Collaborative Innovation in High-Technology Sectors

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Collaborative Innovation in High-Technology Sectors:

Develop your Collaborative Innovation Strategy based on your Goals

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How do you generate value from collaborative innovation? Most managers would agree that virtually all companies nowadays talk about collaborative innovation and its importance; many have engaged in it; but only a few actually succeed in generating value from it. The reasons that managers cite for collaborative failure are plenty, ranging from unfulfilled promises; overestimated organizational capabilities and subsequent inability to deliver; co-ordination failure; interest alignment changes; tensions arising from delayed project results; to underestimation of the time needed for commercialization. These are, however, but symptoms of a root cause which is hardly ever addressed. As a result, firms continue to experience similar drawbacks in new partnerships. The challenge, really, is to craft a collaborative innovation strategy which matches the firm's goals. There is not one best approach to leverage collaborative innovation – but there are optimal solutions. Different goals involve different structures and organizing principles – what we call *collaborative innovation governance modes*. Companies that choose the wrong mode risk ending up with damaged relationships and failed innovation; companies that align innovation governance with their strategic goals stand to thrive in an open, dynamic world of collaborative innovation.

To help managers optimize collaborative innovation efforts, we have developed a parsimonious and integrated framework, matching three main collaborative innovation strategies to governance modes. The strategies are presented in order of complexity of the governance mode; from the least complicated to the most complicated. The first strategy is pursued by firms that have "to protect a position" amidst competitive pressures. In former times, roadmap innovations, characterized by a short-term focus, were sufficient to protect a firm's current position. Increased competitive pressure however forces firms in many sectors to go beyond their existing capabilities and choose a collaborative innovation strategy. The second strategy concerns the "development of a new position." The development of a new position entails that both technology and market are new to the firm. In the current competitive environment, in which time-to-market and cost consciousness are crucial, firms with complementary assets must work jointly to pursue this strategy. The third strategy is adopted by firms that intend "to add a position" or diversify by adapting their core technology and extending its use into an adjacent market. The high risk involved and the lack of resources explain that such firms choose collaborative innovation. We further explicate each strategy below, where we describe cases illustrating each strategy and its implications for collaborative innovation.

Research on collaborative innovation mostly neglects the link between innovation goal and collaborative innovation governance mode. The literature provides various frameworks and criteria for different stages of collaborative innovation relationships, on

issues pertaining to the appropriate kind of collaboration,[1] partner selection issues[2], and alignment of decisions and incentives[3]. However, the lack of integration of these various insights leaves managers with patchy messages from which it is hard to draw lessons. Five detailed cases on collaborative innovation in different industries can shed light on the value of our integrated framework. The five cases involve organizations that are located in North-Brabant (Netherlands), one of Europe's foremost high-tech regions. Below is a brief description of the project cases.

- In 2007, Fokker Elmo, which designs and produces aircraft wiring harnesses for both the military and civil aircraft industry, and TTA International, a small but international company in training and engineering solutions for the automotive industry, decided to jointly develop a software tool that is able to generate wiring diagrams from a database of electrical components for aircraft industry. This software tool revolutionizes the way in which wiring diagrams are generated. Before this tool was developed, the generation of wiring diagrams was a labor-intensive process performed by highly-trained engineers. The process was inefficient, costly and error prone. The efforts of these two companies were supported by the National Aerospace Laboratory (NLR) and Avans University of Applied Sciences and resulted in a revolutionary process innovation that reduced the generation time of wiring diagrams to a fraction of what it used to be and with fewer errors.
- At the beginning of the 1990s, a few director-owners of small- and medium-sized firms working as suppliers in the areas of electronics, mechatronics, embedded software and industrial design, felt the need to enhance their competitive advantage. Given the size of most of these supplier companies, they believed that this could be best achieved if they combined strengths and worked together. To this end, DevClub, a network of approximately 50 technology companies working on product development was founded. Devclub did not go far in terms of collaborative innovation but served as the precursor to DevLab, founded 10 years later. DevLab's creation was an important landmark as it expressed the trust that these smaller supplier companies had developed to collaborate in R&D projects. DevLab's research agenda currently covers 4 focus areas: sensor network technology, independent energy supply, embedded communication, and advanced micro actuators. These areas are researched in a number of collaborative projects.
- In October 2008, CandelLed BV was established by Frans van der Linden, director owner of Bakker Someren Beton; Kees-Jan Kelder of Kelder Product Development, and Arno Verhoeven of Illumicon. The North-Brabant Development Agency (BOM) enabled the establishment of the company by providing seed money in return for shares. CandelLed commercializes a special module that enables integration of a power-LED (light-emitting diode) in concrete elements during the pouring process. The process is revolutionary in that it eliminates the need for complicated post-pouring installation and produces a product that is more durable, has a better finish, and provides more freedom for the product designers. The module itself was developed within the Innovation Zone (I-Zone) program, a regional government sponsored program to stimulate collaborative innovation.
- In October 2006, FEI, a world leader in electron microscopy technologies and applications, introduced Phenom, the world's first personal electron microscope. The new design was revolutionary because of its compact size (desktop model), speed, ease of use and superior image quality. The miniaturization in electronics enabled by scanning electron microscopes was paired with miniaturized hardware to create a revolution in microscopy. Yet the alpha prototype of this revolutionary design was developed in approximately half a year. The risk-sharing partners were FEI, NTS (an integrated systems supplier in the mechatronics field), and Sioux Embedded Systems (part of the Sioux Group, which supplies software services and products for high tech systems, and remote solutions). The combined effort of these companies ensured the development of a superior product in half the time of comparable projects and at lower cost.
- In 2005, Océ Technologies, a leading provider of document management and printing for professionals, finished the development of a Crystal Point Technology printer (Océ ColorWave 600), a 2 A0/min full color wide format printer[4]. Development of the Crystal Point Technology had cost large amounts of R&D money and the company was looking for ways to leverage the technology in different applications. Océ Research identified printed circuit boards (PCBs) as a possible application area. Océ operates in the graphical market and did not have knowledge of the PCB market. Moreover, Océ R&D did not have human and financial capacity for this type of developments. NTS and DRPP (a small company but technology leader in reverse pulse plating, and with knowledge of the PCB market) were invited to join the development on a risk-reward basis of what was called "Lunaris". The combination of resources and capabilities of

[1] G. Pisano and R. Verganti (2008), "Which kind of collaboration is right for you?" *Harvard Business Review*, December.

[2] See for example P.E. Bierly and S. Callagher (2007), "Explaining alliance partner selection: Fit, trust and strategic expediency," *Long Range Planning* 40, 134-153; and S.R. Holmberg and J.L. Cummings (2009), "Building successful strategic alliances. Strategic process and analytical tools for selecting partner industries and firms. "*Long Range Planning* 42, 164-193.

[3] See S.R. Bhaskaran and V. Krishnan, (2009) "Effort, revenue, and cost sharing mechanisms for collaborative new product development."*Management Science* 55(7), 1152-1169.

[4] The innovative power of Océ was one of the reasons why Japan's Canon made a public offer for the shares of Océ, a transaction which was completed in March 2010.

the three companies enabled the fast development of a product concept that demonstrated the reliable production of PCB inner layers based on inkjet technology.

The focus in all cases is on processes, structures, and events within and around the collaborative innovation project and on the perceptions of key participants in the collaboration. It thus includes both a general understanding of decisions, structures, and processes and a specific identification of how these were perceived, at various points in time, by key individuals involved in the collaborative innovation. As the case study analysis shows, all collaborative innovation projects ended successfully with a new product or process developed in less time, with less costs, and higher performance than absent collaboration. Each case, though, also experienced problems along the way, most of which could have been avoided by using the integrated collaborative innovation framework, which is explained below.

Four Stages of Successful Collaborative Innovation

Our research into these cases, and experience with many more collaborative innovation projects over the years, point to four main stages that firms should complete once they decide in favor of collaborative innovation (see figure 1.). The design of this four-stage framework is confirmed by comparative cross-case analysis at the structure, process, behavioral, and outcome levels. The stages are formulated in an ideal order, which runs as follows: identifying the need for collaborative innovation, finding matching partners, formalizing the relationship and executing the relationship. Each stage is characterized by specific challenges and decisions that need to be taken. While some of the challenges and decisions are generic, most are related to the firm's collaborative innovation strategy, especially in later stages.

Figure 1: A Four Stages Model for Collaborative Innovation Success

Need *What can collaborative innovation contribute to your strategy?*

The driver for collaborative innovation should be a clear need for external resources in order to fulfill strategic goals. Despite the hyped status of collaborative innovation, if there is no clear and compelling need, firms should not endeavor in it. Innovation is by nature a hard to predict and complex process with many uncertainties along the road. Relationships add to the uncertainties and complexity and can only be rewarding when the collaborative goal and the need for external resources are unmistakable and clearly understood. The need and goal need to be determined during the strategic planning process. In general, there are big differences between firms in formulating a business strategy. Many firms don't really have one, aside from a very high-level fuzzy statement such as achieving double-digit growth. Some firms develop detailed strategic plans, covering copious volumes of information, which nobody can digest. The challenge, either way, is to translate strategic plans into clearly defined criteria that help to identify opportunities and partners for collaborative innovation. Next, we review examples of the three overall innovation strategies identified above (protect a position, add an adjacent position, and develop (grow) a position), and how these should inform firms' approaches to defining their collaborative innovation needs and strategies.

To exemplify the "defend a position" strategy: Fokker Elmo, which designs and produces aircraft wiring harnesses for the military and civil aircraft industry, decided to automate its still largely manual wiring processes in order to protect its competitive position. Fokker Elmo thus preempted further pressure from airline manufacturers to cut costs and lead times and improve wiring harness design and maintenance processes. The high development costs, risk, and lack of capabilities made it necessary for the company to start the search for a risk-sharing innovation partner. As another example, DevLab, a cluster of small- and medium sized companies, was established to strengthen the competitive posi-

tion of smaller, often competing supplier firms. The cooperation of SMEs and knowledge institutes within these clusters helps to create scale advantages, visibility, reputation and recognition of the participating firms as progressive SMEs within the industry. The critical mass enables the definition of ambitious research projects, which cannot be carried out by individual firms. Concrete project and partner criteria were defined during a brain storm session including the director-owners of member companies. Director-owners formulated the strategic goals for their respective companies that would have to be realized in 10 years time. Next, they identified the gaps between current technology and capabilities and the ones that would be needed to accomplish the expressed goals. The outcome of these sessions served to establish criteria and priorities for technological developments that would be carried out within DevLab. Thus, the process of identifying strategic priorities to defend a position was closely tied with the identification of the needs for collaborative innovation. In general, executives prefer not to share strategic information, especially with competing firms. In cases were collaborative innovation is essential for competitive success, however, sharing information at the strategic level is essential.

The strategy "to develop a position" was selected by three small firms, Bakker Someren Beton, Kelder Product Innovation, and Illumicon. Small- and medium-sized enterprises (SMEs) in general lack the resources to develop new positions. When the current market is declining or not showing the growth that firms aspire, they need to find alternative opportunities. By combining complementary assets and sharing risk, Bakker Someren, Kelder Product Innovation, and Illumicon were able to develop a new position. In this case, the need for collaborative innovation is intrinsic to the strategy to develop a position absent resources; yet, given that strategy is seldom well developed in smaller firms, making the overall purpose explicit was essential to identifying the collaborative innovation need and opportunity.

FEI, world leader in electron microscopy technologies and applications, and Océ, a leading provider of document management and printing for professionals, chose to follow the "add a position" (or diversification) strategy. Under pressure from escalating development costs and the need to generate growth, these firms decided to leverage their core technologies in different markets. The high risks involved with so-called resource-related adjacency[5] innovations, as well as the lack of certain capabilities, explain that increasingly firms adopt a risk-sharing collaborative innovation approach. Resource-related adjacency innovations are most treacherous as relatedness effects tend to mislead firms in several ways. Some managers are tempted to think that they know the new market and

[5] J. C. Panzar and R.D. Willig (1981) "Economies of scope."*American Economic Review* 71 (2), 268-272.

underestimate the effort that is needed for the commercialization stage. The latter happened in one of the cases, so the diversifying company ended up spending more money on marketing and sales than anticipated. In another case, the opposite mistake occurred, as relatedness to the core technology was underestimated when the leading firm entered a different market segment. As the innovation manager explained: "It was only when we were well into the development process that the importance and strategic closeness of the opportunity became clear to [our company]." At that moment, the firm's corporate strategy department became involved, taking painful decisions to reverse earlier made promises to partners and "internalizing" more of the project.

Given that the three collaborative strategies require the involvement of risk-sharing partners in innovation projects, managers need to specify and substantiate the opportunity for all parties involved in the relationship. Why else would third parties join? The instances in which firms want to add or develop a position involve a higher degree of market risk than the "defend a position" strategy. In these instances especially, the business case needs to be solid. For most managers, especially in high-technology firms, opportunity analysis and substantiation consist of technological feasibility studies and market research, including roughly an assessment of the size of the market, market and macro-environmental trend analysis, and a competitor analysis. This macro-level assessment is only half of the market domain story, however, and astute potential partners will not buy into this type of aerial reconnaissance. In one of the cases, the CEO of a firm who was approached to partner declined because of the lack of evidence on potential customers and why they should benefit. He believed that the market risk was underestimated and feared innovation failure accordingly.

In many markets nowadays, the space within which new products can be successful has become increasingly squeezed leading to high levels of innovation failure especially for high-technology companies. For these markets, (and this is a growing number), a holistic approach to new product development has been recommended. The traditional design or engineering led methods, which are applied by high-technology firms, run too much risk of missing their target in the new product success space.

The holistic approach to new product development, called 'Integrated Product Development'[6], is concerned with the breadth of the new product development process. It highlights the interdependence of a large number of factors that are all too often

[6] See Inwood, D. and J. Hammond (2006) *Product Development. An Integrated Approach. See also* Smith, P. G. (2007) *Flexible Product Development*; and McGrath, M. E. (2004) *Next Generation Product Development*.

considered separately, if at all. This involves the implementation of a systematic process, which includes not only the company or team's perspective but also the customer's perspective in all stages of the development of new products. From the customer's point of view, a product is more than just the physical object you develop – it includes after-sales service, intangibles, cost, communication, convenience, distribution channels etc.

Thus, systematic user-driven *research* (including definition of specifications and value proposition development and assessment) and business case design and assessment need to be done simultaneously with exploring the technical possibilities. Integrated Product Development requires several iterations between technical possibilities and improvements; value proposition development and testing; business model conceptualization and validation; business case design and assessment (see figure 2). We emphasize that this is not a random process. Rather it is a methodical approach, which is used to create new knowledge in support of the development and improvement of new products and service

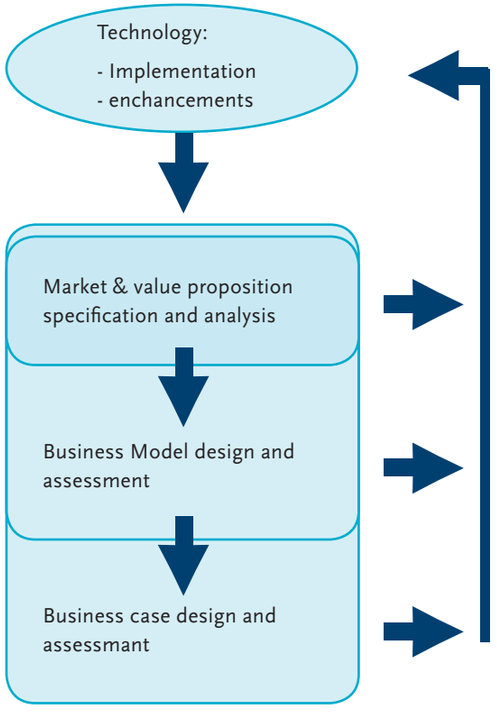
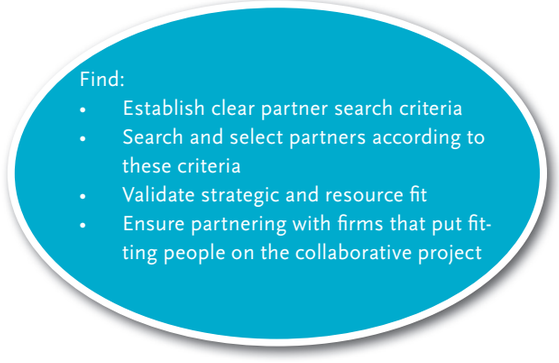


Figure 2: Integrated Product Development

No one would argue that a collaborative innovation partnership can be built on a shaky business case. Time is too short and resources to scarce to waste on a partnership without a strong business foundation. Yet, few take the time and make the effort to do the upfront homework on the market side seriously. Since your value proposition and thus the core of your innovation project is likely to change in the process, managers should not outsource this investigation to market consulting firms but develop these capabilities internally if they do not exist.

Find *Ensuring the optimal partner match*



Once the firm has established the opportunity and need for specific external resources, the question arises as to where the firm can find these resources and which mechanisms the firm can use to find them. Before the search and select process can start, however, managers need to be clear about the criteria that partners need to fulfill to optimize their contribution to the collaborative innovation partnership.

In our cases, we found that the collaboration was most successful when during the partner search firms were precise about the complementary assets they needed from external parties and verified explicitly the quality of potential partners' assets. Few managers get precise, however, about documenting the characteristics of firms they would consider as potential partners. Fewer still systematically rate potential partners against these criteria and decide accordingly. In one of the projects, one partner turned out not to have the capabilities to fulfill their role in commercializing the innovation. In fact, as the project evolved, the different partners discovered they had a different opinion on the process of commercializing the innovation. Short of commercial success, they ended up in lengthy

and unpleasant discussions which ultimately resulted in the forced departure of the underqualified partner from the relationship. Such situations can be avoided by developing a set of critical partner criteria based on the resources and skills that are needed to make the project successful and evaluate potential partners against these. This practice only works well, however, when firms do not selectively reevaluate or change criteria to insure that the partner they think they want surfaces with the highest ratings.

Given the uncertainties involved with collaborative innovation strategies, the search for partners should be systematic and leverage social networks, bearing in mind that closed social networks can actually hamper innovation. The search should be systematic in the sense that partners need to be checked against a set of critical partner criteria. Using social networks to inform the search helps to compensate for information asymmetries, thus reducing the risk of partner failure; but equally, the search should not be bounded to known partners only, especially in the case of adding or developing a position where partners may be required that have capabilities hitherto unfamiliar with your firm".

Fokker Elmo's innovation manager carried out a local search for complementary capabilities by visiting companies and knowledge institutes, working in analog markets. He described how he selected his partners after a visit to the respective partners' companies, and discussions during which a match of capabilities, personalities and sympathy shaped the initial feelings of trust. DevLab partner firms are members of the Federation of Technology Branches (FHI), an association consisting of 800 member firms. Via the FHI, firms are informed about DevLab and its activities. Firms are allowed to join DevLab when they fulfill certain criteria.

CandelLed's collaborating parties learned about each other via referrals and during a regional government innovation session, which aimed at stimulating local firms to innovate jointly in clusters. The partner search mechanisms that were used by these firms were driven by a well-defined need to partner, a precise collaborative goal, and a set of critical partner criteria. All firms were able to find matching partners via social network knowledge. Admittedly, partner search is facilitated by the abundant supply of excellent technology firms in the North Brabant region. Firm proximity played an important role in speeding the process of relationship building and subsequently in enabling the transfer of sensitive knowledge.

FEI took the obvious path to its preferred suppliers, NTS and Sioux, and approached them to join a risk-reward partnership. Océ's innovation manager read about how NTS, an integrated systems supplier, had participated in the collaborative innovation project of FEI in a professional magazine. Upon the positive advice of a regional government official, he approached NTS and discovered that the firm had the capabilities and the base technology to help Océ with the Lunaris project. The manager also discovered how much Océ's not-invented-here syndrome had prevented the company from tapping into the local knowledge. NTS, which is located about 30 km from Océ, produced wide format printers for AGFA, one of Océ's competitors. NTS subsequently pointed Océ to a second partner, which could fill the gap of the partnership in market knowledge.

Arguments about cultural differences and about not-invented-here barriers are often used to argue against engaging in partnerships. These arguments vanish when the collaboration goal is clear and compelling, providing a shared sense of what can and must be achieved, and by whom. Partner selection research points to a need for fit between firms at three levels: structure, culture, and strategy.[7] The cases in our research all point to the predominant importance of strategic fit, involving the meaningfulness of the opportunity for all parties over the duration of the collaboration, and of resource fit, i.e. ensuring that all partners make a relevant contribution. We recognize that the cases concern firms that are all based in the same region, sharing cultural roots of the national type at least. In international collaborations, cultural differences might create some extra challenges, but even then not to the same extent that incongruence of goals and capabilities would.

Choosing a partner is also a matter of putting the right individuals in place. In most firms, individuals who participate in innovation project teams are chosen for the wrong reasons. They are chosen because they are available or have knowledge about the product or technology, but often without regard to their interest in the project or their fit with other members. However, collaborative innovation relationships move forward only when the right team of people is assembled. A manager from FEI explained how they took great care to find an optimal composition of the team of FEI architects, which was going to help execute the project. FEI selected three of its best system architects and one marketer. The combined team's composition was such that it had expertise in the technology, was able to carry out market analysis, and above all was very enthusiastic about the project and the collaborative process. The fact that FEI selected its best system architects to join the collaborative project underlined the commitment of the organization to the project. It is hard to find cases in which managers show the commitment of FEI to a collaborative project which does not contribute to the core business of the firm. FEI was rewarded with a product which demonstrated higher levels of innovation and faster development time than

[7] See for instance C. Marxt and P. Link (2002) "Success factors for cooperative ventures in innovation and production systems."*International Journal of Production Economics*, 77 (3), 219-229.

would otherwise have been possible. Careful project member selection is thus an important determinant of project success. Team members must not only have excellent functional expertise, but also the interpersonal competences and requisite partnering mindset necessary to work collaboratively. During the "find" stage, managers need to ensure that

they partner with firms that will put people with the best fit on the collaborative project. In many sectors, the trend is towards collaborative innovation and the formation of ecosystems which help firms to combine the strengths of different partners and to target increased numbers of opportunities while spreading the risks. This trend implies that

companies need people with a mindset to proactively search for opportunities and matching partners, and who in addition are able to evaluate potential partners rapidly and accurately. Such capabilities should be considered an important source of competitive advantage. While some managers are characterized by such skills and demonstrate a personal drive to meet and learn from other people, others consider this a waste of time or lack the requisite social skills. The former are the people that companies need when collaborative innovation is the objective.

Formalize *Preserving trust via control*

Once appropriate partners have been identified and selected and commitment to the collaborative innovation project is confirmed, agreements need to be negotiated and formalized. Managers, especially from smaller companies, have difficulties with the tradeoff between trust and control which appears at this stage. In line with transaction cost economics[8], control can have a negative connotation if it is understood in the context of opportunistic behavior by self-interested partners. Trust is related to informal elements of relationships, and tends to be seen more positively or less critically. Some commentators hold that emphasizing control elements may lead to distrust.[9] Instead, the cases in this research argue in favor of a complementary relationship between trust and control. In a few instances, some of which we also describe, absence of formal arrangements resulted in damaged relationships and broken trust.

Formal arrangements do not equal excessive control at the cost of trust, a pitfall which large company managers have to watch out for. Trying to protect themselves, these managers often attempt to draft such detailed contracts, involving the company's lawyers and intellectual property officers, that the opportunity vanishes. Remember that speed is essential with innovation, and especially with collaborative innovation. Inefficient collaborative innovation planning, and negotiations that drag on, do not stop the evolution of the market and the advance of competitors. Potential partners might walk away from unproductive discussions and redirect attention to more attractive opportunities, or even to your rivals.

Keeping in mind the balance between trust and control, all types of collaborative innovation strategies should include reflection on financial pie-splitting, intellectual property (IP), working process and governance. These issues should be negotiated and drafted in contracts, joint development agreements, and risk-reward sharing mechanisms. Joint development agreements define development responsibilities, schedules, milestones, and deliverables. This mechanism helps to focus on the details of how the relationship should work (e.g. communication channels and frequency, issue resolution, project reviews). Managers we interviewed recounted how this tool helped speed up decision-making during the project and avoid and rapidly settle conflicts. In order to enable proper drafting and implementation of joint development agreements, specific project management skills and experience proved useful if not essential. To many executives, especially from larger firms, this may sound like a trivial finding. However, many small and medium-sized firms do not possess these skills. Projects that did not involve a player that could bring these skills – and not be tempted to abuse them – turned out to experience tensions and collaboration failure as a result of severely flawed planning in terms of time and budget.

[8] O.E. Williamson (1975) *Markets and Hierarchies: Analysis and Antitrust Implications*. The Free Press, New York; O.E. Williamson (1985) *The Economic Institutions of Capitalism*. The Free Press, New York.
[9] Ghoshal and P. Moran (1996) "Bad for practice: a critique of transaction theory." *Academy of Management Review* 21(1), 13-47.

We also found that financial pie-splitting mechanisms have a serious impact on the collaborative relationship, especially on the alignment of collaborating partners. Alignment of partners, in turn, has a major impact on project success. Each collaborative innovation strategy is characterized by an optimal financial pie-split mechanism. Firms that collaborate to protect a position are best off with licensing deals. In the case of DevLab, for example, intellectual property belongs to the DevLab organizations. DevLab member organizations have free access to all IP. If a DevLab member decides to stop its membership, future use of the IP can be made by means of a license. Fokker Elmo and TTA also decided in favor of a licensing model. TTA is owner of the software and source code. Given the need for further developments to adapt the tool for commercialization in TTA's market, the automotive industry, all licensing income from that market goes to TTA. Given Fokker Elmo's substantial contribution to the development costs, it was allowed to use the software in its own system for free. In case Fokker Elmo would sell a license to one of its customers in the aerospace industry, TTA would receive a share of the royalties.

When firms develop a new position jointly, sharing risks and costs, the most obvious legal construction to seal the deal is the establishment of a joint venture in which partners participate in the profits in accordance to their contribution. In general, the intellectual property will need to belong to the joint venture if venture capital investments are needed. Otherwise, exclusive license agreements with the IP owner must be made. The three SME companies that founded CandelLed (Bakker Someren Beton, Kelder Product Development, and Illumicon) needed to bring their IP into the venture in order to obtain seed money from the BOM. The IP provides some protection for the investor in case the venture goes bankrupt.

Collaborative innovation agreements for resource-related diversification strategies of larger firms, like FEI and Océ, are more intricate. In such collaborations, the organization that decides to add a position brings in its core technology in the joint project. Collaborating partners are selected upon their ability and willingness to make a substantial contribution to the main firm's innovation strategy. When asked to share in risk and costs, these partners want a reasonable return on investment, which goes beyond the traditional cost-plus margins of standard supplier contracts. Three main challenges make the decision on a fair reward complex. The first is the uncertainty of the market impact of adjacency innovations, given that the market is new to the diversifying firm. The second challenge is the difficulty of assessing the level of closeness of the innovation to this firm's core business and business model. Finally, the highly uncertain nature of adjacency innovations makes it hard to predict whether early stage partners will be able to contribute in a meaningful way in later development stages.

Our research suggests that in the case of adjacency innovations, in order to contain the risks involved, firms should take a two-stage approach. The first phase results in a working product concept, demonstrating technological feasibility based on a good understanding of customer requirements. Given the uncertainties which characterize this stage, we advise not to opt for joint venture constructions in risk-reward agreements. Attractive first stage risk-reward constructions could be related to future market success or measurable contribution to product, process, or service performance. In both cases, rewards are based on value creation rather than cost, which is interesting to partners in a risk-sharing mindset.

For example, FEI and its risk-sharing suppliers NTS and Sioux signed a combination agreement, consisting of an amortization part and a risk-reward part. Reimbursement of the amortization part to NTS and Sioux started upon production of Phenom. The amortization part lowers the entry barrier for the partner. The risk-reward part is dependent on the number of Phenom electron microscopes that are sold, up until a certain number. The risk-reward element ensures alignment of the interests of the three partners over the duration of the project, something which is lacking in most collaborative innovation projects.

Stage two is characterized by the development of the actual product, making it ready for production, and building and expanding the market. In high-tech industries, this stage is characterized by large risky investments. Risk is high in adjacency innovations (adding a position) because the market segment, the customers, the definition of the product, and the initial suppliers are different from what the diversifying company is familiar with. The new opportunity does not fit the established mold and culture. The adjacency often requires different ways of organizing and operating that are more suitable to the issues at hand and to future growth. In addition, the high investment and risk involved with adjacency innovations often means that there is a need for additional external investors. The best constructions in these cases are spin-offs or equity joint ventures. Spin-offs are preferred in cases in which the adjacency innovation is close to the core business of the parent company and the parent company might want to preserve the first right to buy back the shares. Equity joint ventures with first stage partners are optimal in cases in which first stage partners are able and willing to continue making a contribution, both in kind and in capital.

Both FEI and Océ established a venture to accomplish this stage. Given the remoteness of Phenom from FEI's core business, FEI decided to spin off the venture (called Phenom World), keeping some of its shares but not the majority. NTS and Sioux decided to continue with the venture, increasing their investment and becoming the main shareholders.

The closeness of Lunaris to Océ's business and business model meant that the company decided in favor of a different venture construction. Océ remains an important shareholder in the venture and has the first right to buy the venture upon its exit. Given its relatedness, the venture could become a future Océ division. NTS and DTT did not participate in this round of investment and agreed to be bought out by Océ. The venture, called Mutrac^{x} B.V., received a large convertible loan from Océ. Océ owns the IP and Mutrac^{x} B.V. has an exclusive license agreement.

Given that many of our high-tech companies are in the mature stage of their life-cycle, and under the condition that these firms have meaningful internal research activities, the creation of spin-offs based on adjacency innovations could be an interesting path to secure the long term growth and survival of the parent company. Firms in general, have little experience with spin-off processes. Similar to collaborative innovation, governance choices in the case of spin-offs condition the value that can be created from them. Hence, when the goal is diversification based on resource-related adjacency innovations, managers need to learn how to best organize the spin-offs and how best to govern them once they are established.

Execute *When the deal is made, the real work starts*

Once contracts, joint development, and financial pie-splitting agreements are formalized the relationship needs to be "implemented". Managers quite often believe that once the deal is closed, the hard work is done. In reality, throughout the project the relationship takes shape and initial feelings of trust need to be confirmed. Relationships are formed between people at all levels and need to be managed accordingly. The strength of these relationships has a significant impact on commitment to the effort, and ultimately on project success. A good relationship provides the lasting power for the collaborative partnership to weather the tough times, acting as a safety net when the project experiences technological or market setbacks.

Relationships at both Phenom and Lunaris projects, for example, were managed intently at all relevant levels. In both cases a steering committee was established, consisting of the key decision-maker of all companies involved with the project and of the project managers. From the start of the project, this committee gathered once a month. The meetings were used for project review presentations, the sharing of new market and technical insights, and discussions on possible changes in the directions of the projects. In both cases, the steering committee also served as the highest escalation mechanism with full decision-making authority in case of difficult-to-resolve issues. Note that this mechanism was established from the start. It is very hard indeed to credibly form an escalation management team after disputes have occurred. In another case, the absence of escalation team with the authority to make decisions resulted in lengthy and wasteful meetings, and ultimately in the involvement of outside mediation to help resolve escalating conflicts.

In the most successful relationships, the executive level demonstrated strong personal relationships of trust. Executives openly shared financial and market data and discussed opportunities and threats as the project moved along. Despite being preferred suppliers of FEI, NTS and Sioux shared sensitive information on engineering hours and material costs needed for development. FEI in turn shared all market information, enabling the partners to make an estimate of potential future sales. The NTS executive explained how essential it was for him to obtain market information from FEI for his own risk assessment. As a supplier he did not know the market of his customer sufficiently well to understand the sales potential of the product they were jointly developing; nor could he assess what functionalities to build into the design. Linarus project partners, while working together for the first time, shared all business case and market studies during steering committee meetings. Océ's innovation manager spoke about an atmosphere of openness and trust, and how parties understood the difference in their respective financial capacity. Hours and materials were recorded in a common register so that all parties involved could later on be compensated in accordance to the investment they made.

For systemic innovations[10] in which parts cannot be developed independently from one another, such as FEI's Phenom, the sharing of tacit knowledge between firms is essential. This is best performed when engineers from the different partner companies work together in one location. The openness and sharing of knowledge of engineers working together on Phenom stimulated innovation and speed. People felt comfortable pointing out flaws in order to foster project success. Achieving goals as a team rather was perceived as more important than individual accomplishment. Similarly, one of the CandelLed executives recounted the enthusiasm and openness that developed when the team worked together in one location on the prototype. The common location and shared goal stimulated the sharing of knowledge between partners.[11]

In collaborative innovation projects that are aimed at adding or developing a position, a heavy-weight project manager with full responsibility and empowerment should be leading the project team. While leadership is the responsibility of all team members, the heavy-weight manager has the respect and authority to intervene when tensions arise in the team. Phenom's project manager recounted how he had to intervene to solve tensions which resulted from the differences in the skill levels between engineers of different companies. He also had to manage the feature creep tendencies of FEI's engineers who were used to working on large, sophisticated systems for high-end markets and to inventing their own features. These engineers now had to commit to project goals of simplicity, speed, and cost consciousness.

The project manager was not alone, however, to steer the project to achieve these well-defined goals. The steering committee had decided that FEI's collaboration partners and risk-sharing suppliers, NTS and Sioux, would monitor the costs and time-to-market of the project. As co-investors, for NTS and Sioux, the sooner Phenom would be produced and sold, the faster they would start earning money. The fact that Sioux and NTS had smaller development budgets than FEI guaranteed strict adherence to the project goals. When cost and time-to-market is important for the success of your collaborative innovation, the firm should empower risk-sharing suppliers to monitor the achievement of the project goal.

While in many innovation projects the core team is small, there are generally many links to peripheral members who are brought in as needed. Suppliers of peripheral resources are not committed to the achievement of project goals. In such cases, the heavy-weight project manager's position and relational skills allow for swift co-ordination and discrete pressure to ensure the timely and accurate delivery of these additional resources.

[10] H. Chesbrough and D. Teece (1996), "Organizing for innovation: When is virtual virtuous?" *Harvard Business Review*, January-February.

[11] See also A. Madhok (1995), "Opportunism and trust in joint venture relationships: an exploratory study and a model." *Scandinavian Journal of Management,* 57-74.

Conlusions

Throughout this address we have demonstrated that collaborative innovation is a strategic consideration requiring a number of tactical steps, which cannot be avoided when relationship and commercial success are the goal. Developing an effective approach to collaborative innovation starts with a solid understanding of your company's overall strategy and how the collaborative innovation strategy can contribute to it. What is the business challenge you want innovation to solve? Are you (like Fokker Elmo and DevLab members) trying to protect your position? Are you (like CandelLed's founders) trying to develop an entirely new position? Are you (like FEI and Océ) trying to diversify into different markets? The three main collaborative innovation goals can be accomplished only with the right governance mode. While there are generic principles and structures, individual collaborative innovation strategies necessitate specific sets of requirements. Table 1. summarizes this argument, linking collaborative innovation strategies, implementation stages, to generic and specific elements of governance modes.

Table 1. Choosing your Collaboration Innovation Approach

Stages / Coll. Innov. Strategy	Need	Find	Formalize	Execute
Common Requirements (apply across all three strategies):	• Specify critical assets you bring and need • Substantiate size of the opportunity	• Search and select based on partner criteria • Tap into local network knowledge • Ensure fitting people are on the team • Validate capability match	• Negotiate and formalize contract, and joint development agreement • Negotiate and formalize financial pie-split	• Manage all relevant levels • Establish escalation mechanism at start
Specific Requirements (depend on strategy):				
Strategy: Protect an Existing Position		• Search in analog markets	• Licensing deal	
Strategy: Develop a new Position		• Validate common goal	• Equity Joint Venture	• Appoint heavy-weight project manager • Share financial and market information
Strategy: Add an Adjacent Position		• Validate common goa	• Establish financial pie-split mechanism in two stages	• Appoint heavy-weight project manager • If cost and time-to-market are crucial, risk-sharing partners should monitor project goal • Share financial and market information

Collaborative innovation strategies are best implemented in four stages. Stage 1 requires managers to ask the generic questions of what unique capabilities they bring to the collaborative process and what capabilities they need partners for. Concrete capability specification helps to optimize the partner search and collaborative process. Firms with deep relationships and relationship skills are much better positioned to optimize partner search and management. Partner commitment however can only be obtained when the opportunity which you want to share is substantial, well defined and quantifiable. How big is the opportunity that you want to share? Estimates need to be substantiated by fine-grained market research.

Stage 2 is concerned with the search and selection of matching partners. This process should be based on the criteria that were specified during stage 1. Search and selection processes can be facilitated and optimized by tapping into managers' local networks, within reason. If the protection of a position is your goal, first search in analog markets. Quite often solutions or partial solutions are out there, but in a different form. The search in analog markets will help you uncover their existence. Firms also need to make sure that potential partners will be willing to put fitting people on the job. Value will be captured only once it is created; the creation process demands a team of skilled and motivated people, setting aside their own ambitions and working towards one common goal.

In stage 3, collaborative innovation partnerships need to be sealed in contracts, joint development agreements, and appropriate financial pie-splitting mechanisms. The common reward mechanism in "protect a position" strategies is the licensing agreement. When the development of a new position is the goal, the establishment of a joint venture, splitting the shares in accordance to contribution, is the preferred mechanism. Resource-related adjacency strategies need to consider two reward phases. In phase one, which leads to the development of a product concept, the risk-reward mechanisms should be a combination of an amortization part and risk-reward part based on contribution. The amortization part lowers the entry barrier for the partner, while the risk-reward part ensures alignment of interests over the duration of the project. Phase two is characterized by the establishment of a venture. Risk-reward mechanisms based on contribution or allocation of shares ensure partner commitment.

Once the relationship is sealed, the hard work of executing (stage 4) starts. Relationship management at all relevant levels is essential to build the strong relationships that are needed to weather potential storms. Given that storms will arise, escalation mechanisms must be established beforehand. Careful team selection is essential for success. Teams should be skillful in their tasks as well as collaborative in their outlook, so as to work efficiently towards the common goal. Appointing a heavy-weight project manager is important in strategies for adding or developing positions. Meetings should be established during which project reviews are held and financial and market information is shared. In case cost and time-to-market are your focus, risk-reward sharing suppliers are the best project monitoring mechanism.

In summary, we have proposed a parsimonious and integrated framework to help managers realize value and avoid the pitfalls of collaborative innovation. Based on extensive field research in one of Europe's foremost high-tech regions, the framework links the specifics of need identification, partner search, relationship formalization and execution with the particular innovation strategy that the firm is pursuing (adding an adjacent position, defending an existing position, or creating a new position). In competitive high-tech sectors where collaborate to innovate is increasingly necessary, the framework offers key to beating the odds with collaborative innovation projects that deliver value in the form of superior products, developed and commercialized faster and at lower cost.

Main Project Outcomes

We have investigated the main project outcomes in terms of the learning and reputation effects for firms that were involved in a collaborative innovation project, the successfulness of collaboration itself, and the market impact of the project result. Learning effects are important as collaborative innovation demands certain skills and capabilities that need to be build while doing. There is a learning curve. Reputation effects are important for firms seeking to continue working in collaborative projects. The successfulness of the collaboration will determine the learning and reputation effect as well as whether partners will be open in future to continue working in clusters on innovation projects. Obviously, market impact is an important indicator of success, which cannot be neglected in studies on innovation.

– ***Learning and reputation effect*** In most if not all cases, especially SMEs benefited enormously in terms of capability enhancement and reputation effects. In cases where employees of partnering firms worked together in one location, tacit knowledge was shared. Learning took place at the technology as well as at the project management level, contributing to SME development.
Positive reputation effects followed from the capability enhancement effect as well as from the demonstration of willingness to collaborate and invest on a risk-reward basis. We dare argue that these learning and reputation effects will contribute to the longer-term competitiveness of these firms.

– ***Relational success*** The collaboration of multiple firms was smooth and successful from the start to the end in cases that used the governance mechanisms that were described in this study.

We found that, in most cases, the government's mediating role was important for the establishment and management of the relationship. Regional government officials are seen as impartial or objective partners, because they are involved as an individual and institution but not financially. In some cases government officials were actively pushing the projects forward and mediated in times of tensions between collaborating parties.

– ***Market Impact*** In general, to date, market impact of most of the innovation projects which were studied as part of this research, (the sample includes more projects than the ones that were described in detail), is not major. For some of the projects it could be too early to make an evaluation of market impact, testifying once again that commercial success of innovations doesn't happen overnight. As mentioned in the text, however, in order to optimize market impact, firms should take a holistic approach to innovation, integrating the market in the development process from the very beginning onwards.

Government Policy Implications

Aside from studying business relevant issues in the collaborative innovation projects, this research has explored the role and impact of the regional government. The interest in the government's role should be seen in the wider context of recurring debates on whether and how governments should be involved with innovation. In most of the projects that were studied, regional government was involved from the start until commercialization. This section tries to follow this structure of involvement. It offers reflections on the allocation of government funding; government involvement with partner selection issues; and project management issues.

1. Allocation of Government Funding

The allocation of government funding to innovation is a very important topic, which deserves more in-depth research and discussion than this work can offer. Given the limited scale of this research, we cannot do justice to the topic but are able to offer some reflections and concerns, which are hopefully useful in the context of the broader debate. This section discusses the difficult issue of project selection; stimulation and endorsement of programs by clusters; the allocation of funding to fundamental research; and finally generation of customer demand.

1.1 Project Selection Most of the projects that were studied involved the development of a new product/new market combination. The selection of an idea or concept involving new product-new market combinations is extremely difficult at the inception stage since the prediction of market success is nearly impossible. As already indicated, improvement of the prediction requires detailed market examination and integrated product development.

The projects that were studied were not always sufficiently careful in using an integrated product development approach. Government subsidy programs do not accommodate this approach. We suggest that if market impact is considered an important criteria for government endorsed innovation, the way in which funding is managed should accommodate this approach. There is sufficient evidence to credibly argue at this point that the chances of market success rise dramatically when an integrated product-development approach is taken seriously.

One of the innovation programs that was orchestrated by government, used "feasibility to be developed within a certain time-frame" as an important selection criterion. The subsidy program would only run during a certain period. Temporary programs encourage projects with a short-term focus but not necessarily high impact. The outcome of this particular program was enhanced capabilities of some firms, a few marketable products but not a single real market success.

An important question in this context concerns the results that we expect from government funded projects. Are we satisfied with enhanced capabilities of individual firms or do we want to add the prospect of enhanced economic growth and jobs? If the latter is what we would opt for, then management of government funding should be carried out accordingly.

1.2 Stimulation and Endorsement of Programs by Clusters In the same context, it is advisable to reflect on the allocation of funds to innovation programs as opposed to projects by clusters of firms. In a simplified sense, project funding deals with a single project (be it small or large) with a focus on producing agreed deliverables, to an agreed schedule and budget. Program funding deals with multiple projects that collectively produce an agreed business outcome – i.e., they have inter-dependencies (e.g., impact the same group of stakeholders, each contribute to achieving a business outcome, and depend upon each other to do so).
The funding of programs rather than individual projects by clusters of firms, such as Brainport Industries and DevLab, will foster long-term strategic thinking, optimization of resource allocation, and the creation of synergies. The spontaneous formation of these clusters points to the need of these firms to collaborate in order to realize their strategic goals. Government could foster the strength of such clusters by stimulating the development of larger-scale innovation programs.

1.3 Fundamental Research None of the cases that have been studied in this work are concerned with fundamental research. They focus on the application of existing knowledge to another domain, product or process or the fusion of existing streams of knowledge to develop something new. Given the challenges that we are facing today and the dramatic cuts in government funding for fundamental research, I nevertheless consider it important to include a few reflections on this topic.

Since our governments and firms tend to admire the innovativeness and dominance of U.S. firms in certain sectors, we include studies of the history of innovation in sectors such as agriculture, chemicals, semiconductor, computers, the internet, and biopharmaceuticals in the U.S. Without exception, these studies demonstrate an aspect of innovation, which is quite often overlooked in European circles, that is that well-funded, well-managed federal (public) research laid the foundation for industries that created great

prosperity and that continue to be dominated by American firms.[12] Many scholars have noted the critical role played by well-managed federal research funds for fundamental research in shaping the United States' most innovative industries. Government support is seen as essential given that the benefits of truly fundamental research are in general very difficult for private firms to appropriate. Henderson and Newell, for example, argue that "In every industry that we review, public support for fundamental research appears to have played a critical role in accelerating innovation in the industry, and there is some evidence that it has generated extraordinarily high returns."[13] Similarly, Cockburn, Stern, and Zausner highlight high, stable levels of public support as the primary foundation of industry's success in the life sciences, suggesting that this funding has led not only to many of the fundamental advances in scientific knowledge that have been indispensable to advances in modern molecular biology, but it has also underwritten the development of a wide range of critical tools and techniques.[14] Moreover, federal support for R&D is considered to have been critical to the early history of the semiconductor and computer industries.

In general, scholars who have studied U.S. innovation policy suggest that it is not only the magnitude of the public commitment to research funding that is critical, but also the ways in which this funding is governed. It is noteworthy that in some sectors such as agriculture and life sciences it took at least twenty years for fundamental research to have a notable effect on practice and that the "stock" of knowledge, not the flow, has the greatest impact on accelerating private-sector innovation. [15] Cockburn, Scott, and Zausner suggest that the recent "surge and retreat", something which is not unfamiliar to Dutch innovation policy, in National Institutes of Health (NIH) funding over the last decade has probably resulted in a less-productive innovation system and significantly distorted researcher incentives and career dynamics.[16]

These findings are important to keep in mind in times in which government funding for fundamental research is shrinking and challenges such as the development of new energy, health-care and food supply systems need more and stable rather than less and ad hoc government support. Especially in the North Brabant region, which is home to a high technology university and institutes, and many high-technology firms, government funding of fundamental research into relevant areas should not be curtailed and carefully managed. This is especially so against the background of the move of many firms towards open innovation, which for some seems to entail cuts in internal research and a shorter-term focus. Indeed, we should be alert that the current emphasis on valorization in both, public research institutes and universities does not lead to the allocation of capabilities and funds away from fundamental research. We need to bear in mind that cutting funding for fundamental research now, even for a short period of time, or not investing timely in new domains such as new energy systems, will have an impact in the longer term as it is the "stock" of knowledge that has an impact. When the stock doesn't grow over a period of time, it will become difficult, if not impossible, to catch up with those countries that continue to invest.

1.4 Generation of Customer Demand It is well-established knowledge that effective innovation feeds off both technology "supply" and market "demand." Given the technology base of this region, supply of technology is still not a problem. It is clear from the cases that innovation could benefit from policy instruments that support and induce demand.

U.S. government policy initiatives could serve also here as a good example of how government induced demand can support innovation. In his study on the semiconductor industry in the U.S., Mowery demonstrates how the prospect of large military procurement contracts in the early years of the industry stimulated widespread entry and extensive innovation. The military was also willing to award large procurement contracts to newly founded firms, something which is hardly seen in European countries. Mowery describes a similar dynamic in the early days of the computer industry. The first electronic U.S. digital computer was purchased by the military, and the first fully operational stored program computer built in the U.S. was purchased by the National Bureau of Standards. Even in the case of IBM's 650 – the most commercially successful machine built in the 1950s – the projected sales of 50 machines to the federal government was critical to IBM's decision to move the computer to full-scale commercial development. Finally, Mowery also documents how the rapid growth of the U.S. software industry between 1969 and 1980, that gave the U.S. industry a worldwide advantage, was spurred by federal willingness to invest in large complex software development projects at a time when the commercial market for such projects did not exists.[17]

[12] R. Henderson and R. G. Newell, (2011) *Accelerating Energy Innovation. Insights from Multiple Sectors.*
[13] Ibid, p. 8.
[14] As mentioned in Henderson and Newell, p. 8.
[15] Ibid, p.9.
[16] Cockburn, I., S. Scott, and J. Zausner (2011) "Finding the endless frontier: Lessons from the life sciences innovation system for energy R&D." In Henderson and Newell, pp. 113-158.
[17] Mowery, D. (2011), "Federal policy and the development of semiconductors, computer hardware, and computer software: A policy model for climate change R&D?" In Henderson and Newell, pp. 159-188.

These are example cases from industries that are mature and established at this moment but that in their early days suffered as much from crossing the "valley of death" between technological proof of concept and first commercialization as new industries and firms do in present days. The U.S. government's direct purchasing power was crucial for the establishment, commercial success and long-term competitiveness of major sectors and firms. We can admire IBM, Microsoft, and Google. But we shouldn't forget the historical circumstances that contributed to the success and ask what we can learn from it.

Government can also induce innovation demand by providing direct incentives to the market to purchase new rather than existing technology. The case of clean energy, for example, is a case in point in which public policy in Germany and Belgium induce demand by subsidizing the installation of solar panels. Government should carefully review all instruments, also the tax mechanism, to identify how and whether new technology purchasing can be stimulated. We found, and this is perhaps detail, that Dutch depreciation policy favors purchases of old rather than new technology, hampering rather than stimulating innovation demand.

Finally, in some of the cases that were studied the purchasing function of local and regional governments and other public institutes such as universities played against innovation. Decisions are often made in favor of established relationships or known and perhaps preferred suppliers. What one doesn't realize perhaps is that the smallest public purchase can serve to induce further demand as it functions as a symbol of trust.

2. Partner Selection Issues

In general, partner scouting and relationship building skills are present but can still be enhanced in regional firms. Given the increased need for collaborative innovation, the building of such capabilities is not a luxury but a necessity.

The efforts made by government officials to organize encounters between firms with complementary assets turned out to be very useful. The facilitation of these encounters are part and parcel of the creation and sustenance of a healthy innovation ecosystem. Such encounters could now be lifted to the strategic level in order to foster strategic rather than ad hoc partnering.

3. Project Management Issues

While perhaps trivial to mention, project management skills are essential for successful innovation. Such skills help with the planning of budgets, deadlines, deliverables. These skills and experience are mostly lacking in smaller firms, resulting in delays in time to market, inability to produce agreed upon results, overshooting of budgets, under-estimation of required resources. The side-effects, in turn, cause friction between partners and disturb the commercialization process.

Government should reflect on how to raise awareness about the need for project management skills for innovation in SMEs and possibly how to make project management training better available to these firms. Such trainings are expensive. SMEs do not have large educational budgets and do not always see the benefit.

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