertise • Identify and influence potentially disruptive technologies
Strategic	<ul style="list-style-type: none"> • Outsource non-core competences • Respond to regulations, standards, or changing market structure
Organizational	<ul style="list-style-type: none"> • Avoid internal rigidities and barriers • Encourage organizational change and innovation

Table 1. Motives for Innovation Outsourcing

Cost Motivation. Cost has traditionally been the most important R&D outsourcing motivation (Belderbos et al. 2004b; Holcomb and Hitt 2007). Economies can be achieved by using a partner's R&D resources (Robertson and Gatignon 1998; Ulrich and Ellison 2005), by creating competition among providers with the lowest labor costs or most efficient processes (Ulrich and Ellison 2005), or by resource sharing (Schilling and Steenma 2002) and risk sharing (Ulrich and Ellison 2005; Bhaskaran and Krishnan 2009). However, the cost motivation has become less dominant for R&D over the last decade (Ro et al. 2008).

Market Motivation. External partners, such as customers or experienced suppliers, can help a firm to

better understand current market needs (Von Hippel and Katz 2002) and secure access to potential new markets (Robertson and Gatignon 1998). Firms attempting to introduce “new to the market” innovations are more likely to engage in collaborative R&D arrangements with external partners (Tether 2002).

Technology Motivation. Growing knowledge specialization and technology complexity prevent firms from achieving competence in all relevant technology fields (Brusoni et al. 2001). Partnering allows technology monitoring, access to knowledge, understanding technology complementarities (Belderbos et al. 2004b; Hagedoorn 1993; Ulrich and Ellison 2005), and broader technology choices (Gavetti and Levinthal 2000). Firms operating close to technological frontiers have a greater need for external knowledge and use more R&D outsourcing (Hagedoorn 1993; Miotti and Sachwald 2003).

Manufacturing Motivation. By collaborating with partners a firm may be able to replace internally developed components with purchased components or subsystems, which may be available more quickly (shortening time to market), more reliable, and cheaper to produce (as opposed to cheaper to develop as in the cost motivation) than newly developed components (Hagedoorn 1993; Belderbos et al. 2004b).

Strategic Motivation. Following a unique technology strategy, firms often chooses to specialize their in-house activities on a few key competencies (Chiesa et. al. 2000), while outsourcing non-core technologies (Tatikonda and Stock 2003; Holcomb and Hitt 2007). The belief is that non-core technologies can often be adequately addressed by complementary suppliers, while partnering can help the firm to influence product standards (Holcomb and Hitt 2007).

Organizational Motivation. A firm’s internal performance tends to be assessed against existing markets and profit levels. These measures may become too rigid when the firm encounters new opportunities (Leonard Barton 1992), thus certain opportunities may be better developed outside the organization in order to avoid such internal barriers (Christensen and Overdorf 2000). Since outsourcing may serve as a driving force, a benchmark and catalyst, for changing behaviors *within* the organization, exposing managers to other organizations may induce changes in their behaviors, especially if the partner is large and reputable (Greve and Taylor 2000).

Outsourcing motivations typically differ for an embryonic technology and a mature technology (Utterback and Abernathy 1975). An embryonic technology is generally characterized by an ill-defined problem structure (uncertain market requirements), unpredictable results and unknown costs (Roberts and Liu 2004; De Meyer and Loch 2007). The most typical reasons for outsourcing at this stage are the market and technology motivations: a need to understand market demands, explore better solutions, build expertise, and identify potentially disruptive technologies.

A mature technology and its market, in contrast, are better defined and understood. Technological uncertainty is reduced, technology output more predictable, and R&D costs more plannable. The pressure to sustain profit margins increases, firms begin to concentrate on their core technologies, and government regulation and technical standards become important competitive weapons. During this phase, the dominant outsourcing motivations are cost, manufacturing, and strategy.

In summary, previous work has identified “absolute” track record dimensions for selecting providers, while a different stream of research has examined outsourcing motivations and preferences toward certain provider types. Our interviews suggest there is a need for some kind of “match” between the outsourcing motivation and the provider’s track record. This match is different from the concept of “fit” in relationship management (Bensaou and Venkatraman 1995). “Fit” refers to the ratio between partners’ information processing needs (from uncertainty) and their information processing capacity (from relationship depth), which influences communication capability and thus performance. The concept of “match” refers to the correspondence between the provider’s track record and the outsourcer’s needs. For example, when a firm seeks market-ready components for a new product in order to achieve low manufacturing costs, it makes no sense to outsource to a university that performs fundamental research on new component concepts. The best choice might be a component supplier whose strengths match the firm’s needs.

But what constitutes a “match”? Lacking a causal theory predicting how the match should be measured, we might conjecture that the provider should have a track record on all dimensions of the outsourcers’ motivations. Is a track record on the domain of the key outsourcing motivation sufficient, or should there be “general background strengths”? Does “match” depend on types of providers? In

the absence of a theory about provider selection criteria, our study seeks to contribute by identifying the specific track record associated with successful outsourcing collaborations.

2.2 Operational Success Drivers in Managing an Outsourced Innovation Project

Our second research question is: How should an innovation provider be managed over the course of the project? We know a good deal about the design of collaborative governance (Hagedoorn 1993; Ulset 1996; Tatikonda and Stock 2003; Belderbos et al. 2004a; Nambisan and Sawhney 2007; McIvor 2009). Innovation outsourcing projects are vulnerable to opportunism on both sides because of uncertainty and monitoring limits. The preferred governance structure will depend on the level of technology uncertainty (Ulset 1996; McIvor 2009) and on the outsourcer's interests (Hagedoorn 1993; Belderbos et al. 2004a).

However, project governance does not address the question of how a project should be operationally managed day to day. For example, what targets should be set and how? How should the parties monitor and communicate progress? How should incentives be treated every day (appeal to formal governance or relational conflict resolution)? How should performance be measured?

Another stream of empirical research has examined such operational decisions. Eppinger and Chitkara (2007), for example, summarized ten success drivers for global product development (not only outsourced, but also including captive off-shore development): management commitment and prioritization to spreading innovation activities around, process modularity, product modularity, keeping the core competences in-house, intellectual property (IP) protection, data quality (sufficient explicit articulation of knowledge to share it across locations and organizations), infrastructure availability, governance and project management, a collaborative culture, and structured change management.

But how complete is such a list, and how robust, or “universal,” is it? How does it depend on the context, for example the uncertainty of the project and on the characteristics of the client and the provider? For example, a study of innovation outsourcing to small Japanese businesses (Okamuro 2007) found that active in-house R&D and close cooperation during the project were always important, but the usefulness of other project management methods depended on the goals of the outsourcer. A study in Spain (Valentin et al. 2004) found that resource commitment and a previous

collaboration history were common success drivers across university and corporate partners, while other drivers varied. The authors explained the provider-specific nature of the success drivers by variations in the providers' organizational structures.

In sum, these results reflect an incompleteness of current theory and understanding. Some general project management guidelines (e.g., resource commitment) may exist, but the list of success drivers may well be incomplete, and moreover, drivers probably vary across circumstances and, especially, providers. No work to date has identified “contingency”, or how such a set of operational management practices may depend on the provider and the maturity of the outsourced technology.

We could, therefore, not hope to find a “definitive list” of operational success drivers. In order to investigate at least some contingencies, we explicitly sampled different provider types and the maturity of the outsourced technology (and thus project uncertainty, as we have explained above). Some types of providers are widely used—component suppliers, customers and users, competitors, R&D organizations, and start-up companies (Miotti and Sachwald 2003; Belderbos et al. 2004a)—and these are the focus of our study. A number of new innovation providers have recently emerged, such as idea brokers (e.g., Innocentive, an internet marketplace), developers for hire (e.g., Rent A Coder), and professional design firms that transfer practices from other industries (e.g., IDEO). These new providers are less widely used by and less relevant for Siemens, our host organization, and are therefore not included in our sample.

Certainly, previous studies have examined typical strengths (reflecting some kind of “track record”) by innovation provider types. Such studies find, for example, that universities tend to be strong in novel idea generation, but weak in transfer to manufacturing, while competitors tend to have very valuable knowledge about current markets, but pose the risk of technology leakage. Representative results are summarized in Table 2. These results may be relevant for our question of how contingent a “list of success drivers” is—if a provider type tends to have certain strengths, maybe certain project management aspects become less critical to watch, and if providers of a certain type tend to have certain risks, maybe this imposes strict project management precautions: for example, if a competitor collaboration risks IP leakage, then maybe a legal framework needs to be included in the project to prevent this risk.

	Strengths/Risks		References
	Strength	Risk	
Universities	Generic knowledge; novel ideas; low cost	Possible huge distance to market; different incentives	Santoro and Chakrabarti 2001, Belderbos et al. 2004b, Cui et.al. 2009
Customers	Market requirement knowledge; potential new product concept	Not for new product categories; may not be appropriable	Belderbos et al. 2004b, Von Hippel and Katz 2002, Von Hippel 2005, Cui et.al. 2009
Component Suppliers	Knowledge of outsourcer's product and system; component expertise; efficiency	Usually not novel ideas; might cause dependence	Wasti and Liker 1997, Wasti and Liker 1999, Belderbos et al. 2004b, Cui et.al. 2009
Competitors	Current market knowledge and technology	Potential technology leakage	Hamel et. al. 1989, Belderbos et al. 2004b, Cui et.al. 2009
Start-ups	Source of creativity; high upside potential; source for acquiring disruptive innovations	Block firm's own IP; high market risk; potential competitor; different culture	Chesbrough 2006, Terwiesch and Ulrich 2008; Cui et.al. 2009

Table 2. Innovation Provider Strengths by Type

Still, theoretical knowledge about this question is so incomplete that we cannot test hypotheses, but have to see what emerges in a qualitative study. However, we know enough to expect that the provider type as well as the technology maturity probably influence project management in some way. Therefore, we have collected data on 31 innovation outsourcing projects across five innovation provider types and two technology life cycle stages, attempting to expand existing success driver lists, and to check for contingency factors by identifying a set of common and a set of provider-specific success drivers.

3. Research Design and Data Collection

3.1. Research Design and Method

The goal of our study is to explore (1) the selection criteria of innovation providers, and (2) the project management practices associated with successful outsourcing projects. Note that selection occurs at the outset, while project management unfolds after the provider is chosen.

Our unit of analysis is a single project with outsourced innovation activity. The dependent variable is project performance, as reported by our interviewees (“successful” or “less successful”). All cases are used together for the first research question (match between track record and client needs), while innovation provider type and technology life cycle stage serve as contingency factors

for the second research question (success drivers). Our research design therefore has two dimensions, as presented in Table 3 (cf. Yin, 2003). Each cell in Table 3 contains successful and less successful projects, classified this way and chosen for the study by the innovation manager of the respective business units.

Innovation Provider	Embryonic Technology Stage	Mature Technology Stage
Universities	<ul style="list-style-type: none"> • 4 successful cases • 3 less successful cases 	
Component Suppliers	<ul style="list-style-type: none"> • 3 successful cases • 1 less successful cases 	<ul style="list-style-type: none"> • 3 successful cases • 2 less successful cases
Customers	<ul style="list-style-type: none"> • 5 successful cases • 2 less successful cases 	
Start-ups	<ul style="list-style-type: none"> • 2 successful cases • 2 less successful cases 	
Competitors	<ul style="list-style-type: none"> • 3 successful cases • 1 less successful case 	

Table 3. Research Design

The “independent variables” that explain success have to emerge from the study and are described in detail in sections 4 (provider selection) and 5 (provider management): as existing theory is immature (see Section 2), we cannot test hypotheses but instead build grounded theory via multiple comparative cases. The cases are selected, as far as possible, to maximize variance (Glaser and Strauss 1967; Strauss and Corbin 1998). Case descriptions allow an understanding of formal and informal processes (Miles and Huberman 1994), while case comparison permits replication (Eisenhardt 1989) and thus greater reliability (Yin 2003). We report representative instances of the emerging variables to illustrate qualitative causality. Further, we take advantage of the relatively large (for this method) sample of 31 cases and triangulate the qualitative case descriptions by simple statistical tests that reduce the risk of obtaining our results “by chance”. The combination of qualitative data to help elaborate a phenomenon and quantitative data to check robustness of relationships can promote both insight and rigor (Edmondson and McManus 2007). As a result, we obtain grounded theory with a first robustness test from statistical analysis.

Consistent with previous studies, we categorize the technology stage as either embryonic or mature (Anderson and Tushman, 1990, 2001). We asked interviewees to evaluate the market and

technology uncertainty of the outsourced technology (high or low). The technology was classified as embryonic if it faced high market uncertainty or high technology uncertainty (or both). Our cross-provider comparison focuses on the embryonic phase, and our cross-phase (life cycle) comparison focuses on the supplier as provider because suppliers tend to be involved throughout the technology life cycle in the host industry. Universities, in contrast, are used mainly during the embryonic phase at Siemens.

3.2. Data Collection

Siemens is one of the largest electronics companies in the world. The company's R&D domains range from radical technologies to process innovations. Siemens complements its in-house R&D efforts by collaborating with hundreds of external innovation partners. Thus, the company provides all the ingredients of a complex innovation outsourcing environment, so the insights derived from this context should be relevant to other organizations and have the potential for generalization.

Our data were collected in 35 semi-structured interviews covering 31 cases at nine different divisions of Siemens in Germany, Austria and Switzerland. The 31 cases are all bilateral R&D collaborations between Siemens and external providers, who are spread across ten countries, including Germany, France, Netherlands, Portugal, Switzerland, U.S., China, South Korea, Israel and Australia. The R&D topics involve diverse themes, such as energy technologies, transportation systems, access control, graphic identification systems, software development, and calculation algorithms.

We followed a variational data sampling procedure (Strauss and Corbin 1998) to collect our data on the dimensions of provider type, technology maturity and project performance (see Table 3). The fact that we cannot, due to our sampling strategy, examine correlations between provider type (or maturity) and project success is acceptable, as previous studies have not found connections between provider type and project performance (Hagedoorn et al. 2000; Belderbos et. al. 2004b).

The interviewees were project managers, senior engineers and innovation portfolio managers. Each interview was documented in a standard format within 24 hours. Additional supporting materials included official project documents, pre-interview summaries, and clarifying follow-up questions and e-mails. The authors also discussed the results of the analysis and managerial implications (as they

became available) with the Siemens partners, who clarified ambiguities and challenged interpretations.

The interviews were semi-structured (see Appendix 3); the questions attempted to avoid imposing implicit assumptions. A typical question was, “Why did you decide to outsource this project?” rather than whether the outsourcing decision was motivated by specific motivation categories. This approach enhanced the validity of the field data and allowed us to capture emerging relevant variables (Yin 2003).

The 31 projects represent about 30% of the important technology outsourcing initiatives in the nine Siemens business units involved (and perhaps 3% of collaborations across all 100 Siemens business units). A selection bias is unlikely as the constraining factor in case selection was the access by two of the co-authors, which is not correlated with project characteristics or success. However, the success reports may be positively biased because the interviewees were personally involved in the case projects. To reduce such biases, we asked (later in the interview) whether the project achieved the original outsourcing goals. In the case of a negative answer in a “successful” project, we had intended to reclassify it into the “less successful” category; this proved not to be necessary, providing some evidence that biases were not strong enough to cause such contradictions. Remaining biases in the success category were shared by all interviewees and so should not invalidate our results, which were based on comparisons across projects.

To assess areas of provider strength, we needed a strength measure that was independent of the project’s success. We recognized that a successful experience may influence a respondent’s evaluation of the provider (respondent bias, Weisberg 2005), of the type: “This project did not give us the hoped-for benefit; therefore, this provider must be weak.” Respondent bias can be avoided by combining multiple interviewees’ answers (Weisberg 2005), but this was, unfortunately, not feasible in our study because the busy innovation managers of the Siemens units (who report through different parts of the company) were not willing to increase the number of respondents per project. An established (although less preferable) alternative was to reduce respondent bias through the wording and context of the questions (Foddy 1994; Weisberg 2005). In line with this approach, we attempted to reduce bias in several ways:

- We addressed motivations first in the interview, then the collaboration and provider strengths, and

finally success. The questions about provider strengths did not immediately follow the questions on outsourcing motivations, which decreased cognitive linkages between these two issues.

- Questions concerning provider evaluation were open-ended, and we never asked directly for an evaluation. Interviewees were always asked to describe the collaboration process broadly before being asked to describe the providers, which reduced the risk of a context effect.
- When interviewees made negative or positive statements about the provider, we asked for supporting evidence, such as numbers and events. This ensured that interviewees made reasoned judgments.
- Data of 14 projects were based on least two interviewees. In addition, we used available formal documents to back up evaluations whenever possible.

4. The “Match” between Outsourcing Motivation and Provider Strengths

Our first research question seeks to identify innovation provider selection criteria. As discussed in Section 2.1, a provider’s track record criterion has not previously been connected to client need dimensions, and the concept of a “match” arose in the course of the case studies. We start out by illustrating the contrast between a match and non-match with two examples.

In one technology development project, Siemens developed a fuel cell with novel materials. The technology had passed a feasibility test three years earlier, but the project team was still struggling to get it ready for market launch due to material and manufacturing facility costs. The project had insufficient manpower to solve the problems, as the project manager noted, “You know, for those uncertain and risky projects, it is very hard to convince the boss to increase investment and hire more employees. Finding partners externally is much easier to get support for.” The project obtained permission to hire an external specialist, a research institution with a high reputation in the relevant area and a good track record. The partner institution assigned a PhD student full-time to the Siemens lab, with guaranteed technical support from the home lab.

However, Siemens realized over time that neither the student nor her home lab were familiar with the lab environment at Siemens: “It took almost one year for them to repeat what we had already done.” In one instance, Siemens wanted to use a standard 5-inch tube, which had proven reliable in

manufacturing. But the provider clung to a 3-inch tube because, “As we later found out, their home lab had only the ability to handle a maximal length of 3 inches.” The Siemens project manager learned a lesson: “We should look not only at general capabilities, but also at specific skills closely related to our requirements.”

In contrast, a second project developing a new automated control system collaborated with a lab at a different German university, which had one of the few experts specialized in this technology. The Siemens team needed “theoretical support” as well as “novel thoughts that were difficult to generate internally”. A professor from this university was involved who had a long history of collaboration with Siemens and “understood Siemens’ vision of future technology very well”. Under his guidance, two PhD students regularly attended Siemens’ development meetings and helped brainstorm new ideas. This collaboration turned out to be productive; as the project manager commented, “We are satisfied with them ... they produced exactly what we hoped for.”

This contrast illustrates that the provider’s specific capabilities matter in so far as they “match” the client’s motivation. Below, we measure this match and show that it seems to make a difference to project success.

4.1. Consistency Check: Motivations and Provider Selection at Siemens

Before we can examine the match between provider strengths and client needs, we coded the 31 projects’ outsourcing motivations as they arose from the interviewees’ descriptions (see Table 4; for reasons of confidentiality, projects are identified only by numbers). Consistent with previous studies, there is some correlation between outsourcing motivations and providers, reflecting their typical areas of strengths. However, there is enough variation to seek a connection between a specific supplier’s strengths and the outsourcer’s motivations (needs).

The motivation for outsourcing changes with technology maturity in expected ways (for component supplier providers). First, the importance of gaining technical expertise and understanding market needs weakens as the technology matures. Second, the manufacturing motivation becomes dominant in mature projects (named in four of five): e.g., “We need market-ready [component] technology that fits product requirements.” Third, the strategic motivation is more prominent at this stage: Supplier technologies tended to complement (rather than compete with) the firm’s core

technology.

Partner Type	Projects	Cost	Market	Manufacturing	Strategic	Technology	Organizational
University	U 1					+	
	U 2					+	
	U 3					+	+
	U 4			+		+	
	U 5	+				+	
	U 6					+	+
	U 7					+	
Customer	C 1	+	+			+	
	C 2		+				
	C 3		+			+	
	C 4		+			+	
	C 5		+				
	C 6		+			+	
	C 7		+			+	
Competitor	CM 1					+	
	CM 2		+			+	
	CM 3	+	+		+	+	
	CM 4	+	+			+	
Start-up	ST 1					+	+
	ST 2			+		+	
	ST 3					+	
	ST 4		+		+		+
Component Supplier (embryonic)	S 1	+	+			+	
	S 2			+		+	
	S 3		+			+	
	S 4					+	
Component Supplier (mature)	S 5				+	+	
	S 6			+			
	S 7			+	+	+	
	S 8			+	+		
	S 9			+		+	

Table 4: Outsourcing Motivations in the Cases (successful projects are shaded gray)

These findings suggest that outsourcing at Siemens is motivated—and the providers selected—in ways that are similar to outsourcing practices found in previous studies. It increases our confidence that the answers to our two research questions (provider selection and management) are also relevant to other organizations (although generalizability cannot be established without additional studies).

4.2. The Match of Provider Strengths and Outsourcer Motivation

We now proceed to our first research question: Does the outsourcer’s motivation need to be matched by strengths of the provider, and if so, how? To examine this question, we coded the interviewees’ descriptions of each provider’s strengths on the same dimensions as the outsourcing motivations, as summarized in Table 5. We then compared Table 5 with Table 4, project by project.

Partner Type	Projects	Cost	Market	Manufacturing	Strategic	Technology	Organizational
University	U 1	+				+	+
	U 2					+	
	U 3		+			+	+
	U 4	+	+			+	
	U 5	+	+			+	
	U 6						+
	U 7					+	+
Customer	C 1	+	+			+	+
	C 2	+	+				
	C 3	+	+			+	
	C 4	+	+			+	
	C 5	+	+			+	
	C 6					+	+
	C 7	+	+				
Competitor	CM 1		+			+	+
	CM 2	+	+			+	+
	CM 3	+	+		+	+	+
	CM 4	+	+			+	+
Start-up	ST 1					+	+
	ST 2			+		+	+
	ST 3					+	+
	ST 4				+	+	+
Component Supplier (embryonic)	S 1	+	+			+	+
	S 2	+		+		+	
	S 3	+	+	+		+	
	S 4					+	+
Component Supplier (mature)	S 5			+	+	+	
	S 6			+		+	+
	S 7		+	+	+	+	
	S 8			+	+	+	
	S 9			+		+	+

Table 5: Provider Strengths on the Six Dimensions of Outsourcer Motivations (successful projects shaded)

Table 6 classifies the project comparisons across Tables 4 and 5 into four groups. The two right-hand groups (27 projects) represent a match: the dimensions where the provider has strengths covering the dimensions of outsourcing needs (motivations) exactly, or even covering the needs plus additional dimensions. The two left-hand columns, in contrast, are non-matches (4 projects): some outsourcer needs are not covered by provider strengths, either because the strength dimensions are a subset of the need dimensions, or the strength dimensions cover some (but not all) of the need dimensions plus some “unnecessary” dimensions. When we count the number of matches among the successful and the less successful projects, we find that the distribution is far from random.

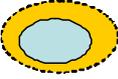
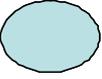
	Strengths cover only a subset of motivation dimensions	Some motivation dimensions not covered by strengths	Set of motivation dimensions equals set of strength dimensions	Strengths cover a superset of motivation dimensions
				
Successful (20)	0	0	2 (10%)	18 (90%)
Less successful (11)	1 (9%)	3 (27%)	0	7 (64%)

Table 6.: Matching Motivations and Provider’s Strengths

None of the projects with a non-match were ultimately successful (a conditional success probability of 0), whereas 20 of 27 match projects (74%) were. Conversely, no successful project is characterized as a non-match, while four (36%) of the 11 less successful projects are. The correlation between “nonmatch” and “less successful” is 0.52 (the corresponding Goodman-Kruskal gamma value is 0.55).

To check these observations statistically, we can view Table 6 as a 2×2 contingency table. We apply Fisher’s exact test (the alternative to a the chi-square test when the number of observations in the cells is small and unequally distributed; see Agresti 1996): The null hypothesis that a nonmatch is equally likely among successful and less successful projects is rejected with a one-tailed significance of 0.01.¹ Checking odd ratios (using the amended log odd ratio estimator θ to correct for cells with zero data points, see Agresti 1996, p. 24), the odds of less successful performance are at least 2.269 times higher for providers without matching strength than for providers with matching strength.

These results suggest that the match between motivations and providers’ strength is a *necessary* but not sufficient condition for the success of outsourcing. In other words, without a match the project is at a high risk of failure, but even with a match other things can go wrong (e.g., the project may lack the operational success drivers discussed in the next section).

5. Operational Success Drivers Managing Innovation Outsourcing

We now turn to our second research question: What operational success drivers emerge for

¹ In a three-way contingency analysis, the provider type as a contingency variable turns out statistically insignificant; thus, the 2x2 contingency table is sufficient (Powers and Xie 2000).

technology outsourcing projects, i.e., can we complement previously identified lists, and most importantly, do we find contingency factors for the importance of the various drivers? To search for contingency factors, we first focus on the comparison across providers for embryonic technologies and then turn to the comparison across technology maturity stages. Table 7 summarizes the contingency factors: we identified several common and several provider-specific project management methods that were associated with success. The remainder of the section explains the details.

“Universal” Success Drivers (across Providers)	Providers	Provider-contingent Success Drivers
<ul style="list-style-type: none"> • Trust and communication • Organizational stability • Defined goals 	Universities	<ul style="list-style-type: none"> • Detailed process control • Incentive alignment • Knowledge transfer (from client to university)
	Customers	<ul style="list-style-type: none"> • Expectations management • Incentive alignment
	Component Suppliers	<ul style="list-style-type: none"> • Detailed progress control • Knowledge transfer (from supplier to client)
	Competitors	<ul style="list-style-type: none"> • IP protection • Incentive alignment
	Start-ups	<ul style="list-style-type: none"> • IP protection • Incentive alignment • Flexible decision making • Participation in partner’s management

Table 7. Common and Provider-Specific Success Drivers for Embryonic Technologies

5.1 Process of Data Analysis

To identify operational success drivers that made a difference, we first grouped the cases by provider type and compared successful and less successful projects per technology maturity stage. Next, we took three steps to analyze our interview data.

1. **Summarize the findings from interview notes.** We summarized all mentioned operational methods that might influence outsourced project success, without imposing predefined categories or hypotheses. 12 success drivers emerged during the interviews: in-house competency, detailed process control, defined goals, knowledge transfer, organizational stability, expectations management, trust and communication, IP protection, incentive alignment, flexible decision making, technology compatibility, and partner flexibility. These 12 drivers formed the “raw material” for our contingency

search.

2. **Code the interview notes.** We coded our interview data in a standard form as illustrated in Table 8, which shows the seven embryonic-stage projects with university partners. The complete data are shown in Appendix 1. Only ten of the 12 mentioned success drivers appear consistently in embryonic stage outsourced projects. “+” denotes “having this success driver” (e.g., in-house competency is identified as being present in three successful and two less successful projects). “-” represents “not having this success driver” (e.g., expectation management is not found in any university collaboration project). Reading down the table columns, some drivers appear in all or most of the successful projects, but in fewer less successful projects. Reading across the table rows, successful projects have almost all drivers, while less successful projects tend to have fewer of them. In other words, we identify *patterns* of success drivers that suggest causal hypotheses.

	Drivers	In-House Competency	Incentive Alignment	Organizational Stability	Defined Goals	Expectation Management	Trust and Communication	Flexible Decision Making	Knowledge Transfer	IP Protection	Detailed Process Control
Successful Cases (4)	U 1	+	+	+	+	-	+	-	+	-	+
	U 2	+	+	+	+	-	+	-	-	+	+
	U 3	-	+	+	+	-	+	-	+	-	+
	U 4	+	+	+	+	-	+	+	+	+	+
Less Successful Cases (3)	U 5	+	-	+	-	-	-	-	-	+	+
	U 6	-	-	+	-	-	-	-	-	-	-
	U 7	+	-	+	-	-	-	-	-	+	-

Table 8. Sample Data Table: Success Drivers of University Collaborations

3. **Check the pattern interpretations for statistical robustness.** A qualitative description gives a feeling for the causal forces in a project, but it does not identify the strength and robustness of the pattern across projects (Strauss and Corbin 1998). Our dependent variable is project performance (successful/less successful), and our explanatory variables are provider type, success drivers (fulfilled/not fulfilled), and technology life cycle (embryonic/mature). We compare success probabilities between cases where a focal success driver is present and cases where it is absent.

Previous studies found no significant correlation between project success and provider type (Hagedoorn et al. 2000; Belderbos et al. 2004). Therefore, we sample on success and treat it and provider type as independent. We then test whether the provider's match with the client's need (yes/no) and operational methods statistically influence success. We search for the commonalities and differences across groups (providers and technology maturity) by cross-checking the statistical significance test and goodness-of-fit statistics across various models (reported in Appendix 2).

To limit alternative explanations of outsourced project performance, we considered three control variables. The first is the provider's size: a large provider may require different operational success factors. However, it turns out that provider size has no discernible influence on the results. For instance, the "IP protection" success driver is critical for competitors (mostly large organizations) as well as for start-ups (small organizations). Similarly, the "detailed process control" success driver characterizes both small and large providers. The provider's size is correlated with its type but has no effect within types.

The second is the strategic relevance of the technology for the outsourcer: A non-core technology project might not need to be as tightly controlled. However, "strategic relevance of technology" is highly correlated with the technology's life cycle stage – three out of four projects of the non-core technologies are mature. The performance variance of the four non-core projects (S5, S7, S8, and ST4) can be explained by provider type.

The third control variable is geographical proximity of the provider to the outsourcing Siemens division (Schidle 2006), in terms of language (categorized as German versus non-German) and in terms of European versus non-European. Geographic proximity was not mentioned as important by any of our respondents, and moreover, a statistical analysis of success versus proximity did not produce any evidence of importance. Thus, we disregarded this variable in further analyses.

5.2. Common Success Drivers for Outsourcing Embryonic Technologies

Three success drivers were named consistently as being present by the managers of successful projects: trust and communication, organizational stability of the partner, and defined goals. We describe them with the following examples.

Trust and Communication. As one interviewee summarized, the rule of thumb at Siemens is “Do not collaborate with organizations that you do not know very well and where there is no mutual interest of continuing the collaboration for a long time.”

An example illustrates the importance of trust. One project aimed to launch a new-generation furnace technology by collaborating with a customer located in South Korea. Compared with a traditional steel furnace, the new technology promised dramatically improved fuel efficiency and, thus, reduced costs. Siemens was one of the leaders in this technology area but lacked any knowledge of manufacturing requirements in a large-scale plant. In addition, the company hoped to reduce the financial risks associated with this novel breakthrough technology by sharing costs with partners.

The partner was a leading global steel producer, owned state-of-the-art manufacturing facilities and had a technical advantage over its competitors. In addition, the partner’s ambition was compatible with that of Siemens: in the words of the CEO, “Our vision is to deliver 21st century technology to the end customers.” The relationship between the two had been ongoing for decades, since the 1960s, and the top managers knew each other personally. The customer’s CEO visited Siemens regularly and was directly involved in this collaboration, which turned out to be successful.

The Siemens project manager commented, “Ideally, two partners should be geographically close. But our industry has become a global, and people have to know and learn to trust each other even across large distances. When we have different opinions, project managers from two sides will sit down and discuss first.” The steering committee included senior management from both sides, further building trust.

Organizational Stability. A change of top management or project management on either side can seriously disrupt both the financial commitment and the expectation of collaboration. In one project, Siemens collaborated with a US-based customer to develop a new process technology for stainless steel. The new technology was quite promising and the U.S. customer was the only potential partner who owned manufacturing facilities for stainless steel. After three years of in-house efforts, Siemens initiated the collaboration with this partner, having checked the partner’s published patent portfolio and R&D expertise.

After the first experimental line had operated in the plant for one year, a disruptive strike occurred at the plant, lasting almost three months and completely shutting down the experiment. For reasons related to the strike the customer experienced a major change in top management. The new top management team did not view the new technology as favorably as their predecessors and as a result “The climate in the steering committee completely changed”, as one Siemens manager recalled. Ultimately, the customer terminated the collaboration citing financial reasons. “They felt that the technology was too risky ... and they did not share the same strategic views with us.” The stability of top management as well as their risk preferences was “extremely important for the success of a large-scale, radical R&D project such as this one”, commented the project manager.

Stabilizing the partner organization requires reducing the dependence on individual employees, as many interviewees mentioned. For example, the most difficult challenge in working with start-ups is their dependence on individual employees, as typified by the observation: “Start-ups don’t have a credible track record.” Their technologies or patents are “embodied in individual employees”, so if something happens to this person or small group, or if the key person leaves, the whole company may die or lose its usefulness. In one successful project, the head of the start-up was both general manager and chief engineer. The outsourcing contract provided that in the event that something happened to him, Siemens could take possession of all design blueprints.

Organizational stability may seem less critical in university collaborations because universities seem relatively stable - some interviewees took the university partners’ stability as given and did not explicitly name it as a success driver. However, our finding is statistically valid for universities as well; for example, star professors may also leave, so although the problem may be less frequent (Valentin et al., 2004), firms still need to pay attention to it.

Defined Goals. Many interviewees highlighted the importance of setting key delivery time (and cost) targets. A target should be specific and operational, for example, it might be stated as “decrease energy consumption by 30%”.

One project involved collaborating with a major customer of Siemens’ laser technology. By partnering with this customer, the new product targeted an emerging market as well as obtaining a stronger position in influencing the technology standard. R&D costs were split according to each

party’s strength, each focusing on modules associated with its expertise. Siemens focused on hardware development, while the customer undertook market research. The technical goal was clearly stated as “improving memory capacity by at least 300% compared with current technology”. Interface requirements were strictly defined in the project handbook. A steering committee involving all the partners met twice a year to review progress. In addition, technical meetings happened quarterly and when approaching milestones. The project manager noted, “Once the target [and interface] is set, each party can work without interruptions.” The project was successful, launching the new product on schedule in 2008. However, along the way targets may need adjustment in response to emerging events such as unexpected system interactions or the unforeseen appearance of competing technologies – for example, Siemens revised its technical goal to “increase memory by at least 450% compared with technology in use” when a competing technology emerged.

Statistical Robustness. A simple yet intuitive step is to compare the project success probabilities with and without the drivers present (Figure 1). At the top, we see the “base” success rate of 65.4% within the sample of all embryonic technology projects. Below, this sample is split into those that have the trust and communication driver present (16) and those that don’t (10). The success probability of the projects with the driver is 93.8%, and of the projects without the driver only 20%. This success probability is different from the base probability with a significance level of 0.02%, using the Fisher exact test. Similarly, organizational stability and defined goals shift the success probability significantly across the entire sample, across all provider types.

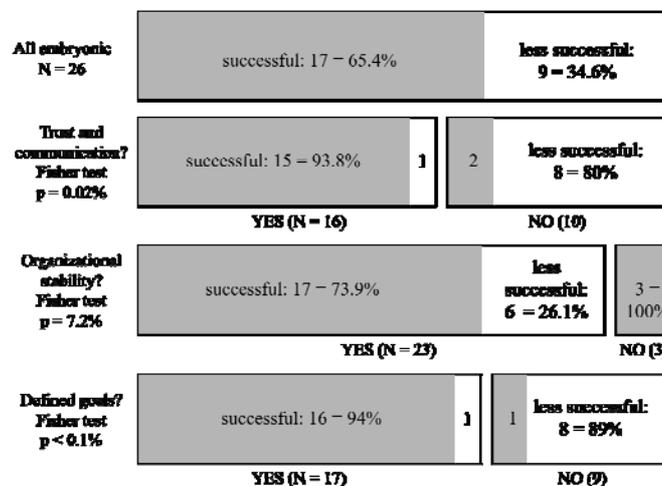


Figure 1: Success probability comparison with and without success drivers

The simple Fisher exact test is confirmed by a more formal analysis, namely contingency tables that include all contingency variables (shown in Appendix 2).

5.3. Provider-Specific Success Drivers for Outsourcing Embryonic Technologies

We now turn to the success drivers that emerged in our interviews as relevant for success, but which did not robustly influence success over the entire sample. As an example, consider IP protection in Figure 2. The top of the figure shows again the base success probability over the entire sample (65.4%). Below, splitting the sample in subsamples with the IP protection present and absent does *not* significantly shift the success probability. However, considering the providers separately changes the picture: in competitor and startup collaborations, the driver does shift the success probability, with a significance level of 10% in spite of the small subsample. This supports a contingency view: IP protection is critical for competitors and startups, but not for other providers. A similar picture emerged for all drivers discussed in this section; the statistical numbers (analogous to Figure 2) are shown in Appendix 2.

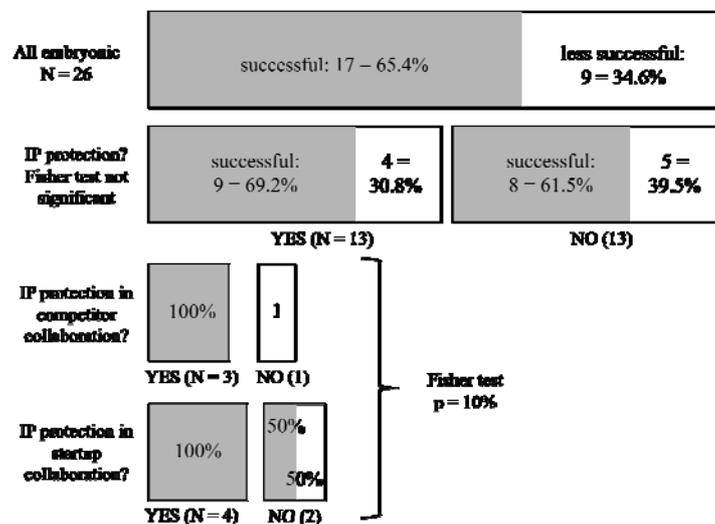


Figure 2: Success probability comparison for provider specific success drivers

Incentive Alignment (universities, competitors, customers and start-ups). Incentive misalignment is a common threat to collaboration; the only provider type where it did *not* emerge as a success differentiator was the component supplier category: All suppliers had previously collaborated with the same Siemens units and had learned to work around and resolve conflicts. Misalignment is illustrated

by the following example. In preparing a potential collaboration with one university on the development of new network algorithms, Siemens evaluated the strength of the university partner using five considerations:

- The partner owned a ready-to-use system to simulate functionalities developed by Siemens in-house.
- The partner actively participated in and contributed to research in the current technological evolution.
- The partner offered well-trained students with the potential to become job candidates in the future, who entered an exclusive agreement with Siemens during their studies.
- The Siemens project manager had graduated from this university and personally knew the researchers.
- The partner was geographically close to the Siemens lab, facilitating communication and progress monitoring.

However, as the project went on, Siemens realized that the university research group had different goals: “We cared about reliability within a small range of feasible parameters, while the university partner loved changing parameters to get robust results for publications.” Also, Siemens found it difficult to “convince the PhD students to constrain themselves into the structured development process of the company”.

In order to tackle these challenges, the project team arranged three months of in-house orientation for the PhD students. For the entire first two years, Siemens project managers met the students every two weeks to monitor progress that could be presented to Siemens’ development team at quarterly meetings. Ultimately, the key reason for success of the collaboration, in spite of these conflicts, was the fact that the project manager had graduated from this university and understood the mindset of the PhD students. This enabled him to mediate between the Siemens team on the one side and the university lab and its PhD students on the other.

Detailed Process Control (university, start-ups, and component suppliers). Process control involves well-defined progress and cost milestones; it is necessary in the presence of misaligned incentives (see the subsection above), but also to enforce Siemens’ quality standards, as the following example illustrates.

Siemens collaborated with a component supplier to develop a new surgery technology. Compared to the predecessor technology, the new technology took less space and offered a higher patient safety standard during operations. At that time, the Siemens business unit had only two

engineers with the required specialized experience, so management decided to collaborate with an external provider. The provider was a relatively small supplier company with a good industry reputation and a positive previous working relationship with Siemens.

After one year, the supplier delivered the first prototype on time. This triggered the hospital testing phase, carried out by provider personnel with only one Siemens engineer (due to the business unit's personnel shortage). Some minor technical issues arose during hospital testing, but the Siemens engineer did not fully report the problems and left the company right after product testing was completed. Hence a personnel issue affected quality procedures, but the provider was not capable of correcting the lapse.

As manufacturing was being ramped up, a serious injury occurred in the hospital. Siemens was forced to repeat the product testing and then decided to produce the product completely in-house rather than outsourcing it to this component supplier. The delay gave Siemens' competitors the time to launch a similar product, and Siemens abandoned the product two years later. The Siemens team drew the following lesson, "In light of the high risk in medical products, in the sense that someone might actually get hurt, you better open your eyes and perform the critical step yourself."

Process control is also important in collaborations with start-ups, but in a different spirit, emphasizing "active participation in governance" rather than "direct control." In one non-successful project, a Siemens employee was assigned to the board of a start-up that undertook a project relevant to Siemens. When another firm offered a better buy-in price than Siemens, this employee was legally unable to vote for Siemens. As the technology successfully evolved toward competing with Siemens's own product, Siemens sold its shares because "We couldn't control it and the shares fetched a good price." This example holds a more general lesson: Fully benefiting from a start-up collaboration requires management involvement to steer its R&D activities. Use whatever leverage you have in a partner's decision making and do not squander it for unrelated or "general policy" reasons.

IP Protection (competitors and start-ups). In one successful project, Siemens collaborated with a major European competitor to jointly develop a new-generation flat panel medical detector technology. As the technology looked quite risky at the time, Siemens wanted to reduce the large technological and financial risks by collaborating with this competitor. Moreover, both partners faced

a challenge from a third competitor in the U.S. market. “We needed to work together to send the same message to the European market”, the project manager stressed. The collaboration lasted for six years, of which the first was spent entirely on negotiating contracts and IP. “The collaboration was successful and we obtained the technology that we didn’t own ... we achieved the desired market share with very low R&D costs.”

“The IP is the key to collaborate with competitors,” the project manager continued. In this project, the parties jointly drew up an IP exchange contract, which allowed each partner to use the IP and share the benefit from selling the technology. In addition, a special clause in the contract specified that “The IP share will be contingent upon an [independent] review of R&D contribution of each side.” The IP negotiation indeed took a lot of time, using expensive high-quality attorneys, but this was a necessary investment in the success of this collaboration with a major competitor.

One systematic way of protecting IP in a competitor collaboration project is to create a “collaborative platform”. All projects with this competitor are organized around identified themes and products/technologies within this platform, keeping other technologies out.

In the past, several start-ups had evolved into competitors, and this occurred with one of the less successful collaborations in our sample. “A start-up can sell the IP to competitors or produce it itself; either [action] blocks us.” Unfortunately, “IP is [most start-ups’] main property, and they tend to protect it very tightly.” In one successful case, Siemens gave the IP to the start-up but retained ownership of the complementary hardware technology to the start-up’s software product, and this technical dependence protected Siemens from a loss of control.

Knowledge Transfer (university and supplier). The expertise of universities and R&D institutes is usually quite general (see Section 2). To fulfill specific project requirements, a university partner needs to acquire “local knowledge” so it can understand what has already been done and what still needs to be accomplished, otherwise unnecessary replication will occur.

In contrast with universities, which need knowledge transfer from the clients, component supplier partners need to emphasize the knowledge transfer to the client. For example, Siemens developed a new patient symptom monitoring system with a component supplier in the U.S. The outsourcing motivation had three dimensions: to get access to the supplier’s expertise in software

development, to benefit from a cost advantage in U.S., and to be associated with a US brand at a time when national identity became a big issue in the U.S. market.

This component supplier had a longstanding collaboration with Siemens and even a personal relationship with someone in Siemens' top management. Moreover, it had gained an industry-wide reputation for an "extremely fast pace to develop new technology". The supplier successfully delivered the first prototype on time, but the subsequent testing stage uncovered problems, and Siemens doubled the project budget to improve the design. The redesign specifically involved manufacturing engineers alongside the supplier's design engineers. Expanded testing and redesign took an extra year but then the manufacturing ramp-up was much smoother than expected. Ultimately, the product was launched on time and quickly became a U.S. market leader.

The Siemens team learned from this project that effective knowledge transfer from R&D – specifically from the supplier's design organization – to manufacturing improved and accelerated the product launch. In the words of the project manager, "You have to ensure your component supplier understands your product requirements. Due to the involvement of manufacturing during the testing stage, we saved a lot of time later."

Expectations Management (customer). Four out of five successful customer collaboration projects have this driver, but only one of two less successful projects (see Appendix 1). Customer satisfaction is usually of the utmost importance for success but it can also become a liability. One major customer initiated a project with Siemens to develop a sports car engine control system within a new car architecture. The project started from scratch, but then proceeded very fast: from the customer order to the first available product in only 18 months. The project manager recalled, "The biggest challenge we faced was managing the customer's expectations." The customer was excited and pushed very hard to see quick results. On the other hand, Siemens needed time to correctly translate the customer's requirements into actionable specifications for in-house engineers and component suppliers. "It is very hard your in-house engineers to work in parallel to the customer," said the project manager. The Siemens team and the customer had a meeting every week. Siemens prepared test reports, samples, and problem and action lists. "I reported to the board directly," recounted the

project manager. “For example, when I need a machine, I would talk to the board, and my boss would ask, ‘How much do you need? Go ahead and do it.’ ”

At one point, the customer requested fifty prototypes with a requirement of very high product reliability. To manage the risks, the Siemens team presented detailed progress reports at each milestone. This built customer confidence and as a result, “Our collaboration worked well even at one point when four prototypes failed.” The collaboration became constructive when “the customer had learned enough to articulate *reasonable* expectations”. The project manager concluded, “It was a large time investment, but it paid off because you need to let customers know what can be done and what can’t be done.”

Flexible Decision Making (start-up). The observations from start-ups subgroup are suggestive; both successful projects have this driver, but only one of two less successful ones. As an illustration, Siemens worked with a start-up company in the U.S. in order to develop a new scan technology that would dramatically increase data collection speed. The provider was screened by Siemens venture capital; it owned two patents on the relevant technologies and the team felt that it needed the start-up’s expertise. Both parties agreed to build a joint venture, with a 15% share for Siemens.

The collaboration was a technical success and the new product was quickly launched. However, the new product quickly cannibalized and threatened other products in Siemens’ line. The Siemens project manager commented, “At first, I struggled to balance the interests of the joint venture and Siemens.” When the start-up’s new scanner started to attract major customers away from Siemens, the Siemens representative on the board strongly suggested revising the design, threatening to sell the start-up’s stock. The founder of start-up finally gave up, “but our trust collapsed”. The relationship between two parties continued to fray over three years of collaboration. “They did not listen to us, and we thought they asked for too much,” recalls the project manager. Siemens started to sell its shares in the joint venture, which ultimately failed.

In another start-up collaboration, the start-ups needed a quick response to the market and financial support from Siemens, but “our financial decision usually took at least two months ..., and then, sometimes, our promise cannot be delivered because corporate has other priorities”. The project manager concluded: “In order to work well with start-ups, we need different mindsets and procedures.

(...) Maybe, putting more investment and building mutual trust instead of selling the shares would have been the better decision.” Another interviewee added, “To work with start-ups, you have to be proactive. ... Always prepare yourself for their needs beforehand.”

5.4 Outsourcing Mature Technologies to Suppliers

In this section we report our observations about outsourcing the development of a mature (as opposed to an embryonic) technology to a supplier. Several success drivers are the same as for embryonic technologies (namely, knowledge transfer, and trust and communication). Two additional demands arise: compatibility of components with the existing system architecture and flexibility, and a willingness to adjust components to accommodate broader system requirements.

Technology Compatibility. In one non-successful project, Siemens collaborated with a well-known processor supplier to develop a new data communication system. The supplier had a good industry reputation and a long history of collaboration with Siemens.

The outsourcing motivation was time pressure; in the words of the project manager, “The system was not very complicated and we had tested technologies in house, but we faced high time pressure, and the supplier had a processor market-ready. In addition, we trusted their experience in processor design, their processor was better than our in-house processor.”

The collaboration went well and launched the first market-ready product within one year, without going through the prototype stage. “We felt we did not need a prototype because almost each component was market ready, and we only to put them together via known interfaces.” But very soon, customers started to complain about product reliability. Sometimes, the system shut down after a few hours and bugs appeared that could not easily be solved.

Siemens hired an external technical consultant to diagnose the problems. They discovered that the root cause was that the processor was not compatible with Siemens’ system technology. Quickly, the team returned the processor to the supplier requesting modifications. However, the supplier did not accept the report and asked for a re-testing. Siemens sent the product to another consultant, whose re-test confirmed that the incompatibility problem still existed.

Finally, Siemens terminated the collaboration. The product launch was delayed for another three months, and the budget was exceeded by 40%. In hindsight, it realized that, “Compatibility should have been verified at the outset in spite of the seemingly mastered interfaces.”

Flexible Partner. In one successful project, Siemens collaborated with a German supplier to develop a special access control system. Again, this project looked easy at the outset: “This technology is pretty mature with more than 50 years of history,” said the interviewee. However, customers (as they often do) demanded customized requirements and additional functions, some of which were not within the Siemens team’s core expertise: “We need both quality and speed, so we sought a supplier with a market-ready technology for the additional functions.”

This component supplier had long collaboration history with Siemens, and was viewed as one of its best suppliers. As soon as Siemens received the customized requirements, “We immediately sent our specification request to them, and they delivered the first version for a test within one week.” But then Siemens’ customer wanted to adjust the requirement again and add further functions. “I called the CEO of the supplier,” the project manager said, “and after a five-minute chat, they promised to deliver a new version in another week, and they did.” This component supplier charged a higher price than others, “But we still rely on them because they can deliver on time and be flexible toward our customers’ needs.”

6. Discussion and Limitations

Technology outsourcing contains two important phases, provider selection and management. Existing theory does not give companies a sufficient basis for *selecting* technology providers (price is not a sufficient criterion, but what does “track record” mean?), nor for *managing* providers (what specific emphasis must be placed on general project management methods in order to successfully work with an external provider?). By conducting a field study of 31 comparative innovation outsourcing case studies at Siemens, we aim to build grounded theory on provider selection and management, two important phases in the innovation outsourcing *process*, in order to fill some of the gaps in existing knowledge. Our results have implications for theory as well as for practice.

6.1. Implications for Theory

Previous work has emphasized that a provider should not be selected based on price or formal quality alone—the track record of a technology provider, that is, a history of successful projects in the focal domain, is a predictor of success. However, track record should not be defined abstractly and absolutely, it must somehow depend on the context and the characteristics of the partners. Our emerging theory suggests one specific way of operationalizing this context-dependence of track record, namely in the form of a “match”: if the provider’s strengths cover (at least) all outsourcing needs of the client, a project’s success probability significantly increases. A match can be articulated as a correspondence between the outsourcer’s needs, or motivations, categorized in some way (for example, with motivation categories that have appeared in previous literature: cost, market, manufacturing, technology, strategic, and organizational), and specific documented strengths on the provider on those same dimensions. This concept of a match complements previous, more general, concepts of organizational compatibility, and allows measurement in the field.

The second phase of technology outsourcing (and our second research question) is concerned with what methods can be used to manage and control an external technology provider. Lists of operational success drivers exist (for example, the list by Eppinger and Chitkara), but we do not know whether they are complete, and how they depend on the context. Our emerging list of 12 success drivers has some overlap with Eppinger’s list (such as in-house core competences and IP protection), but there are also substantial differences. This indicates that there is no “universal list”: Eppinger and Chitkara’s list emphasizes the change involved in globalization, and so management commitment, infrastructure, and process and product modularity appear as key enablers. Our host company has collaborated with many providers for a long time, so some of the internal enablers may already be in place and not be mentioned, while other desired characteristics appear. Any list depends on the context, a “super list” may quickly become very long.

Therefore, we do not attempt to provide a success driver list for individual providers, but we uncover evidence for the contingency impact of provider *types* (universities, customers, component suppliers, competitors and start-ups). A few success drivers are common across providers (trust and communication, organizational stability, and defined goals), but the other seven important drivers differ across providers. Establishing this contingency effect is important: although the specific

success driver list may need to change across contexts, expecting systematic differences across provider types is an important hypothesis to be tested, and it enables the design of better targeted studies.

6.2. Implications for Practice

Figure 3 summarizes our findings in the form of a decision framework over the phases of provider selection and provider management. Direct managerial implications result from both of our key results. First, the match between provider strengths and outsourcer motivations directly translates into a “checklist” or “decision rule” that project managers can implement. As experienced R&D managers, most of our interviewees were well aware that “cost” or “bid price” was insufficient in selecting innovation providers; they mentioned “checking previous track record” or “strong expertise” as an important consideration in provider selection. Our results suggest that assessing a provider’s “track record” means verifying the *specific* competencies of a prospective outsourcing partner, which match the project-specific outsourcing needs. In other words, if a large provider has well-known expertise in a general area, this may be less relevant than the specific competences that a smaller provider may have on specific activities required in this project. The concept of “match” is particularly useful for the outsourcing firm when most of the potential providers have general “technical expertise” (see Table 5).

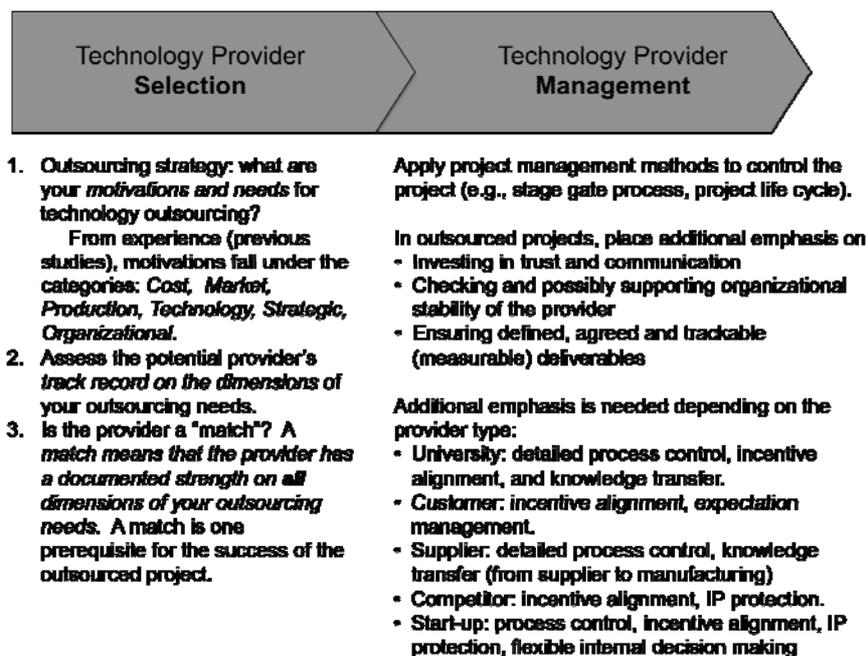


Figure 3. Managerial Implications for Provider Selection and Provider Management Phases

The success drivers indicate what a project manager might want to emphasize in his or her project when an external provider of a certain type is involved. They can provide a minimal checklist that helps to “cover the bases” of important management levers in an outsourced project. The key lesson is not the specific list emerging from our study (and summarized in Figure 3), the key lesson is to be flexible to *manage different projects differently* depending on the provider type and the maturity of the outsourced technology (for example, bringing in lawyers to ensure IP protection in one project, while assuring knowledge transfer in another project). Our list is certainly incomplete and but a starting point, but it is a good habit to always ask, “What are the weaknesses and dangers in this provider, and what can we put in place to manage these weaknesses?”

6.3. Limitations

We make no claim to have identified the complete list of success drivers—every company will need to develop its own list over time. Strictly speaking, generalizability of our results cannot be established without repetition across many companies, but this is a fundamental trade-off between in-depth case studies at one company and broader surveys that are insufficiently rich to identify emerging issues that are not predicted by theory (as in the case of our results). The replication of the outsourcing motivations and provider strengths from previous studies (Section 2) and the consideration of control variables at least suggest that Siemens is not fundamentally different from other companies. Thus the consistent observation of success drivers at Siemens may provide a starting point for others.

The true causality of our findings needs further verification: although our interviews indicate causality in hindsight, in some cases the situations are so complex that the true connection may represent a mere association, or there is a “spiral” of mutually reinforcing causalities (such as communication leading to trust, which lessens opportunistic behavior). Our added statistical tests can confirm association but not causality. In addition, the key limit of generalizability lies in the company-specific commonalities that all cases possess, such as a centrally controlled R&D decision process across Siemens as well as a homogenous employee structure, education level and language.

While this should reduce “noise” in the observations and enable us to distinguish any influences of our variables of interest, it is this commonality that limits the applicability of our results to other organizations. For instance, Siemens’s highly developed managerial accounting methods are likely to make any financial control-related issue a common baseline in our sample, preventing it from appearing as a success driver; organizations with less developed accounting methods may well experience “financial control” as a distinct success driver.

Many detailed questions remain for promising future work—for example, how should a provider be chosen when the outsourcer’s need are evolving and, therefore, uncertain? We want to point out, however, one question that we think is of central importance: our study has examined individual projects. However, it is a strategic decision to determine the portfolio of outsourced projects. Of course, somehow this portfolio should be separate from the outsourcer’s core competencies, but how far should the outsourcer go? How broad should the outsourced portfolio be?

On the way to better understanding, we believe that our lessons are useful to other organizations and other industries as a starting point, with the proviso that appropriate caution and translation to a different context be applied. For example, a consumer product company will seek customer input in a way that is different from that used by Siemens with its industrial customers. Again, our results should be viewed as starting hypotheses from which a company can build its own specific experiences. This study offers a way of thinking about the problem but the choices about specific providers and the operational success criteria discussed here are not necessarily transferable.

Managerial guidance on both innovation provider selection and operational provider management is useful for firms. Our study identifies clear principles with at least some evidence of robustness. This may provide a platform for cross-industry studies.

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Appendix	Less successful Cases (1)	S4	Operational Success Drivers	Embryonic Stage	-	-	-	-	-	-	-		
Provider Type		Projects	In-house Competency	Incentive Alignment	Organization Stability	Defined Goals	Expectation Management	Trust and Communication	Flexible Decision Making	Knowledge Transfer	IP Protection	Detailed Process Control	
University	Successful Cases (4)	U1	+	+	+	+	-	+	-	+	-	+	
		U2	+	+	+	+	-	+	-	-	+	+	
		U3	-	+	+	+	-	+	-	+	-	+	
		U4	+	+	+	+	-	+	+	+	+	+	
	Less successful Cases (3)	U5	+	-	+	-	-	-	-	-	-	+	+
		U6	-	-	+	-	-	-	-	-	-	-	-
		U7	+	-	+	-	-	-	-	-	-	+	-
Customer	Successful Cases (5)	C1	+	+	+	+	+	+	-	+	-	-	
		C2	+	+	+	+	+	+	+	-	-	-	
		C3	+	+	+	+	-	+	+	-	+	-	-
		C4	+	+	+	+	+	+	+	-	-	-	-
		C5	-	+	+	+	+	+	+	-	-	-	-
	Less successful Cases (2)	C6	+	-	-	-	-	-	-	-	-	-	-
		C7	-	+	-	-	-	+	+	-	-	-	-
Competitor	Successful Cases (3)	CM 1	+	+	+	+	-	+	-	-	+	-	
		CM 2	+	+	+	+	-	+	-	-	+	+	
		CM 3	+	+	+	+	-	-	-	-	+	-	
	Less successful Cases (1)	CM 4	+	-	+	-	-	-	-	-	-	-	
Start-up	Successful Cases (2)	ST1	-	+	+	+	-	+	+	-	+	+	
		ST2	-	+	+	-	-	+	+	-	+	+	
	Less successful Cases (2)	ST3	-	-	-	+	-	-	-	-	-	-	
		ST4	+	-	+	-	-	-	-	+	-	+	+
Supplier	Successful Cases (3)	S1	+	-	+	+	-	+	-	+	-	+	
		S2	+	-	+	+	-	-	-	-	+	+	+
		S3	+	-	+	+	-	+	-	-	+	+	+

Appendix 1.2. Operational Success Drivers Mature Stage (Suppliers as Technology Providers)

	Project ID	Flexible Supplier	Technology Compatibility	Organization Stability	Defined Goals	Trust and Communication	Knowledge Transfer	Detailed Process Control
Successful Cases (3)	S5	+	+	+	+	+	-	+
	S6	+	+	+	-	-	+	+
	S7	+	+	+	+	+	+	-
Less successful Cases (2)	S8	-	-	+	-	-	+	+
	S9	-	+	-	+	-	-	-

Appendix 2: Contingency Table Analysis of Operational Success Drivers

The Fisher exact test p-statistics for the success drivers are as follows:

- Incentive Alignment: for the entire sample, $p = 0.001$. For the (university + Competitor + Customer + start-ups) subsample, p improves to 0.00047 in spite of the smaller sample size.
- Detailed process control: for the entire sample, $p = 0.085$. For the (university + start-ups + supplier) subsample, p improves to 0.011 in spite of the smaller sample size.
- IP protection: see Figure 2.
- Knowledge transfer: for the entire sample, $p = 0.045$. For the (university + supplier) subsample, p improves to 0.015 in spite of the smaller sample size.
- Expectation management and flexible partner: not significant because of the small sample, but the numbers reported in the text are suggestive.

We corroborate the Fisher tests, which consider one success factor at a time, with a more sophisticated method, namely contingency table analysis, an established way of analyzing the joint frequency distributions of categorical variables (Agresti, 1996; Powers and Xie, 2000). Common success drivers are those project management actions that statistically interact with project success, independent of provider type. Provider-specific success drivers are the factors that have a statistical association with success given that a certain provider is chosen. As we sampled projects in order to have successes and non-successes for each provider, we cannot examine whether certain provider types are associated with higher success.

As an example, we show the analysis of the common success driver “defined goals”. Table A2 shows the chi-square statistics of five alternative models. Variable A is the fulfillment of the success driver (defined goals yes/no), Variable B is project success (yes/no), and Variable C the provider type.

Model	Variables	G ²	Degrees of freedom	BIC	P value
1	A, B, C	29.06	13	10.665346	0.0064
2	A, B	19.66	1	18.245027	<0.0001
3	AC	1.06	4	-4.599893	0.9006
4	A, B (C as contingency)	26.94	5	19.865133	<0.0001

Notes: A = success driver fulfilled (yes/no); B = project success (yes/no); C = provider type (5 categories)

Table A2. Sample Analysis of Success Driver “Defined Goals”

Model 1 allows interactions among three variables (A, B, and C), while Model 2 allows only the interaction between A and B (presence of driver versus success) regardless of C (the provider type). Model 3 gives no indication that the defined goals driver is fulfilled more for some providers than for others. Model 4 is the conditional interaction of the driver and success given the provider. Among the two most highly significant models, Model 2 (without provider contingency) has the better goodness-of-fit (lower G² and BIC statistics).

In step 2, we choose Model 2, collapsing the three-way contingency table to eliminate provider type. The p value of the Fisher Exact test in the two-way contingency table is 0.000049, allowing us to reject the null hypothesis that fulfillment of “defined goals” is independent of project performance.

However, some interviewees mentioned that “defined goals” was not important in collaboration with start-ups. To check this possibility, we treat “start-up” as a dummy variable and categorize the data set across provider type into “start-up” and “non-start-up” groups. If, indeed, “defined goals” was not a success driver for collaborations with start-ups, the AC model (the interaction between the driver presence and the provider) should become significant in this grouping, but it does not.

Last, if indeed “defined goals” is not relevant in start-up collaborations, the unconditional Model 2 should retain its best goodness-of-fit after we remove the start-up collaboration data subset. But we find that the goodness-of-fit statistics declines in the new data set. From this statistical evidence we conclude that “defined goals” is a significant common success driver, applicable to collaborations with all types of innovation providers. In other words, the evidence does not support some interviewees’ claim that “defined goals” is not relevant in collaborations with start-ups.

Appendix 3: Guided Questionnaire

The interviews were semi-structured: the questions ensure that an initially identified set of issues is addressed. However, the questions are only a rough guide and leave room for emerging issues to surface.

Context questions:

- Name of the business unit / profit center
- Total sales and ROI of the business unit
- Type of product/market (Medical device? Nuclear reactor? Software module?).
 - o Geographical focus (where is the market?)
 - o Where would you position your product in a life cycle?

Innovation relationship questions:

Background information:

- For which innovation have you outsourced R&D activities? Describe
- Was the innovation outcome of incremental nature or was it a radical innovation with no past record? What type of technology, level of maturity?
- When did you start this collaboration?
- At which stage was the innovation at that time? (technology and market uncertainty)
- Why did you seek to outsource this technology, and what was the trigger for this decision?

Lessons learned:

- Have the expected benefits materialized? Do you consider it as a success? What are the success measures?
- Do you have performance indicators measuring this success?
- How was the relationship contractually set up initially?
 - o How did the firms get together? Were there already business relationships?
- How did the coordination work? How did Siemens ensure that the outsourced innovation would fit into its final product?
- What types of resources did both types put into the project (e.g., financial, personnel, IP, equipment, facilities)?
- How did Siemens monitor the progress of the outsourcing partner? Frequency of reviews?
- What were the biggest foreseen risks (technical, market, legal, organizational etc.), and unexpected events that affected the outsourcing relationship?
- What were the main obstacles that, in hindsight, led to problems?
- Name and location of the collaboration partner.
- With which kind of organization did you perform this project? Please indicate size, describe briefly, and indicate how much experience Siemens had in working with this partner organization).
- What were the key strengths of the partner organization, the Siemens organization, the setup of the relationships, that allowed the project to achieve what it achieved?
- Did the relationship change over time? Change in contract? Partner change? Why?

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