UNIVERSITY–INDUSTRY INTERRELATIONS IN MONTREAL IN THE RECONVERSION TO THE KNOWLEDGE ECONOMY

by

Juan-Luis Klein
Department of Geography and CRISES
Université du Québec à Montréal, Montréal,

Claude Manzagol
Department of Geography
Université de Montréal

Diane-Gabrielle Tremblay
Department of Economics and Management
Télé-université, Université du Québec

Serge Rousseau
PhD in Urban Studies
Université du Québec à Montréal

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Canada Research Chair on the
Socio-Organizational Challenges of the Knowledge Economy

Télé-université/Université du Québec à Montréal/

To contact us :

Télé-université

4750 Henri Julien, Montréal, Québec, Canada

fax : 1-514-843-2160

phone : 1-514-843-2015

email : dgtrembl@teluq.uquebec.ca

Biographical note

Diane-Gabrielle Tremblay is the Canada Research Chair the Socio-Organizational Challenges of the Knowledge Economy. She is professor of economics and management at the Télé-université of the Université du Québec. She is a member of the Committee on Sociology of Work of the International Sociological Association, the Executive Council of the Society for the Advancement of Socio-Economics, as well as co-chair of the "social times and working times" committee of the Association internationale des sociologues de langue française. She is also president of the Association d'économie politique and editor of the electronic journal *Interventions économiques.* Also Co-chair of the Bell Canada Research Chair on Technology and work organization, professeur associé with Ecole nationale d'administration publique and UQAM, she has published many articles and books on employment and types of employment, job training, innovation in the workplace and work organization, as well as the articulation between work and family life. See websites for details:

www.teluq.uquebec.ca/chaireecosavoir

www.teluq.uquebec.ca/chairebell

www.teluq.uquebec.ca/interventionseconomiques

www.teluq.uquebec.ca/chaireecosavoir/cvdgt/

e-mail : dgtrembl@teluq.uquebec.ca

Juan-Luis Klein is professor of geography at University of Québec in Montréal (UQAM) and member of the research center CRISES-UQAM.

Claude Manzagol is professor of geography at Université de Montréal.

Serge Rousseau is Ph.D. Candidate in Urban Studies at UQAM.

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Introduction

The Montreal region is now recognized for the importance and dynamism of its so-called high technology sectors. In the forefront, aeronautics, the biopharmaceutical industry, telecommunications and multimedia -- all sectors where new products are developed as a result of technological innovations and research -- are the driving force behind this dynamism.[1] In all these sectors, access to high-level technical skills is a considerable competitive advantage.

In the industrial age characterized by Fordism, firms internalized their research activities. With the crisis of Fordism, they have tended to externalize them, just as they have done with functions that are not at the very core of their technical know-how, thus giving rise to industry-university partnerships. Moreover, relations between these two actors are greatly encouraged by the public actor which contributes to them indirectly, by facilitating their networking, and directly, through funding. The university, industry and public actor thus constitute the components of what some authors have called national systems of innovation (Lundvall, 1992).

However, the concept of a national system of innovation cannot on its own explain the interregional differentiations within nations. In the context of globalization (Manzagol, 2003) and intensified competition which the world's regions and metropolii have embraced (Klein and Fontan, 2003), the national systems include the more local interrelations between industry and university (Grossetti and Losego, 2003). Thus Braczyk, Cooke and Heindenreich (1998, republished in 2003) put forward the concept of regional systems of innovation, a concept that underlies an approach drawn from evolutionary economics and regional science. This approach aims to identify the territorial factors at the local level that play a part in science-industry interrelations, the latter being seen as essential intangible assets for the success of both high-tech firms and the regions in which they are located.[2] Institutions where research takes place, in particular universities, as well as institutions of higher learning, are thus seen as important localization factors for firms in the new economy, that is, the economy of knowledge and skills.

How is this university-industry relationship structured in the Montreal region? This paper will provide a description, albeit brief and incomplete, of university–industry relations. It will show that, in the Montreal and Quebec contexts, relations between these two actors have undergone major changes since the 1980s, evolving towards a partnership-based research system. Traditionally weak, these relations have become much stronger today as a result of a tripartite process in which socio-economic actors, universities and the public actor all play a part. As will be seen, the numerous partnerships stemming from this process are centred on the firm, even the large firm, which have effects on both research and training. Is this the most effective way to build the economy, indeed the knowledge economy?

The progress of university–industry interrelations will be presented in four stages: first, we will analyze these changes in relation to reconversion strategies of the Montreal economy; second, we will examine the factors explaining the rapprochement between the

[1] On the recent evolution of the high-tech sectors in Montréal, see Polèse and Coffey (1999), Shearmur and Terral (2002), Niosi (2002), Klein, Tremblay and Fontan (2003). Documents of Montréal Technovision can also be consulted, particularly those entitled Performance indicators 2001 and 2002 (www.montreal-intl.com).

[2] For a series of theoretical and empirical studies on the concept of regional innovation applied in Canada, see Holbrook and Wolfe (2002).

university and the firm; third, we will assess the results of this rapprochement in terms of the implementation of new partnerships; and fourth and finally, we will consider these changes in the context of the Canadian and Quebec global system of innovation.

1. Socio-Economic Mobilization: the Challenge of Reconversion

First, it must be said that in Montreal, as in Quebec and the rest of Canada, universities and private firms have historically had few links. However, a considerable change has taken place since the 1980s, leading to a denser and tighter science–industry relation. This collaboration between actors who previously ignored each other must certainly be considered as an essential factor in the reconversion of the Montreal production structure to the new economy (Klein, Tremblay and Fontan, 2003).

This change must be examined in the context of the crisis experienced by the Montreal economic structure –a crisis brought to light first in the early 1980s and then in the early 1990s–, as well as in the context of the reconversion strategies implemented (Tellier, 1996; Manzagol and Bryant, 2001). It should be pointed out that the 1980s were particularly difficult for cities which, like Montreal, were part of the Fordist industrial trajectory. Because the infrastructure of these cities relied heavily on labour-intensive industries, they were hard hit by the competition from emerging countries which offered this type of firm more attractive conditions in terms of profitability. As a result, the cities were confronted with the challenge of reconversion (Benko and Lipietz, 2000; Fontan, Klein and Lévesque, 2003). The prospect of developing high-tech activities was thus proposed, implying close collaboration between the socio-economic actors, including firms and universities. Firms and universities thus embarked on a rapprochement process punctuated with diverse and diversified strategies and experiments.

1.1 The Strategic Choices of the 1980s

Faced with the crisis which shook the production infrastructure of the Montreal region, its socio-economic actors –governments, firms, community organizations– were increasingly mobilized. Thus, there was a proliferation of actions, studies and reports seeking to develop means that were likely to revive the prosperity of the Montreal region. The various courses of action and recommendations resulting from this mobilization were structured around two themes: (1) local development and (2) economic reconversion to knowledge intensive sectors (Fontan, Klein and Lévesque, 2004). Armed with clear perspectives, that is, the mobilization of the communities' social capital, the first theme accounted for the establishment of numerous community-based development organizations, the most well-known being the *Corporations de développement économique communautaire* (community economic development corporations). More ambitious, but also more risky, the second theme experienced both success and failure. This second theme --the reconversion to the knowledge economy—is our subject of interest because it covers the intensification of links between university and industry.

The mobilization of Montreal actors to carry out the reconversion to high-tech activities began in the early 1980s and gave rise to several actions. The most important among these were the Greater Montreal Socio-Economic Conference held in 1981, the Interministerial Committee on the Development of the Montreal Region, whose report was disseminated in 1986, and the Socio-Economic Summit held in 1986. The first concrete proposal –the creation of high technology and innovation parks-- was formulated at the Socio-Economic Conference of Greater Montreal. The aim of this strategy was said to be "to foster the

interface between the business community which has the know-how and the education and research community which is responsible for disseminating knowledge." (Y. Lamarre, cited in Manzagol 1991) (translation). Suffice it to say that the links were weak, the dissemination was limited, and thus physical proximity was seen as an essential asset in strengthening them.

In 1986, the Interministerial Committee on the Development of the Montreal Region emphasized the urgent need to turn Montreal into a growth pole and an international metropolis by relying on its principal forces: the industrial mass, the university base and research capital. It recommended the establishment of university-firm relations and consultation structures, as well as the consolidation of seven development areas (first and foremost, high technology: aeronautics, spatial technology, telecommunications, micro-electronics, information technology and biotechnology). The Committee also recommended that a high-technology park be created, an idea that was supported at the 1986 Montreal Summit. Local governments saw it as an opportunity for development: the City of Montreal expressed its interest, the South Shore promoted its assets, and the City of Laval wanted to set up a growth pole for R&D activities.

1.2 Creation of the CITEC

The main realization of the recommendations of the Interministerial Committee was the creation of the *Centre d'initiative technologique de Montréal* (CITEC, technological initiative centre) in 1987. A Montreal-based non-profit corporation, this Centre's main mission is to foster R&D and the creation of scientific and technological jobs in Greater Montreal.[3] Its aim is also to foster and develop relations between firms, universities and governments. CITEC brings together the main institutions of higher learning in the region. Its members include, among others, the universities in Montreal and their affiliated schools as well as prestigious companies such as Bell Canada, Marconi, Spar Aerospace, Ericsson, Pratt and Whitney, and CAE Electronic. With the support of start-up grants from the federal, provincial and local governments as well as the private sector, and under the leadership of Raymond Cyr, President of Bell Canada and principal promoter of the project, CITEC implemented a sectoral strategy and a territorial strategy. While the sectoral strategy was sound and resulted in considerable collective learning on the courses of action to take, the territorial strategy was defined more on the basis of political interests, which resulted in failure. The lessons learned from the latter had more to do with the courses of action to be avoided. The sectoral strategy identified a small number of market niches that match with the strengths of industry and research in Montreal, development prospects for the next 10 to 20 years as well as a network approach that favours the creation of a dense web of relationships and partnerships. The strategy involved the establishment of four working groups: aeronautics, biotechnology, microelectronics and information technology. The mandate of the groups was to produce a strategic plan for each of these sectors. This strategy also sought to encourage cross-fertilization of firms and universities, by facilitating the application of university research to the needs identified by the firms engaged in technology-oriented R&D.

The territorial strategy, on the other hand, involved the creation of a science park with two campuses: one located within the City of Montreal, in the area around the Ville-Marie

[3] By greater region, we mean the City of Montreal and the different suburbs under its influence. In statistical terms, this corresponds to the Montreal Metropolitan Region.

expressway and the other in Saint Laurent[4] Municipality, an inner suburb. Given the local dynamic of production, there was little justification for this dual foothold. Rather it was motivated by pressures from the City of Montreal which refused to subsidize an organization that created jobs outside its administrative boundaries. The City of Montreal insisted on the creation of a site in its own territory. Inspired by European and North American experiences, it wanted to create, based on physical proximity, an environment conducive to generating innovative milieux. It also wanted to project a dynamic image to the outside world. As a result of the involvement of major business leaders, the project was viewed with optimism. Moreover, the initiative benefited from the creation of an important technological development fund by the Government of Quebec. At the same time, venture capital funds (Biocapital, Capitecq, and later Innovatech) were set up with the support of the government.

However, the territorial strategy implemented by CITEC did not yield the expected results and turned out to be a failure. Several reasons accounted for this failure, the most important being undoubtedly the serious crisis of 1991-94 which followed on from the 1980s crisis and destroyed nearly 15 per cent of the remaining industrial employment in Montreal. In this troubled climate, firms did not make any investments and the business leaders who had helped in the establishment of CITEC were not followed by their own firms. Moreover, exacerbated by this very same crisis, but also being part of a firmly rooted tradition, the competition between the municipalities that made up the Montreal region paralyzed the development of both campuses. Because of unfavourable economic conditions, lower-cost spaces became available in the Montreal territory. Thus, when firms whose managers had participated in establishing CITEC had to set up or relocate their business, they chose off-campus sites. Private-sector enterprise was not the only one to ignore its commitments to CITEC. The federal government, which had invested considerable amounts, opted for a site on the South Shore of Montreal when setting up the Canadian Space Agency in 1990.

Weighed down by its failure, CITEC, in its initial form, disappeared in 1994. Although the CITEC adventure was certainly disappointing, it nevertheless gave rise to a useful organizational learning process which helped to create substantial social capital. This learning process developed through the habits of meeting, collaborating and forming long-term links. This immaterial capital would be beneficial to subsequent initiatives, including the strategy of industrial clusters initiated by the Government of Quebec as well as actions of promotion groups such as Montreal TechnoVision, the Montreal Financial Network and Montréal International.

1.3 Saint-Laurent Technoparc

Furthermore, although the Montreal campus was a definite failure, largely due to improvisation and the weak integration of the selected site into Montreal's industrial infrastructure, the fate of the Saint-Laurent campus was different. After CITEC as such disappeared, the site's management was transferred to Saint-Laurent Municipality, which renamed it Saint-Laurent Technoparc. Driven by favourable economic conditions and managed from a real estate development perspective without concern for potential synergies between firms, the Technoparc has since grown rapidly. As of 2004, it houses 17

[4] Until 2001, Ville-Saint-Laurent was an autonomous municipality. As a result of the merger of all the municipalities of the Island of Montreal into one large city, the new City of Montreal, Ville-Saint-Laurent has become a borough of the new city. But this process is not definitive because a demerger is always possible and Ville-Saint-Laurent could become an autonomous city, a situation to be followed.

firms -- including major firms such as Nortel Networks, Astra-Zenecca and Thales—which represent approximately 3600 jobs, most of which are related to high technology.

Besides the overall economic recovery during the second half of the 1990s, the success of Saint-Laurent Technoparc can be attributed to the characteristics of the environment in which it was integrated. Saint-Laurent Municipality is considered to be one of the main high-technology hubs in North America. The Montreal region's major aeronautics, biopharmaceutical and telecommunications firms are located there. However, the success of Technoparc does not come from entrepreneurial dynamism alone. The role of the municipal government in the construction of this technological space must also be considered. It has proven to be imaginative on numerous occasions in implementing innovative tools for the development of its industrial space. The most effective tool in stimulating its recent technological growth was without a doubt the Saint-Laurent Economic Development Department, which replaced the Saint-Laurent Economic Development Corporation in 1990, which in 1983 had succeeded the municipality's Industrial Development Department.

The mission of the Economic Development Department (EDD) is to stimulate the municipality's industrial growth, to promote its economic potential and to act as an intermediary between the private sector and the different levels of government. In addition to the traditional duties related to industrial promotion, inspired by the principles of local development and development of the production system, this Department undertook to facilitate, indeed to stimulate, the building of production networks and partnerships at the local and metropolitan levels.

2. The Universities' New Attitude: Towards Collaboration with Firms

Spurred on by the same changes which led socio-economic actors to encourage the rapprochement between industry and universities, that is, changes related to the transition to the new economy, universities and institutions of higher learning, strongly supported by government organizations, in particular by the federal government, also sought to collaborate with the production sectors.

2.1 An Impetus from the Government

In the early 1980s, the Universities-Enterprises Forum, a pan-Canadian bipartite body, gave rise to two reports: "*Ensemble vers l'avenir*" (Maxwell, 1984) and "*Investir plus sagement*" (1985). According to these reports, although industrial dynamism relies on a strong scientific base, Canada was only investing 1.5% of its GDP in R&D, and there was not enough cross-fertilization for discoveries to be transferred massively from the university laboratory to the market. Collaboration between universities and firms was thus perceived as a necessity and a source of mutual benefits (a boost to targeted and better funded research; for universities, placement of graduates; for firms, staff training, access to skills and lucrative scientific sectors). Research parks –the experience of the Research Triangle in North Carolina and that in Ottawa-Kanata, Ontario was explicitly referred to– were identified as the best instrument for cross fertilization, a promise of increased productivity and enhanced competitiveness. Thus, it was necessary to create the favourable conditions leading to the abolishment of the traditional barriers between these two very different environments: the conflict of orientation (fundamental/applied), professional secret (publication/patent) and control of projects.

The reorientation of the federal councils (Natural Sciences and Engineering Research Council of Canada, Medical Research Council of Canada today replaced by the 13 Canadian Institutes of Health Research and Social Sciences and Humanities Research Council of Canada) was symptomatic of this phenomenon. As principal instruments of university research funding, they encouraged greater collaboration and more partnerships with the explicit aim of contributing to the emergence of an economy as well as a society of knowledge. Networking was systematically favoured, and the federal government and its provincial counterparts sought to stimulate job creation through R&D spin-offs.

Thus, at the federal level, the annual budget of the Natural Sciences and Engineering Research Council of Canada (NSERC) increased from $100 million to $800 million (current dollars) in 25 years. Besides independent research grants for professors and scholarships for students, both its principal targets originally, the oriented programs became increasingly important, that is, industrial research awards programs, co-operative R&D programs (whose costs were partly assumed by NSERC), networking programs, strategic project programs, industrial research chairs (funded by firms which in return received a tax deduction). In parallel with encouraging partnerships, the federal government also gave an impetus by funding of 1000 Canada Research Chairs at universities, coupled with a substantial grant from the Canadian Innovation Foundation. NSERC also provided an incentive to facilitate the commercialization of research results.

The provincial government took the same approach as the federal government. In addition to gradually re-orienting its main research funding organizations towards concerted action and partnership, it launched the Valorisation-Recherche Québec (VRQ) program, encouraging universities to create organizations to carry out technological transfer and commercialize research results. The aim was to encourage universities to group together in order to form a critical mass that is large enough to fund the commercialization of the research conducted within their institutions. Following this program, Quebec universities created companies specialized in valorizing research and scientific discovery. This university endeavour to valorize, that is, to commercialize research results was in line with a change in institutional culture as reflected in the different partnership experiences with private firms. A few examples derived from the involvement of the Université de Montréal and the Université de Québec in the science-industry interrelation are used to illustrate this change.

2.2 The Rapprochement Between the Université de Montréal and the World of Industry

The university-firm rapprochement has been considerable over the last 20 years, with numerous effects on the overall activity of universities in terms of teaching and study programs for example. The Université de Montréal, with its affiliated schools and hospitals, is a good example of this partnership. To foster this rapprochement, the Université de Montréal created Univalor. A first cell, Préval, “prevalorizes,” supports the research until it is patented; then Univalor, with 20 specialized employees, takes over. In the last two years, Univalor received 152 declarations of invention, applied for 120 and obtained 24 patents. In its June 2003 portfolio, Univalor had 62 patents and 80 patent pending technologies and managed the capital stock of 18 spin-off companies that it supported after having launched them. In addition, it kept the shares of three spin-off companies which had left the fold and also carried out 35 transfers (licences and assignments).

Moreover, the Université de Montréal has been strongly influenced by the new institutional and socio-economic context stemming from the university-industry rapprochement. For example, the École Polytechnique offers a master’s degree in aeronautics where young engineers can pursue their training through seminars led by

engineers working for firms such as Bombardier, Pratt and Whitney, etc. Similarly, at the request of the biopharmaceutical industry, the Polytechnique has created a pharmacist-engineer specialization. Since there are more research contracts in universities, collaboration with firms in the area of training is also more important, that is, firms take in advanced students who do their master's or doctorate degree in an industrial setting. They also fund industrial research chairs and laboratories on university premises, for example, Pratt and Whitney's advanced machining laboratory at the École Polytechnique and the Bell Laboratory in the Information Technology Department.

The campus of the Université de Montréal and its affiliated schools has expanded with new buildings which house new laboratories as well as organizations and institutions conducive to the development of research and its applications. For example, the NRC decided to set up an aeronautics research centre on campus where some 100 highly-qualified researchers will explore and propose solutions and innovations to industrial producers. Moreover, in the new Bombardier Pavilion, the Université de Montréal and the École Polytechnique decided to launch the " Technopole" project: a small science park where researchers from various disciplines work on joint projects and explore industrial issues in order to produce synergies that generate innovations to be commercialized. The targeted research fields are: aeronautics, new materials, biotechnologies (with which researchers from the Université de Montréal Hospital Centre will be closely associated), and nanotechnologies. Eventually, 700 researchers, professors and students will work in this science park. The biopharmaceutical industry is by far the leading research partner at the Université de Montréal. One third of the research funding of the Biochemistry Department comes from contracts from industry, which replaces the Chemistry Department's traditional "clients" such as Alcan and Noranda. It is also the biopharmaceutical sector that generates the majority of spin-off companies.

2.3 Université du Québec and the Industrial Community: the Case of the Institut Armand Frappier

The Université du Québec has also formed links with firms, driven by the same factors that influenced the Université de Montréal. However, because of its distinctive characteristics, the most important of which is that it is a pan-Quebec network, its links were formed in a specific way. In 2001, several of its branches, including the Université du Québec à Montréal, together with Concordia University, created Valorisation innovation plus (VIP), a limited partnership, in order to commercialize research results, identify technologies that can be commercialized, protect intellectual property and manage royalties and licences stemming from the sale of technology. In March 2002, the company's name was changed to Gestion Valéo. During 2002-2003, Gestion Valéo examined 50 files and retained 37 files for assessment, in particular in the fields of telecommunications, micro-electronics, biotechnologies and nanotechnologies, and created two spin-off companies.

To illustrate the rapprochement and the institutional specificity of the Université du Québec, we will examine the case of the Institut Armand Frappier (IAF) of the Université du Québec and its participation in the establishment of a science park. Specialized in biopharmaceutical research and located in Laval, a Montreal suburb, the IAF participates in the establishment of the Laval Science and High Technology Park by fostering technology transfers, encouraging contacts between its researchers and those of the science park's firms and developing the commercial potential of its research results.

The Institute was set up in Laval in 1937 with the mission to contribute to searching for solutions to public health problems through the discovery of new vaccines. This mission was

the basis of today's IAF. The IAF became a centre of the Université du Québec network when the latter was created in 1969. In 1987, the IAF and the City of Laval Development Corporation, which became Laval Technopole in 1995, created the Laval Science and High Technology Park. The creation of the science park marked the IAF and the City's intention to develop long-term relations between the university community and the business community within a localized context, with the common goal of being part of the knowledge economy. Moreover, for the IAF, these relations with firms represented new funding opportunities. One the one hand, this rapprochement favoured research sponsorships. On the other hand, since the IAF owned a large part of the lands on which firms came to set up business, this was an opportunity for it to develop its landholdings. Large-scale developments and tax advantages, granted by both the City and the government, filled the conditions for the development of the Science Park. In addition to the establishment of major firms, the Science Park also had a business incubator: the Québec Biotechnology Innovation Centre (QBIC). The IAF's goal is to create a synergy with the high-tech firms that are likely to set up business in Laval by embarking on a process of technology transfer and cross fertilization with the latter.

Until 1989, the Institute included two units, one specialized in research and the other in production. The latter was separated from the Institute to become an independent company, first IAF Biochem and then Biochem Pharma. Until 2003, this company was a flagship of the Quebec biopharmaceutical industry. The IAF as such was absorbed in 1999 by the Institut national de la recherche scientifique (INRS, national scientific research institute), another branch of the Université du Québec, and maintained academic research and training of students in health, microbiology and biotechnology. Biochem Pharma, which was first privatized and then acquired by a multinational company, Shire Pharmaceuticals, was finally closed by the parent company in July 2003 as part of the consolidation of operations, thus depriving the Montreal pharmaceutical industry of an important driving force.

As shown by Gingras's study (2001), IAF researchers create partnership links with companies' research teams which lead to exchanges of knowledge and expertise, which in turn result in the transfer of technology and the creation of new companies. According to this study, at the IAF, the technology transfer involves both researchers and administrators. Within the administration office of the INRS, of which IAF is part, there is a person in charge of scouting for and identifying ideas that are developing within the IAF research studies and assessing their commercial potential. Once the ideas have been identified, the INRS assesses their valorization and commercialization potential. After the assessment, and in the case of a potential commercialization, there are two possible courses of action: the researcher either creates a spin-off company himself or assigns a licence to operate to an already existing company.

2.4 The New University Mission

The examples mentioned above are all different yet convergent, thus attesting to the change in mentality which is taking place in Montreal, Quebec and Canadian universities. Traditionally, industry used to ask the university to provide it with highly qualified scientific staff, a highly skilled work force, and the university did just that. Today, a more intense relationship with immediate benefits is expected. Thus, the university has received a new mission, that is, to respond to the needs of firms, in particular those that operate in high technology and are oriented towards the knowledge economy. It is therefore becoming a localization factor in the era of the knowledge economy.

Largely stimulated by government research funding organizations, universities are seeking to position themselves in the growth sectors of the economy and to become actors in maintaining the competitive position of firms in these sectors. The recent acceleration of networking among firms owes a great deal to government support (Canada Research Chairs, Canadian Innovation Foundation) and the orientation of programs linking funding to partnership with industry. Universities have clearly mobilized around these goals, with research leaders turning into real entrepreneurs in order to multiply arrangements and partnerships. The aim of these partnerships is to, on the one hand, give firms access to leading-edge research in the field of high technology and a highly specialized work force and, on the other hand, to ensure increased funding for universities. These are the new terms of the university-industry partnership sought by the socio-economic communities, the public institutions and the universities themselves.

3. Productive Changes: the Knowledge Economy in Montreal

From 1981 to 2001, the proportion of Montreal's work force employed in the manufacturing industry, the construction industry and related activities decreased from 34.5% to 25.6%. At the same time, the proportion of the work force employed in business services doubled from 5.2% to 10.6%. In general, just as in the province of Quebec and Canada as a whole, the sectoral structure of employment in the Montreal region has changed profoundly.

On the whole, the knowledge-based jobs, as measured by the OECD classification of occupations, account for 23.7% of the total number of jobs in Canada. The concentration of these knowledge-based activities in the large metropolii cannot be denied: 12.5% of knowledge-based jobs are concentrated in Montreal, and 19% in Toronto. Using a stricter classification than that of the OECD, based on knowledge production and expertise services (Lavoie and Roy 1998), the concentration of knowledge-based jobs in the metropolii is all the more evident. Of the 2.056 million jobs compiled, 274,000 jobs or 13.3% are concentrated in Montreal (as compared with 23% in Toronto).

As is revealed in each census, the knowledge economy is not to be conflated with manufacturing employment. The number of jobs in the five major high-tech sectors (pharmacy, biotechnology, office systems, telecommunications equipment, aerospace and scientific material) increased by only one third in Canada between 1981 and 2001, while at the same time, total employment increased by 36.7% and knowledge-based employment increased by more than 80%. With 53% of the Canadian total, Toronto and Montreal had most of high-tech manufacturing jobs in 2001, though slightly less so than in 1981 when they had 60% of these jobs. Most noteworthy is the fact that by 2001, Montreal, with 28% and Toronto, with 25%, had reversed their relative positions.

These figures on employment in the sectors associated with knowledge and skills attest to the reconversion trend in the Montreal economy and the metropolitan economy in Canada. Knowledge-based jobs are concentrated in Toronto and Montreal. Moreover, it should be noted that Montreal's high-tech specialization is mainly seen in the production area, whereas the knowledge-based service jobs are much more highly concentrated in Toronto, particularly in computer services, management consultancy, etc. This distribution of employment and high-tech activities is in keeping with a trend towards spatial specialization in Canada's economic restructuring, as clearly shown by Polèse and Coffey (1999). However, Montreal's supremacy in the high-tech industry is really only evident in the aerospace sector (48% of Canadian jobs versus 18% in Toronto), and is less pronounced in

the biopharmaceutical sector (34% versus 31%) and in telecommunications equipment (24% versus 20%).

Montreal's economy has reconverted to the high-tech sectors. But does this reconversion come with frequent and productive links between firms and universities? Nothing is more uncertain. A recent survey of innovative firms in the biopharmaceutical, aeronautics and telecommunications sectors shows that much remains to be done.[5] The great majority, that is, 73 or 91%, of the 80 firms studied state that they innovate. These innovations relate to the product (new products or product improvement), the production processes, and the organization of work and the workplace. It goes without saying that many firms innovate in more than one area: 76% in their product, 43% in their process and 54% in their organization. However, it is only in the case of product innovations that interrelations with the university are important and this only applies to a very small number of firms. Thus, 21% of firms affirm that their principal partner in innovation is the university. In the case of process innovations, the relationship with the university is the exception and in the case of organizational innovations, it is quasi-inexistent.

Partnerships with universities for the purposes of innovation are most common in the biopharmaceutical sector. Of the 33 biopharmaceutical firms studied, 29 innovate and 28% of them do so with university partners. These figures show that despite the efforts and the discourses on university-firm partnership, the distances that traditionally separate these two actors remain great. Subsequent studies confirmed that in the telecommunications sector, but even more so in the information technology and multimedia sectors, research and innovation are conducted in a very different way than what is observed in the biotechnology sector (Tremblay, 2003; Tremblay, 2004).

4. Montreal in the Canadian and Quebec Innovation Systems

The information economy is a knowledge economy and even a skills-based economy. As was seen, the factors which govern the production, accumulation and diffusion of knowledge account for economic growth. The strategies pursued by the socio-economic actors, governments and universities seek to integrate Montreal into this new economy. This has led to a profound change in its production infrastructure and in relations between the partners in the production and use of research.

It is no longer the oil companies and the resource processing firms which call the tune but the new technology firms, primarily those operating in the telecommunications, aeronautics, engineering and bio-pharmaceutical sectors. In Canada, the university sector has become a crucial actor in R&D. Although governments are still the main source of funds for universities, from now on private funding will make up a significant share of their research funds. Montreal's situation is comparable to that of Canada as a whole. From now on, francophone universities will play a leading role since provincial policies have helped them catch up and put them in a position where they can seek a substantial share of federal funding.

The development of research in Montreal and the industry-university relationship cannot be assessed without referring to the role of government laboratories which are the driving forces as well as the producers of research and partners/competitors of universities. The

[5] This survey was conducted by a research team formed by Jean-Marc Fontan, Juan-Luis Klein and Diane-Gabrielle Tremblay and took place from 1990 to 1991. For information on the results of this survey, see Klein, Tremblay and Fontan (2003) and Tremblay, Klein, Fontan and Rousseau (2003).

role of Quebec organizations –public and parapublic such as the CRIQ and the IREQ– is remarkable. The role of the laboratories of the National Research Council of Canada is crucial owing to the extensive means at their disposal and, because of this, their concentration in Ontario has long been deplored. The Biotechnology Research Institute (NRC-BRI), established in 1987 and which now has 250 researchers, is its flagship laboratory. It is the main component in Montreal's biotechnology system. Multidisciplinary research (biology, microbiology, engineering, etc.) relates to three sectors: health, environment and bioprocess. In terms of publications and international visibility, the group of researchers is the most effective of the NRC. Its importance for firms is therefore understandable. For example, in the health sector, the goal of the subgroup of molecular genetics and protein engineering is to discover and validate promising pharmacological targets, in particular for the treatment of cancer and infectious diseases.

Universities are present in joint groups, such as the structural biology group where BRI researchers collaborate with their counterparts at McGill University and the Université de Montréal as well as at Merck Frosst and Astra Pharma. The BRI plays a major role by providing laboratories and leading-edge equipment and ensuring the incubation of many biotechnology firms. In 2003, 16 partners were developed in this way (for example Angiogène, a venture capital biotechnology firm). In the near future, another NRC laboratory -- the Industrial Materials Institute -- will become a crucial partner.

Following the orientation given by the governments and provided with funds to foster university-industry links, universities have embarked on a vast production networking movement. One example among others is CRIAQ (Consortium for Research and Innovation in Aerospace in Quebec) founded in 2003. Centred at the École Polytechnique, it is a non-profit organization which brings together six universities and six firms (including Bombardier, Pratt and Whitney, CAE, etc.) thanks to the financial support of Valorisation Recherche Québec (VRQ). More prospective but constituting a major stake in the future of the entire industrial scientific complex of Montreal, NanoQuébec–Innovation has since 2001 brought together six Quebec universities with an initial contribution of $10 million from VRQ. Its goal is to rapidly develop an operational network from an initial core of 70 researchers that will make Quebec a world centre of nanosciences and nanotechnology.

However, partnership building is not only limited to the field of hard sciences. Indeed, the Center for Interuniversity Research and Analysis on Organizations (CIRANO) is an initiative of seven Montreal universities associated with the top major firms (Bell, Bombardier, Banque de Montréal and HydroQuébec). It receives government support to develop applied research on partnership issues and to transfer new knowledge, in particular in the field of risk management, leading-edge quantitative techniques and processing of large databanks, as well as in the electronic business sector.

CEFRIO (the Centre francophone d'informatisation des organisations*) is a liaison and transfer organization which brings together a few hundred of Quebec's major firms and all the universities in Quebec. CEFRIO gives mandates to university professors to conduct, in partnership with the firms, research on subjects such as knowledge management, computerization of firms, and work organization in the information technology context. The research results are then widely disseminated and transferred. A more integrated local system is being consolidated through these increasingly numerous and intense partnerships.*

Moreover, the "Community-University Research Alliance" (CURA) program, launched by the SSHRC in the late 1990s should be mentioned. The program aims at partnership and the transfer of knowledge between universities and communities. For example, the creation

of a research consortium on social economy (CURA Social Economy) led jointly by the Université du Québec à Montréal and the Chantier d'économie sociale, an organization which brings together all social economy firms and organizations in Quebec. Besides these two partners, other main partners include the Université du Québec en Outaouais (UQO), the Université du Québec à Chicoutimi (UQAC) and Concordia University, as well as the Confédération des syndicates nationaux (CSN, Confederation of National Trade Unions), the Fédération des travailleurs et travailleuses du Québec (Quebec labour federation), and a great number of social organizations supporting the social economy.

Conclusion

Montreal universities have undergone profound changes over the last decades. These changes are largely due to a redefinition of the role of universities -- a redefinition which has brought them closer to private-sector firms. They are part of the "competitive advantages" brought to the fore by communities in order to foster economic development and growth. The intensification of university-firm relations is also part of a context where public-private partnership plays an increasingly important role in economic governance. Thus, this change in the university's attitude, no doubt encouraged by the socio-economic actors, can only be understood by putting it in the broader context of the Quebec and Canadian innovation system. In an innovation system where all the components are increasingly interrelated, the development of synergies is stimulated by the orientations formulated and supported by public policies. While the creation of knowledge is encouraged, the importance of technological transfers and commercialization is emphasized.

More intense relationships between universities and firms have certainly had effects on research. Academic research, which is more applied than in the past, produces a highly transferable, indeed marketable, good: knowledge. In the context of the new economy, knowledge-based development defines the orientations of development strategies. But, not only new technologies are involved. Know-how and skills are also involved, which explains the changes in educational programs induced by university-firm relationships since they are largely adapted to the needs of firms.

The redefinition of universities was certainly necessary since academic activities had to be linked more to the needs of development. However, it would be simplistic to target only the sectors involved in high technology, indeed in technological innovations. The redefined government programs tend to focus mainly on these sectors. Moreover, these programs are largely defined on the basis of the needs of firms, even large firms, although some government actions have a broader perspective. Yet, the new economy, especially when it is defined as a knowledge economy, is more than just a few sectors, no matter how successful they are. The new economy is composed of new ways of doing things in all fields and sectors, even in all spheres of society, not only in production sectors. Indeed, our goal should be to establish a knowledge society and therefore, a broader examination of the role of universities in building a "knowledge society" is essential.

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