WORKING DRAFT

INNOVATION IN THE AUTOMOTIVE PARTS INDUSTRY:

A CASE STUDY OF THE WINDSOR-ESSEX REGION

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Introduction

In an earlier contextual paper (Fitzgibbon et al., 2004), we provided an overview of the structure and recent performance of the automotive parts industry in Ontario and discussed the major challenges currently confronting the industry. New investment during the 1990s totaling almost $20 billion, the development and uptake of new technologies, and the continued pioneering of new advanced manufacturing methods all underscore the fact that the automotive industry is just as important in the so-called "New Economy" as it was in the Old.

In 2002, the industry accounted for nearly 20 per cent of Ontario's GDP and employed close to 150,000 workers in vehicle assembly and parts manufacturing. The "automotive cluster" in Ontario is also highly significant within the broader North American economy as evidenced by a recent cluster mapping exercise conducted in Ontario by the Institute for Competitiveness and Prosperity (Institute for Competitiveness and Prosperity, 2002). The researchers in that study used the methodology developed by Michael Porter to map the 41 clusters he identified for the United States onto Ontario. The automotive cluster in Ontario ranked considerably higher than it did for the U.S. economy as a whole.[1]

We stressed that rather than being one coherent and homogeneous industry, the automotive parts industry consists of a number of distinct sub-industries that simply share a common set of customers. The various sub-industries exhibit significantly different

[1] At the provincial and state level, Ontario ranked third, behind only Michigan and Ohio, and at the Census Metropolitan Area (CMA) level, Toronto, Oshawa and Windsor ranked 2nd, 11th , and 14th respectively (Institute for Competitiveness and Prosperity 2002, pp. 35-38).

industrial organizational characteristics such as capital intensity, degree of technological complexity of products, and skill requirements.

Although the automotive parts industry in Ontario performed well during the 1990s, recent developments have significantly increased competitive pressures and uncertainties regarding its future. Principal among these have been the relative shift during the 1990s of vehicle assembly capacity from the Great Lakes region to the U.S. South and Mexico, the significant increase in the value of the Canadian dollar against the U.S. dollar since mid-2002, and, especially, the changes in OEM supply chain management practices.

Delimiting the "Ontario automotive cluster", either industrially or geographically, is not an easy or straight-forward exercise (see Fitzgibbon et al., 2004). While the Canadian automotive industry is heavily concentrated in southern Ontario, it stretches over several hundred kilometres and is a significant presence in a number of quite widely separated communities including the Greater Toronto Area (GTA), Windsor, Oshawa, Kitchener-Waterloo, London, Guelph, Stratford, Brantford, and St. Catharines. Furthermore, at a much broader geographical scale Ontario is part of a major trans-border "cluster" of automotive production that is centered on Detroit and includes southern Ontario and the states of Michigan, Ohio, Illinois, Indiana, Kentucky and Tennessee

Our ISRN study focuses on the ***automotive parts industry*** and the intensive interviewing phase of the project is centred on two sub-regional automotive parts "clusters" in Ontario; namely, the Windsor-Essex County area and the Kitchener-Waterloo-Cambridge-Guelph area. This paper draws on the results of our interviews in the Windsor-Essex cluster. We characterize the structure of the automotive industry in

this region and highlight the different forms that learning and innovation take in different segments of the parts industry. In particular, we focus on the automotive tool, die and mould industry (TDM) in Windsor-Essex. We demonstrate that this is not only an important and significant part of the automotive industry in that region but that it also exhibits many of the characteristics of a classic regionally embedded industrial cluster.

We estimate that there are approximately 250 establishments in the Windsor area engaged in tool and die, fixture, and industrial mould-making, the vast majority of which are linked to the automotive industry. Over the last two decades employment in this industry grew significantly, and Windsor achieved a global reputation for innovation and quality in automotive industrial mould-making. The initial formation of the cluster was facilitated by the arrival of skilled European immigrants, the presence of a large lead anchor firm, and public investment in technical education. Subsequently, the cluster grew through skilled workers acquiring training and knowledge within one firm and then leaving to establish a network of new enterprises. Today, informal and tacit knowledge flows between firms through the movement of skilled workers between plants and through social and family networks. Despite its previous success, the Windsor TDM cluster now faces some serious challenges.

The remainder of the paper is structured as follows. First, we provide a brief analysis of the structure of the automotive parts industry in Windsor-Essex drawing a distinction between what we label the "core automotive parts industry" and the TDM sector. We then trace the origins and evolution of the TDM cluster and discuss the form that innovation takes within that cluster. The paper concludes with an exploration of the

challenges currently facing the TDM cluster as a result of the restructuring of the automotive supply chain and changing assembler-supplier relationships.

The Structure and Composition of the Automotive Parts Industry in Windsor-Essex

The involvement of the Windsor area in the auto industry dates back to the first decade of the twentieth century.[2] For various reasons, defining the extent of the automotive parts industry poses a real challenge (see Fitzgibbon et al, 2004). It is not surprising, therefore, that estimates of the number of establishments and the number of workers that constitute the automotive industry in Windsor vary widely. For the purposes of this study we use a modified version of a database compiled by Bill MacArthur, the University of Windsor – IRAP Industrial Liaison Officer.[3]

Within the Windsor-Essex region, there are approximately 500 plants with production related directly or indirectly to the automotive industry. These plants, which employ over 48,000 workers, can be grouped into four broad categories according to their manufacturing outputs (Table 1)[4] – (i) assembled vehicles - a single plant owned by

[2] Although for the sake of brevity we will simply refer to our study region as 'Windsor' it includes not only the City of Windsor but those areas of Essex County adjacent to Windsor and including the communities of Tilbury, Wallaceburg, Oldcastle, Leamington, Tecumseh, Amherstburg, Maidstone and Kingsville.

[3] We are extremely grateful to Bill MacArthur for allowing us access to this database and for sharing his knowledge of the Windsor automotive industry. His help has been invaluable.

[4] Slightly more than half the plants could be coded into more than one subcategory. Among the plants that produce in more than one category, there are clear patterns of overlap between subcategories. For example, while there are 80 plants that specialize in moulds and 83 tool and die makers, a further 44 plants produce both products. There is also considerable overlap and connection between firms offering specialized engraving and polishing and those producing moulds and between tool and die makers and fixture makers. While plants producing metal and plastic automotive parts are sharply differentiated, there is significant overlap between metal parts, metal stamping and parts subassembly. It is fair to say, however, that automotive parts and automotive production goods are closely related but separate 'industries'.

Table1: Automotive Industry Related Establishments: Windsor-Essex County, 2003

Category[1]	No. of plants[2]	Percent of total	Employment			Avg. date of establishment
			Total[2]	Mean	Median	
Total	**504**		**48605**	**75[3]**		**1980**
Final assembly	1	0.2	11500	----	----	1925
'Core' Auto Parts						
Subassembly of Parts	27	5.5	9240	342	100	1976
Auto parts – metal	30	6.0	10899	363	118	1971
Auto parts – plastic	25	5.0	3768	151	86	1984
Stampings	35	6.5	4072	120	57	1972
Other auto parts	22	4.6	4811	209	86	1975
Machinery, Tool, Die and Industrial Moulds						
Tool and die	127	25.2	4429	36	23	1981
Fixtures	67	13.3	2610	39	26	1982
Moulds	124	24.6	6129	51	30	1983
Production automation/control systems/instrumentation	57	11.3	2739	49	31	1983
Engraving/polishing/detailing	26	5.2	461	18	11	1981
Design/prototypes/testing	97	19.2	5277	56	29	1981
Other production goods	105	20.8	3539	34	16	1980
Metal Processing						
Other metal fabrications	99	19.6	4346	45	18	1980
Metal treatment	17	3.4	848	50	25	1980
Other Production Services						
Sequencing/packaging/recycling	10	2.0	798	80	34	1965
Production consumables	14	2.8	445	33	14	1979

Source: Table derived from Database courtesy Bill MacArthur

[1] Subassembly includes everything from welding of several parts together to complete vehicle subsystems. Other auto parts is comprised mainly of producers of electrical parts and producers who did not specify which parts they produced. Production consumables include oils, fluids, cleaners, abrasives, chemicals and paints. Other production goods include complete production machines and goods which did not fit into other categories.

[2] Subcategories do not sum to total because plants were coded in all categories that applied. (883)

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[3] The average employment for all plants is calculated without the Daimler-Chrysler Windsor Assembly Plant.

DaimlerChrysler, (ii) components and automotive parts normally categorized by Statistics Canada as forming the core of the automotive parts industry, (iii) production goods such as machinery, tools, dies, and industrial moulds, and, (iv) metal fabrication and treatment. A further category of "service" activity includes sequencing and packaging and design, prototyping and testing, services that are often carried out in addition to a plant's primary production. For the purposes of this paper, we focus on categories (ii) and (iii).

'Core' Automotive Parts

Windsor has a broad range of core automotive parts plants tied to assembly plants in Windsor and nearby Detroit.[5] Metal stamping, engines and engine parts, and plastic parts stand out as the three most important automotive parts sub-industries in both Canada and Ontario with regard to employment and value of output (Fitzgibbon et al., 2004). All three are well represented in the Windsor area. The plants in this core group tend to be older, except for those producing plastic parts. They range in size from the very small to a large engine plant employing more than 2000 workers. However, the majority of these plants employ between 90 and 400 people. Ford has two engine plants and two aluminum casting plants in the city and GM operates a transmission plant. Many of the other larger plants in this group are owned by leading transnational parts makers such as Lear, Siemens, Magna, Krupp Fabco, Benteler, Flex-N-Gate, Autoliv, Nemak, and Woodbridge who are Tier 1 suppliers to the OEMs. Metal stamping has always been important and although the number of stampers in Windsor has shrunk significantly over

[5] Windsor itself now has just one vehicle assembly plant – Daimler Chrysler's Windsor Assembly plant A second DCX assembly plant – the Pillette Road plant which assembled full size cargo vans – closed in 2002 and plans to build a new flexible DCX assembly plant on a greenfield site in Windsor were cancelled.

the last decade there are still some important Canadian-based stamping companies such as the NARMCO group and AG Simpson.

Machinery, Tool, Die and Industrial Moulds

As soon as we began our interviewing in the Windsor automotive industry we heard what was to become a repetitive theme; the importance of the local tool, die and mould industry which is tied almost exclusively to the automotive parts industry. Over the last two decades, Windsor mould makers have achieved a global reputation for innovation and quality. While the TDM industry is rarely if ever included in discussions of the automotive parts industry in Ontario, people interviewed in Windsor automatically include it when questioned about the automotive parts industry and clearly view it as a very important aspect of the automotive parts industry in Windsor.

We estimate that there are approximately 250 establishments in the Windsor area producing machine tools, dies and industrial moulds, the vast majority of which are linked to the auto industry.[6] Although there are some plants with more than 100 employees, particularly among mould-makers, the TDM sector consists of mainly small plants with fewer than 50 employees (Table 1). Many of these plants are highly specialized, use highly sophisticated CAD/CAM capital goods and a highly skilled labour force. The ability to develop products from conception to use on the customer's production line appears to be a necessity for even the smallest plants.[7] Desrosiers ((n.d),

[6] Fo example, it is estimated that 80 percent of Canadian mould makers are located in Ontario with 50 percent of those located in Windsor (USITC 2002, p. 4-3). From our interviews with mould makers in Windsor it appears that at least 80 percent of their customers are in the automotive industry.

[7] Many of the establishments in the engraving/polishing/detailing and metal processing categories also provide specialized services to the TDM sector.

p. 82) reported that employment in the Windsor-Essex County machine, tool, die, and mould sector more than doubled between 1991 and 1999, increasing from 4,400 to 9,140. He states that the growing TDM sector in Windsor "… is not only a significant generator of employment in its own right, but also a power draw to suppliers of automotive aluminum, iron and magnesium castings, moulded plastic components and stampings. This has long been recognized by the Windsor-Essex County Development Commission, which has focused on MTDM [machinery, tool and die, and mould] as a cornerstone of its automotive business development strategy." (Desrosiers n.d., p. v). The TDM sector is an acknowledged technological leader and exports much of its production outside the region. Hence, it does not see its future to be linked so directly to the health of the local assembly sector as does the "core" automotive parts industry.

Innovation in the Windsor-Essex Automotive Parts Cluster

> … Windsor-Essex County is uniquely positioned within the automotive manufacturing belt of southern Ontario. Its location directly adjacent to Detroit gives local automotive suppliers unique access to OEM decision makers. Many industry observers and executives believe that Windsor-Essex County is the only viable Canadian location for automotive research and development (Desrosiers (n.d.), p. ix).

In this section, we draw distinctions between the sources of innovation in different segments of the Windsor automotive cluster: the Tier 1 and Tier 2 plants that comprise the core automotive parts segment of the Windsor regional economy;. the OEM plants belonging to Daimler Chrysler, Ford and GM; and the TDM sector. But first, a few comments regarding the generally low levels of R&D spending in the Canadian automotive parts industry.

Despite the emergence of a small core of globally competitive and innovative Canadian-based auto components suppliers, such as Magna, Wescast, Linamar and Woodbridge, it is estimated that only two per cent of Canadian auto parts firms have a strategy based on proprietary product technology, and overall research and development expenditures in the auto sector are less than half of the Canadian manufacturing average (Industry Canada, 1998).[8] Furthermore, while the absolute performance has improved, Canadian-owned automotive parts plants continue to lag behind foreign-owned plants in terms of productivity and wages (Holmes and Kumar, 2001). The general lack of automotive R&D activity in Canada is in part a legacy of the integration of the Canadian and US industries in the post-Auto Pact period when the Big Three automakers centralized R&D and design to the United States, particularly to Michigan and California (Fitzgibbon et al, 2004).

Our interviews support the view that there is not a strong knowledge-based innovation strategy amongst Canadian auto parts producers in general. Indeed, a former senior manager at a large Canadian-owned automotive stamping plant stated bluntly:

> There was no culture of knowledge development at the company level – only at the plant and very little exchange between plants. If you were innovative in the plant you were like a 'Skunk Works' since [you] didn't want to reveal how much you were spending to firm executives (Interview, Former Automotive Stamping Company V-P, Toronto, November 2002).

Until the last decade or so in addition to overall vehicle design the assemblers also undertook most of the design, development, and testing of parts. The suppliers only

[8] In a recently published list of Canada's top 100 corporate R&D spenders there was only one automotive parts firm – Magna International. Although Magna ranked second in absolute number of dollars spent on R&D in, 2002 this represented only 2.8 percent of revenue (Research Infosource, 2003).

carried out the manufacture of parts to the designs and specifications of the assemblers – so-called "build-to-print". As the expectation that Tier One suppliers will participate in vehicle platform development teams from project inception has increased, so has the R&D capacity of some leading Canadian suppliers such as Magna[9].

Given this context, what forms do innovation, learning and knowledge transfer take within the different segments of the Windsor-Essex automotive parts industry? Wolfe and Gertler (2003) identify two distinctive "models" of cluster development into which many of the ISRN case studies seem to fall; the regionally embedded and anchored cluster and the entrepôt type cluster. In the former:

> [W]hile global knowledge flows are certainly important to the competitive success of local firms, the local knowledge/science base represents a major generator of new, unique knowledge assets. Local universities and research institutes constitute an important part of this base as "anchors" that generate highly skilled graduates, spin-off start-ups, and new, publicly available knowledge …. In many cases, there appears to be one or a few "anchor" firms or lead institutions that play a critical role in these processes. (Wolfe and Gertler 2003, p. 28).

In the case of the entrepôt cluster, much of the knowledge base required for innovation and production is simply acquired through market transactions, often from non-local and even global sources. Even so, local institutions and actors still play a crucial role in enabling firms located within the local cluster "to exploit this knowledge effectively and combine it with other local assets and capabilities for success" (Wolfe and Gertler 2003, p. 29).

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[9] Desrosiers (n.d., p. 34) stresses that " … in-house design, development and testing facilities, and a sales office and/or R&D centre in Detroit are absolute requirements for parts companies wishing to function as system integrators and to be included on the teams". Interestingly, Frank Stronach, the founder and current Acting CEO of Canadian –based Magna International, now the fourth largest auto parts manufacturer in North America, recently stated that Magna will move its corporate headquarters from Aurora, Ontario to Michigan (Globe and Mail, April 2004, p. B1)

A variant of the entrepôt model probably best characterizes the "core" automotive parts industry in Windsor-Essex[10]. As noted above, first-tier suppliers, must now engage in innovation and R&D activity. However, since virtually all of the first-tier supplier plants in Windsor (Lear, Magna, Benteler, Siemens, Autoliv etc.) are embedded in large transnational corporations, much of the formal R&D activity takes place elsewhere within the corporate structure and, most often, in facilities located in Michigan or other parts of the United States.[11] Our interviews with OEM and Tier 1 auto parts plants support this view. While many plant managers refer to incremental innovation, particularly incremental process innovation, occurring within their own plant, most formal R&D and especially product deign and development is carried out by the company in other locations.

The focus on incremental process innovation is also very evident among the Tier 2 automotive parts plants due to the structure of the supply chain in the North American auto industry and the way in which OEMs control intellectual property and value price reduction:

> [T]he car companies ultimately determine successful intellectual property, which is evident to the extent that it is incorporated into vehicle designs. Relatively few companies are rewarded for a strategy of original product development. In contrast a company being perceived as being a low cost, high quality "build-to-print" supplier is always valued – products at a lower price is the prime competitive requirement in the industry. Consequently most Canadian parts manufacturers are necessarily more concerned with developing process productivity improvements, rather than speculative product development or applied R&D (National Forum on Automotive Innovation and Investment, 2002, p.5).

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[10] We say "variant" since the knowledge base in the Windsor-Essex core automotive parts industry is gained not through strictly market transactions but rather through intra-company and OEM-supplier knowledge transfers.

[11] The state of Michigan claims that over 85 percent of all U.S. automotive R&D is concentrated in Michigan (Automotive News, April 19 2004, p.26G).

The relative importance of incremental innovation over formal product R&D means that automotive parts firms in the Windsor area rely heavily on the tacit knowledge of their workforce for product and process improvement. However, during the 1990s, outside of a handful of large and mostly unionized component manufacturers, available evidence suggests that investment in training and other human resource strategies remained a relatively low priority for automotive parts makers (see Canada Consulting Cresap, 1991; Paget Consulting Group, 1996). As such, automotive parts producers have relied on the public secondary and post-secondary education system for skill development.

In an effort to foster collaborative R&D with the Big Three and establish Windsor as the "Automotive Intellectual Capital of Canada", the University of Windsor has established several research centres and Industrial Research Chairs linked to automotive engineering over the last ten years. However, the University's collaborative research efforts are largely geared to the OEMs and the plant managers we have interviewed in both the "core" automotive parts sector and the TDM industry in Windsor have made only the occasional reference to the role played by the University of Windsor in the automotive parts cluster.[12] In contrast, they have frequently stressed the importance to their companies of the pool of well-trained skilled production workers produced by St. Clair Community College and, in the past, area technical high schools.

The structure and organization of the TDM sector in the Windsor-Essex County region is very different and, as we shall show in the next section, in some respects

[12] An exception is Nemak which produces aluminum engine blocks for Ford engine plants. An industrial chair in materials science at the University of Windsor is linked to Nemak.

resembles a classic, regionally embedded cluster. However, innovation in the TDM sector is also mainly incremental.

The focus on incremental innovation across most of the automotive parts industry in Windsor-Essex was reflected in the interviews with local officials who administer both the IRAP program and the Scientific Research and Experimental Development Program (SR&ED) administered by the Canada Customs and Revenue Agency (CCRA)[13]. While the tax credit program has been available for over 20 years it is clear that recently it has been playing an increasingly significant role in subsidizing the innovation being undertaken by Windsor automotive components firms. It is estimated that over 200 automotive parts firms in Windsor have now utilized the SR&ED program and that participation in the program has grown by 30 percent over the last three years. It was stressed to us that most of these credits went for incremental process innovations undertaken by small- to medium-sized firms rather than to innovations resulting in patents:

> We are not seeing claims for research, but for development and product and process change—incremental advance is OK (Interview, CCRA Official, Windsor, 6 October 2003)

> Q: What ballpark percentage of firms, in your opinion, is doing pure R&D, and who are qualifying for a tax credit?
> A: In terms of pure R&D: 10%, if that. Qualifying for R&D from the Tax Act: 80%-85%. The R&D incentives are administered through the Tax Act. Our office has a pretty large practice in terms of R&D and it is used pretty extensively. …. It is for those

[13] The SR&ED program is a tax credit program that allows Canadian-controlled private corporations to receive tax credits of between 20-35% for eligible expenditures incurred in R&D related activity that "will lead to new, improved, or technologically advanced products or processes." The credits can be carried forward to offset taxes on profits for up to seven years. The program is the largest single source of federal government support for industrial research and development. An important point to note in the context of a later section of the paper is that one effect of this program is the formalization and codification of what formerly were largely tacit incremental changes.

> marginal technical improvements that if you can make them qualify and if you are going to spend the money anyway, then make your claim and get some of your money back. Ontario has a very strong R&D credit arrangement – it is probably the best in the world – and it certainly is pushed forward by the local government office (Interview, Senior Partner, Tax Consultancy, Windsor, 11 August 2003).

While growth in the uptake of the tax credit program is due partly to the CCRA raising program awareness among firms, it also reflects the restructuring of the automotive supply chain and the recent slowdown in the industry:

> the Big 3 right now are pushing a lot of the R&D down the line –and as a result of that –the Tier 1s are pushing the Tier 2s and they keep pushing as well. So its no longer the case where the guy at the end of the line gets a drawing and he exactly makes exactly to that drawing. They are usually given, "This is the space you have got –this is what it's got to do-please develop this for us". So definitely that's a part of the reason as well – and another reason as well is that especially in automotive when things get slow – we tend to see a rise in our claims - because. …instead of laying people off they push their resources to R&D (Interview, Federal Government Official, Hamilton, 27 November 2003).

The important points about the SR&ED program are that it recognizes the importance of incremental innovation and that, in the process of documenting the innovation to claim the tax credit, firms effectively codify knowledge which formerly may have remained tacit.

The Windsor-Essex Tool, Die and Industrial Mould Cluster

The remainder of the paper focuses almost exclusively on the TDM cluster. In the next section, we describe the origins and evolution of the cluster and discuss the process of incremental innovation within the cluster. In the final section, we discuss some of the challenges now facing the cluster.

Origin and Evolution of the Cluster

> Many expressive words can be used to describe Windsor mould makers. Workaholic … ultra competitive … secretive … egocentric … eccentric… fiercely independent … scholastically uneducated … jet setter … rich… extravagant. But two words sum them up. THE BEST (Halberstadt, 1990, p. 8).

The Windsor-Essex mould making industry has developed over the last forty years and now consists of a dense network of over 150 small and medium sized firms many of which were spun-off from a large anchor firm that no longer exists. Many of the firms are highly specialized, privately owned by self-made entrepreneurs with little formal education but strong skilled technical backgrounds, and employ highly skilled mould makers who earn high wages in non-union shops. A recurring theme is that "most of the [mould] shop owners are not trained business men. They learned to run a business as a result of being good mould makers" (Halberstadt, 1990, p.14). While there is little formal cooperation or information sharing among these highly competitive firms, there nevertheless appears to be a significant amount of informal knowledge that flows between firms through the movement of skilled workers and through social and family networks. Most innovation appears to be incremental and to originate from the skilled workers on the shop-floor, rather than through more formal R&D activities. Although initially built by and with skilled immigrant workers, the industry now relies heavily on local secondary educational institutions and the community college to provide the necessary supply of skilled labour.

In relation to the formation and growth of the tool and mould industry in Windsor, virtually all interview respondents stressed the critical role played by one company - International Tool Limited (ITL) - and its founder Peter Hedgewick. International Tool

no longer exists but some people estimate that as many as 80% of the current mould shops in Windsor trace their roots back directly or indirectly to ITL. Hedgewick left one of the local area technical schools, Walkerville Technical School, in 1936. After a brief spell working at Chrysler, he took an apprenticeship at Standard Machine and then took a job at Windsor Tool and Mould (Halberstadt 1990, p. 11). When he started work there in the 1940s, Windsor Tool and Mould specialized in producing moulds for toys and Hedgewick started to pick-up a lot of tacit knowledge about working with plastic. In 1944, he left Windsor Tool and Die and set up ITL in a two-car garage to make moulds for plastic toys. Over the next 40 years, ITL grew to become "the largest independent tool shop in the world" employing over 800 people producing moulds and tools, mainly for the automotive industry. Labour-management conflict led to problems at ITL and in 1987 the company was taken over by the Ventra Group and Hedgewick was forced out of ITL. Ventra closed ITL shortly thereafter. [14]

In the late 1940s, Hedgewick recruited skilled workers from war-ravaged Europe, who then trained scores of skilled mould makers at ITL. In turn, many of these mould makers later left and went out to start up their own mould shops (Figure 1). The cluster expanded rapidly after 1970 (Table 2). By 2000, the Windsor area was the leading TDM cluster in Canada with over 300 firms, representing 20 per cent of Canada's tool and die makers, and 50 per cent of all industrial mould manufacturers. More importantly, the region had developed a world class reputation for mould design and quality (DesRosiers, 2002).

[14] Hedgewick, a self-made man with little formal education, is quoted as saying "After the PhDs took ITL over it became a nothing!" (Halberstadt 1990, p. 11). In the same article another self-made mould maker, Ed Bernard, states "Mould making is not something you get into if you're not smart enough to be a dentist". On a number of occasions in our interviews with mould makers and tool makers we have encountered a similar scorning of formal academic education.

Table 2: Date of Establishment of Tool and Die and Industrial Mould Makers Present in Windsor-Essex in 2003

Decade Plant Established	Tool & Die Makers	Mould Makers
Prior to 1950	4	0
1950-1959	7	4
1960-1969	11	12
1970-1979	27	29
1980-1989	35	35
1990-1999	37	37
2000-2002	4	4

Source: Table derived from Database courtesy Bill MacArthur

Learning and Innovation in the Cluster

Innovation in the TDM cluster has been primarily incremental and largely dependent on tacit knowledge. Certainly, local high schools and technical education centres are acknowledged as playing an important role in the cluster's formation with entrepreneurs and skilled workers gaining basic formal knowledge in aspects of machine tools and mould making. However, the development of the cluster was principally a function of tacit knowledge being acquired by a worker at one firm who then either left to work in another shop or branched out on his own. ITL was acknowledged as a critical learning site for such skills. One mould maker stressed the role of skilled European immigrants in the early days at ITL:

> [T]he best part of it [ITL] was in this engraving room we were in - we had some of the top engravers from Germany, from Holland. These were immigrants after the war ….those were the guys that trained us. When Pete [Hedgewick] had the business he would go to Germany ….he literally found the best that were in that trade and brought them over. They ended up training the Canadians here who picked it up. You couldn't have asked for a better training ground (Interview, Mould Maker, Windsor, 13 August 2003).

This process of skilled workers effectively spinning off one from the other continued to play a key role in the development of the cluster in the 1980s and 1990s. One respondent described this process:

> There are a lot of mould shops which started off because a guy working in a shop decided to try it himself. So he gets a small shop and gets some machinery and he can get some work as a subcontractor. He makes some money and he borrows to get some more equipment. So he might have worked in a shop that had forty or fifty people , and 5-6 years later he had twenty or thirty of his own (Interview, Senior Business Advisor, Ontario MEOI, Windsor, 13 August 2003).

The constant churning in the local labour market caused by skilled workers moving between different employers is another important mechanism by which knowledge gets transferred and built upon between mould shops in the cluster. As one mould maker put it:

> If there 's a 100 shops here - employees –you know-move from one shop to another…they are taking trade secrets with them. Now you can look at that in a negative sense but you can also say that the [new] employees that we are hiring will all have the benefit of the knowledge pool … my new employee to me will be a benefit to me just like the guy I lost will be a benefit to one of my competitors. The synergy there is something that's really difficult to measure …but easy to imagine, because every time someone may move ..they have a new potential for learning ... because of the different environment ..that's something that a college can't provide. You know, in a town that has only say two different shops to go one from the other - you are not going to get that overall increase in not just…….knowledge but confidence to attempt to do new things (Interview, Mould Maker, Windsor, 8 October, 2003).

The Windsor TDM cluster benefited from the strong informal social and familial networks existing in the local labour market. These networks were both a cause and consequence of the spin-off of new firms and the movement of skilled workers between mould and tool shops. With a population of slightly over 300,000, Windsor is small enough that many people in the area have at least some connection with each other. Many

respondents remarked about how well-developed such networks were and how they were the product of often shared ethnic origin (there is a large Italian population), common secondary school education and then similar subsequent work experiences in the automotive assembly or parts industry. One respondent spoke of an "incredible competitive intelligence in the area", which meant that "if you were from this region and I had a conversation with you, by tomorrow morning half of Windsor would know about it" (Interview, Senior Business Advisor, Ontario MEOI, Windsor, 13 August 2003). Another likened these relationships to "a network or brotherhood, they have all grown up together and they know who is in the business" (Interview, Manager, Machine Tool Firm, Windsor, 13 August 2003).

There is a formal trade association that represents mould makers. The Windsor Association of Mold Makers (WAMM) was launched in 1982 and eventually became the Canadian Association of Mould Makers (CAMM). However, participation in the trade association has always been mixed with some major Windsor mould makers not joining. The strong, and often acerbic, personalities among some mould shop owners, as well as grudges dating back to when they worked together at ITL gave rise to tensions within WAMM some of which still persist today (Halberstadt, 1990, p. 12). While the trade association reinforces some of the strong informal links, most respondents considered the informal networks to be much more significant in the formation of local social capital.

The strength of these informal networks was considered by at least one mould maker to be a source of competitive advantage to the region through the sharing of capital equipment between competitors:

> There is a lot of capital equipment we don't have to invest in. We invite time on other people's machines so there is potential for sharing that kind of capital cost. It goes on a lot, perhaps even to the level of global uniqueness, because we found that the American firms we deal with are amazed [by it]. In Windsor, it is nothing for us to call up someone to compete even with our own customers and say, "Can you ruffle this block or wirecut this?". The relationship is not adversarial. ..we can advance our technology by using our neighbouring shops advanced technology rather than investing in the whole package ourselves (Interview, Mould Maker, Windsor, 8 October, 2003).

By being able to build on the networks and the tacit knowledge of their skilled employees, the Windsor TDM cluster has been highly successful without a high level of investment in formal research and development or patenting. Interviewed provincial and federal government officials involved in administering R&D support programs stated that the cluster had produced relatively few patents or "world first" innovations. A local financial analyst who works with many TDM firms stated:

> I'm not aware of any world class innovations in terms of parts. Certainly, margin is the big word: you don't hit homeruns and if you do it takes you ten years to do it – it's incremental (Interview, Senior Partner, Tax Consultancy, Windsor, 11 August 2003).

A tool and die manufacturer stressed the importance of the cumulative nature of informal learning to the innovation process:

> From project to project we try and learn and we are mandated by our customers to integrate automation into the builds of dies, so we are driven that way. We have developed stuff, but we never approach it from patenting (Interview, Tool and Die Manufacturer, Windsor, 13 August 2003).

Given the nature of the supply chain in the auto industry many innovations tend to be customer driven, yet almost all respondents emphasized the role of internal tacit knowledge as a critical source of ideas and innovation. The relatively small size of the

TDM shops and a high proportion of skilled workers make informal knowledge development an important strategy. One respondent estimated that “80 per cent of the products is the result of our own initiative – we have replaced almost all of our products over the last 2-3 years through innovations” (Interview, Machine Tool Firm Manager, Windsor, 8 October 2003). A mould maker emphasized the iterative nature of innovation between customer needs and the expertise of the mould maker:

> It’s the guts to try something different. We quote a job and we get some feedback about what it’s being quoted for and we hear it’s being quoted for $50,000. And we ask if they would consider me building this another way, and I think I can build it for $40,000. So there is some design innovation there saying I think I can do just as good a job and it won’t cost you as much. That has something to do with it. Then there is the ability to try something. We have gotten some R&D credits on some of the work we have pulled off. We have done some jobs that the plastics manufacturers say, “You can’t do that.” And we ask, “Why not?” And they say, “Well, those two pieces just won’t melt together” and we suggest putting a third material between the two and we can get these two things to melt together. You come across these little innovations. You run up against a stumbling block and you find a way around it (Interview, Mould Maker, Windsor, 13 August 2003).

In summary, the Windsor TDM cluster owes its development to a combination of a favourable location, the role of ITL in the early formation of the cluster, and the way in which firm spin-offs and the transfer of tacit knowledge between plants has fostered innovation. The presence of good basic technical education through the secondary schools and the local community college has been important. Tacit knowledge development, however, appears to have been crucial to the largely incremental system of innovation in the cluster.

Challenges Facing the Windsor-Essex TDM Cluster

Although the TDM cluster prospered during the 1980s and 1990s when profit margins were high, changes in the last five have had an increasing impact on the Windsor MTDM cluster. In an earlier paper (Fitzgibbon et al, 2004), we discussed a range of issues facing the broader automotive parts industry in Ontario. Some of these issues, such as the loss of market share by GM/Ford/Daimler Chrysler and the southward shift in the centre of gravity of North American vehicle assembly capacity, are clearly of crucial importance to the core automotive parts plants in Windsor Essex, which are highly dependent on their close proximity to Big Three assembly capacity in the Windsor/Detroit region. The situation with regard to the Windsor TDM sector is somewhat different. It is an acknowledged technological leader within North America and internationally and exports much of its production outside the region[16]. Hence, the cluster does not see its future to be linked so directly to the health of the local assembly sector as does the "core" automotive parts industry.

Perhaps the greatest source of uncertainty with regard to the future vitality of the broader automotive parts industry has been generated by the OEM's focus on cost-cutting across the supply chain and the associated changes in assembler-supplier relationships (Fitzgibbon et al, 2004). These changes have left many parts companies scrambling to redefine their role in a rapidly changing industry. In virtually all of the interviews conducted with plant mangers in Windsor, supply chain issues have been the greatest concern. This is true of both the core automotive parts sector and the TDM sector. In the latter case, we find that the greater financial power of OEMs and first-tier suppliers

[16] A number of our mould and tool maker respondents estimated that no more than 10 percent of their output went to customers in the immediate region (Windsor/Detroit). Mould were being supplied throughout North America and overseas.

means that smaller but highly skilled and innovative mould and tool suppliers are increasingly being squeezed with respect to product pricing. At the same time, their tacit knowledge and innovative capacity are being appropriated and utilized by the OEMs, often without due recognition of the suppliers' intellectual property rights. Here we focus on how these and other changes related to technological change and the availability of skilled workers are threatening the future vitality of the TDM cluster in Windsor-Essex.

One of the most important changes with regard to the TDM industry has been a significant increase in global competition driven largely by the emergence of China as a low cost producer. While still lacking the sophistication and creativity in tool design to design and produce high precision complex machine tools and moulds, China is rapidly moving up the value chain with a low cost, well-educated labor force (United States International Trade Commission, 2002, p. xviii). Moreover, by running machinery 24 hours a day, seven days a week, delivered prices are 30-75 per cent below those of North American producers. However, even more significant is how the OEMs are using this increasing global competition in the MTDM sector in the re-shaping of their supply chain practices. The Big Three OEMs are becoming more aggressive in demanding annual price cuts from their suppliers. Suppliers are expected to achieve cost savings by re-engineering components, finding cheaper material, or coming up with simpler designs. Similar pressures are also being experienced by the suppliers of tooling to the automotive industry. As one mould maker pointed out supplier prices are increasingly measured against 'world prices' (usually meaning China) for an equivalent product:

> Price being the almighty thing in quoting today, forgetting that you got thirty years of service on your last job, price seems to be the deciding factor that purchasing agents are going for today. I'm talking about a world price. It's a world price that we have to match (Interview, Mould Maker, Windsor, 13 August 2003).

Mould makers interviewed in Windsor are also concerned over cash-flow problems and issues related to intellectual property rights resulting from the changing practices of OEMs and first-tier suppliers. The design, engineering, testing and production of some moulds can take more than a year to complete and cost upward of $1 million. Historically, the mould maker would receive part payments from the customer at a number of different times during the production of the mould, which helped defray product development costs. Now, the mould maker is often forced to wait until the mould has actually gone into production at the customer's plant before receiving any payment[17]. Since the vast majority of mould makers Windsor are small to medium sized enterprises with limited external sources of financing, this change has created serious cash flow problems.

Although the Windsor mould makers are highly skilled, innovative, and regarded as North American leaders in their industry, until recently there was limited formal patenting activity since the ownership of intellectual property was not a major concern and the patenting process was expensive. Mould makers are now concerned that customers are increasingly using the expertise of mould makers in Windsor to design and engineer the mould and then giving that intellectual property to companies in Asia, and especially China, to produce the tooling at lower cost. As one mould maker described:

[17] The practice now is for no payment to be made until the supplier delivers the mould or machine tool to the customer's plant and the mould or tool is run successfully for at least 24 hours. In the industry this is referred to as Process Part Approval (PPAP) and was mentioned frequently as a problem in our interviews.

> [I]n a lot of cases our customers are now taking a lot of our intellectual property and giving it to our competitors to see what they can build it for. And the competitors in many cases, especially the offshore ones, have not made the investments … and not paid for the experience that has created the innovation. There is only a real short term benefit [to the customer] because you know - when you cut the main artery it is not going to be long before there is no more flow there. I heard of one case just recently … the business owner said that they had just got a $50 million contract from GM on a stipulation that … half the work be done with the sharing hired partner overseas. So … after doing that, and spending about $400,000 of design work, GM brought the purchase order, paid them a cancellation fee for the design work - and it all went to China (Interview, Mould Manufacturer, Windsor, 8 October 2003).

Mould makers point out that should this trend continue, it will significantly undermine the innovative capacity of the mould making industry in Windsor since so much of the expertise and innovation in mould making arises from the hands-on experience of highly skilled production workers. The present over-capacity in the cluster means that TDM firms are not in a strong bargaining position to resist OEMs downloading development costs and appropriating intellectual property from their suppliers. As one tool maker stated:

> We went to a meeting with one of our largest customers in Detroit, 15 tool shops in the room, and the buyer said, "Well the industry has matured to the point that you know that we're not going to be putting dates on our purchase orders for PPAP. You guys understand that?" Do you know how many people complained? Nobody. With an over-capacity and such a competitive situation in the industry right now, nobody would dare bring it up (Interview, Tool and Die Manufacturer, Windsor, 14 August, 2003).

However, many firms within the TDM sector increasingly are becoming more protective of their knowledge and are seeking new ways to codify and protect their intellectual property without having to resort to expensive and time consuming formal patenting. A number of leading TDM firms in Windsor recently formed the Initiative for Automobile Innovation (IAI) to lobby government to not only better protect their

intellectual property from the OEMs, but also to develop a new institutional framework in which new ideas can be developed. As one respondent argued:

> There is a lot of brain drain from Canada to the US and technology drain going to Asia as well and [the IAI] would be the way to control and stop it. We are hoping that it would create an environment of trust and reputation where if I have an idea, rather than worry about the corporate world stealing it from me and abusing me and leaving me with nothing, I can bring it here and it can be assessed and developed and I can have a stake in it – a piece of the action (Interview, Mould Maker, Windsor, 8 October 2003).

The net result of the pressures to simultaneously reduce prices and absorb greater costs has been a decline in profits and significant changes in the nature of the TDM cluster.[18] Several respondents noted that, as profit margins had tightened, the number of spin-off companies had declined significantly and with it a reduction in the transfer of tacit knowledge between different work sites (Interview, Senior Partner, Tax Consultancy, Windsor, 11 August 2003; Interview, Senior Business Advisor, Ontario MEOI, Windsor, 13 August 2003).

Furthermore, this is occurring at a time when many of the initial generation of entrepreneurial, skilled workers who founded and built the highly successful mould making industry in Windsor are nearing retirement. Many of the companies that they founded remain privately owned and it appears that relatively little succession planning has taken place to ensure that these companies will continue to flourish and prosper once their current owners have retired. Some are cashing in by selling their multi-million dollar assets to financial capital which has little knowledge or interest in developing the

[18] According to one local tax consultant "the margins in this area [TDM] used to be 45 percent, now they are down to 22-24 percent" (Windsor Financial Analyst, 11 August 2003).

business. Thus, respondents noted a significant decline in the number of local tool and die firms since the late 1990s. These developments led one interviewee to remark:

> The business model is broken. Previously, MTDM was a craft industry. The ability to engineer, design and build tools was the formula for success. But now in a market characterized by hyper-competition and over-capacity, business strategy is becoming a more important success factor. I'm not sure how well equipped the small operations are to deal on a new playing field (Interview, Windsor City Official, 11 August 2003).

Another major issue for both the automotive tooling industry in Windsor and the larger, more innovative parts makers is the supply and retention of skilled workers. A recurring theme in many of the interviews is the poaching of workers in the skilled trades. After being trained in the tooling and mould shops and the auto parts plants, they are either lured away by the prospect of higher wages and greater job security offered by the Big Three plants in Windsor or by higher paying jobs across the border in Michigan to which they can commute. There is also an issue with regard to changing levels of skill and, more importantly, experience. Some argue forcefully that as a result of the use new advanced manufacturing technology, knowledge that was previously tacit and gained through hands-on experience is becoming codified within CNC machines and CAD/CAM systems and this is leading to a diminution in the innovative and problem-solving capacity of mould and tool makers. While tacit knowledge remains significant to the efficient operation of the technology, the latest technologies incorporate a high degree of the discretionary skills formerly needed by skilled workers. Thus, new CNC technologies reduce the amount of hand finishing needed for products, allow for gauging and compensation for tool wear, and reduce the overall time required to develop a sufficiently

skilled workforce (United States International Trade Commission, 2002, p. 2-5, 2-6).[19] A number of MTDM respondents commented on how tacit and codified knowledge was being reconfigured with the adoption of new technology. For example:

> It [tacit knowledge] was more important in the past when it was largely a skilled artisan driven craft. That's changing. The CAD/CAM revolution has changed a lot of that. We can now machine very close tolerances. We have five-axes capability. The amount of polishing that's required is much less… some of the know-how that becomes more important is making sure that the designs that are coming out of engineering are actually doable… something may look good on paper, but when you try to put it into practice you are going to have all kinds of problems – poor steel conditions, those sorts of things. So there is a role for it [tacit knowledge]. It's something that we continuously try and marry - the skill set and knowledge that's on the floor with the guys that are in engineering. (Interview, Mould Plant Manager, Windsor, 14 August 2003)

> The black magic that was needed to make a mould function, there is still little processing techniques, secrets, know-how that they bring to the party. But this is basic science and physics. There isn't anything that goes on in that mould or that stamping die that couldn't be defined with an equation. People don't want to accept that. They still want to think of it as that old black magic, that art, that "only I know how to do it." There is still some of that. It's more in the processing. (Interview, Mould Plant Manager, Windsor, 14 August 2003)

> The craftsmanship is being diluted. Troubleshooting, and the concept of machining – how things need to be done. They know how to do it mechanically – program this in, this file goes in. But if something happens, what do they do next? (Interview, Plant Manager, Tool and Die Company, Windsor, 13 August 2003).

The imperative to purchase new technology has also significantly raised the costs of entry to the industry since the real costs of acquiring start-up technology is now much higher than 20-30 years ago (Interview, Mould Maker, Windsor, 13 August 2003). Increased

[19] The US ITC study reported that previously it took a 5 year apprenticeship plus 5 years of work experience to produce a fully skilled toolmaker. Now, a tool and die trainee working with the latest technology can acquire 70 per cent of the skill-level of a traditionally trained toolmaker within 2 years although for high precision tool and die production 6-7 years experience might still be required.

capital needs, current overcapacity, and lower profit margins have combined to reduce the rate of new firm formation and the overall number of learning sites for employees in the TDM sector.

Conclusion

In this paper we have focused on the structure of the automotive parts industry in Windsor – Essex and the nature of innovation in the industry. We have stressed the importance of the automotive machinery, tool, die and mould industry to the Windsor regional economy. Within the automotive industry, the Windsor-Essex TDM industry is recognized as a dynamic world leader. However, it tends to be overlooked by most academic writers and commentators on the automotive industry. Members of the industry in Windsor–Essex certainly feel that the industry is not well understood by government policy makers.

We have highlighted significant differences in both industry structure and the nature of innovation between the TDM sector and what we call the core automotive parts segment of the regional economy. Many of the plants in the core automotive parts segment belong to large transnational corporations and are closely tied to the OEM assembly operations in the broader Detroit/Windsor area. The future size and vitality of this segment of the industry depends largely on the extent to which Canada remains an attractive place to invest and on the region's ability to attract new assembly investment (Pilorusso 2002). There is some linkage between research at the University of Windsor and the OEM plants in the area, especially with regard to Daimler Chrysler and the Ford aluminum engine casting plants. However, most of the core automotive parts plants in the region acquire knowledge either through intra-firm transfers from their own corporate

product research, design, and development engineering facilities in the United States or Europe or from the OEMs. At the local plant level, innovation tends to be incremental and focused on cost reduction through process improvements.

There are a number of smaller and locally-based Tier 2 parts suppliers who are under tremendous competitive pressure. Much of this pressure comes from the supply chain management practices of the OEMs and Tier 1 suppliers, especially as a result of the price squeezing that has become so prevalent in the last few years. It is telling that Windsor has lost a significant number of Tier 2 stamping plants in recent years. For decades these suppliers have relied on their links to the Big 3 automakers in the Detroit/Windsor region. Many of the Tier 2 parts makers tend to be somewhat parochial and are experiencing great difficulty in adjusting to the changed competitive environment in the industry which demands a more international outlook. As the European-born and educated manager of one automotive parts firm that is actively pursuing new opportunities in China put it:

> for us, there is more of a shortage of people with an international background. Windsor is ethnically diverse and our company is a good example. But it would be nice to have more people willing to travel, willing to relocate into other countries. Most of the ones that I do have, themselves have a foreign background …. I don't know how to put it. [Windsor] is still a very small town environment. It doesn't have an international focus. Toronto is much better.(Interview, Automotive Parts Company, Senior Manager, Windsor, 8 October 2003)

The TDM sector in Windsor-Essex bears many similarities to a classic regionally embedded industrial cluster. The cluster developed over the course of forty years and consists of a network of numerous small- and medium-sized firms many of which spun-off from an initial large anchor firm. There is a strong entrepreneurial culture within the

cluster. These firms are privately owned by self-made entrepreneurs who possess little formal business or engineering education but extremely sophisticated technical skills. Venture capital is virtually non-existent in the sector and so expansion was largely self-financed through the very high profit margins that exited in the industry during the 1980s and 1990s. The workers in these plants are highly skilled tradespeople who have acquired their skills and tacit knowledge through apprenticeships and experience. The spinning-off of numerous new plants, the circulation of skilled workers between firms, and strong informal social networks all lead to learning and knowledge transfers within the cluster. Again, innovation is largely incremental. This sector has virtually no connection to the automotive research activity at the university but relies heavily on the local community college for basic formal technical training for the workforce.

Given that much of its product is exported outside the region, the TDM sector sees its future tied less to the fate of the vehicle assembly industry in Detroit/Windsor than does the core automotive parts industry in the region. However, a number of concerns have emerged over the last few years with regard to the future of the industry. The automotive machinery industry in Windsor was hit hard by competition from Germany and Italy in the 1990s. Windsor mould makers now worry about increasing competition from China. New supply chain management practices are having an adverse impact on the TDM sector though price squeezing and the appropriation of intellectual property. Increasingly, Windsor mould makers are being called on to provide mould design and engineering development work, but the actual production of the mould is then outsourced to low cost producers such as China. A critical question is how sustainable the

current situation is for continued innovation within the cluster. This point was made by one mould maker commenting about OEM practices:

> Now a lot of other shop owners were saying, "That's not right, that's short term vision. Do they want you to dispose of all your manufacturing capacity and just provide them with the design experience which is a direct result of that manufacturing experience". And if you think about it and if you would do that, eventually your design logic would no longer have a manufacturing focus and that very benefit that you would be providing would be lost. Even our original ideas would slow down- because original ideas are driven from the needs of manufacturing, which you understand because you are a manufacturer. These guys [the OEMs] are congratulating each other for short term gains, but in the long term they don't realize that they are eroding their own foundations". (Interview, Mould Maker,Windsor, 8 October 2003).

There are also concerns that the innovative and entrepreneurial dynamism of the cluster is being lost as new firm formation is slowed by rapidly increasing capital start-up costs, overcapacity, and shrinking profit margins. The shift to ever more sophisticated CNC and CAD/CAM technologies which codify and incorporate a lot of formerly tacit knowledge is also sapping the problem-solving and creative skills of the workforce.

In automotive policy debates in Canada most attention is focused on the vehicle assembly and the core automotive parts industries while the TDM sector is virtually ignored. We need to broaden our conception of the automotive parts industry and encourage policy makers to be sensitive to the way the differences that exist between the different segments of the industry might impact on the kinds of new policies devised for the automotive industry.

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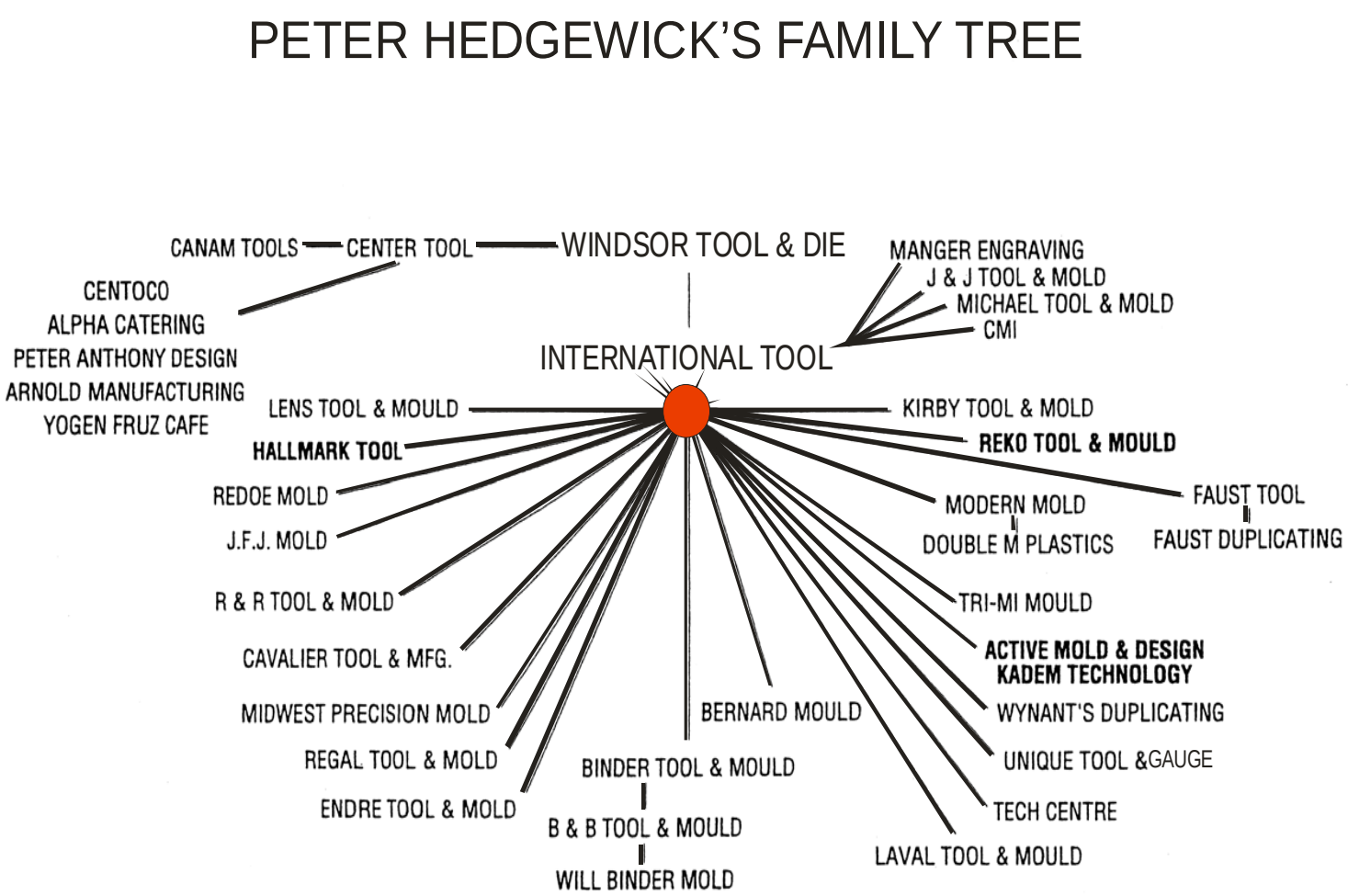
Figure 1: Firms spun-off from International Tool Ltd. prior to 1990



Source: Halberstadt, A., 1990, p. 9