"WHO EVEN KNEW WE HAD ONE?"[1] THE GTA'S MICROELECTRONICS INDUSTRY AND THE ROLE OF NON-MARKET GOVERNANCE

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Abstract

This paper examines the non-market governance processes that have strategically supported and shaped the microelectronics industry in the Greater Toronto Area (GTA). With focus on governance actors from each level of the state from the early stages of the industry's development, the analysis shows how the federal level, once central to early strategic investments, has become increasingly less of a participant. Such a finding is in keeping with the claim by Swyngedouw (2003) and others, that advanced economies are experience a rescaling as a result of knowledge intensification whereby the networks involved in coordinating the economy are less dominated by the national level and increasingly animated by actors and institutions at the local and regional levels. Within the GTA, however, strategic economic coordination at the local level has been far from coherent, leaving a void in multilevel governance pattern that supports this important industry. There is some indication that this may be changing. In recognition of the importance of local level in localizing strategic investments, creating institutional supports for firm creation and growth, and in shaping the socio-economic environment, several new actors have emerged recently with locally focused strategic intentions. Given the many institutional barriers within the GTA, both cultural and political, it is far from clear, however, whether such developments will ever transpire into an integrated 'economic community' capable of responding continually to the restlessness of knowledge intensive industries.

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* The surprise of finding a microelectronics industry in Canada, let alone the GTA, prompted such a query by David Ticoll in an article, 'Is Canada's chip sector outlook a grim fairy tale?', Globe and Mail, November 25, 2004.

INTRODUCTION

As knowledge industries have come to depend ever more on a state's non-economic institutional capacity (Jessop, 2000:69), the caliber and location of these institutions have become increasingly relevant. The presence of federal R&D institutions, universities, high tech incubators and other support organizations, and increasingly, the quality of the local socio-economic environment, are an integral element to successful knowledge intensive economic regions, and are all factors widely recognized in the burgeoning industry cluster literature. Yet none of this develops on its own through the coordination mechanisms of a 'free market'. Indeed, it requires that choices be made, most often by non-market actors, over the allocation of resources on several fronts. One is the type of investment, whether it be, for example, a new research laboratory, new research program administered through existing universities, or a quality of life investment that will help retain and attract a highly skilled workforce. Second, a decision must be made with regard to the recipient – will this be a nanotechnology investment, or workforce training initiative targeted at a particular industry? Third, is the location of this investment. Will these investments strengthen existing economic centres, or will they be used to develop economically weaker and under resourced regions?

Moreover these decisions typically have a spatial dynamic within the state. With the most resources at their disposal, national governments are invariably essential actors, able to respond to challenges of global industrial shifts by funding major strategic R&D investments for emerging industries. In both Canada and the United States, for example, federal governments have been, to various extents, leaders in developing the microelectronics industry, initially through defence departments who, after World War II, were quick to recognize the merits of microelectronics to defence technology. Yet it can be actors at the local level, by virtue of its scale, which influence the location of these investments. As the following case study reveals, local actors are important in channeling resources made available through national and regional government programs into their respective regions thus helping thicken the institutional capacity for a particularly industry. A successful proposal for a federally funded national centre of excellence from a local university department, for example, can be a significant factor in building a regional concentration of an affiliated industry.

All of this makes the study of governance patterns an important dimension to understanding not only why industries concentrate in particular regions but also in what

ways non-market actors, at their respective levels influence strategic investments that benefit knowledge-intensive industries. Such is the focus of this paper. By examining the actors and institutions supporting the strategic investments that have shaped the microelectronics industry in the GTA, the paper attempts to gain some insight into the importance of the local dimension of economic governance within a multilevel context as it effects a knowledge intensive industry. The analysis is assisted by the use of two conceptual categories developed in the paper that, it is argued, can better accommodate the multiscalar dimensions of economic governance. Instead of the more common actor-centered typology, popularized by Schmitter and Streek (1985), which analyzes governance by actor type (e.g. state, market, association), this paper uses functional categories that group actors according to manner of governance.

First, however, the discussion begins with a brief review of spatial changes in economic governance that have accompanied the transition to knowledge-based industry. As some observers have argued, these changes have empowered the local level to the extent that local actors have become influential in influencing regional economic trajectories in a globalized economy.

The spatial reconfiguration of economic governance and the development of economic communities in North America

In advanced capitalist states, the institutions underpinning economic activity are typically rooted at different spatial scales. At the local level, informal norms and trust are essential to contractual coordination in the market place (Hodgson, 1998), while the national level is where much of the regulation of the capitalist system transpires. Indeed, for its role as regulator, the national level is typically the most prominent site of economic governance. Consider the agricultural industry where national level institutions stabilize most, if not all, of the transactions that take place outside of the farm. Trade policy guarantees access to markets; monetary policy stabilizes prices and cost of borrowing for investment in farm equipment; and national transportation policy can affect distribution costs. Thus the locus of institutional support and coordination, or governance, is predominantly national as opposed to regional or local.

As several authors have argued (e.g. Swyngedouw 2003, Jessop 1993, 1994), national governance was also central to the industrial Fordist economy of the 1960s and 70s whose dominant mode of growth was achieved through the mass production of complex consumer durables through the mass use of semi-skilled labour (Jessop 1994:252). Here the

macroeconomic regime responsible for sustaining growth in production and consumption, and the many organizational forms, social networks and institutions that governed the workings of the regime, were rooted at the national level. National demand management policies, for example, catered to the supply-driven character of production whereby, through large capital spending, these policies sought to ease the fluctuations in the economic cycle, helping stabilize growth which in turn promoted further investment for ever greater economies of scale (Jessop, 1994: 255). Related to this were national policies encouraging mass consumption through labour policies and collective bargaining, which helped ensure that wages rose along with efficiency, which subsequently translated into greater domestic demand. And on the social end of the production regime, national governance was again crucial to trade unionism, which helped the state towards full employment targets and, in the expansion of welfare which catered to the social failings of the Fordist system.

Not all economic governance transpired at the national level but enough did so as to make the national state the pre-eminent scale of governance. With the growing internationalization of production that characterized this golden era of growth, for example, networks of capital required supranational governance to stabilize the monetary system, achieved through the Bretton Woods agreement (Swyngedouw, 2003). But even then, credit for the production system remained regulated at the national level.

With knowledge- and innovation-intensive sectors now taking on the role of the hegemonic production system in economic policy in many advanced capitalist states, this long-standing dominance of the national level governance is, according to many observers, being challenged from below. For what differs in innovation intensive economies is a) the type of non-market institutions that are important in underpinning the essential, and indeed often more complex, set of transactions of knowledge intensive production processes and, b) the spatial scale at which these institutions are situated. Whereas the Fordist economy depended extensively on trade unionism and collective bargaining mediated amidst often hostile government-industry relations, innovation-driven economies are increasingly dependent on institutions supporting a cooperative climate conducive knowledge creation and learning - universities, research institutes and research consortia, as well as local norms and trust (Lundvall and Maskell 2000).

This shift is evident in the now central role of North American state and provincial governments have in supporting technology-based economic development at the regional

level (Osborne 1988, NSB 1991). Currently, most if not all states and provinces have lead S&T offices, compared to 1980 when there was little to no focus at all on technology driven economic development (NSB 2001). Moreover, many regional governments have developed strategic initiatives of varying levels of sophistication that have helped strengthen the R&D capacity of colleges and universities, encouraged firm creation by providing institutional supports for entrepreneurs and technology startups, and have facilitated the adoption of new technology into processes and products.

This shift to 'supply side' governance has thus changed the relative importance - and mix - of non-market institutions that support economic transactions, many of which, as an extensive literature on innovation and economic geography points to, are often locally or regionally based (e.g. Maskell 1998, Cooke and Morgan 1998, Metcalfe 2001). The effect of this has been a spatial reconfiguration of networks that coordinate economic activity and is what Swyngedouw (2003) calls the 're-scaling of the economy'.

Evidence of this rescaling can also be seen in the rise of new patterns of governance that coordinate the strategic decisions-making at the local level, especially in the US and to a lesser extent in Canadian city-regions. With national governments in North America increasingly committed to the principles of free trade as a basis to national industrial policy, they have backed away from traditional firm-oriented economic development policies that prevailed in Fordist era of mass production and national champions. The effect, however, has been what one City of Toronto official calls a 'silent downloading' of economic adjustment to the local level. And, coinciding at a time when local institutions have become central to success of high tech communities, this downloading has had the effect of opening up space for economic planning at the local level. Communities, often driven by civic leadership, have been led to engage in a collaborative process of strategic planning with local industry and subnational governments in the interest of realigning their economic assets to take advantage of emerging economic opportunities, and to attract national and international investment.

According to Henton et al. (1997:22), communities engaged in this type of collaborative approach are 'economic communities'. They are 'places with strong, responsive relationships between the economy and community that provide companies and communities with sustained advantage and resiliency.' As to the style of governance that characterizes these communities, the authors argue that that these regions are 'marked by mediating people and organizations that help interests come together to deal constructively

with forces of change.' Austin, Texas, is perhaps one of the most exemplary case of this new approach. The commitment among local actors to shaping the long-term economic prospects of the locality is one of the most important factors in accounting for Austin's transition to a high-tech economy (Creutzberg 2004). Guided by locally commissioned strategic plans and strong civic leadership, local governance actors were essential to developing and embedding knowledge assets within the locality and in so doing positioning the region at the forefront of the global microelectronics industry.

CAPTURING MULTILEVEL DIMENSIONS IN GOVERNANCE ANALYSIS

A common starting point in the literature on economic governance is to distinguish among the different mechanisms of economic coordination and proceed to characterize the role of each in a particular case study of governance (e.g. Hollingsworth et al. 1994). The state's role is thus contrasted against the role of markets and, more recently, associations, in the economic governance of a particular region or sector. Indeed, each of these categories - state/ market /associations - have become repertoires in their own right, with respective critiques of each of the opposing governance modes (Amin 1996). As a typology, it has been particularly influential in shifting the analytical focus beyond the limited institutional repertoire that prevails in the economic literature of market vs. corporate hierarchy, and towards a far more comprehensive understanding of the institutional complexity of the economy. In a compilation of national case studies on economic governance by Hollingsworth (1994), for example, the state is analyzed not only in its capacity as regulator, creating and maintaining the framework of market legislation, but also for its active role in fostering sectoral development, and as an enabler or facilitator of non-market coordination in particular industries. In more recent work, Cooke and Morgan (1998:19) identify a fourth role whereby states can act as 'de facto public entrepreneurs' especially where industries are nationalized.

As for treating associations as a distinct category of governance, as originally espoused in the pioneering work of Streek and Schmitter (1985), this has brought greater awareness to their role in mediating between state and market governance. For Rogers and Cohen (1992:438), for example, such mediation involves helping to resolve tensions in industry adjustment and interest coordination. They note a broad range of functions where such mediating is required including: the pooling of resources for training in particular regions or trades; for developing and sharing research and development funds'; and for overcoming inadequate links in product design between primary producers and suppliers.

More recently, associations, chiefly in the form of civic entrepreneurs acting in a community or local context, have been identified as increasingly important in constructing an institutional milieu capable of adapting local infrastructure to the requirements of locally-based global high technology firms (Henton et al. 1997). This can include everything from guaranteeing a water supply for chip manufacturing plants to strengthening school curriculums to establishing or developing the learning and research infrastructure, such as a new research facility, in support of local firms.

Yet, as useful as it is in casting light on the diversity of actors and their respective roles in economic governance, the typology is less effective in scalar and functional differentiation. Within the associational category, for example, there is considerable diversity and indeed discontinuity in associational functions, as is alluded to by Rogers and Cohen who identify a range of functions from training to inadequate links in product design within the supply chain, and in the example of locally based civic entrepreneurs. Thus some aspects of associational governance are explicitly carried out within industry, as is some standard setting or collective research, while other associational activity is primarily intermediary, such as the influencing of public policy. Moreover, this functional diversity is often related to the scale of activity. For example, in the case of influencing public policy, this typically involves industry or trade associations whose membership, and hence their own level of operation, is commensurate with the level of government with whom they interact. A national industry association, for example, typically deals exclusively with national policy issues. While such organizations are indeed associational, they have few linkages with, for example, civic entrepreneurs engaging the local community in establishing the requisite infrastructure to seed local industry. Thus despite both being involved in resolving tensions stemming from industry adjustment, these two examples of associations – national industry associations and civic entrepreneurs - do so from entirely different focal points and scale. These distinctions are lost, however, when such actors are lumped together in a single category.

Likewise with the state. As was noted previously, the state's economic governance role is diverse, ranging from national level macroeconomic management to *animateur* of local business networks. Accommodating this range within a single category makes it difficult to draw out in a systematic manner the often distinct roles, and patterns of associational and market engagement related to different levels of the state. At the international level, for example, economic governance such as that which is provided

through trade agreements, is largely institutional, with established rules for resolving trade disputes and governing industry whose activities may extend into any one of the signatory states. Quite different to this 'framework governance' is the manner in which some local level governments in North America have been engaging in strategic economic development with associational actors and firms with the goal of tapping into global markets, not unlike the approach taken by East Asian developmental states, such as Japan, Korea and Taiwan, in developing their economies. Moreover, when such functional diversity is grouped as a single conceptual category, the tendency, especially in international comparative studies, is to gravitate to an explicitly national focus at the expense of subnational levels. This framework therefore tends to leads to conclusions as per Hollingsworth et al (1994:273) that 'the degree and mode of state intervention in a sector seems to be determined almost exclusively by national factors, with only marginal impact of sectoral technologies and economics." It is not so much the conclusion that is problematic but rather the industry case studies that do not consider subnational dynamics in their analysis.

An alternative typology that better addresses the scalar dimension of governance is offered by Cooke (1992, 2004) in his characterization of governance regimes responsible for technology transfer. Here the author identifies three models conceptualized from regional technology policy case studies of Japan, Germany and France. Each model captures variations among five variables related to technology transfer: the initiation process of technology transfer (e.g. local versus non-local), the sources of funding, research competence (i.e. basic research versus applied research), technical specialization and the degree of supra-local coordination. The first of these models, the 'grassroots approach', characterizes an approach where the initiation process and funding are local. This is contrasted against a 'dirigiste approach' where both the initiation of actions and funding are national activities carried out outside the particular region. And third, in between these two models, is the 'network approach' where both the national and local levels are involved in these activities. Thus rather than group by type of actors, as in the tradition of Schmitter and Streek, the typology differentiates governance by *attributes*, which in this case relate to technology transfer. In so doing it is able to isolate patterns that emerge among sets of actors as defined by their involvement in the particular attributes, and identify the scale at which such governance transpires.

For a broader analysis of regional sectors, however, the typology is limiting in two respects. First, having been cast from an analysis of technology transfer and later extended to governance of regional innovation systems, the typology is specialized, focusing on a subset of variables, not all of which are related to governance. The level of technical specialization and research competence, for example, are attributes of a regional innovation system and not necessarily specific to the governance process *per se*. Second, by characterizing modes of governance by scale, the typology risks overemphasizing one level at the expense of the others, or rather, at the expense of a more nuanced multilevel analysis. Indeed, the pitfalls of a purely regional focus that such a typology can generate, are well noted by Lovering's (1999) sharp critique of what he calls the 'new regionalism' approach to regional development, whereby the region is held to be the primary focus of policy.

With these limitations in mind, an alternative to the actor- and attribute- centered categories is presented here in an attempt to better capture the patterns of interaction among the different types of governance actors, irrespective of their level. To this end, a distinction is made in the manner of non-market economic governance, such that governance may be identified as either being 'framework' oriented or 'strategic'. Together, these categories capture the dominant approaches by which states govern the economy, while revealing distinct differences in the types of actors involved, their initiatives, and respective levels at which coordination is achieved.

Framework versus strategic governance

'Framework governance' is essentially steering by indirect and neutral means, governing from the periphery through regulation and the tax system. Desired ends, such as innovation or research and development are often incentivized, though in a broad manner, without excluding access to such benefits to any one firm. Framework governance is thus in keeping with the neoclassical approach whereby a state's role is limited to influencing firm activity through policy that does not discriminate to the level of a firm or industry. It abides by the political principle of non-interference and the notion that markets, operating within a regulatory framework, are left 'free'.

In North America, framework governance is the most prevalent manner through which states exercise influence over the direction of industry, encompassing as it does, macroeconomic conditions such as financial management and the overall tax climate. It characterizes the essence of the systems of political economy in Canada and the US. Governments, at the national as well as subnational, are the central actors in shaping the

regulatory environment, though often with the cooperation of industry and trade associations. Framework governance also prevails at the international level through trade agreements which govern by way of negotiated rules, the terms of trade and the resolution of trade disputes. These may be sector-specific and bilateral, as in the case of the 1996 Japan- U.S. Semiconductor Trade Agreement, or comprehensive and multilateral such as NAFTA and the WTO.

Strategic governance, on the other hand, is the deliberate steering of resources to achieve a specific outcome in a specific location that typically would not transpire through market processes alone. It is self-directed and carried out with the guidance of a desired state of development. This type of governance informs much of the state-centered repertoire on economic development, with Japan's economic development an exemplar of how the national level can take leadership in this type of coordination (Johnson, 1982). In the context of North American liberal system of political economy, however, such governance continues to be controversial, not only in academic but also political circles, where it is reminiscent of full scale national planning of former communist regimes.[1] Despite the controversy, few, if any, of these governments have shied away completely from developing programs that support the development of particular industries. In microelectronics alone, there are nine major programs currently being supported by Western governments, five of which are in the US (Wessner 2002).

Strategic governance is also the manner of governance that increasingly involves regional and local level actors. Unwilling to subject their economic future to the vagaries of external market forces, the local and regional actors have instead turned to strategic efforts aimed at developing and localizing the research and learning infrastructure to the benefit of particular knowledge intensive industries. Civic entrepreneurs, often in collaboration with municipal and regional governments, for example, formulate strategic plans to guide the building up of knowledge infrastructure and recruit firms of a chosen industry with the goal of strengthening existing capabilities within the region. In the table a summary is given of the actors and types of initiatives typically involved in this kind of governance.

Table 1: Two manners of non-market economic governance

	FRAMEWORK GOVERNANCE	STRATEGIC GOVERNANCE
PRIMARY ACTORS	National / regional governments Industry associations	Civic entrepreneurs Municipal / regional governments University professors Regional associations Technology / business associations
INITIATIVES	Trade agreements Innovation support programs Funding of basic research R&D Tax credit Higher Education	Localizing R&D facilities and knowledge investment (federal and firm) Strategic business recruitment / retention Curriculum development at local institutions Strategic planning Leadership incubators Building of technology commercialization support institutions
GOVERNANCE PATTERNS	Policy networks Policy communities	Community-led socio-economic governance networks

Patterns of relationships within the two manners of governance

These locally rooted efforts have produced governance patterns that are quite distinct from the models that exist in the political science literature. Policy networks and policy communities are two such models that loosely try to capture the actors and relationships involved in shaping policy. Policy networks, according to one definition, refers the to 'the dependency relationships that emerge between both organizations and individuals who are in frequent contact with one another in particular policy areas' while policy community captures the 'shared framework' and established pattern of behavior' within which decision making takes places (Atkinson and Coleman, 1992:158). Both these concepts attempt to answer questions related to 'who participates and who wields' power in the policy-making process, recognizing that states are often only one actor in the process.

With their focus on policy outcomes, these two models are indeed relevant, but in the context of framework governance as defined above. As Atkinson (1989) finds, in his study of industrial policy networks in Canada, the character of the policy network is closely linked to the nature of industrial policy; where pressure pluralist networks exist, policy has

typically been reactive, catering to the immediate needs of individual firms. This bears out in his examination of the telecommunications sector, where he finds a policy network comprised of competing industry associations and state agencies with very little coordination apart from individual links between dominant firms and relevant agencies. The result has been a national policy that is poorly coordinated, reactive and which lead to state departments and agencies to 'carve up the industry and claim narrow responsibility'. An updated study of the microelectronics industry would likely find a similar configuration though with a slightly different set of actors, namely the two competing national associations, Information Technology Association of Canada (ITAC) and Canadian Advanced Technology Association (CATA) and Industry Canada.

In the area of strategic governance however, these models are much less relevant for two reasons. First, the set of actors involved in strategic governance, such as civic leaders, municipal governments and university professors, typically are not associated with those involved in framework governance. Second the initiatives that are the focus of strategic governance do not necessarily involve public policy even though they may have a public good component. Two examples are the building of institutions by private actors that support local technology transfer or commercialization, and the process of adapting curriculums of local higher learning institutions to the needs of local industry. Both initiatives require only a degree of coordinated decision-making within the locality and not any modification to the framework conditions at the local, regional or national level.

Of interest in the following case study is the pattern of relationships that have animated strategic governance in the GTA's microelectronics industry, and in particular, the degree of involvement by local level actors, who as the literature suggest have an increasing role to play. What is revealed is that while the GTA has benefited considerably from strategic governance, it has been remarkably sporadic and uncoordinated and with very little involvement of the local associative system. And though the federal government has been dominant, it is no longer a significant strategic actor. There are signs, however, that the federal retrenchment from strategic initiatives is being off-set to some degree by the emergence of several new actors with locally focused strategic intentions.

STRATEGIC GOVERNANCE AND THE MICROELECTRONICS INDUSTRY IN THE GREATER TORONTO AREA

The Greater Toronto Area is an expansive region located on the north shore of Lake Ontario in South-West Ontario that consists of five political regions and twenty-five

municipalities. Accounting for approximately 11% of the country's GDP, the region is Canada's largest, and most diverse economy with automotive manufacturing, finance and food processing among the most prominent of its industries. And having placed thirteenth in a 2003 global patent ranking, the region, as noted in city promotional brochures, is among the most innovative in the country (City of Toronto, 2004a).

The GTA is also home to the country's largest ICT sector, which in terms of employment, is more than double that of Montreal, the second largest regional ICT sector, and four times that of third placed Ottawa (Beckstead et al 2003). A 2004 study on Toronto's IT industry places proudly places the region as the third largest ICT sector in North America after San Francisco and New York with over 3,332 ICT facilities and a labour force of some 148,000 (E&B Data, 2004). Among the largest employers are IBM Canada (11,000), Celestica (4500), Hewitt Packard Canada (2000) and Microsoft (900). Manufacturing accounts for approximately 19% of employment and 8% of facilities, compared to software development at 15% and 18% respectively and IT services at 43% and 28%. In the microelectronics subsector, there are approximately 66 firms (2000 estimates), based in the region including the largest fabless integrated chip supplier outside the US, ATI Technologies.

Explanations accounting for the region's technological strength have typically identified a set of factors more relevant to framework governance than to strategic governance. In a recent ICT report on the GTA (E&B 2004), for example, the authors point to three locational advantages for the region's IT firms. The first is total operating costs, which in a 2004 KPMG study, were found to be the lowest among all large U.S. metropolitan areas. The proximity of the GTA to all major North American metropolitan markets is also considered to be a significant advantage for ICT firms, and indeed for the many multinational firms that base their Canadian headquarters in the region. Third is the size, cost, quality and diversity of the labour pool. With five universities and six colleges, the region's educational institutions produce more than 7000 ICT related graduates annually, the result of which is a labour pool frequently cited as one the region's greatest strengths. City economic development officials in Toronto point to a fourth factor underpinning its high technology economy, namely the size and sectoral diversity which together generate a strong local demand for many subsectors of the IT industry especially software and multimedia.

Such an explanation is made all the more convincing in the context of the ongoing – and understandable - neglect by federal government's long-standing regional economic development efforts. Since the federal government took a more decentralized approach in its economic development strategy in 1987 with its creation of new regional agencies, Toronto, and southwest Ontario more generally, has been the only region in Canada without any representative agency providing economic development assistance (OECD, 2002). To the west, the federal government funds the Western Economic Diversification fund, to the east, the Atlantic Canada Opportunities Agency, in Quebec, Canada Economic Development, and to the north of the GTA, the government, through Industry Canada, supports the Federal Economic Development Initiative for Northern Ontario. Though each cater to the specific economic needs of the region, which has in the past involved supporting and restructuring existing industries, these regional agencies have been moving towards funding innovation-based initiatives, providing the institutional support for building knowledge based industries. Programs supporting SMEs, innovation, commercialization of R&D and entrepreneurship are typical, several of which have been apart of cluster building strategies. Between 1987 and 2000, total spending amounted to some $48 billion with annual budgets in the order of $400 million for the three main agencies, with no comparable spending made in the GTA.

The Federal government has also bypassed the region in its vast network of over twenty Technology Centres and Research Institutes run by the National Research Council. These facilities, which conduct research in a wide range of high technology areas such as IT, nanotechnology and advanced manufacturing, offer Canadian businesses and universities access to state-of-the-art equipment, research and training programs, as well as design, fabrication and testing facilities. And finally, the one existing federal program that has been centered in Toronto and which has catered explicitly to industrially relevant microelectronics research, has had its funding terminated as of 2005, after 14 years of operation. The program, Micronet, has been one of the most successful of the federal government's Network Centres of Excellence.

At the provincial level, the GTA has remarkably faired little better. The province, since the conservatives came to power in the mid 1990s, has taken a largely hands-off approach to the economy, governing very much within the mode of framework governance, aggressively cutting taxes and reducing expenditures. The conservatives did, however, retain one strategic investment, the Centres of Excellence program, a program similar in

design and goals to the Federal Network Centres of Excellence, though not without cutting its budget (Wolfe and Gertler 2001).

Thus the laissez faire explanation is not without merit. It does, however, overlook decades of history during which several important strategic efforts were made, the most significant of which have been from the federal level actors over some three decades following World War II. And remarkably, as is evident from the following section, the federal government has been a central coordinator of the GTA's knowledge base without any explicit regional intentions. As with economic development in Toronto in general, the region has benefited despite efforts made to ensure that Toronto and Ontario, would not be the sole benefactor of federal efforts, thus becoming the much feared vortex that would draw in all the best skilled employees from across the country (Fisher et al, 2001).

Early roots: Defence Research Board and the University of Toronto

The foundations of the GTA's microelectronics industry can be traced back to both Canada's Defence Department and the academic ambitions of the University of Toronto. After the Second World War, the Defence Department had come to recognize the strong link between peacetime defence planning and industrial capacity in mobilizing the country for future war efforts. It had taken Canada four years to ramp up its industrial effort to be an effective contributor World War II and if Canada were to be prepared for future conflict, it was essential that the country sustain a national capacity to develop and implement science-based weapons systems (Vardalas 2001:50). To this end, the Defence Department created the Defence Research Board (DRB) in 1947, charged with providing scientific advice to the Minister of National Defence, supporting the research requirements of the Canadian Armed Forces and contributing to the collective defence research effort of Canada's allies.

Within this mandate, the DRB spearheaded Canada's entry into electronics. Indeed the DRB would become the central actor in fostering both a scientific and industrial capacity in Canada - and incidentally within the GTA – spirited by a strong nationalist sentiment of self-reliance. In mid 1947, it established the Electronic Advisory Committee identified the need for an electronic computer in Canada. This was the first statement of strategic intention in the area of electronics by the federal government. Moreover, it was a position strongly supported by the military, navy and air force, all of whom expressed concern at the time of having to rely on foreign countries to pursue their research.[2] The

Committee also made recommendations on mobilizing Canada's industry for its high-tech needs, noting in a memorandum existing industrial inadequacies:

> "It is essential to the Canadian defence programme to enlist the services of Canadian industrial laboratories…Since few Canadian industries are now equipped with the necessary laboratory facilities, it is believed that the Defence Research Board should foster and support the establishment and maintenance of such laboratories by appropriate means with the industries… Such laboratories would form the nuclei of highly qualified groups so essential in the event of future conflicts and without which Canada was so handicapped in World War II." (cited in Vardalas, p.52)

This desire on part of the DRB to develop digital electronic computing capacity in Canada coincided with the University of Toronto own efforts to learn more about the research efforts underway in the US in this area. By 1946, professors had set up an interdepartmental Committee on Computing Machines that recommended a computational laboratory be set up as a training centre for digital computation and that the university consider developing their own electronic computer. The centre became a reality in 1948 after the university had successfully approached the DRB and the National Research Council (NRC) in its request for support. In providing funds for a five-year program, the University of Toronto, in collaboration with the DRB and NRC, created Canada's first centre of computers, whose goal it was to build an electronic digital computer by the program's end (Vardalas, p.23)

The Computation Centre's first prototype of the UTEC (University of Toronto Electronic Computer) Mark I was completed in 1951, the same year the Dean of Engineering at the University decided to buy its first computer from Ferranti Ltd., a British firm. With money coming from the DRB and NRC, this computer purchase ultimately undermined the rationale for the Computation Centre's R&D efforts, and was disbanded in 1952. Despite its failure, the effort had nonetheless developed Canada's first concentration of computer expertise within the region. After disbanding, several key members of the engineering group began their own computer firms, the most successful of which was KCS Data Control, which became the country's most successful computer consulting firm by the early 1960s, and whose biggest success came with having designed the world's first computerized urban traffic control system for the City of Toronto in 1962 (Vardalas, p.41).

Multinationals and the development of a microelectronics knowledge-base

A second event in the development of the GTA's microelectronics foundation, came, with some irony, from a collaborative venture between Ferranti's Toronto subsidiary

and the Royal Canadian Navy (RCN). Despite having indirectly undermined the University of Toronto's computer R&D efforts in its selling of a computer, Ferranti would develop the region's first industrial capacity in digital electronics in an ambitious seven year project that came to an end in 1955. The project, called DATAR (Digital Automated Tracking and Resolving), promised to coordinate the maneuvers of convoy escorts and anti-submarine groups and was considered an essential R&D endeavor by the RCN if it was to meet its commitments to anti-submarine warfare taken on after the war. With essentially no technological expertise in Canada to develop the system, the navy sought out Ferranti to carry out the project, which had previously expressed interest in participating in the DRB's program of applied research defence related electronics.

Though successful in developing a prototype for DATAR by 1955 that impressed both the US and Royal navies, the collaborative project collapsed for want of customers. Both the US and British navy were in the process of developing their own system, which ultimately prevented the RCN recouping its R&D costs through much hoped for sales to allied navies. But as with the collapse of UTEC, all was not lost with the termination of DATAR. Ferranti Canada had not only built up a group of 30 engineers and scientists in Toronto, including one of its leading inventors form the UK, but had also positioned itself at the frontier of computer development at a time when computers were shifting to solid state transistors. With this foundation, Ferranti-Canada won contracts to build a mail sorting system for Canadian Post Office Department, building on DATAR technology, and later a computerized airline reservation system for Trans-Canada Air Lines. Though the mail sorter was never implemented, Ferranti-Canada had considerable success with the transistor-based computer reservation system, implemented in 1961. With few follow-on sales for its custom systems, the subsidiary entered the general computer industry, choosing to develop computer based on its reservation system technology and quite different from that being sold by its parent firm in the UK. The result, the FP6000, thus became Canada's first computer to be fully designed and built in Canada.

The F6000, however, did not sell. By the early 1960s, IBM was dominant, and the cost of marketing together with the marketing know-how was beyond the capacity of the Canadian subsidiary. Moreover, Ferranti-Canada, which had been set up to provide electrical goods to the growing power industry in Canada, had little support from its parent firm in its high tech endeavors (Vardalas, p.162). In 1963, Ferranti Ltd. sold all of its civil computer operations to International Computers and Tabulators (ICT) as part of an industry

consolidation effort by the British government, putting an end to the Toronto-based Ferranti-Canada.[3]

Ferranti-Canada, however, was not the only subsidiary of a multinational to have nurtured the technological capacity in microelectronics in the GTA. In fact, the GTA owes much of its original microelectronics knowledge development branch offices of multinational corporations, often criticized for their poor R&D efforts. In the early 1970s, the GTA was home to the national offices of Fairchild Semiconductor, Canadian Marconi, Canadian General Electric and Canadian Westinghouse and Control Data Corporation, many of whom had established themselves in the region in response to the protective tariffs of Canada's National Policy.[4] Though most were merely sales and marketing offices, a few did have R&D departments, like Ferranti Canada, and would have a lasting impact for the region in the transfer of technology and knowledge.

One such company Canadian Westinghouse, a subsidiary of the large US conglomerate whose Canadian operations had originally been focused on power generation equipment. By the mid 1960s, Canadian Westinghouse decided to form is own department of microelectronics, in the shadow of its parent firm, which had become the 5th largest producer of microcircuits in the world. The company hired a Canadian Ph.D. recruited from IBM to head up the new venture in integrated circuits and began to develop digital, and later, analog circuits. Its first success came with having designed the company's first operational amplifier**.**

Much of its chip manufacturing capacity in Canada, however, was the result of a strategic decision by the parent firm in 1968 to divest from all commercial microelectronics manufacturing. In so doing, the Canadian department was given an opportunity to acquire some of the parent's IC product line for continued production and distribution. And this they did for another four years, manufacturing six integrated circuits for an established client base. By 1972, the Canadian operation had become an isolated entity within the firm and was closed down. For those managing the group, this closure gave them the opportunity to spin-out as a separate firm. The group acquired the rights and production assets of one of the circuits from Westinghouse, that of its hearing aid amplifiers. The new company, was called Linear Technology, later renamed Gennum Corporation, and would emerge as world-leading supplier of hearing aid amplifiers.

Although Canadian Westinghouse had been recognized by the DRB as part of Canada's industrial capacity in electronics and did get involved in a transistor training

program in the mid 1950s, the subsidiary was unusual for not having had much involvement with the federal government early electronic procurement programs. In the late 1960s, the federal government had a renewed concern for the lack of industrial capacity in Canada. By this time, with a new Department of Industry, Trade and Commerce (DITC) established in 1963, and with the Defence department's leadership on technological self-reliance having come to an end, strategic initiative in the area of electronics now came from the civil side (Vardalas, p.173). One of DITC's first efforts was to mobilize the US multinationals to carry out more R&D and export production in Canada. As Vardalas (p.174) writes, "under the banner of 'moral persuasion', DITC was determined to prod, coax, and if need be even coerce US computer manufacturers to invest in R&D and high-level manufacturing activities in Canada to a level commensurate with their sales in Canada". With Toronto home to most US multinational, this strategy would benefit the region considerably.

One of DITC's first engagements within the context of its 'moral suasion' industrial strategy was the US firm, Control Data Corporation (CDC). By the late 1960s, CDC had become a significant force in the global computer company second only to IBM in sales. Its strategy to build high-end scientific computers for governments and universities proved prescient particular given its success with its famous Cray supercomputers. By 1969, the company was preparing for a new generation of supercomputers under a new circuit architecture that would challenge IBM's dominance of the high-end business market. The mainframe computer was named PL-50 and it would be designed in Canada.

CDC established its Canadian subsidiary in 1962 and in Toronto as did most US multinationals setting up branches in Canada. Overseen by a country manager, CDC Canada was given a clear sales and marketing mandate. Its transformation to an R&D unit was unusual not only for a US multinational but also for CDC which had yet to carry out any R&D outside the US. The decision by its founder, William Norris, to carry out such a big project outside the US, was driven by necessity. With its R&D resources stretch to the limit, Norris looked for the first time to R&D partnerships with other governments as a way of leveraging its costs for what was considered a very critical R&D program. In Canada, with DITC poised with its new strategy, it found a willing partner (Vardalas p. 237). CDC applied formally for assistance under DITC's Program for the Advancement of Industrial

Technology in 1970 to bring its PL-50 R&D effort to Canada and by the end of the following year CDC Canada's R&D efforts were well underway.

The deal with the federal government promised CDC $23.1 million over 5 years, a figure that would account for a considerable 44% of the estimated total development costs. In return CDC would agree to four objectives and one condition. The objectives were that a permanent mainframe R&D facility be established to which the infrastructure and know how be transferred to allow for the full design of the PL-50 in Canada. Also CDC was expected to foster Canadian component supply industry through sourcing within Canada, and agreed to the condition that once designed the full production of the PL-50 would be done in a plant located in Quebec City. For this it would get an additional $10 million from the Department of Regional Economic Expansion (Vardalas, p.244).

After two years, CDC abandoned the PL-50 program due to technological limitations of the proposed STAR architecture. The Canadian group, however, had also been upgrading one of CDC's older models, and repackaging it as the Cyber 70. This computer, which was manufactured in Toronto in an expanded facility in Mississauga, sold surprising well. Indeed, it was sufficiently successful to persuade DITC to reassign PL-50 money to develop a second line of computers that would incorporate the latest circuit technology but with an emphasis on cost and efficiency. The Cyber 173 computer, as it was called, ultimately became CDC's most profitable, cost-effective computer ever built and led to the development of an entirely new line of computers (Vardalas, p. 259).

CDC's Canadian group was eventually shut down in 1992, along with the parent firm, which collapsed in the shift away from mainframe to minicomputers, and under intense Japanese competition. The group had nonetheless become a flagship R&D subsidiary for CDC and validated William Norris's enthusiasm for R&D partnerships. International collaboration had become a core component to CDC's R&D strategy in the 1960s engaging as it did in several US and European computer manufacturers. In the early 1980s when Japanese competitions was being felt, Norris was all the more convinced of the importance of collaboration, leading him to launch the first large scale R&D consortia in the United States – MCC (Microelectronics and Computer Technology Corporation). MCC, of course, was the organization that would begin the transformation of Austin's economy in 1983. Though CDC Canada did not have the same impact on Toronto as MCC did for Austin (Gibson and Rogers 1994), there was nonetheless a legacy. A part from having developed Canada's only mainframe capacity, CDC Canada through its various R&D

programs, built up the technological competencies over the years that would persist after it closed. Indeed, according to anecdotal evidence, most of the engineers stayed put in the GTA and Canada, taking up opportunities in other microelectronics firms.[5] As for creating a network of suppliers, as was hoped for by DTIC in the terms of its initial deal, CDC Canada managed to do so for only the less sophisticated components, relying on non-Canadian firms for the production of their semiconductor circuits.

In this respect the economic impact of CDC Canada was similar to that of MCC, which over the course of its life, had little of the anticipated spin-offs. Yet where William Norris' venture in Austin was very much a success was in its mobilizing symbolism that would change the mindset and prospects of Austin's regional economy (Creutzberg 2004). Norris' venture in Toronto, however, had very little of impact of this sort on the region, with little to no evidence of there being much regional recollection of CDC Canada's achievements either among the region's microelectronics firms or IT associations.

The local component

Though multinational subsidiaries, together with the Federal government, did play an important role in developing the knowledge base in the region, the GTA has not been without its own microelectronics startups. In 1955, for example, Polish immigrant Jack Tramiel founded a typewriter company that would later turn its focus to electronics in the 1960s and 1970s, producing electronic calculators. In 1976 the company, called Commodore, moved operations to the US and a year later would go on to revolutionize the computer industry with the inexpensive Commodore computer (Jung 1998). Commodore, however, was somewhat unusual in having little to no link to the Federal government's microelectronics efforts. Moreover, until the firm left for the US, much of its value added manufacturing was carried out in Europe, drawing little on the Canadian economy.

The founding of ATI Technologies is all-together a different story, though one that is nonetheless linked to the success of Commodore. Its founder, Kwok Yuen Ho also an immigrant, though from Hong Kong, came to Toronto in 1983 impressed by "a lot of open space and lots of opportunity" (Business week, 1999). With an electrical engineering degree from a top Taiwanese university and work experience in several large Hong Kong based electronic firms, Ho, together with two other Hong Kong engineering émigrés, created Array Technologies Inc. in 1985. By the end of the first year, the company had designed a successful graphics-enhancing chip, which it had sold to Commodore at a volume of 7000 a weak. Fifteen years later, ATI had grown to become the dominant supplier of graphic

accelerator chips, and by 2004, the second largest fabless chip design companies in the world with some $2 billion in annual revenue. According to a senior executive at the firm, ATI is currently linked to some 12 spin-out microelectronic companies, many of whom remain in the GTA, including Genesis, the second largest microelectronics firm in the region.

ATI's links to the GTA, however, extent beyond its spin out companies. In fact, ATI owes much of its early rapid success to the federally-funded Microelectronics Development Centre (MDC) based at the University of Toronto, which provided the firm with its first five microchips. The founders, when starting their firm, had the expertise in graphic cards but very little money and no chip design knowledge or capability. The company's concept was to develop a single chip that would incorporate all graphic standards of the day, thus making all computer applications compatible with the various displays that were on the market.[6] In 1985, MDC was approached by ATI to be their chip designer, which they continued to be until ATI developed their own internal capacity. This was done by employing MDC engineers, once the program had been closed in 1986.

MDC was typical of the new approach to industry support that took root in the 1980s in Canada. Created by the Department of Trade and Industry Canada, MDC was a part of a national program that supported some twelve technology and industry focused centres housed within universities across the countries. Each were given five-years of funding in the order of $1 million a year after which the centres would close. In the five years of its existence, between 1983 and 1986, MDC was considered only modestly successful.[7] It did nonetheless create one of the first ASIC (Application Specific Integrated Circuits) design facilities in Canada, acting as consultants, providing advice and design expertise to help small companies take advantage of microelectronics.

Institutional development and dissipation in the GTA

MDC was only one of several initiatives that would contribute over the years to the thickening of the knowledge infrastructure within the GTA in the area of microelectronics. And although none were a part of any strategic vision from the instigators in supporting and developing the microelectronics industry, they all shared a common focus on training. The most significant of these has been the Canadian Microelectronics Corporation (CMC), a non-profit organization established in 1984. At the time, CMC was an unusual organization, and in fact an institutional innovation that was created specifically for the knowledge needs of the microelectronics researchers and industry. In providing

universities across Canada with access to the most up-to-date software, hardware to design chips and access to foundries to manufacture prototypes, CMC has allowed Canadian researchers to stay on the frontier of design. And for the Canadian microelectronics industry in general, this 'national design network' as it is often described, has been indispensable in providing industry-caliber training for graduate students who have been able be productive immediately upon entering industry. CMC has become globally recognized and replicated in the US, Taiwan and in Europe.

Whereas MDC was an initiative of the federal government, CMC was founded largely under the initiative of a professor in the Department of Electrical and Computer Engineering at the University of Toronto. Together with group of researchers from other universities in Canada, and with support from the country's leading microelectronics firms, Professor C.A.T. Salama approached the federal granting council, NSERC, with a proposal for CMC. NSERC has supported CMC ever since making it the federal governments most consistent and stable initiative supporting the microelectronics industry in the fifty-year history of the industry.

Another influential initiative supported by the federal government and spearheaded by Salama has been Micronet. As a Canada-wide network of microelectronics researchers committed to pre-competitive research, Micronet was one of the original proposals accepted under the federal government the Networks of Centres of Excellence (NCE) program which it launched in the late 1980s. As with CMC, Micronet has been considered an essential program in training engineers and scientists in the microelectronics industry, and central to retaining both companies and individuals in Canada.[8] As one interviewee noted, there was a "strong pull to go to the US to access markets, funding and people. If these initiatives had not succeeded, a lot would have gone." For all its success however, the federal government terminated the program after reaching the fourteen-year limit established in the terms of the NCE program, with no plans of developing a follow-on program.[9]

Though both these programs were very much national in their focus, they have allowed the region, centered at the University of Toronto, to build an expertise in a growing niche area of microelectronics. Indeed, the University of Toronto is now recognized as one of the world's leading centres for Field Programmable Gate Arrays (FPGA) design, having recruited a professor attributed with having created "the science of FPGA design". As a result of this expertise, several firms have been drawn to the GTA region including in the

world's largest FPGA company at the time, Xilinx Inc., of San Jose, California, which opened the Xilinx Toronto Development Centre in 1993. Another was Altera, which set up The Altera Toronto Technology Centre after buying a faculty member's company, Right Track Cad Corporation, two years after it was founded. In reflecting on its rapid success, its founder noted that CMC was indispensable in starting up Right Track Cad, as it allowed access to modern IC processes.

The provincial role

The Ontario government's role the GTA's microelectronics industry has been essentially similar to that of the federal government, providing ad hoc support for industry initiatives and establishing of strategic research networks. And as with the federal government, the provincial government has funded these microelectronics-specific programs outside of any long-term strategy. Its first initiative came after the government established the Ontario Task Force on Microelectronics in 1980, which made a range of recommendations on stimulating high tech investment and improving the R&D climate. One of the report's recommendations was to establish a microelectronics technology centre, which the government acted on in 1982 when it funded several technology centres across the province. Funded through the government's BILD (Board of Industrial Leadership and Development) program, these technology centres were significant to the extent that they represented a shift away from a focus on manufacturing and import substitution that had characterized much of its earlier industrial policies, to a more strategic focus on technology.[10]

These centres, one of which was the Ottawa-based Ontario Centre for Microelectronics, lost financial support after four years despite having been considered a successful. The funds were subsequently reallocated to the Premier's Council Technology Fund from which the Liberal government would later fund its most significant strategic effort to date, the university-based Centres of Excellence (COE). The COE program, which funded seven centres in total, had been developed by the province with the goal of commercializing research through the linking of industrial and academic research. Launched in 1986, it was the first of its kind in Canada and, indeed, prompted the federal government to create their own version, the Network Centres of Excellence initiative (Fisher et al, 2001:310).

Of the initial seven COEs, researchers at the University of Toronto's Department of Electrical and Computer Engineering were dominant in two, the Telecommunications

Research Institute of Ontario (TRIO) and the Information Technology Research Centre (ITRC). According to a review by the Department (1998), these Centres, which had shorter-term research goals than the Federal networks, both had become tightly linked with local industry. In 1997, the two were merged into CITO (Communications and Information Technology Ontario) with reduced government funding and, in 2004, were merged again. Despite such consolidations, the OCE program has been the Ontario government's longest running strategically oriented R&D program supporting microelectronics.

External links in the creation of the GTA's knowledge base

By most recent accounts, the biggest benefactor of early federal government initiatives was Ottawa, a region most strongly identified with microelectronics in Canada (Mallet 2002, Harrison et al. 2004). Currently home to the second highest concentration of fabless semiconductor design firms outside of the US (Arensman 2003), Ottawa is also where much of Canada's federal R&D laboratories had been originally located. One of which, the Communications Research Centre, is credited to having drawn Northern Electric to the region, which itself was created following the break up of AT&T.

Though most influential in developing Ottawa's microelectronics region, these initiatives did have a spill-over effect on the labour pool within the GTA's own microelectronics industry. In 1962, at the request by the Defence Research Board and the National Research Council, Northern Electric entered into a collaborative program to build a semiconductor manufacturing capacity, the result of which was the creation of the Advanced Devices Centre (ADC). In 1968 ADC was incorporated as a separate company, Microsystems International Ltd (MIL), again in partnership with the Federal government who provided some $37 million in subsides and loans (Thomas, 1983:26). Through this partnership, MIL became the country's first foray into semiconductor manufacturing which, having acquired chip-manufacturing processes from Intel and a plant in Malaysia, became the world's second largest supplier of DRAM memory chips in the early 1970s, after Intel. In 1975, unable to keep up with the fast pace of the semiconductor industry, MIL went bankrupt, and the facilities were repurchased by Northern Telecom.[11] MIL had nonetheless made its mark. Out of its collapse, the Ottawa region established much of its initial microelectronics industry - Newbridge, Mitel, Mosaid, Calian - from the entrepreneurs and experienced pool of engineers and scientist who had worked for MIL. According to a prominent business leader, this same group of ex-MIL employees also helped build the

microelectronics industry in the GTA, as several relocated to take advantage of the work opportunities.

CHARACTERIZING THE PATTERN OF STRATEGIC GOVERNANCE IN THE GTA'S MICROELECTRONICS INDUSTRY

The foregoing account highlights three salient factors that have characterized the pattern of governance of the GTA's microelectronics industry over the past fifty years. The first is the importance and indeed effectiveness, of the federal government, multinationals and the University of Toronto in fostering the knowledge and research base from which the industry developed. Second, is the remarkable absence of any coherent long-term microelectronics strategy from the early 1970s onwards. And third, is the absence of any significant associative leadership in the development of the non-market institutional capacity supporting industry. The effect has been an undeveloped, if not uncoordinated, 'governance system' with little logical coherence apart from a few nodes of leadership each with a predominantly national outlook.

The lack of strategic leadership has been ironically one of the most consistent attributes of the industry. The several strategic initiatives that have come and gone over the years have been supported by a myriad of departments and agencies (The Royal Canadian Navy, the Defence Research Board, DTIC, NSERC, the National Research Council, the Department of Science and Technology) none of whom have managed to organize their efforts. In 1982, in one of the few federally-funded reports on the industry, from the Labour Canada Task Force on Microelectronics and Employment, the authors describe Canada's efforts as 'rudderless', and recommend that 'urgent' action be taken 'to develop a coherent strategy embodying well-defined goals including the attainable niches for Canada; and a consistent set of public and private sector policies to enable the microelectronic technology to flourish, and thereby extend its full advantages to the Canadian people'(p. 32). A similar call was made some twenty years later by one the industry's loudest voice, Doug Barber, president of Gennum, who, writing on the need to address invest in skills, pointedly noted that "Canada will get from 15th place to 5th [in R&D] only if federal and provincial governments take strategic action now in the areas of greatest economic opportunity", referring as he was to the microelectronics, photonics and wireless industries (Barber et al. 2001).

The lack of continuity in the coordination efforts of the industry, made all the more so by the absence of any long-term strategy, complicates efforts to identify any

consistent pattern of governance. Both the University of Toronto and the federal government, through the individual agencies and departments, have at various times both been sources of leadership with respect to mobilizing resources in support of the industry. And while there has been some consistency among the catalysts of strategic initiatives, particularly from within the University and in industry, there has been little in the way of either formal or informal engagement to support the idea of a coherent governance network. In fact, much of the GTA story has been more about government rather than governance.

There have nonetheless been a few coalescing strategic governance structures that have had an important impact on the regional industry and which underscore the ad-hoc and often non-committal relationship between the government and the industry. One such example was the Canadian Semiconductor Design Association (CSDA). Founded in 1984, CSDA was a private R&D consortia consisting of five Ontario-based microelectronics firms that sought cooperation on core design capability to help overcome resource limitations.[12] This was Canada's first such consortia and came a year after the US-based MCC initiative in Austin Texas. In their second year of operation, CSDA received a one time grant of $500,000 from NRC's IRAP program helping seed their cooperative work. In 1988, the provincial government stepped in with $22 million over five years, helping stabilize the initiative through the economic recession of the early 1990s.

Along with making each other's R&D results available to one another under CSDA guidelines, the consortium supported prototype work and some process development work, funding 50% of costs, with a remarkable degree of success. According to the director at the time, who kept track of sales records, CSDA had supported the R&D for products that would later go on to generate $490 million over ten years. CSDA is credited to having been very important to its members' survival during the recession by enabling them to continue R&D at a time of constrained revenues. By 2000, the consortium was folded into the Strategic Microelectronics Council (SMC), which was the first and only association to represent the microelectronics industry. Unlike the development-oriented CSDA, however, SMC was a policy and lobbying organization a broader representation beyond microelectronics manufacturing.

The associative dimension

The engagement of associations in the ongoing development of the knowledge and infrastructure of the region has been minimal. Both at the national and local level, associations have been either non-strategic, or simply, ineffective in mobilizing resources

in support of the needs of the local and national microelectronics industry. The one exception is, arguably, the eMPOWR initiative taken on by SMC. Faced with a significant shortage of skilled employees, SMC and its 42 members came together around a proposal to convince the federal government to triple the number of graduates and professors with the requisite skills in microelectronics, photonics, optoelectronics, wireless and radio engineering (MPOWR) to the sum of $480 million over five years (Barber 2001). In its largely unsuccessful efforts, SMC became absorbed into the much larger ITAC (Information technology Association of Canada) in November of 2001, deciding that it would benefit from the stronger voice of a larger association (Re$earch Money, 2001). Yet once a part of an organization with an even broader focus, the eMPOWR proposal was diluted significantly with a more generic lobbying position for investment in the university disciplines relating to the microelectronics and software sectors. Though the effort was successful in bringing new funding, the actual program was far from the strategic goals of the original proposal: a $1 million program administered through NSERC that would provide yearly support of a mere sixty students (ITAC 2002).

Apart from eMPOWR, which had been nurtured from within a much more specialized association, no other strategic initiative catering explicitly to the microelectronics industry has been successfully established. The two most influential national high tech associations, ITAC and CATA, have had essentially no major role in the strategic governance of the microelectronics industry either at the national or local level. With a national outlook and tradition of policy lobbying, these associations operate within the realm of framework governance, representing the high tech industry on a number of policy issues related to the federal regulatory context and which reflect the general interests of their diverse membership base.

Local associative system

At the local level, the collection of associations supporting the IT and high tech industry within the GTA is significant both in size and diversity. At the peak of the IT boom in 2000, one provincial official put the number at 18 to 25, 'depending on how you count them'. These associations carry out a range of functions from the bringing together of entrepreneurs and investors, as does the Toronto Venture Group through its various events, to education programs promoting careers in science and technology carried out by The Learning Partnerships. With a GTA focus, this program is one of several education related programs carried out by the Learning Partnerships which it administers through

partnerships with business, the education system and the community. The most directly relevant to the IT industry, however, are two regional high tech associations, the York Technology Association (YTA), founded in 1982, and the Mississauga Technology Association (MTA) founded eight years later in 1990. In addition to being among the longest running associations among the group, they also have the largest of the local associations with membership lists of over 150 and 100 firms respectively.

Yet for all such institutional development, the associations have not been able to integrate themselves under any one governance framework nor act as a coherent system of institutional support for the IT industry and technology sector more broadly. As with their supra-local counterparts, the dominant associations within the GTA, do not have a tradition of collaboration and have been unwilling to share membership lists. The effect has been a lack of support for a single voice for the region's IT industry, a lack of any strategic direction and a duplication of services particularly among the regionally focused technology associations.

Such fragmentation has been a frustration for both firms and the provincial government. In 2002, staff within the Ministry of Enterprise, Opportunity and Innovation (now MEDT) took the initiative to encourage consolidation among the associations by pushing for some form of federation or single organization. The effort, however, did not succeed. According to the senior official who led the effort, one association, Smart Toronto, had endeavored "to play a leadership role but no one wanted to give it to them."

Such 'jealousy at local level', as one association founder described it, has been only one mitigating factor in attempts to recast the associations into a more coherent system. According to one senior provincial official, industry for its part has typically not wanted any help apart from skills development, preferring tax cuts to creation of local infrastructure. These preferences have understandably been reflected in the agendas and programs of the associations that typically advocate for a similar set of tax related issues while doing little to engage members in a strategic planning regarding regional institutional development.

This absence of a 'can-do spirit' within the region's associations and the related inability to mobilize industry to strive for a higher degree of civic engagement is well demonstrated in the rise and fall of SMART Toronto, the IT association that represented IT industry and later multimedia, in the City of Toronto. When launched in April 1995, SMART Toronto had been designed as an 'implementing organization' and not simply

another policy advocacy and networking group. Indeed, it was given a clear mandate by its founding members, namely to give the 35 municipalities in the GTA access to the federal government's national broadband network, CANARIE. According to original plans of the federal agency, CANARIE was to bypass the city entirely, which alarmed many Toronto business leaders at the time, concerned as they were with the prospect of Toronto 'falling behind in the information age'.

SMART Toronto was not only successful in building a linking network that made Toronto a node in the national network, but it also established an InfoTech Centre for members to showcase their own network technologies, conduct meetings, participate in training seminars and conduct CANARIE-sponsored pre-commercial research on advanced communications technologies. As the only Toronto technology association, it was also considered an appropriate vehicle for promoting the strengths of Toronto's IT industry, an activity that was considered by its founders as crucial to the competitiveness of the industry. To this end, the association helped sponsor the first GTA wide report on the IT industry in 2000, called SMART Community, which advertised the many strengths, size and diversity of the IT industry helping support efforts to attract investment to the GTA.

In the technology enthusiasm of 2000, however, the association shifted its emphasis from the provision of physical infrastructure to the more traditional role among GTA associations of providing general services, particularly venture capital networking and more intangible goods such as a sense of community. This shift away from being an 'implementing organization', together with the high tech downturn in 2000, ultimately brought forward the end of SMART Toronto. In 2003 after a significant drop in membership revenue, the association's remaining members were absorbed into CATA, effectively disbanding the local focus and representation in the City of Toronto. In commenting on its collapse, one of its founders and former IT executive, noted that many firms can not see the benefits of associations and typically view any attempt to develop the IT industry and attracting firms as a risk to retaining their best employees. With local industry much more competitive than cooperative, there has been only a tentative engagement to the associations and generally low degree of civic engagement.

RECASTING OF ECONOMIC GOVERNANCE IN THE GTA: THE EMERGENCE OF A COMMUNITY CONSCIOUSNESS?

For all the discontinuity, competition and instability that has characterized much of the institutional supports at the local level in the GTA, there have been a few developments

within the past few years that suggest both a growing consciousness of the local governance space and its importance to knowledge industries, and an emerging strategic focus among a few local governance actors. Such awareness is apparent in the new breed of associations within the GTA, among departmental activities within the University of Toronto, and in strategic initiatives among some municipal governments. As with the local associative system within the GTA, however, these developments affect the microelectronics industry only within its broader relation to the technology or IT sector.

The new landscape of associative governance

One of the first institutional developments that has sought to strengthen the local economic governance capacity came in 1997 following recommendations from the Provincial governments' Greater Toronto Area Task Force Report (1996) published a year earlier. Along with recommendations on municipal amalgamation within the GTA, the task force recommended that a public-private economic development partnership be established to act as a single marketing body for the GTA. Such an organization would, in addition to international marketing, collect strategic economic data, develop a retention strategy and monitor the general performance of the region as whole thus help foster cooperation rather than competition that has been the prevalent mode of interaction among the five regions that make up the GTA. As one of its founders noted, the corrosive effects of regional competition had reached the point where, at a trade mission to Hong Kong in the mid 1990s, three delegations from each of the dominant regions in the GTA had showed up, 'baffling organizing officials' who considered them all to be apart of the City of Toronto.

The recommendation was acted on with the establishment of the Greater Toronto Marketing Alliance (GTMA) in 1997, which was tasked with coordinating and controlling, for the first time, the international marketing efforts of the region's 29 municipalities and regions. Not only was the GTMA unusual for its representation of all five regions, but also for its representation of three levels of government, private sector actors, and non-profit organizations. And, it was set up with a very specific mandate, namely to raise the profile of the GTA and recruit firms that fit the economic profile of the region.

With a budget of $2 million a year, approximately 60% of which is from government participants, the GTMA, according to one of its founders, is working but is struggling to achieve its goals. Though successful at preparing reports on the regional strength of its various economic sectors, the organization has not managed to develop a capacity to engage local firms as part of an overall retention strategy. This stems in part

from a lack of trust among some firms especially among those that do not desire competitors to locate within the region, and from jealousy among technology associations in protecting their contacts. The effect has been that the GTMA has yet to be seen as an industry partner in the region. Indeed, from interviews among IT actors, the GTMA has typically not been identified as a source of leadership for high tech industry, and among one prominent legal firm supporting the IT industry, its existence was unknown.

Despite these challenges however, the GTMA has been a milestone from the local economic governance standpoint. Prior its establishment, few private sector individuals and firms had been asked to participate in regional economic development, the result of which has been little private support for such efforts. As GTMA's first annual report notes (1997-98), for the first time the business community has become 'an equal partner with the public sector, to play a key role to promote economic development and to attract new international investors to the GTA'.

Another indication of the local institutional strengthening in the GTA came with the establishment of the Toronto City Summit Alliance. Perhaps no other organizational development in the GTA better reflects the developing awareness, and indeed the challenges, of associative governance at the local level in fostering an institutional capacity for knowledge industries. A coalition of some 50 civic leaders in the Toronto region, the Alliance was formed in 2002 largely from the initiative of its founder, David Pecault, a civic leader concerned with the many issues in the GTA, both social and economic, that were not being addressed effectively by any one group or level of government. With the help of working groups comprised of its members, the Alliance initially identified three 'implementation efforts' that would begin to address some of these issues, the most relevant to the high tech industry is a weak capacity to develop further the region's research infrastructure.

Though strong in research, the region's research institutions, according to founding civic leaders interviewed, have been notably inadequate in improving their leveraging of research through commercialization, attracting additional federal and provincial research dollars, and in cooperating with each other to coordinate R&D initiatives and help attract and retain leading researchers. In the words of one civic leader, " [the GTA] is the best example in Canada of neglect at the local level and showing what happens if the local level does not think of where it is going to go and get its act together."

To address these issues, TCSA created the Toronto Region Research Alliance (TTRA), and in so doing has become a significant advocate and actor for locally rooted economic governance within the GTA. Moreover, with an objective to build capacity and infrastructure in specific research areas relevant to the region's economic growth, it is one of the few actors with strategic planning intentions. In support of these efforts, the TTRA is working towards developing a commercialization fund with government and VC funding, assist in recruiting of anchor firms that complement the region's sectoral strengths, and promote increased government and private sector investment to 'help bring key projects in the strategic plan to fruition'(TCSA 2003).

Though it remains too early to assess the impact of the Alliance, or its stability as a governance institution for the region should current government support be withdrawn[13], its success in bringing together all levels of governments together with industry, universities and colleges for scheduled meetings is a notable achievement in itself. As one founder commented on past multilevel relations: "we have had dysfunctional relationships between three levels of government and this has seriously handicapped us. [From the standpoint of the province], Ontario has done less well in adapting to the normal complexities of different levels of government... It is a complex province, which does not present a single view… this provides a convenient excuse for the province [not to take leadership on issues]".

The University of Toronto

Though the University of Toronto as a research institution has not engaged the local industry in any strategic capacity, there is emerging interest and indeed initiative from professors within engineering departments in developing the institutional supports for the high tech industry. In the Department of Electrical and Computer Engineering, for example, a new goal of creating a culture of entrepreneurialism has been added to the department's strategic plan, complementing recently established seminars bringing local success entrepreneurial success stories to the students. Two other initiatives in this area include an annual workshop on the basics of starting high tech companies and the development of a new entrepreneurial course for 2005-06 that caters specifically to electrical engineering. As one faculty member noted, "there are professors who care about these issues in the department and so we do something about it."

The Department's activity highlights the complex engagement that the University of Toronto has with the GTA economy. As Canada's largest and one of its most prestigious research institutions, the University of Toronto's primary concern is with its research

reputation at the national and international levels and its role as a first class educational institution. The 1999 Report of the Expert Panel on the Commercialization of University Research, prepared by the federal Advisory Council on Science and Technology only emphasized the University's stance in this respect. The report provoked university-wide disapproval over its recommendations, one of which was that researchers identify 'innovation' as their fourth mission, in addition to teaching, research and community service, as a way of improve commercialization of federally funded research,

Yet the University does nonetheless present itself as an economic partner encouraging commercialization through its technology transfer office. Since the 1960s, for example, spin-off companies have grown on average, approximately 90% per decade, reaching a projected 75 new firms for the 2000s, according to its own brochure. In licensing revenue, the University has received more than $10 million from 2000 to 2003. Yet for all such activity, the University does not see a role for itself in the local context, preferring to view its economic activity nationally, and pursuing technology transfer efforts as a way of raising funds for its research goals and not to develop any industry cluster. For the faculty within the Department of Electrical and Computer Engineering, however, fostering a local microelectronics industry is considered an important goal. With all but one federal funding source (NSERC Discovery Grant) requiring an industry partner, the ability to engage local firms is a considerable advantage to their own research.

Municipal strategic engagement

As previously noted, municipal governments within the GTA have been largely inconsequential to the microelectronics industry having had little involvement in any strategic development of the knowledge infrastructure. Since the mid 1990s when the provincial government forced amalgamation of seven of the regions municipalities into one City of Toronto, much of its role has been defined by efforts to improve the competitiveness of industry in the framework sense of economic governance. Indeed, the amalgamation itself was done on these terms, with the province, under a newly elected conservative government, instituting several additional municipal reforms justified on competitive neoliberal grounds. In addition to cutting provincial transfer payments to municipalities, downloading the cost of several provincial programs such as housing and public transit, the province revamped several policy areas affecting municipalities including the deregulation of urban and development controls, loosening of employment standards, and establishing workfare (Kipfer et al., 2002).

While the City of Toronto continues to view economic development as a process to promote Toronto as an 'investment platform' for industry, there are activities to suggest that such a view is changing. The city, driven, ironically, in part by provincial downloading in the mid 1990s, has begun to consider a more active and comprehensive approach to economic development that includes a more targeted focus on particular industries. According to one economic development officer, there has been in effect a 'silent downloading' of economic development by the virtue of the provinces 'quiet withdrawal' from the area when downloading several of its policy portfolios to the municipal level.

The provincial downloading of programs was thus a transition for changes that have yet to be fully realized by the municipal government. "We have been turned into a province', commented one city official, 'which has given us a new voice in both federal and provincial policy.' One of its first experiences in this new role came with the national debate over bank mergers in 1999 during which the city was asked to give their opinion on the issue. According to the official, this was very much a maturing point for the city, for it was the first time that the city's largest industry, the financial services sector, engaged it on issues of its own competitiveness. "Our council at that time freaked. They did not know how to deal with it. It was very immature. Our city was not ready for those kinds of decisions even though the banks, government all wanted our opinion. This was a defining moment in looking at the potential at playing a greater role economic issues."

This shift to a more industry focused economic development approach was reinforced a year later with the release of 'Toronto Competes', a report initiated by the City's Economic Development Office and prepared by the American ICF Consulting group. The report for the first time examined Toronto's economy from a cluster perspective identifying ten such agglomerations. It also advocated for a more comprehensive approach to economic development highlighting the links between economic competitiveness and quality of life, and emphasizes the importance of neighbourhoods, housing mix, schools, and other human services to Toronto's long-term success. And importantly, it emphasized the importance of implementing strategic policies catering to business start-up and expansion and in supporting the institutional support for knowledge industries. "In the knowledge economy, investing in 'soft' infrastructure research, education, training and mentoring is also critically important. Building strong interconnected networks of people to advance technology transfer, design, e-communication, arts and culture is essential to developing a sustainable economy."

Emergence of integrated socio-economic governance in Markham

Despite such intentions, the City of Toronto has yet to make any significant headway in this direction. This is in contrast to Markham, the municipality to the north of Toronto and home to a significant segment of the GTA's high tech industry including ATI, IBM, Sun Microsystems and Surface Mount Technology Centre. Indeed, the City of Markham, self-described as Canada's high-tech capital, has been a pioneer in supporting the institutional development for its high tech industry on several fronts. Most notable is its strong support for the region's first 'floating advisory board' called the Innovation Synergy Centre (ISC) established in 2003. Though a non-profit, government funded organization, the ISC is entirely a private initiative staffed by experienced executives who offer advice to more mature firms – some 140 to date - on a wide range of issues related to management, government R&D programs, business monitoring, marketing and financing. ISC has established formal links with 10 organizations including the National Research Council, York University, YTA, CITO and Markham's Small Business Centre and Economic Development Office, in effect acting as a broker to the region's economic institutions.

Being a founding partner to ISC is the most recent effort by the City of Markham in transforming its attitude to economic development from a real estate approach of green fields and low taxes to a more integrated institutional approach that mobilizes the knowledge and infrastructural resources to achieve both economic and social goals. The most notable example of this 'joined-up governance' approach was in the city's engagement of IBM in its global search to locate its Software Solutions Laboratory. With no authority to provide IBM locational subsidies, the city suggested IBM consider a site next to its new energy venture, Markham District Energy, which would allow Markham to provide IBM with all of its heating and air-conditioning needs, at cost, in a twenty year contract.[14]

With this offer, together with federal and provincial support for their training and education needs, Markham was successful in securing an IBM facility with a global mandate in 2000, a goal that had eluded the federal government decades earlier with its 'moral persuasion' strategy. Moreover, given the efficient and environmentally superior production of electricity, heating and cooling offered by the new energy system, the City of Markham was able to combine its economic goals with its environmental objectives related to sustainable and efficient energy use. And with IBM as its first client, and Motorola its second, the city has managed to demonstrate the viability of a reliable and sustainable

system that is soon to support much of Markham's smart growth development while reducing green house gas emissions.

In the same year that IBM established its research centre, the city produced its first three-year comprehensive economic strategic plan that formalized this more integrated approach to economic development. Along with more targeted marketing, the plan articulates goals to develop high tech infrastructure with the assistance of associations, leverage major corporate investments, while maintaining a dialogue with the region's firms regarding their needs as well as the effectiveness of Markham's strategic programs. The plan also identifies the major challenges facing the region including traffic congestion and lack of a local university or college. In 2003, this latter concern was partially addressed by creating partnerships with both York University and Seneca College that would include in the running of the Innovation Synergy Centre.

A GTA model?

Despite evidence of more sophisticated actors and institutions catering to strategic mobilization of resources in support of high tech industries, it is still too early to assess whether a locally-based, integrated set of governance relationships can be spoken of in any meaningful way. There is nonetheless a network that does exist albeit with only weak linkages between the various nodes of actors. Metaphorically, the structure of governance is best likened to an archipelago, whose islands of cooperation are all engulfed in a thick fog that prevents them from seeing the collective whole. It is, for example, simply not part of the local consciousness to have officials with the City of Toronto meet with engineering professors within the University of Toronto to discuss their cluster strategy. Nor is there much of a shared understanding between the local financiers of high tech and the GTMA whose task it is to recruit firms internationally and promote local expansions. As for the firms themselves, they often do not recognize the link between their own performance and the local quality of life, or the potential of governments or associations to go beyond framework policies to improve the quality of the infrastructure.[15] And supra-local governments, for their part, are reticent to take on a leadership role that would concentrate investments in a particular region, an attitude best exemplified by the Ontario government's seed funding approach which allows it to invest in an ad-hoc manner only when approached by a viable project such as CSDA.

Yet for all such 'disconnectivity', it is possible to identify a few attributes of the strategic governance network that has, or is seeking to, localize investment in support of the

microelectronics industry and high tech more broadly. It has been undoubtedly multilevel, and yet with little institutionalization or coordination between levels. And remarkably it is been largely without a regional focus. Since the 1980s, the federal and provincial governments have developed similar programs, though without any regional design. In all but one investment, it was the actions of individual professors that made these investments strategic, first by localizing federal R&D dollars and second by putting proposals forth that would build up the knowledge base in microelectronics design. More recent developments, notably the synergy centre in Markham, suggest another localizing aspect with respect to determining the effectiveness of federal investments in deriving economic benefits. For it is typically local actors, such as those spearheading the Synergy Centre, who take on the responsibility for developing the supporting institutions for firm creation and growth which has shown to be especially important for early stage technology firms which are typically under resourced.

As new actors emerge, however, the GTA is in a position to establish a much more integrated governance network that could respond better to the industry's socio-economic needs. Though such a development may not appear all that important given the region's success, it will likely be essential to the industry's future competitiveness. As several noted in the interviews, there is a feeling that Canada's microelectronics industry is on borrowed time, with little signs that governments are interested in strategy development and investment at the level enjoyed by competing regions in the US, Taiwan and Japan, despite the federal government's much trumped up innovation strategy. As one prominent microelectronics researcher commented, 'the federal government has lost its focus – they thought microelectronics was done.'

With federal withdrawal from the strategic arena, the local level may become the best scale at which to formulate strategic plans that identify long term economic goals and commitments and which guides the development of the necessary institutional capacity to achieve such goals. With time horizons of up to fifteen years, it can be the most stable level of strategic economic governance, disassociated from political priorities and ideologies of senior levels of government. Also the local governance dimension will become all the more relevant to the extent that it shapes the local socio-economic environment, a factor that has become increasingly important in location decisions of firms and in the attraction and retention of skilled employees.

CONCLUSION

This paper has focused on the organizational structure of the decision-making that has brought strategic investment in the GTA region. By using the notion of strategic governance as a distinct category of economic governance, the analysis has attempted to capture the key actors and their interrelationships that have shaped the developmental trajectory of the microelectronics industry, giving equal consideration the different spatial scales. The GTA, it is argued, is possibly at a transitional point in its recognition of how the local level can be an important helping establish a local capacity in global knowledge intensive industries through strategic planning, capability building and in shaping the socio-economic environment in support of strategic firm recruitment and retention efforts.

Yet the analysis also points to another conclusion that is tangential to the objectives of the paper. This is the importance of past federal strategic initiatives in building up the regional capabilities in microelectronics. To be sure, many were failures from a business standpoint. However, when understood in the context of knowledge accumulation and learning, they were a success. Without early Defence department R&D efforts, without MIL and MDC, it is very unlikely that Canada let alone the GTA would have a microelectronics industry worth investigating. Indeed, it is remarkable just how rare such an industry is outside the US. In a 2003 global ranking of top fabless IC design firms, for example, there are only three countries with firms in the top 30: the US (20), Taiwan (6) and Canada (4) (IC Insights, 2004). This result is in no small way associated with the efforts described in this paper.

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Notes

[1] Robert Gilpin provides an illuminating account of the controversy surrounding Japan's economic development, culminating into the 1991 East Asian Miracle Project carried out by the World Bank which denied any strategic role in East Asian newly industrial countries. The countries, the report concluded, had simply got their fundamentals right, despite the report's own acknowledgement of effective state intervention. R. Gilpen Global Political Economy, 2001 Princeton University Press: Princeton, p. 323-326.

[2] An informal survey of the three services by the electronic Advisory committee revealed the concern that "Until Canada is equipped with a suitable computer centre, she will be obliged to rely upon foreign aid for many of the designs which require large-scale calculations. If it is agreed that Canada should be independent in this respect, then the time has arrived to initiate a computer centre in Canada.". cited from Vardalas, p. 22.

[3] The FP6000, which launched ICT's entry into the computer industry, became a considerable success and was later recognized as the first 'true time-sharing, multi-programmable computer on the world market'. Vardalas, p. 165.

[4] Protective tariffs of the National Policy of the turn of the century. By 1913, there were some 93 US manufacturing plants in Toronto alone, increased US investment in the form of American owned plants, built or acquired by takeover in response mainly to protective tariffs. Source: Historical Atlas of Canada, Plate 28.

[5] Celestica, Mitel and ATI Technologies were among some of the destinations for the ex CDC employees. At its peak, CDC Canada had 397 engineers and scientists working, a number which later fell to 125 with the termination of the PL-50 program. Vardalas, p. 269.

[6] Until ATI's innovation, certain computer applications such as spreadsheets, only worked with certain displays. At the time there were 4-5 graphics standards each supported by discrete chips.

[7] A part from ATI, the only other startup company affiliated with MDC was Semi-Tech, a company that focused primarily on computer assembly. The founder, James Henry Ting, had within a decade built Semi-Tech Group into one of Canada's fastest growing businesses and 10th largest employer in Canada acquiring some 120 companies mostly in East Asia. By 2000 however, the company collapse with some $2 billion in debt, making it Hong Kong's largest bankruptcy in history. See http://www.asianpacificpost.com/news/article/81.html

[8] According to one observer, without these programs, Nortel would have not been able to expand as fast as they did in Canada, which at one point was hiring half the graduates involved with CDC out of the University of Toronto.

[9] Micronet is accredited with 12 spin offs and is the most highly funded centre of all NCE programs with half of its 4.1 million annual budget coming from industry partners.

[10] Until the early 1980s, the Ontario government's main R&D support was channeled through its university programs and the Ontario Research Foundation, the latter of which was an independent laboratory established in 1928 in the GTA that offered comprehensive research and development capabilities in industrial technology to companies not large enough to have their own. The funding of the technology centres, under the Davis government concerned over the state of the economy's competitiveness, was thus a significant departure from past initiatives..

[11] According to one of its chip designers, Michael Cowpland, who later would emerge as an influential entrepreneur, it was terrible management that brought MIL down. "They put the wrong people in charge. They were going from a monopoly situation, where they were guaranteed a profit, to the world's fastest moving, most ruthlessly competitive, vicious industry… and they got take to the cleaner"(Thomas p.44).

[12] The five firms were Mitel Semicondcutor, Tundra (then Calmos), Zarlink, Mosaid and Gennum

[13] The TRRA is currently supported by corporate donations and seed funding from the Ontario Ministry of Economic Trade and Development and the National Research Council of Canada.

[14] The district energy venture was made possible by the passing of the Electricity Act of 1998 allowing municipalities to invest in certain energy related businesses.

[15] Such reluctance of Canadian business to accept a broader role for government has long been acknowledged by other observers including Atkinson and Coleman (1989) who argue that a firm centered culture has inhibited the development of foresighted industrial policy.

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