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CASE STUDIES OF COLLABORATIVE INNOVATION IN CANADIAN SMALL FIRMS

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Executive Summary

Innovation has become a necessary component of a successful business strategy among firms of all sizes. In fact, many studies demonstrate that research and development (R&D) and technology-based innovation strategies are strongly associated with superior business performance. Smaller firms may face limited resources for R&D and commercialization and, consequently, incur higher risks. In addition, the innovation process is not solely dependent on R&D, as factors such as human resource strategies and management capabilities of the firm are also key. Therefore, the need for collaborative R&D and commercialization is particularly critical for small and medium-sized enterprises (SMEs) hoping to make gains in terms of innovation.

To understand the factors that make collaborative R&D and commercialization work, this report examines the strategies used by five companies. Each company has engaged in a variety of collaborative activities with varying degrees of success. The findings of these case studies are intended to provide insights into new policy directions for government.

> Overall, the findings of the case studies suggest that the collaborative strategies used by the firms can be classified into two broad categories of activities: "research push" and "commercial pull," which comprise six distinct types of collaboration. Research-push collaborations include spinoffs from university laboratories and contract research performed by these companies. Commercial-pull collaborations include sponsored research, joint ventures and technology watches (a process of networking with researchers to identify promising technologies as early as possible).

The principal findings of the collaborative strategies used by the firms are summarized below.

- The R&D must be credible for there to be any hope of collaboration.
- Spinoffs need to make the transition from research push to commercial pull as rapidly as possible.
- Successful business development is not only about science and technology. Individuals make an enormous difference; good personal relationships, inspiring mentors and advisors are key. Selection of the chief executive officer (CEO) is also particularly important.
- Protection of intellectual property (IP) is expensive and time consuming. Often, high-tech SMEs have to sell their businesses to large corporations to protect what they have. In addition, patents are not always the key to competitive success, particularly in industries that are moving so fast that patents become obsolete long before their expiry.
- In collaborations with large firms, SMEs can best protect their intellectual property in two ways: (i) establish a niche market that is too small to interest large firms or (ii) cede IP ownership to the large firm in return for a guarantee of exclusive rights to supply the product.

- Controversy surrounds the best formula for ownership of IP emerging from university labs — some advocate university-owned, others inventor-owned. Resolution appears to depend on the specific circumstances of each university.
- One of the main barriers to collaboration is the ability to access potential partners — researchers in the case of SMEs new to R&D, large firms in the case of SMEs seeking joint ventures. Establishing networks between stakeholders and persistence appear to be the most promising solutions.
- Another barrier for university spinoffs is the lack of incubation facilities that provide a full range of services for new firms. While there are examples of effective incubation in the case studies, findings suggest that incubators that have better funding would be able to provide a better range of services to effect outcomes for individual firms.
- During the risky phase of business development between launching a spinoff and commencement of revenue flows, there is a lack of financing. This financing would be best supplied by angel investors.
- Collaborations generally demand detailed written agreements that establish the rules for IP ownership and participation requirements. These agreements can often extend to 50 pages or more.

Broad policy implications that can be drawn from the findings of the case studies suggest that:

1. Technology transfer offices (TTOs) would be stronger and more effective if they consolidate and serve networks of research institutions to give them critical mass.
2. TTOs need significantly greater funding to improve their incubation facilities and outreach activities to service both researchers and established businesses.
3. Encouragement of angel investors is likely to ameliorate the financing crisis during the risky period when spinoffs are creating the infrastructure for commercial applications.
4. If universities wish to improve their commercialization outcomes, they may wish to encourage a culture of commercialization, which could include expanding the number of Entrepreneurship Chairs and establishing university centres of national excellence.

Overview and objectives

Innovation, research and development (R&D) and commercialization in smaller firms
In the ever-growing global economy, innovation activities have become increasingly important to how firms achieve competitive advantage and, hence, the long-term success of a firm, regardless of employment size. As globalization has become more pervasive, innovation has become an integral part of strategies to guarantee firm survival and success. This imperative presents fundamental challenges as to how firms organize their innovative activities. Innovation is a difficult process to "manufacture" and complete successfully. Spending on R&D is one measure of innovative effort, but large R&D expenditures do not always guarantee successful innovations. In particular, the ability to translate new ideas into a business application, i.e., commercialization, is a critical element in the process. At different stages, small and medium-sized enterprises (SMEs) will need to engage in collaboration to ultimately be successful.

The nature of R&D in SMEs will vary according to the age, size, industry and business culture of the firm. Technology firms that are founded on the basis of a promising technological breakthrough are obviously heavily focused on their R&D; other firms tend to see R&D more as a necessary response to client needs. Some industries are R&D intensive (such as pharmaceutical or information technology (IT) firms), whereas other industries have more mature product ranges and, therefore, a lower rate of innovation, demanding less R&D spending (e.g. retail and wholesale trade). In terms of business culture, R&D in SMEs may be organized or haphazard — it may be conducted by one person or a team of people; it may be a unit within the firm or a partnership with another organization, including customers and suppliers.

The focus of R&D may be evolution of existing practices, expertise and technologies; it may be part of the implementation of a strategy for expansion, where objectives for improvement or innovation are established; or it may be a corporate culture where new things are constantly tried out and those that show promise are selected for development (the "mud against the wall" strategy).

Given the limited resources of SMEs, they are likely to be more successful if they collaborate with other organizations. This includes seeking ideas and expertise not just from internal sources, but also from linkages with other firms — often extending to licensing the intellectual property (IP) owned by other firms. Research suggests, however, that smaller firms often do not collaborate because they face significant barriers to inter-firm co-operation. They suffer from the inability to identify suitable partners, to forge co-operative agreements and to acquire tacit knowledge.

It would be helpful, therefore, to look at examples of small firms that have been effective in conducting R&D in collaboration with other organizations. Such collaboration can also extend into commercialization efforts as well. This report has chosen four SMEs. A fifth firm, which is now a mid-sized firm, is also used as a case study because it has been engaged in and learned from a range of collaborative innovation activities for more than 30 years. The objective is to isolate key factors that contribute to successful SME strategies for collaborative innovation.

To aid the discussion, this report begins by classifying different types of collaboration. Of the four SMEs, one is a university spinoff that has been through the entire cycle of birth, growth and sale to a large company, one is an engineering firm that did not come out of a university but has acquired a significant R&D component, and the other two are relatively young, high-tech spinoffs.

The mid-sized firm, IPL Inc., is a plastics manufacturer with annual sales of $220 million that has been conducting R&D actively for 30 of its 68 years of existence. It stands as a benchmark for the four SMEs. IPL is an excellent example of a firm that has engaged in both collaborative R&D and collaborative commercialization activities. It responds to client needs with innovative R&D; it develops its own products through collaborative and in-house R&D; and it has a strategy to contact as many potential collaborators as possible in a bid to join forces with them in collaborative R&D.

All of the firms have collaborated in several different ways, coming from different vantage points (see *Types of collaboration* below). They have all been successful to greater or lesser degrees and they each offer some insight into what works and what doesn't work when small businesses interact with business incubators, government facilities and other third-party R&D partners.

Objectives of the study

This study examines collaborative innovation to identify the conditions necessary for successful collaboration by SMEs.

This objective can be broken down into identifying factors that (a) facilitate collaboration, (b) create barriers to collaboration and (c) cause collaboration to succeed or fail.

These factors are drawn from specific circumstances of the four SMEs examined. Although these circumstances cannot be taken as being representative of all companies performing collaborative R&D, they do apply to most companies and offer insights into the way collaboration works or doesn't work.

As part of this objective, a number of issues emerge suggesting some changes that would be helpful to SMEs in the process of identifying and implementing potential collaboration in R&D.

A second objective of this study is to identify policy implications for government to improve innovation and the commercialization of R&D in SMEs.

SMEs and collaborative R&D

The four SMEs examined in this study have all collaborated with other organizations to perform R&D, as has the benchmark company IPL. The firms and their collaborators are listed below.

Company	**Collaborators**
The C3 Group, Waterloo	University of Waterloo The University of Western Ontario
Verafin Inc., St. John's	Memorial University of Newfoundland Genesis Centre Newfoundland and Labrador Credit Union Precarn
SemBioSys Genetics Inc., Calgary	University of Calgary University Technologies International DowElanco (Dow AgriBusiness) Martek Biosciences Arcadia Biosciences Aqua Bounty Technologies Lonza
Polyplan Inc., Montréal	École Polytechnique Polyvalor/Univalor Bombardier
IPL Inc., St-Damien, la Beauce	Université Laval / University of Florida National Research Council Canada Ford Nissan Magna International Lear Bombardier

Types of collaboration

In looking at collaborative innovation, there are two basic sets of circumstances that establish two different dynamics of collaboration — research push and commercial pull.

The first category — research push — usually involves a young business that is built around some intellectual property that has the potential to be commercialized. The challenge in these firms is to build the infrastructure for a successful company, including hiring appropriate managers, financing the research phase prior to revenue flows and protecting the IP. Part of this evolution includes "beta-testing," where the technology firm finds a co-operative client that agrees to be the test bed for fine tuning the product during the process of implementing it for their own operation.

In the second category — commercial pull — the demands of clients are driving R&D. All firms that have successfully navigated the research-push phase go on to the commercial-pull phase as they diversify their original technology through the development of new products and processes. This diversification includes not only new product development, but also the research agenda itself, which comes to be determined by market considerations rather than scientific curiosity. There is a second source of commercial-pull firms — those that may not originally have depended on protected IP for their growth, but, as their client base widened, have developed an R&D unit to enable them to respond to client needs.

These collaborations can be further divided into six different types of collaboration as listed below.

Type of collaborative R&D		**Case study**	**Collaborators**
		Research push	
1	**Spinoffs:** A university-based researcher launches a new venture to commercialize research perfected in the university's labs	Verafin Inc. SemBioSys Genetics Inc. Polyplan Inc.	Memorial University of Newfoundland / Genesis Centre University Technologies International Polyvalor/Univalor
2	**Contract research:** A spinoff performs contract research for a large company that, during the course of adapting the SME's IP to the client's requirements, serves to refine the technology into a commercially viable form	Polyplan Inc. SemBioSys Genetics Inc. Verafin Inc. IPL	Bombardier Martek Biosciences, Arcadia Biosciences Newfoundland and Labrador Credit Union National Research Council Canada, Ford, Lear
		Commercial pull	
3	**Sponsored research:** An SME contracts with researchers to perform R&D that it requires (the SME owns the resulting IP)	The C3 Group Verafin Inc. D. Kelly (Verafin Inc.)	University of Waterloo The University of Western Ontario Memorial University of Newfoundland Memorial University of Newfoundland
4	**Joint ventures:** An SME that has identified a market for a product needs R&D to develop the product, so it signs an agreement with a large organization to develop the solution jointly (shared IP)	The C3 Group Verafin Inc. IPL	 The University of Western Ontario Precarn Magna International

Type of collaborative R&D		Case study	Collaborators
5	**Invention watch:** An SME builds a relationship with researchers whose work is relevant to its business so that it can identify inventions that it might be able to commercialize (IP bought or licensed)	The C3 Group Verafin Inc. IPL	University of Waterloo The University of Western Ontario Memorial University of Newfoundland Multiple organizations
6	**Invention brokering:** Same as invention watch, but the active agent is the intermediary rather than an SME and the motive is to ensure that inventions with commercial potential don't fall between the cracks		Univalor* University Technologies International*

* There are no accompanying SMEs with Univalor and University Technologies International. This reflects the evolution in the role of these two organizations, which are transcending their original role as technology transfer offices (TTOs) to become proactive in searching out inventions rather than waiting for researchers to disclose them. The Genesis Centre has not evolved into this role.

Based on this construct, the tables that follow list factors that facilitate each type of collaborative R&D, barriers to collaboration, and causes of success or failure.

Facilitating collaborative R&D

Type of collaborative R&D		Facilitating factors
1	Spinoffs	1. Creating an entrepreneurial environment in the research facility so that commercialization is viewed as feasible 2. An adequate screening mechanism that can promptly inform researchers: a. whether their discovery has the potential to be commercialized b. what their role will be in the commercialization process (along with associated probabilities of success)
2	Contract research	1. Access to companies with products for which the technology will be useful
3	Sponsored research	1. A relationship between SMEs and researchers that is sufficiently close that researchers are open to direction and the SME does not ask researchers to stray too far from their academic competence
4	Joint ventures	1. A niche small enough that large companies will not want to compete with it 2. A history of collaboration with the firm (preferably originating from a small project that was successful and developing from there)
5	Invention watch	1. SMEs need research contacts 2. SMEs need to have an easy and trusting relationship with a range of researchers
6	Invention brokering	1. Personal relationship between the TTO and researchers that engenders trust on both sides 2. Support for commercialization in the research facility

There are some conditions that are essential to facilitate any type of R&D collaboration. Chief among these is the quality of the SME's existing R&D. If the SME has a relevant R&D program, researchers and institutions will respond by being willing to collaborate. The C3 Group found this to be essential and Verafin demonstrated the power of its technology by attracting Precarn as a collaborator. Without this credibility, collaboration is unlikely to proceed. This is true for almost all types of collaboration.

It is worth noting that, in all but one of the collaborations arising from commercial pull, it was essential that the leaders of the SMEs had personal relationships with the researchers. No matter how precise the science or engineering in a project may be, it is the nature of individual relationships that makes the difference. Without that comfortable relationship, few collaborations will proceed. Both The C3 Group and Verafin concluded that "it all boils down to the people."

In research-push collaborations, the effectiveness of individuals in key positions was also often critical to the success of the collaboration. This was particularly true for Verafin, which initially

benefited from the entrepreneurial orientation of key professors, but noticed an immediate decline in the pace and effectiveness of collaborations when these professors moved on to other activities. By contrast the hiring of key personnel not suited to the positions threatened the spinoff in the Polyplan case.

Personal contact is also important between researchers and the business world. Among other benefits (such as the power of example), these contacts encourage researchers to appreciate the importance of market factors contributing to commercial pull.

Findings from the case studies also suggest that selection of the CEO for a spinoff is of critical importance. The key issue to be decided when forming a spinoff is whether the researcher will lead it or an outside CEO will be hired. This was a conscious and carefully considered decision for both University Technologies International and Univalor, whereas Genesis Centre favoured making the researcher the CEO or not backing the project at all. Either way, an appropriate screening mechanism was recognized by all three firms as being vital to selecting the CEO.

It is noteworthy that when SMEs are collaborating with large companies — in joint ventures, for example — it is useful, as The C3 Group found out, to have had some previous successful dealings with the company. This will build up the credibility that is essential to sustain in-depth negotiations and provide the level of detail required to form a joint venture with a large company.

In some instances, it may also be critical for SMEs to develop niche products or services that are of little interest to big companies. The experience of The C3 Group in this regard is instructive — it prefers the niche market approach rather than mount a costly defence of a patent against a large company. This is because such a defence will be a losing battle since large companies possess more patience and significant legal and financial resources. However, an SME can still make a useful contribution to a large corporation provided it does not directly challenge the large company's IP.

An alternative approach to dealing with large companies is to allow them to own all or part of the IP in return for guaranteed rights of access. This approach has been used by both The C3 Group and IPL, which developed products with major collaborators on the specific understanding that they would get exclusive rights to market the resulting product, even if only for a limited time. In other instances, even if a small young company develops a breakthrough technology with valuable IP, the small firm may choose to sell the technology simply because it does not have the financial, human or other resources to take it to the next step.

Barriers to collaboration

Type of collaborative R&D		Barriers to collaboration
1	Spinoffs	1. Absence of incubation resources that: a. have strong private-sector support or input b. serve enough research facilities to possess critical mass 2. Unavailability of financing during the "gap" after establishing the spinoff and before sales revenues start to flow
2	Contract research	1. Technology that does not have enough commercial potential to interest at least one division of the client
3	Sponsored research	1. No means of connecting with research institutions
4	Joint ventures	1. The first contact is always the hardest
5	Invention watch	1. No means of connecting with research institutions
6	Invention brokering	1. A research culture that is highly suspicious of commercialization — that may view it as skewing research priorities, for example

There are three levels of assistance that incubators can bring to spinoffs:

1. Negotiation of technology transfer agreements (including initial assessment of whether it is worth doing at all)
2. Expertise of writing business plans, incorporating a company and developing human resource capability
3. High-level, strategic expertise that can enable the spinoff to protect its IP (patents and other forms of IP) and enable the company to compete internationally

The first level of assistance is vital, but is not an extensive process (see facilitating factors, above). An interesting question is whether this is best accomplished as part of the incubation in the second and third levels of assistance (as in the case of University Technologies International and Genesis Centre) or whether it should be separated and dealt with exclusively by the university (as in the case of Univalor). In the former case, there is arguably a conflict of interest for the TTO, which is acting for both the researcher and the university in developing the spinoff while simultaneously negotiating an agreement between the two parties, acting on behalf of the university. At École Polytechnique, the university negotiates the agreement with the researcher, in the context of an extremely elaborate IP policy statement, so that Univalor can concentrate entirely on commercialization.

Based on the case studies examined in this report, the second level of assistance causes the least concern of the three levels. Obviously, it is important to provide spinoffs with a sound basic foundation and structure, but the expertise to accomplish this is easily obtained. This kind of assistance is vital to prevent failure rather than to cause

success. It is unlikely to be a determining factor in advancing a company's progress significantly.

The expertise required to effect the third level of assistance is extremely difficult to obtain. It demands people who have already "been there." One point of view (Univalor) is that the only realistic way to achieve this result is to hire a top-notch professional CEO who does not need incubation services. At the other extreme is University Technologies International, which is developing its own expertise to handle this role in-house.[1] The middle view (Memorial University of Newfoundland's Genesis Centre) is to recruit mentors from among the university's alumni who have developed the required expertise.

The best solution depends on the specific circumstances of each university, but the principal is the same — incubation, as it is generally thought of, cannot do the job without acquiring a more advanced level of expertise and experience than is commonly the case in Canadian universities. It takes specific individuals with the right credentials and experience to guide a spinoff effectively through its early phases. As this quality of assistance is expensive to acquire and needs to be used to the fullest extent possible, incubators need to acquire the critical mass to afford and use it effectively. Two conclusions that emerged from the case studies were that:

a. Research institutions should form networks that feed into a single TTO (both Univalor and University Technologies International have done this).
b. Funding devoted to TTOs should be raised significantly to enable them to fulfill the roles described above.

The other barrier that may cause confusion is the need for financing during the most difficult phase in the development of spinoffs. In most cases, these companies are too immature for venture capital, so they must rely on more traditional sources of financing, which are not always well equipped to deal with them. These SMEs need not only understand investors who can empathize with their challenges, but also investors who can contribute to the strategy and who can introduce them to other organizations that can help them. Polyplan, for example, found this to be lacking in its investors.

It is likely that, as Marc Leroux, CEO of Univalor, says, capital for spinoffs today is "much wiser than it was before." He says that investors in Quebec used to invest very small amounts in many projects. "Now, the capital is much more patient and much choosier." That choosiness is, of course, a vital skill at this point of development of a spinoff.

Nonetheless, institutional capital in Canada is sometimes not well suited to financing emerging technology companies both because of a lack of understanding of the technology and because companies at this stage of development often do not progress as fast as they would like. The solution to this gap may well lie in angel investors, provided they can be given greater encouragement to fill this specific need.

[1] *It should be noted that less than 10 universities in the U.S. have been able to develop this level of expertise and services provision. The remaining U.S. and Canadian universities have yet to develop this level of expertise.*

Another factor that emerged as a challenge in the case studies was the ability to establish contacts with researchers or to get the first contract with a large company in a joint venture. In both of these situations, the SME had to demonstrate an R&D capability that meets the minimum (but unspecified) requirements of the client or the researcher. Without it, there will never be enough interest to even start a discussion.

A good example of this is IPL, which won its first contract with a major automobile company in 1982. IPL had been trying for 10 years to break into the automobile market for plastic products without any success. It finally hired a suppliers' agent in Detroit who had been a buyer for Ford and even he was having difficulty getting IPL in the door. So IPL asked him to find out which of all the parts that went into all Ford models was the most problematic. The answer that came back was a door-hinge cylinder that cost 10¢ to make but cost $250 to replace when it was defective. IPL took two years to find a solution. This success opened the door for them and brought them Q1[2] status at Ford as an official supplier. From there, IPL developed a significant market for its products in the Big Three, Magna International and the Japanese companies, mostly for products that demanded unique expertise and significant R&D expenditure.

Not all markets are this hard to penetrate, and networking with researchers, in particular, should not be an impossible task. However, the first contact is, as always, the most difficult. The C3 Group (and a host of companies in the Kitchener–Waterloo region) found a solution to this problem in Communitech, a networking and service organization for high-tech companies and researchers that opens the door for those equipped to walk through it. The C3 Group can now carry out the technology watch on its own and has so far extended its contacts to two universities.

IPL has taken this a step further with its own technology watch. It has identified 10 interesting universities and private research centres that are conducting research that is compatible with the skill set of IPL and it is systematically going to visit them all. If they find potential avenues for collaboration, they will sign an agreement suited to the specific circumstances. The intent, as they progress, is to build a larger list of collaborators that will lead the company into new areas of research as well as help identify market gaps that can be further exploited, with or without collaborators.

Marc Leroux, at Univalor, has a database of 4000 companies that are potential collaborators, but finds it much more difficult to build a network of university researchers. Commenting on the challenges associated with establishing a network of research collaborators he notes that: "I have a group of about 200 researchers whom I know. I call them repeat offenders — I love them, I like them, I nurture them all the time. But it's very delicate. If you push too hard, you'll have the whole academic community on your back. The contact between the world of business and the world of universities is not a connection that goes click, like that. You have to know the protocol."

[2] *Q1 refers to the top tier of suppliers that have demonstrated their competence to Ford and are integrated into Ford's supply chain, enabling them to quote on business opportunities.*

University Technologies International suggests that all IP created at university labs should be owned by the university. This would allow the university to pursue a more aggressive commercialization program (as does the University of British Columbia, for example). On the other hand, the University of Waterloo, which makes no claim at all to IP developed in its labs, appears to have created a culture of commercialization among its researchers. This latter case, however, may be a reflection of the extensive network — Communitech — that links high-tech companies to researchers in the region.

Causes of success (the absence of which may cause failure)

Type of collaborative R&D		Success factors
1	Spinoffs	1. Finding individuals who can help researchers recognize their problems and solve them; these people may be: a. peers who have experienced whatever the researchers' current problems are b. mentors who can advise researchers on a broader level 2. Securing top-flight business management if researchers cannot do the job in (1) above themselves 3. Very strong marketing orientation in terms of: a. a thorough understanding of the market for the technology in the spinoff b. general theories and techniques of marketing and selling internationally 4. Expertise in managing IP and patents
2	Contract research	1. Managing expectations of the client by putting in writing any agreement on deliverables and their timelines 2. Keeping abreast of changes in the client's management and strategies 3. Being prepared to change prior agreements if circumstances change 4. Ensuring that the product is successful for the client
3	Sponsored research	1. Good understanding on the part of the SME of the competencies of the researchers 2. Ability to keep researchers on track through clear direction, including specific goals, timelines and milestone payments
4	Joint ventures	1. Good understanding of differences in perspective, strategy and objectives of each party involved 2. Experience or competent assistance in negotiating and writing extensive and detailed R&D contracts with large companies that have access to required legal, marketing and R&D expertise 3. Clear statement of the roles of each party and ensuing rights to IP 4. Realistic appraisal of the relevant importance of their own contribution to the joint-venture IP
5	Invention watch	1. Mutual respect 2. Ability to visit researchers informally and unimpeded 3. High comfort level on the part of researchers that the SME will not try to steal their IP
6	Invention brokering	1. Mutual respect 2. Ability to visit researchers informally and unimpeded 3. High comfort level on the part of researchers that the SME will not try to steal their IP 4. Sensitivity to the risk of appearing exploitative to researchers

Perhaps the most critical aspect to the success of collaborative innovation is the importance and difficulty of attracting top-notch talent to lead spinoffs. There are relatively few researchers who can make the transition from laboratory to international competition (Verafin's Jamie King, for instance). Even someone such as Maurice Moloney in SemBioSys, who understands the challenges and barriers of marketing a new technology internationally, concluded that he had to find one of only four people in the world whom he considered competent to be the CEO of his company. Consequently, the pool of available competent people to run these ventures is very small and furthermore such people will only be attracted by exciting and good quality technology and research. This suggests that an important part of any incubation service for spinoffs should be directors or advisors who know where to look for these kinds of CEOs.

The thorniest issue in any collaboration is that of intellectual property. When university-based IP is licensed to an external company, it is far less complicated than a spinoff. The real skill in licensing IP is knowing how to leverage the value of the IP to raise the price as high as possible. The more difficult debate in these cases revolves principally around the fairness of the split between the university and the researcher of the benefits that flow from the licence. It is quite common to set this split at 50/50, but, based on the cases studied here, it is probably a good idea to allow for some flexibility in situations where the balance is clearly something else.

For spinoffs, there are two camps debating the split of IP — an argument that might appear to be more about semantics, but that does have a powerful impact on the researchers' motivation. In "inventor-owned" institutions, the inventor owns the IP and is required to pass on to the university a percentage of the proceeds. In the case of "university-owned" IP policies, the university owns the IP and is required to pass on to the inventor a certain percentage of the proceeds. In effect, the proceeds are the same in both cases, but inventor-owned IP policies offer more control to researchers, whereas university-owned IP policies offer control to the TTO, on behalf of the university. The debate really comes down to the researchers' and the TTOs' perceptions of who is competent to lead and manage a spinoff.

Among the cases studied here, two researchers — in SemBioSys and Verafin — had the capability to manage the spinoff effectively (by hiring a top-notch CEO in the former), whereas a third — in Polyplan — came close but seems not to have had the expertise required. Interestingly, in the case of Polyplan, Polyvalor's successor, Univalor, has an institution-owned IP policy, but Polyvalor did not, so the decision was left to the researcher, who tried to hire a professional CEO, but was unable to close a deal and so stepped into the breech himself. Once again, the solution appears to revolve around individuals and their specific skills and flaws, rather than the specific IP policy in place.

Identifying and managing collaborations

Identifying collaboration opportunities

Findings from the case studies suggest that for research-push collaborations, the choice of collaborators is often straightforward — choose the most appropriate researchers in the field. For SMEs that have the minimum level of R&D credibility, the challenge becomes one of putting them in touch with researchers who are interested in the same field. Generally, this is best accomplished through organizations that seek to establish networks, such as Communitech in the Kitchener–Waterloo region. Other cities in Canada are either building or have similar types of organizations in place to facilitate networking activities, such as the Ottawa Centre for Research and Innovation (OCRI), the Toronto Region Research Alliance (TRRA) and Montreal International. Smaller cities may also use Chambers of Commerce or other types of intermediary organizations.

Managing collaborations

When managing collaborations, it is apparent from all of the cases studied here that the legal form of the collaboration is not important. What counts is sharing IP rights, which needs to be meticulously negotiated and documented. In cases where this is not done, detailed documentation of work as it unfolds may help, but it is highly undesirable to be negotiating IP rights after an unexpected discovery has emerged.

The other key aspect to managing collaborations is that a research-push spinoff should morph into commercial pull as soon as possible. This changes the personnel and management requirements of the firm, but, most important, it also alters the R&D agenda to accommodate changing market realities.

Policy implications

In trying to facilitate and encourage collaborative R&D, a good portion of the gaps and shortfalls are not susceptible to broad remedies — they depend on the individuals involved or the constraints of specific circumstances. Consequently, in the policy implications that are outlined in this section, only those situations that are amenable to broad applications are listed. Such broad areas of policy could include:

I. Enhancing the role of technology transfer offices. The preferred technique, where possible, would require TTOs to serve networks of research institutions so that they can centralize and strengthen the technology transfer activities of consortia of research institutions, rather than serve one institution alone. This would create critical mass and help focus on the process of commercialization.

II. The process of commercialization in universities may benefit significantly from an increase in funding for commercialization. This increased funding would:
   A. attract top management talent
   B. provide access to advanced marketing expertise
   C. contribute to bridge financing or access to financing partners.

III. There is a gap in financing spinoff companies during the phase between incorporation and the point when revenues are generated from sales. The most likely source of additional funding would be angel investors, who would require the requisite incentive structures.

IV. There was consensus among the technology transfer respondents in the cases studied here that most professors are not aware of the market potential of their work. Some ideas that emerged to foster greater awareness of the market potential of research activities include:
   A. encourage universities to institute policies that would promote a culture of entrepreneurship so that researchers would be more receptive to commercialization of their research
   B. expand the number and quality of entrepreneurial chairs held by experienced entrepreneurs with academic qualifications
   C. create tighter links between universities and major companies involved in research, perhaps by designating specific universities as centres of research excellence.