# Ontario Manufacturing, Knowledge Networks and Community Colleges

# A Report to the Toronto Regional Research Alliance (TRRA)

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## Introduction

This study is part of an on-going series of research projects on Advanced Manufacturing funded by the Toronto Regional Research Alliance (TRRA).

This Report is an extension of research in a previous TRRA-funded project *Ontario Manufacturing, Supply Chains and Knowledge Networks: A Report for the Toronto Region Research Alliance*, (Birnbaum et al. 2010).

The field research involved interviews with 34 key informants in the manufacturing sector of the Southern Ontario economy. The interviews were supplemented with discussions with representatives of three community colleges. We thank the companies along with Mohawk, Conestoga and Georgian Colleges for their cooperation.

## Objectives of the Study

The objective of the study was to examine the differential regional economic benefits of Community Colleges and Research Intensive Universities. Results of the previous research suggests that knowledge transfer from research intensive universities is primarily oriented to product innovation. Community Colleges are more associated with process innovation. The hypothesis is that colleges produce more 'sticky' knowledge transfers and talent flows than universities.

## Advanced Manufacturing and Supply Chains

Why study knowledge networks in manufacturing firms? The answer is that they are vital to the future of manufacturing.

It is now widely acknowledge that Ontario manufacturing, and manufacturing industries across developed countries are now intimately immersed in global supply chains. As the latest scholarship in the area (Herrigel 2010) suggests, a firm's position and functioning within global supply chains turns on its learning capabilities. In this sense, the manufacturing economy and the knowledge economy are one.

Manufacturing supply chains and specifically OEM-Supplier relationships have undergone a constant evolution.

The classic industrial supply chain was the arm's length market relationship, usually associated with General Motors in its heyday. The job of the supplier firm was simply to meet contract requirements for specified parts and components. This was a dominant form of Ontario manufacturing for most of the Postwar period.

The Japanese auto manufacturing revolution brought Toyotaism. An integrated, though captive supplier relationship where there is joint development of design, manufacturing and quality functions shared between OEM and supplier. This model now dominates across the auto industry and is copied by other major manufacturing OEMs.

Contract manufacturing takes place at the other end of the spectrum, where design and manufacturing are completely split. The supplier takes on the manufacturing and assembly functions as agreed with the OEM. There are examples in Ontario, but the classic cases are in Asia, in particular Taiwan.

Relational contracting is a more integrated form of relationship in which OEM and Supplier form long term relationships and plan future developments. However, it runs the risk of exclusivity and possible loss of sole sourced contracts.

Sustained Contingent Collaboration

Industrial studies academics identify Sustained Contingent Collaborative (SCC) as the norm for manufacturing supply chains going forward. OEM and Supplier have close and mutually dependent relations around design, quality and manufacturing. Both labour under the unrelenting pressure of continuous cost reduction pressures and the need to constantly innovate.

For these reasons, SCC is fundamentally a learning-based process. And, it is in this environment that Community Colleges are or will be operating with their Ontario manufacturing partners now and in the future.

## Definition of Innovation

Because of the central importance of innovation for the future of manufacturing, it is useful to proceed from a common definition. A useful reference is found in the work of colleagues also conducting recent TRRA-funded research in the Financial Services and ICT sectors.

The definition used by the OECD, Canada's Science, Technology and Innovation Council (STIC) defines innovation as "the process by which individuals, companies and organizations develop, master and use new products, designs, processes and business methods. These can be new to them, if not to their sector, their nation or the world" . It includes the introduction of new or significantly improved products, processes and methods that impact an organization, industry and/or an entire ecosystem of networks and in turn drives development and prosperity.

Innovation is a highly interactive and multidisciplinary process, requiring and facilitating institutional interdependencies, locally and globally. (Wolfe 2010)

**Previous TRRA Study**

A key finding of the research on knowledge networks in auto, steel and advanced manufacturing was that the innovation that occurs within a sector is greatly determined by how that industry is structured. Factors such as the nature of supplier relationships, the ownership pattern of the industry and the nature of the product itself play a large role in determining how new products and services are developed and in how R&D resources are allocated. It is striking how differently the innovations within the industry are created and then used.

Auto Sector

The automotive sector's innovation is entirely dictated by a firm's place on the supply chain. The OEM firms come up with the overall design of a new model and create specifications that they require their part suppliers to fill. Virtually none of the OEM research is done in Canada. However, significant design does take place at the Tier 1 supplier level. Suppliers in Southern Ontario have been successful in ensuring that new technology for the automotive industry is developed within the province. The large Tier 1 suppliers have the resources to engage in forward thinking innovations that will allow them to anticipate the OEMs future directions and push technology forward.

Innovation also is involved in the automotive sector through the materials providers. While plastic makers and steel mills are not directly involved in the tiering system, the creation of new plastics and steels are integral to making lighter and more efficient cars.

Overall, Ontario is only innovative along certain parts of the auto supply chain.

Steel Sector

Within the steel sector the consolidation of the industry has resulted in great changes to how knowledge flows. Local steel mills have integrated vertically and access information as available within their parent companies' global network. Another key finding was that the steel sector focuses most of its innovation on the process side. Steel's intermediate status in the manufacturing chain forces innovation to the process side. Most 'product' innovation in steel takes place in the basic metallurgy of its internal processes. Process and product innovation incubate together in the melt shop. But, steel customers from automotive to construction also tended to view steel as commodity and this in limits to some extent, the sector's ability to develop new products.

## General Advanced Manufacturing

Advanced manufacturing firms can be loosely grouped into two types that greatly determine how the firms innovate.

The first group are those in niche areas who do not face much direct competition. The second group are those in highly competitive markets. Firms that operate in niche markets tend to focus heavily on custom engineered products for heavy industry, largely for use within the manufacturing process. Since these firms were focused on highly-specialized markets, relatively little attention is given to game changing product innovations, but rather towards gradual improvement. These firms tend to be largely inward looking in terms of innovation practices. They rarely collaborate with other firms or universities.

Advanced manufacturing firms in competitive markets have been much more impacted by the economic downturn than those in niche markets. In a competitive market, price becomes more of a factor than superior engineering ability. This results in a somewhat different focus in research. While pushing technology forward is important, there is also a much greater focus on reducing overhead costs through process innovations.

A number of firms regard the Greater Golden Horseshoe (GGH) as being an ideal location for their business. This opinion is most common among start-up firms that have received local support from government or angel investors and firms that service larger companies in steel and automotive. Technical knowledge is seen as being very advanced in the GGH. Several universities with engineering programs and co-op placements offer a deep pool of talent which is augmented every year. The benefit of clustered activities in the GGH means that firms can pick and choose from different suppliers for the best price and that there is a broad pool of technical knowledge available in the area.

Many large companies devote research and development staff in house whose major responsibility is to undertake pure research in areas of the company's core competency. As part of this, larger organizations often searched for "game-changing" technology that would allow them to go jump ahead of others. This is mostly done internally, rather than in partnership with universities, to assure protection of any intellectual property created.

In smaller companies who are not start-ups based around a new technology, there is less room for pure research and development. In these companies, ideas for new products mostly come from customer's needs. However, on the process side, engineers who work on a wide variety of projects often apply insights discovered on one project to whatever they are currently working on and this internal knowledge transfer provides a competitive advantage.

Larger firms employ Information Management systems to retain, and direct internally-generated information effectively which is considered an important way of maintaining a competitive advantage. The first tactic used is to catalogue previous work in a searchable database that can be used to inform current work, the second tactic is to create a system that ensures that new ideas within the firm are properly capitalized upon. Both strategies are associated with large firms where the hierarchical organizational structure means that information is often lost, or is not elevated from the shopfloor to the R & D department. The new system of knowledge management is a means of insuring that small innovations are identified and leveraged.

## Industry Collaboration

In all three sectors, collaboration among peers, competitors, and research institutions exists. Such consultations can happen on a regular basis with another firm and may be the beginning of a partnership or they can also happen only rarely and may just be a consultation with collection of peers. Most respondents indicate that these collaborations form when they are unable to meet the needs of a particular customer, and in efforts to retain the customer, they look for outside help to solve the problem. Many interviewees talk about the importance of networking and building relationships when considering collaboration, especially when it involves sharing closely guarded information. Most often, IP is rarely shared between collaborators unless extensive agreements are signed. With universities firms undertook collaborations for a variety of reasons.

## University Collaboration

Collaborating with universities or research institutes was a polarizing topic among interviewees. The companies most amenable to partnering with universities for research were large, profitable firms with long-term research goals. These companies often had their own research and development teams for immediate and short-term solutions, but participated in university collaborations on long-term projects that would advance fundamental knowledge in the industry. This is especially true in the steel sector. This type of project gave these firms access to new technologies and expertise before their competitors.

Amongst smaller firms there are often partnerships with universities on specific problems. The most common reason for this type of partnership was taking advantage of the university's capital intensive machinery and equipment for product analysis, but these projects also occurred around problems that firms simply could not solve in-house.

When companies are searching for university partners they looked at several key factors: IP protocol, expertise on the relevant subject matter, and relationships with individual researchers. Universities that had progressive IP rules were favoured as first choices.

## Intellectual Capital (IP)

An important finding was that by and large, patenting was not seen as something essential by firms in any of the sectors. There were many barriers listed by these firms as to why they chose not to patent. The most obvious one was the cost. Firms that were in sectors such as steel where innovation was largely process-based were especially reluctant to patent their innovations. A particular concern was expressed with respect to the rise of Chinese manufacturing where it is felt that patents reveal too much explicit information that can subsequently be mined for cheaper manufacturing techniques without repercussions. This is an important issue potentially effecting the development and flow of IP in Ontario manufacturing.

Firms in Southern Ontario are clearly involved in global networks of knowledge transfer. While most firms did state a preference towards working with local universities and firms, but this was only if the expertise locally was equivalent to that abroad.

Across all three sectors the most important contribution universities provides to industry is producing a highly talented workforce. Most firms interviewed suggest that the regional talent pool is excellent and that this is due to the presence of good universities and colleges. They were especially supportive of co-op programs. Universities are less highly rated when it comes to their research capacity. There are perceived barriers in terms of knowing how to make connections with university researchers, with many respondents stating that they would like to work with universities but do not know how.

## Contrasting University and College Manufacturing Partnerships

Resources and time did not allow for a systematic survey of Ontario Colleges and their manufacturing partners. However, even the limited sample summarized here is atleast suggestive of the system of knowledge transfer between colleges and manufacturing firms, as compared to universities and their industrial partners.

The following Chart is presents a comparative summary of the characteristics and differences in the relationships of colleges and universities with their industrial partners:

**Comparison Chart of University and College Industrial Partnerships**

| **Factor** | **Universities** | **Colleges** |
|---|---|---|
| Intellectual Property Policy | Yes. UW exception | No |

| | | |
|---|---|---|
| Technology Transfer Offices | Yes | No |
| Typical Client Firm | MNC | SME |
| Project Scale | $1M+ | $75K |
| Time Lines | 3-5 years | 4-8 months |
| HR-student Requirement | Yes | Yes |
| Research Question | What? | How? |
| Nature of Innovation | Product | Process |

The intellectual property rights policies and role of technology transfer offices are two areas where colleges and universities most diverge. Most universities have elaborate technology transfer rights regimes where the institutions assert a primary claim over IP produced within their sites. These rights in turn may be monetized or licensed through technology transfer offices. The familiar exception is the University of Waterloo where the IP rights remain with the inventor.

No such policy regime exists within the Colleges. They neither seek it nor are they equipped to pursue it. There are no technology transfer offices within the colleges. Neither ar they equipped to do commercialization.

The typical firm involved with a university is a multi-national corporation or a mid-sized firm (MNC) with an active presence in international markets and with overseas facilities. The college firm is more typically a small to medium sized business (SME) with an emphasis on the smaller side of the scale.

Project scale is another clear differentiator. University projects are multi-year, multi-million dollar undertakings. The typical college venture is four months or one semester, costing $75,000.

Both kinds of institutions view inclusion of present or future student involvement or flows as important. For universities, the long range goal is either funding graduate student research or curriculum extension to supply a long range cohort of students with the relevant skills. The colleges have shorter term objective of placement of co-op students.

The fundamental question for a university-manufacturing projects is a “What?” i.e. how does a better understanding of material sciences issues better inform the configuration of downstream capital equipment to produce a successful product. The typical college issue is “How?” i.e. how to configure existing equipment or integration to satisfy improved energy, efficiency or product standards requirements.

Finally, while the boundaries are at times fluid, in the typical university case, the objective is IP-based product innovation. The typical college case is process improvement where the IP is already established.

## Findings from Field Research

1. Profile of Ontario Manufacturing Companies

Companies interviewed for this study were predominantly small and medium sized enterprises (SMEs) in the Hamilton and Kitchener-Waterloo areas. It is argued that "a healthy SME sector contributes prominently to the economy through creating more employment opportunities, generating higher production volumes, increasing exports and introducing innovation and entrepreneurship skills" (Dababneh & Tukan, 2007, 4). Companies in this study had as little as two, but as many as 2500 employees. Most SMEs interviewed in this study had an established client base and supplier list. However, interviews were also conducted with start up companies eager to break into existing or emerging markets with a new product and/or process. For contrast, an interview was also conducted with executives at two large, multinational corporation (MNC) with locations in Ontario. Moreover, while most firms were typically part of a larger supply chain, one MNC was involved in the production process from concept to market.

Nearly all companies were materials manufacturers involved in designing, machining, casting, and/or processing products using mostly metal alloys or other base materials. However, Ontario has a very diverse manufacturing sector, which includes food processing, life sciences, nanotechnology, and information technology (Government of Ontario, n.d.). In order to represent such diversity, interviews were also conducted with two start ups venturing into these so-called 'non-traditional' sectors of manufacturing. For example, CO2 has developed a unique testing kit for biotechnology that it seeks to mass produce in the near future, and CO3 is developing compostable packaging as part of its business strategy to improve the organic food industry. Due to the continuing evolution of manufacturing in Ontario – particularly as large MNC manufacturers in traditional sectors relocate – it was determined that interviewing a variety of manufacturers was necessary to reflect not only the present, but also the future for innovation in Ontario.

There has been recent interest in the role of Ontario's community colleges in research and innovation, particularly in partnership with SMEs. Nearly all companies interviewed in this study have worked with an Ontario college or university in some capacity. Haimowitz and Munro (2010) found that applied research collaborations between Ontario manufacturers and Ontario community colleges help businesses overcome barriers to research and innovation. SMEs have turned to colleges and universities for help with product development, process improvement, marketing, recruitment, and training, as well as for access to resources, including equipment and personnel. Academic institutions, colleges in particular, have turned to SMEs for student co-op placements and training opportunities, and increasingly, to pursue joint research projects that improve manufacturing in the province.

This study was primarily interested in the perspective and experience of Ontario manufacturers with academic institutions and their role in innovation. However, interviews were also conducted with research and development personnel at Ontario academic institutions located within the study area. Persons interviewed were responsible as faculty and/or administrative staff for developing and growing their institution's research and development partnerships with Ontario businesses. Interviews with academic institutions helped triangulate study results, as well as identify communication gaps between manufacturers and academic institutions on the role, accessibility, and success of institutions in research and innovation. Interviews were also conducted with a select number of 'knowledge networks', which were found to be important players in the innovation story.

A baseline case was selected for this study. CO1 is a non-ferrous foundry with two plants in a single community. The company specializes in non-ferrous sandcasting technology, has an on-site tool and die shop, and provides metallurgical, engineering and technical support to its customers. CO1's primary product constitutes 60 percent of the company's business. The company recently began making a new custom product currently not produced in Canada, when it saw a competitive opportunity in the market. CO1 is open to input and ideas from a variety of sources that might help innovation in product, process, marketing, and website technology. Even EX1's job title conveys CO1's commitment to innovation: "continuous improvement manager". Moreover, CO1 has active relationships with both universities and colleges, and is also plugged into B2B knowledge networks and government agencies. CO1 was contrasted against other SMEs to determine convergence and/or divergence with the key themes identified in this study.

Table 1 below provides an overview of the companies interviewed for this study. To protect the confidentiality of the companies, it identifies them only by code, industry, size and affiliations with academic institutions.

**Table 1: Company overview**

| Company Code | Industry | Size by # of employees, type | Academic relations |
|---|---|---|---|
| CO1 | non-ferrous foundry | 125, SME | UN1, UN2, UN5, CC1, CC2 |
| CO2 | biotechnology | 2, start-up | UN1, UN2, UN4, CC1 |
| CO3 | organic food processing and packaging | 2, start-up | UN4, CC2 |
| CO4 | steel product manufacturing | 750, MNC | UN7, CC2 |
| CO5 | heavy steel product manufacturing | 2500, MNC | UN1, UN3, CC1 |
| CO6 | materials handling / cranes | 35, SME | UN2, CC2 |
| CO7 | ferrous foundry | 75, SME | UN8, CC1 |
| CO8 | steel manufacturer | 83, SME | none |
| CO9 | steel manufacturer | 20, SME | CC2 |
| CO10 | concrete / building materials | 4, start-up | CC3 |
| CO11 | exercise equipment | 1, start-up | CC3 |

| | | | |
|---|---|---|---|
| CO12 | architectural | 1, start-up | CC2 |

*Sources: interviews; Industry Canada*

**Product versus Process Innovation: The Grey Area in Manufacturing Innovation**

Product and process innovation appear to be connected, particularly when academic institutions and manufacturing firms work together for innovation. A product must be designed such that it can be manufactured, meaning that any innovative new product must be inherently easy to manufacture, or must accompany a process innovation. In fact in some cases, product innovations are limited by process technology. In defining product versus process innovation, colleges, such as CC2 argue that the line between 'what' a product is, and 'how' it is produced is blurred. According to CC2, the conventional wisdom that universities answer **what**, and colleges answer **how**, does not always apply, since it is not easy to separate 'what 'from 'how.' Thus, colleges must be involved in both the what and how of product and process innovation.

CO1 is a non-ferrous foundry, and does not design any of the products it produces. While they consult with clients regarding the finally design of a casting, the primary avenue of innovation is in lean manufacturing and continuous improvement, in order to offer their cast metal products at a lower price. Currently, they are exploring the application of a lead-free brass alloy to their manufacturing process.

As part of an effort to improve their casting process, CO1 have redesigned some of their process equipment. While this can be considered a process innovation, they converted it into a product through obtaining patents, and selling them to collect royalties. They converted what was originally a process innovation into a product, due to its generally applicable nature.

CO1's current lead-free alloy project can be seen as an example of both product and process innovation. The goal of the project is to select a lead free alloy for their primary product, which accounts for 60% of their production.  While the ultimate purpose of the innovation is to enhance the product, the true innovation is in, and limited by the process.

CO1's selection of lead-free brass alloy depends on finding an alloy that can be cast using their current equipment, without significant modification.  Their current methodology is to work as a junior partner on a project with CC1, and with consultation from universities, to find an existing lead-free brass alloy for which they can cast within the parameters of their current process. Failing that, they will attempt to experiment with new combinations to produce a lead-free product within their process constraints and clients' specifications. CO1's experience with process equipment patents and their lead-free brass alloy project demonstrates how a process innovation can also be a product innovation, and how a product innovation can be limited by, or require process innovation.

As a large golden horseshoe based company, CO5 relies on local personnel to design, manufacture and market their products.  Due to their reliance on the US market for 70% of their sales and the relative strength of the Canadian dollar, they have focused their innovation around lean manufacturing (process innovation) and product superiority (product innovation).

An ongoing example of product innovation for CO5 is their efforts to alter the materials selection for one of their key products from being composed solely of steel to a combination of steel when necessary, and aluminum, where material properties permit, for weight reduction.  Through their relationship with UN1, CO5 gains access to knowledge from  academics in other industries, as it attempts to adapt steel and aluminum welding technology to existing products.

The company's product innovation, which combines aluminum and steel, will likely result in a competitive edge for CO5.  While CO5 likely considered substitution of steel with aluminum at an earlier time, the innovation would have been limited by the lack of ability to weld steel and aluminum in a manufacturing process.  Thus, while a steel / aluminum hybrid product may be considered a product innovation, the enabling innovation was the process of welding the two material together.  In this case, a process innovation led directly to a product innovation. In a manner similar to CO1, CO5's process innovations are intricately linked to their products through the ability to process alternative materials.  Both aim to produce new or different products through an alteration of their process.

CO4 is an MNC headquartered in US,  and has a manufacturing facility in the Golden Horseshoe area.  Their local facility focuses entirely on manufacturing, while product innovation and other business services reside within their US headquarters.  Furthermore, their Canadian facility occupies a position in the company's supply chain, only manufacturing a portion of their final product.

CO4 turned to a student team at CC2 to design and implement a flexible manufacturing cell into their manufacturing process.  This cell was intended to improve efficiency in one of their unit operations and is a definitive example of using a college for process innovation.  The project was inspired by a process innovation conducted by another group of students from CC2 for another manufacturing firm, and applied robotic materials handling to a packaging operation previously performed manually by employees.  This innovation was entirely process-based as it improved manufacturing without impacting the final product.

Moreover, CO4 used UN7 for assistance adjusting the ratios of their surface treatment chemicals during their manufacturing process.  This adjustment would yield improved surface characteristics in their manufactured product.  This innovation was achieved in conjunction with UN7, as CO4 required UN7's scanning electron microscope to provide the surface analysis.  While the change impacted the final product, it resulted in a slightly different manufacturing process, making it difficult to classify as either a process or product innovation.

As was the case with CO1, CO4 turns to colleges for process improvements, and universities to address specific challenges, related to their final product.  While CO4's US headquarters provides new products for their local facility to manufacture, the academic institutions play a role in process and product improvements.

For a start-up firm like CO2, product innovation often comes from the founder's experiences working in the field of their innovation (life sciences).  While CO2 is able to manually produce a prototype of their product, the key to bringing it to market is in developing a method of mass manufacturing. The manufacturing of CO2's product is a significant challenge because the parts are "clear" and with small tolerances.  The company is currently working with four post secondary institutions on this challenge, including CC1, UN1, and UN2.  Through these relationships, CO2 is guiding and receiving help from student teams in adopting automated robotic technology to mass produce their product. While they have turned to UN2 for programming of the automated process, the key to their manufacturing and process innovation is being driven by students in a joint process automation technology program between UN1 and CC1. As the university did not have the appropriate robotics technology, CO2 purchased the equipment. Their president claims that the robotics lab will be a "show-case of current technology." In the future, as the company's needs change, they anticipate working with students in the biotechnology program of UN1 and CC1.

Though academic institutions are providing CO2 with key knowledge and support in process innovation, EX2 feels that such relationships succeed "through continuous oversight", and points out that he "steers the students at [UN1]". In EX2's words: "Universities don't have solutions to your problem, but they know how to find the solutions."

For CO2, it appears that process innovation is the second stage of innovation. They approach academic institutions with the "what" in hand, and then ask "how" they can make it a reality. To find the answer, CO2 seek sadvice from both, colleges and universities. CO2's experience appears to be typical of other start-up companies. CO10, CO11, and CO12, for example have turned to colleges to help bring products to market and plan on using universities for marketing purposes as well. So while product and process innovation are essential for a start-up firms' physical manufacturing capabilities, assistance in marketing products and services can help overcome the barriers in converting an innovation to a strong business model.

In summary, through field research, it was found that while some innovations can easily fit into the category of process innovation, most product innovations result in a need to advance the manufacturing process as well. While start-ups appear to rely on academic institutions to help implement their product ideas, companies like CO1, CO4, and CO5 use institutions for advancing their process and products incrementally.

**Life stages of a firm: MNCs, SMEs and Start Ups**

The life stage of a firm also seems to influence the relevance of an Ontario university or college, or more accurately what an academic institution can provide, move a firm' business forward. Colleges and universities, as we have seen, often offer very different 'services' to businesses, and there seems to be a trend in which type of academic institution suits businesses in different stages. The life stage of the SME, for the purposes of this paper, refers to either one of two categories: start up or mature.

Often, a start up SME has minimal, if any staff; more than likely, a start up has one or two principals involved in developing a new product or service. If a start up is producing, it is likely on a limited basis and not yet involved in mass production. Moreover, its clients may be 'interested parties' for the new product, butt not necessarily placing orders. If this is the case, capital for research and development may be borne by the SME. However, silent investors and government grants may also be funding the project. More than likely, the start up SME is resource constrained, in terms of people, money, and equipment.

Mature SMEs, on the other hand, have adequate resources – people, equipment, and capital – and an established customer base. Adequate, however, does not necessarily equate to abundant: the availability of resources does not mean that mature SMEs have forever filled all of their resource needs nor that established SMEs are not interested in being innovative. Rather innovation is primarily market or customer-driven, rather than driven by the need to find an initial entry point into a competitive marketplace. In other words, the mature SME may be tweaking and altering itself as demand requires. Mature SMEs may also apply for government grants or funding, in order to remain innovative in their market. The mature SME are, at least, relatively self-sustaining and stable.

Moreover, there is some distinction between the needs of a small-, or medium-sized company, and the needs of a large MNC, which may lead a business to seek the assistance of one type of academic institution over another. If, for example, product innovation is more of a 'speciality' of universities and an SME needs help creating a new product, the SME may turn to a university. On the other hand, an MNC with an internal R&D department may refer to a community college for assistance with smaller projects that are less likely to become ensnared in legal limitations and patent applications.

Our baseline case, CO1, could be characterized as a mature SME. Established in the mid 1960s, CO1 has grown its customer base by producing a limited number of specialized alloy composite products. However, CO1 recently added a new custom product, which is not new to the market, but CO1 has identified a need in the market for a Canadian-based manufacturer and has the tools and knowledge to produce it. CO1 is also investigating product improvement for its current 'top seller'. The product improvement, or more accurately, alteration, is in response to a change in marketplace demand. CO1 is working with CC1 to change the material to a non-leaded alloy, while maintaining product design. But CO1 also has a relationship with CC2 and four universities: UN1, UN2, UN5, and UN6. All of these relationships are with engineering departments, but with varying capacities.

Two companies interviewed stood out as particularly good examples of start up companies engaged with academic institutions. It is a start up firm in the life sciences industry and has designed a unique molecular testing kit, and is looking to find a way to mass produce the kit for wider usage in testing labs. They have strong relationships with several universities - UN1, UN2, and UN3 - as well as CC1; more significantly, CO2 has an office within the life sciences building at UN1.

CO2 believes that universities can provide solution services similar to those of high-priced consultants, without the same level of expense. EX2 originally approached industry for support, but found "it was going to be expensive because it wasn't apparent to them how to manufacture." Industry ultimately declined work from CO2 as the risk of going over-budget in a project with many unknowns was too great. CO2 turned to a university when it was having a problem with polymerization in its product. For start ups, this kind of deep search for effective partnerships is what can help fledgling firms fly. Laursen and Salter (2006) argue that "external search depth is associated with radical innovation. In early stages of the product life cycle when the state of technology is in flux, innovative firms need to draw deeply from a small number of key sources of innovation, such as lead users, component suppliers, or universities" (p. 146). Without someone with a polymer chemistry background on staff, it made sense for CO2 to widen its search for effective partners in the academic community. It is important to point out, however that such elemental science is not available from a community college, and so therefore, in this case, the community college could not solve CO2's problem.

However, CO2 is engaged with CC1 via a joint educational program between UN1 and CC1. Moreover, CO2 points out that it had to 'chase down' individual faculty at UN1 in order to establish a research relationship. EX2 also suggests that university faculty are not as interested in reaching out to start-up SMEs, and may use partnerships only as an opportunity to be released from their teaching responsibilities; EX2 has walked away from possible relationships for this reason. EX2 also said that he is comfortable engaging with universities, in part because he is a university graduate himself.

Contact with CC1, on the other hand, was initiated at the institutional level; the first point of contact with a community college, according to CC1, is via the applied research office. CC1 is providing robotic support to CO2 in the implementation of an automated assembly for mass production of the testing kit. Interestingly, though the contact information for CO2 was provided by CC1 as an example of CC1's research CO2's office is housed in UN1. In this case, CO2 was engaged in product innovation – the improving of the actual test kit elements – with UN1, and process innovation – automation of the production process – with CC1.

CO3 is also a start up, in the early stages of testing, preparing ,and packaging 'pure, natural, high quality super foods that are allergen and intolerance free'. Food processing is the third largest manufacturing sector in Ontario, after transportation and electronics (Government of Ontario, n.d.). CO3 is also producing 100% compostable packaging to improve the preservation of the various organic 'super foods' it will prepare. CO3 is working with five researchers at UN4 to study the impact of local, organic food – both fresh and frozen – on human health and the economy. EX3 says that UN4 is an 'active participant, but is not moving (CO3's) innovation forward'. CO3 is also working with CC2 to develop the aforementioned compostable packaging. EX3 has found that CC2 has been a 'steward of innovation' actively trying to help CO3 meet its business plan goals, and that colleges in general 'fill the research gap' between what firms need and what universities provide. Unlike CO2, CO3 is engaged in designing and testing the packaging with a community college. So while the packaging may be considered CO3's secondary product, it is, nonetheless, a product being produced by CO3 and supported by research and development at CC2.

CO5, a large, multinational corporation based in Ontario, has a slightly different relationship with universities and colleges than start ups and mature SMEs. CO5 spends approximately $4 million per year on research and development and has introduced 31 new products in the last decade. Unlike many start up or even mature SMEs, for whom company executives suggest the cost is too high, CO5 puts significant emphasis on patenting its IP.  In order to protect against reverse engineering of products, the company currently has 260 new patent applications waiting for approval. Despite the patent protection, CO5 manufactures 100% of its products and keeps as much information as possible internal to the company.

CO5 identifies innovation as an absolute variable in order to remain competitive in the marketplace; however it typically relies on its internal R&D department for innovation. This is not to say that CO5 disregards academic institutions as sources in research and development. CO5 has turned to UN1 and UN2 for science-based research projects, for example, to take advantage of advanced materials selection to improve existing products or assist in the development of new products. CO5 has also worked with CC1, but considered it a 'training-based relationship', most commonly in drafting, welding and quality control. However, CO5 appears to be less 'resource dependent' than our baseline SME CO1, and certainly less than start-ups CO2 and CO3, which turn to academic institutions not only for human capital, but also equipment and potentially, co-funding opportunities. CO5 has the financial capital and equipment – and a great deal of human capital as well– to conduct R&D almost entirely internally.

**Location, location, location: Proximity to academic institutions and knowledge networks**

Most companies reported that proximity to academic institutions was essential in developing a relationship, while knowledge networks appear to have a geographical component as well. Only one firm reported that proximity to academic institutions was irrelevant, in their case, due to Internet technology. CO1 considers the location of universities and government facilities in proximity to them as ideal:

> They're close by; obviously there's some practicality about that. Most of our resources are within an hour a way. CanMet was in Ottawa, and we did use them prior, but it's a lot easier to use them now than we did before because six hours as opposed to one hour is quite a difference. So the decision making on hooking up would be made easier with the distance lowered, for sure. In this industry, the set up is excellent right now, with CanMet coming to Hamilton, right beside Mac, between Mac and Mohawk with Ryerson and all the other engineering (departments)…this is an excellent place to be located as a manufacturer for sure. There's great benefit in being located right here, right now the way the college, university and government agencies are setting themselves up. And they are going

> to lean on each other and create a network here that's going to be difficult to find anywhere else in North America, I have a feeling. If you go to the United States, the universities interested in our industry are very widespread, so I don't think there's anywhere near the collaboration that can happen here because we're all within an hour. I dare say in North America, we're in very good situation here. As a manufacturing company, it's ideal.

One of the advantages that CO1 sees to their particular location is not so much proximity to a single academic institution, but rather proximity to an entire network of researchers and experts in the manufacturing industry.

The vice-president of product engineering at Hamilton-based manufacturer CO5 completed an engineering degree at UN3 in eastern Ontario and attempted to use his connections at the institution to establish a collaboration with PhD level students at his alma mater. Due to the distance, he claims they could not "advance a connection" and the project did not begin. CO5 now works with local institutions and has found these relationships much more sustainable.

While the proximity to institutions was a key factor to success and development of a relationship for most manufacturing firms, it was not the only factor. Companies, such as CO2 are emphatic that personnel from the institution be committed to their firm's success:

> We've walked away from deals that go nowhere that help someone get a release from their instructional duties.

Contrary to the overall trend of manufacturing companies aligning with geographically close academic institutions, CO7 asserts proximity does not matter. Their technical specialist frequently turns to his Internet-based network of five or six people from all over the world, including one professor emeritus at UN8 in England. Through technology CO7 is able to bridge the gap of distance. CO7 attempts to integrate software modelling and simulation into their foundry operation. As such, any process for which they might require collaboration can be virtualized in a computer model. They therefore have the capability of collaborating over the Internet, using information normally only available to staff on the plant floor. This helps negate the need for in-person collaboration, and may become a more common occurrence as collaboration technology becomes more widespread.

### Two Models for Education and Training of New Employees

The two main colleges involved in this study, CC1 and CC2, have different approaches to educating engineering technologists to work in the manufacturing industry. CC1 offers a more traditional program with a co-operative education element, in which students learn theory and then apply it to projects and co-op terms. CC2 offers "project-based learning" in which students are assigned to projects and gain theoretical background knowledge and experience through working on the project in the classroom. The model offered by CC1 follows a traditional sequential course-based method, in which students learn the theory behind their chosen field, and then learn to apply it through projects and work terms. The work terms, in the case of CC1 are slightly unconventional, as they aim to place students with companies on joint projects, between the college and a manufacturing firm.

Over the course of the field research for this study, we interviewed two companies participating in joint projects with CC1. In each case the student was paid through the college, and was assigned to develop a standard for the foundry industry (in the case of CO7) or help select a lead-free brass alloy (in the case of CO1). The projects were funded in part through the FedDev program, with contributions and resources being made available through the manufacturing firms and the colleges. Through this program, CC1 students get valuable work site experience, as an integral part of their education.

The model employed by CC2, meanwhile, tends to bring the work site into the classroom through projects from various firms. As CC2 has adopted project-based learning, students are exposed to projects from a variety of enterprises in an attempt to simulate the method by which a professional engineer typically works - in teams and on projects. While this format appears to place a high degree of pressure on CC2 to develop relationships with industry, EX2 argues that

“What we were asking the researcher to do was less about our needs than theirs” indicating that some companies may feel that the research collaborations are geared more towards educating the students than assisting the firm.

Companies that have collaborated with CC2 include CO4, CO6, and CO12. The projects ranged from designing and implementing a manufacturing cell, to marketing materials handling equipment, to designing an interior architectural clock. Of note is that while CO7 participates in CC1’s co-operative education program, they would only accept a student who had not been educated in foundry science. This appears, implicitly, to be advocating for the project-based approach of CC2, in which a student learns and applies theory to project work.

## Communication, Information Sharing and Knowledge Networks: Opportunities and Challenges for Getting ‘Linked In’

One challenge to establishing research and development collaborations between Ontario manufacturers and academic institutions is a lack of awareness regarding what an academic institution can offer an SME, and what an SME needs for a fruitful relationship.

In general, collaborative R&D can perform two key function of innovation for a firm: 1) generate new knowledge; and 2) enhance the firm’s ability to assimilate and exploit existing knowledge from the external environment, both in terms of the firm’s ability to imitate new processes or product innovations, and in terms of the firm’s ability to exploit knowledge of a more intermediate sort that provides the basis for subsequent applied research and development. (Laursen & Salter, 2006).

Unfortunately, many SMEs are simply unaware that community colleges can provide applied research that might help their firm remain competitive. CO8, for example, had little knowledge that colleges and universities offer any R&D assistance to SMEs, or that government grants were available:

> Obviously I wouldn’t use them if I didn’t know about them…That’s just a lack of information on my part, but maybe on their part in terms of selling themselves as an organization that does that.

Munro and Stuckey (2011) point out that "given the low levels of business awareness of colleges' applied research services, as reported in *Innovation Catalysts and Accelerators,* an investment to promote and market applied research services may be required" (Conference Board of Canada, May 2011, p. 6). Ontario manufacturers and colleges could benefit through increased awareness, on the part of manufacturers, of the applied research offerings of local colleges.

Among the companies interviewed in this study, those with the least connection to a college or university – for example, those who only turn to institutions for potential employees – also had the least knowledge of what a college or university can provide.

SME awareness of what a college can provide may be lower than awareness of what a university offers. CO6 assumed that universities are more interested in advancing theory, while colleges are more interested in the practicalities of development:

> I believe universities are more interested in coming up with an equation rather than colleges. They call it, having a big 'R', small 'd' and the college is vice versa.

However, when CO6 approached UN2 with a potential marketing-oriented research project, UN2's research and development director referred EX6 to the nearby community college (CC2). The university's R&D director felt the project was more 'development oriented' and better suited to the capabilities of CC2. Because of the referral and the success of the project that followed, EX6 intends to approach CC2 for co-op students in marketing and web design. In other words, the university provided the SME with information about a college's R & D program, which it might otherwise have not been aware. This raises another point: the value of networking to building relationships.

One way to build relationships is through formal and informal business networks. Miller, Besser, and Malshe (2007) conducted a study of 377 small business owners who had memberships in various business networks and organizations in their regional communities in the United States. They found that small businesses attributed at least some of their success to their formal network organizations. Moreover, the business owners' perception that success is linked to networking supported their continued participation of those networks, and the ongoing growth of those organizations that served their communities (Miller, Besser & Malshe, 2007).

Ontario SMEs have a wide range of organizations in which to 'plug in'. CO1 has an extensive network of groups and consortia in which it participates.

> It's a very useful network…the benefit of that is you can be talking about a software developing firm and we're manufacturing big old castings and you think 'what the heck would they have in common', but it's interesting that each would look at problems in slightly different way that opens up your mind to other possibilities that you hadn't previously thought about. So it is actually useful.

CO1 applied for – and subsequently received – a grant from the Ontario government, which provides manufacturers with funding to help them be 'competitive and innovative' (Yves Landry Foundation, n.d.). In order to qualify for the funds, however, CO1 was required to use a 'preferred vendor' in its area of interest – lean manufacturing training. KN1 a national manufacturer's networking group, facilitated the introduction of a preferred vendor to CO1.

Moreover, KN1 has connected manufacturers to a reputable consulting company that assists in preparing applications for the Scientific Research and Experimental Development (SR&ED) tax incentive. For CO1, SR&ED is a big part of their ability to innovate as federal grants and tax incentives are a key ingredient in their innovation strategy. As EX1 stated,

> We take our SR&ED very seriously and document it very carefully….It's sink or swim. If you're not heavily involved in innovation, you sink.

CO1 also looks to KN2, a distinctly local networking group for advice and ideas. KN2 acts as an online hub for industry, researchers, institutions and government to meet and make 'deals', or simply to solve day to day problems. of business. According to KN2, "academic institutions can post co-op and research opportunities on (KN2's website), whereby facilitating access to R & D funding from senior levels of government.” Unlike KN1, KN2 does not have requirements for membership; any individual or firm can join.

One reason CO1 is so ‘plugged in’ to academic institutions is through the informal networks of EX1, whose job title is, as previously mentioned, ‘continuous improvement manager’. Laursen and Salter (2006) found that firms use *external search breadth* and *external search depth* as strategies for tapping into knowledge beyond the firm (p. 146). The result is that “firms who are more open to external sources or search channels are more likely to have a higher level of innovative performance” (p. 146).

EX1 is a graduate and former instructor in a nearby university, and as such has many relationships within other academic institutions.

> I have friends in those institutions that I’ve known in this industry for a long time. The people in the universities and colleges and government institutions in this industry anyway have been fairly tight over the last ten to twenty years, I would say.

EX1 will typically approach this personal contacts from institutions such as UN1, UN2, UN5, CC1, and CC2 on an as-needed basis, when CO1 execs “require an answer to a question.” At times they are referred to others within the institutions or the industry - “it all comes down to who’s doing research in specific areas and who has knowledge about certain things.” Typically these personal consultations are informal and unpaid, though EX1 is billed for work with some personnel from UN2 who own their own businesses. While billing is conducted through the business, the project allows CO1 access to university resources, to which external consultants would not have access.

CO1’s connection to CC1 was initiated by CC OFF1, who has been cited by other SMEs as the key actor in building relationships with the college. Says EX1:

> He’s well connected with other universities and colleges, with industry groups, he’s always at meetings, he’s very vocal, so as an individual he’s done a lot to

> integrate the foundry business with colleges and universities.So the impetus comes more from the colleges and universities than us going to them per se. Now we don't have any problem going, because we have a relationship, but the relationship was first started probably from their side.

Indeed, networking by CC OFF1 was an important reason why some SMEs became connected, and in some cases remain connected to CC1 in the first place. Just like in business-to-business (B2B) networking, personal connections are integral to building bridges between SMEs and academic institutions.

Other companies in the study also participated in formal and informal networks to varying degrees. EX7 shares knowledge and ideas with colleagues in India and the United States via online networking. Start up SME CO3 is engaged with KN5, a regionally-based research innovation centre funded by federal, provincial, and municipal governments, as well as UN2. KN5 works specifically with start up companies to 'promote commercialization of research and technology rising from academic institutions' in the region (Waterloo Accelerator Centre, n.d.). KN5 offers such services as training, mentorship, and even office space, as well as networking opportunities.

CO4's relationship with CC2 began with networking and hiring co-op students, but then evolved into CO4 sitting on CC2's curriculum advisory committee. A project with CC2 was initiated after CC2 invited them to a student project showcase. After seeing a project for an automated manufacturing cell and discussing it with faculty, management at CO4 decided to commence a year-long project with a student team to design and implement a similar cell to mitigate a process bottleneck at their facility. CO4 also has an institutional relationship with UN7, which commenced when CO4 contacted the university regarding access to a scanning electron microscope. This relationship developed into a student research project.

### Hiring, alumni, and 'The Way It Used To Be'

A dominant trend in interviews with manufacturing firms of all sizes was that the hiring of new graduates is a source of new ideas and access to academic institutions. Some firms see college graduates as filling a particular role in the production department of their firm, while viewing university graduates as oriented towards product design and engineering. College programs, meanwhile, are attempting to adapt to the needs of industry and essentially turn out versatile graduates able to fill both, the production, and the product design roles.

CO1, our baseline case, has never hired a new graduate out of a university, though some of their managers have university degrees. When asked about hiring of new graduates, EX1 said

> ... a college can give me a floor supervisor, and I need that more than I need an engineer. I will need more of them than I need engineers, in my business anyway. And I would think that the kinds of (college) co-op programs – turn out more of a usable type of potential employee than a university would, for my business. So I’ve hired zero university grads, but I have hired college grads in the last three years.

In other words, CO1 finds that college graduates are better equipped for their purposes than university graduates.

EX1 hired a CC1 student three years ago, which he argues was ‘instrumental’ in linking CO1 and CC1 for the kinds of collaborations already discussed in these research findings. Furthermore, EX1 feels that one of the key benefits of R&D collaboration and co-op programs with colleges is access to students that he might want to hire in the future.

CO6, which builds materials handling equipment, works with CC2 and UN2. So far, EX6 has hired an engineering co-op student from UN2. EX6, himself a university graduate, believes that university engineering programs turn out workers better suited to the needs of his firm; however his experience working with CC2 has encouraged him to turn to CC2 for co-op students or new hires for other areas of his business, such as web management or marketing. Indeed, a shift in Ontario from traditional to higher technology manufacturing will rely more – not less – on community colleges for workers. Boothby and Drewes (2006) argue that “in an economy of rapidly emerging technologies, colleges have a qualitative importance in delivering necessary skills to the labour market as a primary suppliers of technologists” (p. 1).

EX1's preference for college graduates is also held by other SMEs interviewed in this study. CO9, a small, recently restructured company has little use for academic institutions. However, EX9 had plans to hire welding students from CC1. EX9 prefers to hire from colleges over experienced workers. According to EX9, new welders have lower expectations – in terms of wages and benefits – of employers, and fewer demands than workers who come from a unionized environment. CO7, a casting company, has hired college graduates as well, and had a co-op student from CC1 at the time of interview. EX7 is a graduate of CC1; however, EX7 feels that community colleges, despite having the necessary quality equipment and tools to teach the basics of casting, are doing a poor job preparing students for innovative careers in the casting industry.

> The problem isn't the technology: It's the culture behind how the technology is approached."

EX7 admits he would hire a college graduate, but only on high recommendation from his contact at CC1. As previously argued, CC OFF1 is indeed a significant reason why there are partnerships between CC1 and certain Ontario SMEs involved in manufacturing.

CO2 plans to hire students currently working on its development projects. Like CO9, CO2 values new graduates for their pliability and minimal demands on employers. What differentiates CO2 from that of other manufacturers interviewed in this study is that it plans to hire students not from a university or from a college, but from both: the joint university-college technology program with which it currently works. This raises a common theme already identified by several interviewees in this study: employers in the manufacturing sector may be in need of a more versatile graduates in order to be truly innovative in their industry.

Not only may there be a need for a more versatile graduate by SMEs, but potentially across the manufacturing sector. Moreover, CC OFF1 believes that one Ontario-based MNC is shifting its hiring policy for one department from engineers – graduates of universities – to engineering technologists, which are typically graduates of community college programs. CO5, one of the

MNCs interviewed in this study, however, appears committed to hiring university graduates: 15 people on EX5's team of 33 are engineers, and five have PhDs.

**Discussion**

The argument has been made in previous studies that between college and university, there is a well defined line in the sand: colleges are a source of process innovation, and universities accelerate product innovation. While this study does not wholly repute the argument, it was found that the line dividing product from process innovation is not always clear. Companies confirm that colleges are engaged in applied knowledge transfers that often improve processing functions (ie. costs and efficiency), and yet helped to expand the definition of what process innovation means through enabling new products to be made. They also have found that universities are a source of knowledge for the science behind the process as well as assisting in commercialization and mass production. As products are limited by manufacturability, product innovation at a university or a college requires a component of process innovation for new and better products to be produced. In other words, process innovation can often stand alone to improve process efficiency , or can contribute to final product innovation, and while colleges appear to play a larger role in improving process efficiency, both colleges and universities are equal contributors to process innovation leading to product innovation.

Moreover, the life stage of a company – and not necessarily a company's size – may determine what form innovation needs to take to make the company successful. A start-up SME may be more likely to engage with an academic institution that can offer product innovation, and an established SME may be more likely to be seeking innovation in processing. If universities are more likely to provide product innovation, then start-ups may look to universities in the early stages of development.

The ability of the applied research offices of colleges to act as a single contact point for firms interested in collaboration may encourage start-ups without connections to universities to make initial contact with a college. As CO2 found, the applied research office "corrals" the professors and attempts to facilitate moving projects forward, while the universities allow firms to pursue relations with individual professors. The more institutional approach of colleges may be required due to their reliance on firms to provide projects and co-op opportunities as an important component of their students' education. The incentive for the university professors to engage with firms appears to be the opportunity to provide students with what EX2 at CO2 refers to as "fun" opportunities, and an "easy" source of funding for their labs.

But company size may have an impact on whether or not a university shows interest in pursuing an R&D relationship. Some respondents argued that universities are not interested in the business of smaller companies. Though the reason for this is unclear, it might not be that universities are disinterested in SMEs, but rather, in need of the business of MNCs – which come with higher profiles and more funding. However, the study confirmed that universities do work with SMEs. CO2, a small start up company in life sciences manufacturing, has strong relationships with both a university and a college through a shared academic program as well as a relationship with another university. While different types of institutions serve different functions for CO2, all are serving the same SME in its effort to become an innovator in its area of business. Further research on the subject of 'soliciting innovation' by universities and/or colleges might identify specific characteristics that make certain companies, regardless of size or life-stage, an attractive candidate for R&D collaboration.

Colleges, on the other hand, seem to have found their niche research market in SMEs. With fewer resources and lean manufacturing, SMEs have increasingly turned to community colleges for access to human and financial capital, as well as access to high-tech equipment. What both college and firm have discovered is an opportunity to solve day-to-day problems, but more importantly, to be emerging leaders in their industry. While colleges were traditionally interested in pursuing relationships with large companies for graduate hiring purposes, the project-based learning model of CC2, the desire of CC1 to place students on joint projects, and the employment market for college graduates (CC1 has found that they can no longer rely on one company to hire a large proportion of their graduating class) has potentially increased the need of colleges to diversify their relations. The modern college requires a large variety of relationships with smaller companies, as opposed to a handful of relationships with larger companies.

Despite increasing awareness of what colleges offer in terms of innovation, they remain grossly underfunded:

> Ontario's colleges are poised to play an important role in organization-level innovation—one that can help to improve the province's innovation performance and achieve productivity gains and economic growth. Yet, while the college applied research lever has produced excellent results to date, it is operating on a very small scale with limited resources. To make the most of Ontario colleges' applied research potential, strategies to increase support and funding should be adopted.
>
> Conference Board of Canada

Lack of understanding or awareness of the role academic institutions can play in innovation is a barrier to collaboration with manufacturers. Those companies interviewed with the least collaboration with academic institutions were also the least likely to be aware of what exactly a university or college could do for them. While colleges and universities both tend to have an applied research office, colleges appear to be more aggressive in their desire to collaborate with SMEs. Moreover, colleges and universities need to better understand the specific services each can offer. As with CO6, which was referred to the local college after approaching the nearby university, colleges and universities must do a better job of marketing not only themselves, but also their academic institutions in their community for innovation in Ontario to take root.

Business and social networks often fill the void in communication, acting as conductors of information on resources, including academic institutions. Informal networking, however, is equally, if not as important as formalized networking groups, for sharing information on, and making contacts at colleges and universities. Many respondents shared that it was because of a personal connection – either with someone at a university or college, or through someone who knew someone – that they felt they could comfortably approach an academic institution; otherwise, they were unsure what to ask or even where to start.

Awareness of applied research capabilities can also stem from government institutions. FedDev's Technology Development Program aims to provide financial support to encourage research collaborations between the private sector, post-secondary institutions and not-for-profit organizations towards the development of new technologies (FedDev Ontario, n.d.). As a funding source, it appears to be a key factor in encouraging collaborations between SMEs and colleges: CC2 alone has started 16 different projects through the grant program.

SMEs, on the other hand, are quite clear about what they need from academic institutions: a more versatile , and creative employee. In response, CC2 has moved toward a project-based learning model. For example, engineering students would participate in hands-on projects, and learn theory as it needs to be applied. CC1, on the other hand, seems to be taking a different approach, placing students in the plant – rather than bringing the plant to the classroom. Interestingly, despite having a co-op student from CC1, one respondent implicitly advocated for the CC2 model.

## Conclusions

There are two broad conclusions arising from the research.

1. Ontario manufacturers are deeply integrated into global supply chains. If the latest academic scholarship is correct, then the future viability of manufacturers turns on their learning capabilities. This involves the technical capabilities of the firms, the knowledge networks they participate in and access to technical and human resources in the colleges.

2. Colleges differ in the priorities they assign to manufacturing and their structures and processes for engagement and partnership. The most evident relationships are around training of apprentices and applied research. The latter is a work in progress but is distinct from the IP-focused efforts of universities.

## References


Birnbaum, E., Cohen, D., Harris, M. and Warrian, P. (2010) *Ontario Manufacturing, Supply Chains and Knowledge Networks: A Report for the Toronto Region Research Alliance*, University of Toronto 2010

Boothby, D. & Drewes, T. (2006). Post-secondary education in Canada: Returns to university, college and trades education. *Canadian Public Policy.* 32:1, 1-21.

Dababneh, R. & Tukan, F. (2007). *Booklet of standardized small and medium enterprises definition, 2007.* USAID. Retrieved August 2, 2011 http://pdf.usaid.gov/pdf_docs/PNADM845.pdf

FedDev Ontario (n.d.). *Technology Development Program.* Retrieved August 15, 2011 from http://www.feddevontario.gc.ca/eic/site/723.nsf/eng/h_00332.html

Government of Ontario. (n.d.) *Industrial sectors.* [webpage]. Retrieved August 1, 2011 from http://www.ontario.ca/en/communities/economy/ONT03_020923.html

Haimowitz, J. & Munro, D. (2010, November). *Innovation catalysts and accelerators: The impact of Ontario colleges' applied research.* The Conference Board of Canada.

Herrigel, G. (2010) *Manufacturing Possibilities*

Industry Canada (n.d.). *Canadian Company Profiles.* Retrieved August 14, 2011 from http://www.ic.gc.ca/eic/site/ccc-rec.nsf/eng/Home

Yves Landry Foundation. (n.d.) Yves Landry Home Page. Retrieved July 16, 2011 from http://www.yveslandryfoundation.com/

Miller, N., Besser, T. & Malshe, A. (2007). Strategic networking among small businesses in small US communities. International Small Business Journal. 25:6, 631-665.

Munro, D. & Stuckey, J. (2011, May). *Applied innovation: Next steps for colleges.* The Conference Board of Canada.

Waterloo Accelerator Centre. (n.d.) About Us. [webpage]. Retrieved August 1, 2011 from http://www.acceleratorcentre.com/about

Wolfe, D. et al, (2011) *Innovation in Financial Services and ICT Sectors in the GTA*, University of Toronto.