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How Provider Selection and Management Contribute to Successful Innovation Outsourcing: An Empirical Study at Siemens

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It is becoming increasingly common to involve external technology providers in developing new technologies and new products. Two important phases involved in working with technology vendors are vendor selection and vendor management. Because for both steps theory development of key decision guidelines is still immature, 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 often associated with successful outsourcing is the provider's "track record" or previous experience. Our cases suggest that there is no standard "track record" for success but that a "match" between the client firm's outsourcing motivation and the provider's strengths appears to be a necessary condition for a successful outsourcing collaboration. As to the second phase—managing the vendor—we identify a number of operational project success drivers. There seems to be no universal checklist, but the most important drivers seem to be contingent on the type of vendor chosen and on the maturity of the technology. We compare five provider types—universities, competitors, customers, start-up companies, and component suppliers—and find that some success drivers are common to all providers, while others are relevant only for certain types of provider. Moreover, drivers in the case of a mature technology are more focused on successful transfer to manufacturing than on 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
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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: the average growth rate of outsourced R&D between 1993 and 2003 was twice the growth rate of in-house R&D (National Science Foundation 2008, Roberts 2001). This trend toward shifting innovation activities outside seems to be continuing, driven by a combination of more complex technologies, globalizing markets, dispersed expertise, and the accelerating pace of technology evolution (Dyer 2000, Eppinger and Chitkara 2006).

Despite 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 outsource them, and how to make the cross-organizational knowledge transfer work. Literature does not provide managers with 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 a set of "operational success drivers" that guide the management of outsourced projects. Although not able to form a universal list, we demonstrate that the key project success drivers are contingent on the *type* of provider, taking into account the five types noted above, as well as the maturity of the technology. Some drivers are relevant across all providers (namely trust and communication, organizational stability, defined goals, and incentive alignment), and others are provider specific. For example, the transfer of project-specific knowledge will be critical in collaboration with a university, while the protection of intellectual property (IP) will have greater importance in collaborations with start-up companies and competitors.

Given 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 combination of methods is common when some theory is available but is immature (Edmondson and McManus 2007, Strauss and Corbin 1998).

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. The project management literature laments that price is often used as the dominant selection criterion, rather than "track record," to the detriment of a project's ultimate 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 (Schiele 2006), and technology capabilities (Ruckman 2005, Schiele 2006). Other studies have examined the benefits of collaborating with different types of innovation provider (Belderbos et al. 2004a, Terwiesch and Ulrich 2008, Von Hippel 2005). 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, many practitioners do not think this way. For example, a typical description of a provider—"They did/did not offer what we needed"—suggests that track record is a requirement only in as far as it matches the client's needs. Such a proposition has not been made previously. Although Doz (1996) found in a study of alliances that the mutual process compatibility of the two organizations and mutually adjusted expectations increased the probability of success, this notion of compatibility is different from provider capabilities that match the client's needs.

However, there is a literature related to this issue of matching needs and capabilities, namely studies of R&D outsourcing motivations that correspond to the outsourcer's needs (Hagedoorn 1993, Holcomb and Hitt 2007, Terwiesch and Ulrich 2008, Ulrich and Ellison 2005). 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.

Outsourcing motivations usually 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 (De Meyer and Loch 2007, Loch et al. 2006, Roberts and Liu 2004). Typical reasons for outsourcing at this stage are market and technology motivations: a need to understand market demands, explore better solutions, build expertise, and identify potentially disruptive technologies.

In contrast, a mature technology and its market will be better defined and understood. Technological uncertainty is reduced, technology output is more predictable, and R&D costs are 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 "definitive" track record dimensions for selecting providers, while a different stream of research has examined outsourcing motivations or needs. The theoretical gap between these two streams suggests that some kind of "match" between the outsourcing motivation and the provider's track record may be needed. 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. A better choice might be a component supplier whose strengths match the firm's needs.

But what constitutes a match? Lacking a causal theory to explain how the match should be measured,

Table 1 Motivations for Innovation Outsourcing

Motivation	Advantages	References
Cost	Reduce investment by R&D cost and risk sharing Partner's low development cost (better process, cheap labor, competitive pressure in provider market, larger scale, etc.) Has become less dominant a motivation over the last decade (Ro et al. 2008)	Belderbos et al. (2004b), Holcomb and Hitt (2007), Robertson and Gatignon (1998), Ulrich and Ellison (2005), Schilling and Steenma (2002), Bhaskaran and Krishnan (2009)
Market	Understand current market needs Gain access to potential new market Get help with "new to the market" innovations	Von Hippel and Katz (2002), Robertson and Gatignon (1998), Tether (2002)
Manufacturing	Gain access to components that shorten time-to-market cycle Obtain lower manufacturing cost or total cost of ownership	Hagedoorn (1993), Belderbos et al. (2004b)
Technology	A trend to increasing technology complexity prevents mastering all relevant technologies Technology monitoring and access to technology and general expertise, especially close to industry frontier Identify and influence potentially disruptive technologies	Brusoni et al. (2001), Belderbos et al. (2004b), Hagedoorn (1993), Ulrich and Ellison (2005), Gavetti and Levinthal (2000), Miotti and Sachwald (2003)
Strategic	Focus in-house expertise, outsource non-core competences Respond to regulations, standards, or changing market structure	Chiesa et al. (2000), Tatikonda and Stock (2003), Holcomb and Hitt (2007)
Organizational	Avoid internal rigidities and barriers when facing new markets with different requirements Outsourced components as benchmarks may encourage organizational change and innovation	Leonard Barton (1992), Christensen and Overdorf (2000), Greve and Taylor (2000)

we might conjecture that the provider should have a track record on all dimensions of the outsourcers' motivations. But would a track record in the domain of the key outsourcing motivation be sufficient, or should there be general background strengths? Will match depend on which type of provider is used? In the absence of a theory about provider selection criteria, our study seeks to identify 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 (Belderbos et al. 2004a, Hagedoorn 1993, McIvor 2009, Nambisan and Sawhney 2007, Tatikonda and Stock 2003, Ulset 1996). 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 (McIvor 2009, Ulset 1996) and on the outsourcer's interests (Belderbos et al. 2004a, Hagedoorn 1993).

However, project governance does not address the question of how a project should be operationally managed on a day-to-day basis. A different stream of empirical research has examined such operational decisions. Eppinger and Chitkara (2006), for example, summarized 10 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, IP protection, data quality (sufficient articulation of knowledge to share it across locations and organizations), infrastructure, 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? To what extent does it depend on the context (e.g., 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 summary, these results reflect an incompleteness of current theory and understanding. Some general project management guidelines (e.g., about resource commitment) may exist, but the list of success drivers may well be incomplete. Moreover, drivers may vary

Table 2 Innovation Provider Strengths by Type

	Strengths/risks		
	Strength	Risk	References
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)

IP, intellectual property.

depending on the circumstances and from one provider to another. No work to date has identified "contingencies"—how such a set of operational management practices may depend on the provider and the maturity of the outsourced technology.

Previous research has examined typical strengths (a 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 valuable knowledge about current markets but pose a risk of technology leakage. Representative results, summarized in Table 2, may be relevant to our question of how contingent a "list of success drivers" is. If a provider type tends to have certain strengths, it may be that certain project management aspects become less critical to watch. Likewise, if providers of a certain type tend to have certain risks, this may necessitate strict project management precautions. For example, if a competitor collaboration risks IP leakage, then a legal framework may need to be included in the project to prevent the risk occurring.

As theoretical knowledge about this question is too incomplete to test hypotheses, we have to see what emerges in a qualitative study. However, we already know enough to expect that the provider type as well as the technology maturity probably influences project management in some way.

We collected data on 31 innovation outsourcing projects sampled from five provider types with differing maturity of the outsourced technology, in order to expand our knowledge of success drivers and their contingencies. As some types of providers are widely used, e.g., component suppliers, customers and users, competitors, R&D organizations, and start-up companies (Belderbos et al. 2004a, Miotti and Sachwald 2003)—these are the focus of our study. A number of new emerging innovation providers such as idea brokers (e.g., Innocentive, an internet marketplace), developers for hire (e.g., Rent A coder), and professional design firms (e.g., IDEO) are not included in our sample because they are less widely used by and less relevant to Siemens, our host organization.

3. Research Design and Data Collection

3.1. Research Design and Method

Our goal 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 (about the 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 in this way and chosen for the study by the innovation manager of the respective business units.

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. As far as possible, the cases are selected, 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 and Graebner 2007) and thus greater

Table 3 Research Design

Innovation provider	Embryonic technology stage	Mature technology stage
Universities	Four successful cases	
	Three less successful cases	
Component suppliers	Three successful cases	Three successful cases
	One less successful cases	Two less successful cases
Customers	Five successful cases	
	Two less successful cases	
Start-ups	Two successful cases	
	Two less successful cases	
Competitors	Three successful cases	
	One less successful case	

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 results "by chance." The combination of qualitative data to elaborate upon a phenomenon and quantitative data to check the 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 categorized 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 QJ;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 interests range from radical technologies to process innovations. Siemens complements its in-house R&D efforts by collaborating with hundreds of external innovation partners. It thus offers 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 within nine different divisions of Siemens in Germany, Austria, and Switzerland. The 31 cases are all bilateral R&D collaborations between Siemens and external providers, spread across 10 countries: Germany, France, Netherlands, Portugal, Switzerland, United States, China, South Korea, Israel, and Australia. The R&D topics involved are diverse, ranging from energy technologies, transportation systems, access control, graphic identification systems, and software development to calculation algorithms.

We followed a variational data sampling procedure (Strauss and Corbin 1998) to collect 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 found no connections between the two (Belderbos et al. 2004b, Hagedoorn et al. 2000).

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 B); 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 represented 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 was unlikely as the constraining factor in case selection was the need for 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 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, in order to reduce cognitive linkages between the two issues.
- Questions concerning provider evaluation were open-ended and indirect (and thus more neutral).
- 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 from 14 projects were based on at 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 3 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 was 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 could handle only 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 insofar as they "match" the client's motivation. Below, we systematically measure this match.

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 strengths.

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

Table 4 Outsourcing Motivations in the Cases (Successful Projects are Shaded Gray)

Partner type	Projects	Cost	Market	Manufacturing	Strategic	Technology	Organizational
University	U1					+	
	U2					+	
	U3					+	+
	U4		+			+	
	U5	+				+	
	U6					+	+
	U7					+	
Customer	C1	+	+			+	
	C2		+				
	C3		+			+	
	C4		+			+	
	C5		+				
	C6		+			+	
	C7		+			+	
Competitor	CM1					+	
	CM2		+			+	
	CM3	+	+		+	+	
	CM4	+	+			+	
Start-up	ST1					+	+
	ST2			+		+	
	ST 3					+	
	ST4		+		+		+
Component supplier (embryonic)	S1	+	+			+	
	S2			+		+	
	S3		+			+	
	S4					+	
Component supplier (mature)	S5				+	+	
	S6			+			
	S7			+	+	+	
	S8			+	+		
	S9			+		+	

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.

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.

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 (four 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 "unneeded"

Table 5 Provider Strengths on the Six Dimensions of Outsourcer Motivations (Successful Projects Shaded)

Partner type	Projects	Cost	Market	Manufacturing	Strategic	Technology	Organizational
University	U1	+				+	+
	U2					+	
	U3		+			+	+
	U4	+	+			+	
	U5	+	+			+	
	U6						+
	U7					+	+
Customer	C1	+	+			+	+
	C2	+	+				
	C3	+	+			+	
	C4	+	+			+	
	C5	+	+			+	
	C6					+	+
	C7	+	+				
Competitor	CM1		+			+	+
	CM2	+	+			+	+
	CM3	+	+		+	+	+
	CM4	+	+			+	+
Start-up	ST1					+	+
	ST2			+		+	+
	ST3					+	+
	ST4				+	+	+
Component supplier (embryonic)	S1	+	+			+	+
	S2	+		+		+	
	S3	+	+	+		+	
	S4					+	+
Component supplier (mature)	S5			+	+	+	
	S6			+		+	+
	S7		+	+	+	+	
	S8			+	+	+	
	S9			+		+	+

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.

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 was characterized as a non-match, while four (36%) of the 11 less successful projects were. The correlation between "non-match" and "less successful" is 0.52 (the corresponding Goodman–Kruskal γ value is 0.55).

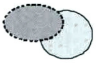
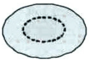
The shift in the success probability is large enough to be statistically relevant: Fisher's exact test (the alternative to a the χ^2 test when the number of observations in the cells is small and unequally distributed; see Agresti 1996, Powers and Xie 2000) rejects the null hypothesis that a non-match is equally likely among successful and less successful projects, with a one-tailed significance of 0.01.

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 technology outsourcing projects, i.e., can we complement previously identified lists, and, most importantly, do we find con-

Table 6 Matching Motivations and Provider's Strengths

	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%)

tingency factors for the importance of the various drivers (Table 7)? 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.

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. We summarized all the stated operational methods that might influence outsourced project success, without imposing predefined categories or hypotheses. Twelve 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.

We then 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 A. Only 10 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 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.

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

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

"Universal" success drivers (*across* providers)	Providers	Provider-contingent success drivers
Trust and communication	Universities	Detailed process control
		Incentive alignment
Organizational stability		Knowledge transfer (from client to university)
Defined goals		
	Customers	Expectations management
		Incentive alignment
	Component suppliers	Detailed progress control
		Knowledge transfer (from supplier to client)
	Competitors	IP protection
		Incentive alignment
	Start-ups	IP protection
		Incentive alignment
		Flexible decision making
		Participation in partner's management

IP, intellectual property.

Table 8 Sample Data Table: Success Drivers of University Collaborations

	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)	U1	+	+	+	+	–	+	–	+	–	+
	U2	+	+	+	+	–	+	–	–	+	+
	U3	–	+	+	+	–	+	–	+	–	+
	U4	+	+	+	+	–	+	+	+	+	+
Less successful cases (3)	U5	+	–	+	–	–	–	–	–	+	+
	U6	–	–	+	–	–	–	–	–	–	–
	U7	+	–	+	–	–	–	–	–	+	–

IP, intellectual property.

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 (Schiele 2006), in terms of language (categorized as German vs. non-German) and in terms of European versus non-European. Geographic proximity was not mentioned as important by any of our respondents; a statistical check of the influence of proximity on success 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.

5.2.1 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, which 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 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.

5.2.2 Organizational Stability. A change of top management or project management on either side can seriously disrupt both the financial commitment to and the expectations of a 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 US customer was the only potential partner who owned manufacturing facilities for stainless steel. After 3 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 1 year, a disruptive strike occurred at the plant, lasting almost 3 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.

5.2.3 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 emergence 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.

5.2.4 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 do not (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.

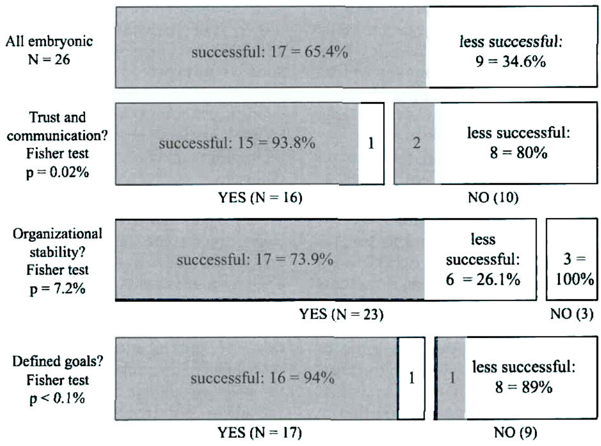
No statistical analysis by itself establishes causality, but a formal comparison of the success probabilities (with the Fisher exact test) suggests that our qualitatively identified differences are large enough to be statistically significant.

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 into sub-samples with the IP protection present and absent does *not* significantly change the success probability. However, considering the providers separately changes the picture: in competitor and start-up collaborations, the driver significantly shifts probability of success in spite of the small sub-sample. This supports a contingency view: IP protection is critical for competitors and start-ups, but not for other providers. Similar statistical robustness of the qualitative observations emerged for all drivers discussed in this section.

5.3.1 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

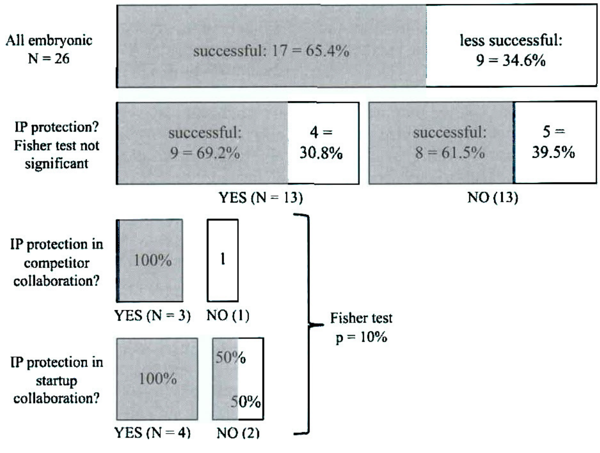
Figure 1 Success Probability Comparison with and without Success Drivers



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 on the basis of five considerations:

- The partner owned a ready-to-use system to simulate functionalities developed by Siemens in-house.

Figure 2 Success Probability Comparison for Provider-Specific Success Drivers



- 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 3 months of in-house orientation for the PhD students. For the entire first 2 years, Siemens project managers met the students every 2 weeks to monitor progress that could be presented to the 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.

5.3.2 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 sub-section 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 with 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 1 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 2 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.

5.3.3 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 US market. "We needed to work together to send the same message to the European market," the project manager stressed. The collaboration lasted for 6 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 reputable and expensive attorneys, but it proved to be 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.

5.3.4 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 United States. The outsourcing motivation had three dimensions: to get access to the supplier's expertise in software development, to benefit from a cost advantage in the United States, and to be associated with a US brand at a time when national identity became a big issue in the US 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 its "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 US 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."

5.3.5 Expectations Management (Customer). Four out of five successful customer collaboration projects have this driver, but only one out of two less successful projects (see Appendix A, Table A2). 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. Conversely, Siemens needed time to correctly translate the customer's requirements into actionable specifications for in-house engineers and component suppliers. "It is very hard for 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 50 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."

5.3.6 Flexible Decision Making (Start-Up). The observations from start-ups sub-group 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 United States 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 3 years of collaboration. "They did not listen to us, and we thought they asked for too much," recalled 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.

5.4.1 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 1 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 had 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. The team quickly 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 3 months and the budget was exceeded by 40%. In hindsight, Siemens realized that, "Compatibility should have been verified at the outset in spite of the seemingly mastered interfaces."

5.4.2 Flexible Partner. In one successful project, Siemens collaborated with a German supplier to develop a special access control system. Again, the 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 needed 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 involves two important phases, provider selection and management. Existing theory does not offer 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 cannot be defined abstractly and absolutely; it will 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 will significantly increase. A match can be articulated as a correspondence between the outsourcer's needs or motivations, categorized in some way (for example, following those that have appeared in previous literature: cost, market, manufacturing, technology, strategic, and organizational), and specific documented strengths of 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 2006), but we do not know whether they are complete, and how much 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 again indicates that there is no definitive list: Eppinger and Chitkara's list emphasizes the change involved in globalization, hence management commitment, infrastructure, and process and product modularity appear as key enablers. Our host company had collaborated with many of the providers for a long time, so some of the internal enablers may already be in place and not necessarily be mentioned, while other desired characteristics did appear. Any list will depend on the context; even a "super list" may quickly become very long.

While we do not attempt to provide a list of success drivers for individual providers, 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 will enable the design of better targeted studies.

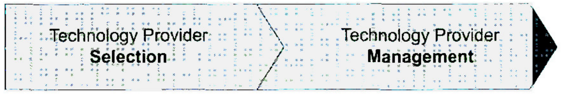
6.2. Implications for Practice

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, 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 recognized expertise in a general area, this may be less relevant than the specific competencies that a smaller provider may have on the 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). Second, 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 to be flexible enough to *manage different projects differently* depending on the provider type and the maturity of the outsourced technology. 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 and Future Research

Although 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 no fundamentally different from other companies, the generalizability of our results cannot be established without repetition across many organizations; even with generalization, a definitive list of drivers is improbable because of contingencies. The true causality of our findings thus needs further verification. The main limitation on generalizability lies in the company-specific common-

Figure 3 Managerial Implications for Provider Selection and Provider Management Phases



1. Outsourcing strategy: what are your *motivations and needs* for technology outsourcing?
   From experience (previous studies), motivations fall under the categories: *Cost, Market, Production, Technology, Strategic, Organizational.*
2. Assess the potential provider's *track record on the dimensions* of your outsourcing needs.
3. Is the provider a "match"? A *match means that the provider has a documented strength on **all** dimensions of your outsourcing needs.* A match is one prerequisite for the success of the outsourced project.

Apply project management methods to control the project (e.g., stage gate process, project life cycle).

In outsourced projects, place additional emphasis on
- Investing in trust and communication
- Checking and possibly supporting organizational stability of the provider
- Ensuring defined, agreed, and trackable (measurable) deliverables

Additional emphasis is needed *depending on the* provider type:
- University: detailed process control, incentive alignment, and knowledge transfer
- Customer: incentive alignment, expectation management
- Supplier: detailed process control, knowledge transfer (from supplier to manufacturing)
- Competitor: incentive alignment, IP protection
- Start-up: process control, incentive alignment, IP protection, flexible internal decision making

alities 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 also 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 shared baseline in our sample, preventing it from appearing as a success driver, whereas organizations with less developed accounting methods may well experience "financial control" as a distinct success driver.

While many detailed questions remain for future work, we would single out one question of central importance. Our study examines individual projects, but it is a strategic decision to determine the portfolio of outsourced projects. 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?

With the appropriate caution and translation to a different context, our lessons may be useful to other organizations and other industries as a starting point. For example, a consumer product company may seek customer input in a way that is different from that used by Siemens with its industrial customers, but our results can be viewed as an initial hypotheses upon which a company can build its own specific experiences. Our study establishes a clear framework with at least some evidence of robustness, and this should provide a platform for cross-industry studies.

Acknowledgments

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Appendix A

Table A1 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	–	+	–	+	–	–	–

Table A2 Coded Data Table: 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 proection	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	+	–	+	+	–	+	–	+	+	+
Less successful cases (1)	S4	–	–	+	–	–	–	–	–	–	–

Appendix B: 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?).
  - Geographical focus (where is the market?)
  - 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?
  - 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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Management Insights

Researchers' Perspectives on Supply Chain Risk Management
ManMohan S. Sodhi, Byung-Gak Son, Christopher S. Tang

Supply chain risk is near the top of CEOs' agenda according to surveys by IBM, McKinsey and others. As such, it is an attractive field for supply-chain researchers, who have approached it with diverse viewpoints owing to their different domains. Sodhi, Son and Tang have sought to study this diversity from the perspectives of these researchers themselves in three steps: first, by reviewing the researchers' output, i.e., the recent research literature, second, by surveying two focus groups of researchers, and finally by surveying operations and supply chain management researchers. Their findings characterize the diversity in terms of three "gaps": (1) a definition gap in how researchers define SCRM, (2) a process gap in terms of inadequate coverage of response to risk incidents, and (3) a methodology gap in terms of inadequate use of empirical methods. In the survey in the third step, researchers confirmed these gaps and also suggest ways to close these gaps. Thus, these findings create a basis for researchers to collaborate with each other, with industry and with research journals.

Pricing Decisions during Inter-generational Product Transition
Hongmin Li, Stephen C. Graves

Technology products frequently go through product transitions during which a new generation of product replaces the old generation product. High uncertainty in a new product introduction often leads to extreme cases of demand and supply mismatches. Pricing is an effective tool to either prevent or alleviate these problems. Li and Graves study the pricing decisions in the context of a product transition during which a company sells both the old and new products. Their analysis sheds light on how product replacement, along with substitution, competition, and inventory scarcity, affect the optimal prices for the two products during the transition. In particular, the pricing decisions are strongly influenced by the demand replacement effect. As the new product gradually replaces the old product, the optimal prices of both products decrease initially, and then gradually recover, after controlling for the impact of inventory and competition. In addition, the authors demonstrate how certain product or market characteristics, such as the speed of the transition, customers' price sensitivity, and the speed of product obsolescence affect the pricing decisions in the transition.

Innovation Outsourcing: An Empirical Study at Siemens
Zhijian Cui, Christoph Loch, Bernd Grossmann, Ru He

It is becoming increasingly common to involve external technology providers in developing new technologies and new products. Two important phases involved in working with technology vendors are vendor selection and vendor management. Based on 31 case studies at Siemens, this study provides guidelines for managing these two outsourcing phases. A selection criterion often associated with successful outsourcing is the provider's "track record" or previous experience. Cui, Loch, Grossmann, He find that there is no absolute "track record" criterion that can be used; rather, the relevant track record needs to constitute a "match" between the client firm's outsourcing motivation and the provider's strengths. As to the second phase – managing the provider – they identify a number of operational project success drivers by comparing five provider types – universities, competitors, customers, start-up companies and component suppliers. They find that some success drivers are common to all providers, while others are relevant only for certain types of provider. For example, detailed process control is particularly important for university and component suppliers as providers, while IP protection is critical for competitors and start-ups. Moreover, drivers in the case of a mature technology are more focused on successful transfer to manufacturing than on development itself.

Measuring Seat Value in Stadiums and Theaters
Senthil Veeraraghavan, Ramnath Vaidyanathan

It is critical for revenue management firms such as stadiums and theaters to make pricing decisions based on consumer perceptions of the value of a seat. The *seat value* might depend on several factors including popularity of the event, the location of the seat