

Ottawa Then and Now: Do Technology Clusters Change Over Time?

Sylvie Ménard is Marketing Manager, Advertising and Brand, Export Development Canada. Her current research interests include the study of relationship marketing and networking both inside and outside of organizations.

Judith Madill is Professor of Marketing in the Eric Sprott School of Business, Carleton University. Dr. Madill's current research interests include the study of small business financing and relationship marketing as well as not for profit marketing.

George H. Haines, Jr. is the Distinguished Research Professor of the Eric Sprott School of Business, Carleton University. Dr. Haines's current research interests include the study of Canadian financial markets for small business financing.

Allan Riding is Co-holder of the Deloitte Professorship in the Management of Growth Enterprises, School of Management, University of Ottawa. Dr. Riding's current research interests include the study of Canadian financial markets for small business financing.

Abstract

One potential strategy, in Canada and elsewhere, for the stakeholders concerned with local economic development (LED) in the face of competition from countries whose advantage lies in an abundant labor force, is the development and nurturing of advanced technology clusters. Although much has been written about the potential contributions of non-private sectors to such clusters, apparently the driving impetus for such successful clusters in Canada has come from the private sector. Accordingly, this paper focuses on the private sector players in one of the successful advanced technology clusters in Canada: the Ottawa cluster.

The objective of this study is to achieve a better understanding of the forces that create and shape regional technology clusters by studying the Ottawa cluster over time, instead of taking a single snapshot at one point of time. The particular focus of this study is to ascertain what, if any, changes occurred in the Ottawa technology cluster between 2000 and 2003.

There are three principal topics investigated. First, has the composition of the cluster itself changed? To investigate this, the paper examines the differences between the population of firms operating in the cluster in 2000 versus 2003. Second, what are the survival rates for firms studied in 2000 at the height of the so-called "technology bubble" in 2003? Third, have there been any changes in the reported frequency of and value placed upon networking within the cluster between 2000 and 2003? Two separate yet comparable surveys of the Ottawa Cluster in the Spring of 2000 and again in Spring of 2003 were completed.

The CEO for each company listed in the Ottawa Business Journal sampling frame (both technology firms and firms listed as suppliers to technology firms) was sent a faxed package asking for participation in the study and offering several alternative methods for participation in the study including self-completion of a questionnaire to be faxed back as well as the opportunity to complete the questionnaire on line. Response rates for both studies were quite strong (over 20% in 2000 and slightly less than 20% in 2003). Non-response checks made on the data showed that in both 2000 and 2003 there was no statistical significance

between the sample and the population-sampling frame in age of firm or in number of employees. This was true for both advanced technology based firms and for the supplier firms. Comparison of the two populations of firms in the Ottawa cluster showed no significant differences in either the age of the firms or the size of the firms. In depth analysis on size of the firms showed that when all firms with more than 100 employees were excluded, it was found the size of the firms dropped from 28.46 employees in 2000 to 21.96 in 2003: a statistically significant reduction in size.

With respect to survival, at least 90% of technology firm respondents operating in 2000 were still operating in 2003. Similarly, at least 95% of the supplier firm respondents that were followed up were still operating in 2003. Finally, technology firms in the 2003 sample used significantly more linkages than in 2000. Interestingly, while they used more linkages, they valued these linkages significantly less. Individual tests are run and reported for each type of organization networked with to identify where the differences arose. Discussion is presented about what these results might mean for both theory and management practice.

Introduction

The objective of this study is to achieve a better understanding of the forces that create and shape regional technology clusters and the nature of the networks that appear to be central to regional cluster formation. The particular focus of this study is to ascertain what, if any, changes occurred in the Ottawa technology cluster between 2000 and 2003. Ottawa is Canada's leading technology cluster and home of such leading companies as Mitel, Newbridge Networks (now a division of Alcatel), Corel, Cognos, March Networks, and others. The origins of this centre were examined by Steed in the early 1980s (Steed and DeGenova, 1983) and in the business media at around the same time (e.g. Mittelstaedt, 1980, Sweetman, 1982, McDougal, 1986). More recently, the origins of this centre have also been discussed by Chamberlin and de la Mothe (2003), Harrison, Cooper and Mason (2004), and Madill, Haines, and Riding (2005a).

By providing a contemporary account of a Canadian technology cluster at two points in time, this study enables comparison with similar regions in the USA and Europe and highlights aspects that may be unique. Thus, one of the contributions that this study will make is to expand the geographical range of studies of technology clusters. Perhaps the most influential seminal study, however, is Saxenian's comparison of Silicon Valley and Boston's Route 128 (Saxenian, 1994), followed up by the studies reported in Kenney (2000) and Lee et.al. (2000). Wolfe and Gertler (2004:1082) deftly summarize these three volumes of research: "...a series of studies that enrich our understanding of the historical trajectory of Silicon Valley's development, its institutional underpinnings, and its operating dynamics. The papers in these volumes trace some of the critical junctures in the history of the Valley and, especially, the central role played by key anchor firms in stimulating the growth of related firms at different stages in the Valley's evolution. The influence of forces at different spatial scales is also highlighted, in particular the key support mechanisms provided by the federal government, including defence procurement and critical funding for pre-commercial research. The nature of entrepreneurship, interfirm relationships, and the role of knowledge flows in the Valley are also covered. Although these analyses offer competing explanations of the underlying dynamics that have sustained the growth of the Valley's firms through successive waves of technological innovation, their authors agree that its dynamism can be attributed to the nature of its 'ecosystem' which involves the continuous creation of the multitude of diverse, specialised firms and support organizations the constantly interact with each another to accelerate the innovation process." Aside from these three volumes of research, there seem to be few studies of clusters that occur more than once. Perhaps this is due to the prejudice against replications in research (would a study then and now be considered a replication? why?), or perhaps it is because people believe that clusters of firms are immutable objects, or perhaps there are other reasons best not stated. Whatever the reason for this lack of

research, the central purpose of this study is to break with this tradition, and present a study of a cluster that compares certain key aspects of the cluster at two different points of time.

The purpose of this paper is to compare the nature of the Ottawa technology cluster between 2000 and 2003 on three particularly critical and interesting dimensions. First, has the composition of the cluster itself changed? Second, has the frequency of technology firms' linkages within their cluster altered? Finally, has the value placed upon such linkages by advanced technology firms changed? This paper follows the work of Chell and Baines (2000), George et al. (2001) and Shane and Cable (2002) in defining networking as the action by which an individual develops and maintains contacts for business development purposes.

Conceptual Context and Research Propositions

The resource-based view of the firm suggests that firm capabilities that are valuable, rare and inimitable, determine long term competitive advantage (Barney, 1991; De Carolis et. al. 2006). The heart of the argument for advanced technology firms engaging in frequent and highly valued networking is that such networking creates capabilities within the firm which lead to long term competitive advantage. There are several proposed connections in this argument that have not been subjected to careful empirical examination. Following from this, one of the central purposes of this paper is to see whether advanced technology firms really do link more frequently and value these linkages more highly than do other firms.

Madill, Haines and Riding (2004) collected data in the spring of 2000, an exploratory survey which examined empirically the usage and value of networks and linkages within the Ottawa technology cluster, as well as how firms market and manage their relationships. The study was undertaken within the Ottawa technology cluster to learn specifically about relationships and linkages among organizations in a cluster environment. Previous work in this area (Ryans et al, 2000) argued that technology firms need to develop more external relationships in order to be successful than non-technology based firms. Interestingly, to the contrary, the study by Madill et al. (2004) found that within the Ottawa cluster, technology firms have formed fewer linkages. At the time the data were collected, the technology "boom" with high profits and high growth was ending. Since then, the technology sector has experienced a significant downward slide in sales and profitability and many technology companies are facing very difficult times. Some of the largest technology companies in the Ottawa Cluster (e.g. Nortel and JDS Uniphase) have downsized and faced falling revenues as well as depressed stock prices (Harrison, Cooper, and Mason, 2004).

This study is designed to build upon the 2004 Madill, Haines and Riding research. Thus, this study compares technology and non-technology based supplier firms using data collected in both 2000 and 2003 to assess the quantity and value of their networks and linkages within the cluster as well as comparisons of the sample with the population, and comparisons of founding teams and independence between 2000 and 2003. Survival rates for firms in the cluster between 2000 and 2003 are also studied and reported.

Importance of Topic

There is most definitely a need for additional research with regard to the use of networks and linkages in technology driven companies as opposed to those that are non-technology driven. Conflicting views exist on this issue {Granovetter,1973, 1985; Curran, et. al., 1993; Johannisson, 1995a and 1995b,1998; Katz and Williams,1997; Chell and Baines,2000; Collinson,2000; Freel,2000; George et. al. 2001; Vanhaverbeke, 2001; and Shane and Cable, 2002}. Clearly, a further study beyond Madill, Haines, and Riding, 2004, comparing technology-based with non-technology based firms in terms of networks and linkages would be useful. As well, such a study should enhance the development of resource-based theory.

It should further be acknowledged that although industry clusters have been years in the making (e.g. the Ottawa tech cluster began formation some 40 years ago), the topic is still relatively new in the research literature. As Cooper and Folta put it, “while the generalities of cluster locations have been established, many research questions need to be addressed to add to the understanding of clusters and their importance” (Cooper and Folta, 2000).

Research Methodology

Population Definition and Sampling Frame

The population for the study comprises of technology intensive firms and non-technology based firms that supply the technology intensive firms in the Ottawa cluster. The sampling frame was a commercial database purchased from the *Ottawa Business Journal*, which provides an industry classification for each firm. The use of this database as the sampling frame is appropriate in this situation because there is no other up-to-date listing readily available that distinguishes the technology industry classification. This was also the same sampling frame that was used in Madill, et.al., 2004, 2005b.

Unit of Analysis

SMEs (small and medium sized enterprises) are defined as firms with annual revenues of \$50,000,000 or less and 500 employees or less. Storey (1994, p.13) provides support for this in his definition of SMEs as he divides the sector into three as follows:

Micro-enterprises are those with between 0 and 9 employees;

Small enterprises are those with 10 to 99 employees; and

Medium enterprises are those with 100-499 employees.

Type of Sampling

Given that the population of technology firms in the Ottawa cluster was a manageable number (769 technology-based firms and 698 non-technology supplier firms), the entire population of firms provided by the commercial database in 2003 were sent a faxed survey, as was done in the previous original (2000) study.

Data Collection

Madill, et. al., 2004, used the fax/fax-back technique. This method seems not to have presented any undue difficulties and yielded relatively decent response rates (26% and 22% respectively for high technology and non-technology based supplier firms). Following suit, the questionnaires were thus sent out as a fax-back form and were addressed to the attention of the CEO. A similar package that was sent in Madill, et. al., 2004 was sent. The package consisted of a fax cover sheet, a personal letter from the researchers, a one-page description of the research project, a return-fax cover sheet, and the questionnaire. The entire package faxed consisted of 11 pages.

Follow-up letters were also faxed out two weeks after the initial distribution to encourage participation. An additional option of filling out the survey online was offered to the recipients, which helped bring up the response rate. This fieldwork was carried out during the months of May to July of 2003.

It is noted that ongoing research has been conducted by the researchers in this area, interviewing firms from the 2000 Ottawa cluster survey that had indicated they were willing to be contacted again (Madill,

Haines, and Riding,2003). This further interviewing included some questions on networks and linkages. Of the advanced-technology firms in the 2003 technology database, 68 (8.9%) were contacted as possible participants in the 2000 further study, and 9 (1.2%) actually participated in an additional interview process. Of the non-technology based supplier firms, 36 (5.2%) were contacted and 5 (0.7%) agreed to participate in the interview process.

Fax Back Surveys

The research questionnaire for this study was based on the one used by Madill, Haines and Riding (2004). A similar questionnaire was used along with some additional questions. In view of the recent research efforts described above, the firms who participated in the recontact interviews were not asked to participate in the 2003 research study.

Cover Letters

Each questionnaire was accompanied by a fax cover sheet, a personalized introductory letter, and a generic description of the current and previous research titled "Knowledge Transfer in Regional Technology Clusters: The Case of Ottawa". A separate letter was written to those particular companies who participated in the 2000 study, which acknowledged their contributions to the research, and asked for their further co-operation.

Pre-Test

Pre-testing was performed in the last week of April 2003. The survey included an additional question as recommended by Aaker and Day (1983) which goes as follows, "We would appreciate any suggestions you may have for making this questionnaire clearer or easier to answer. For instance, were any of the questions confusing? Why?". The pre-test survey was delivered to some graduate students at Carleton University who have full-time employment in technology firms in the Ottawa region. Further, the survey was also distributed to a few additional contacts from both the technology and non-technology databases. The pre-test phase was quite useful in making sure that the intended audience would understand what was asked of them. Two pretest respondents suggested that the questions be re-arranged into "a more strategic and rational order", a change that was indeed made prior to faxing out the survey to the sample at large.

Results

The 2003 technology database purchased from the *Ottawa Business Journal* (sampling frame) contained 759 companies classified as technology firms and 691 classified as suppliers to the technology firms (non-technology). For this study, 587 (77.3 percent) technology firms and 493 (71.3 percent) non-technology firms actually received the survey. The remaining firms were unreachable in that they either had no fax number or the faxes bounced back or they were participating in the follow up interviews to the year 2000 survey.

The total sample size attained for the 2003 research study was 182 firms. Of these firms, 96 were classified as technology firms and 86 were classified as non-technology firms (supplier firms). That calculates as a 16.4% and 17.4% response rates respectively.

Some of the firms in the sample had also participated in the original study conducted in 2000 (Madill, et.al., 2004). Of the 94 technology firms and 47 non-technology firms in the 2003 sampling frame, who had been previous respondents in the 2000 study, 17 technology (18% response rate for repeated

respondent) and 4 non-technology firms (9% response rate for repeated respondent) responded again in 2003.

Comparison of 2003 sampling frame with the 2000 sampling frame

This section explores empirically four questions that might be asked about what happens to clusters over time in a demographic sense. First, it is useful to know whether there are any differences between the population (as defined by the Ottawa Business Journal sampling frame) and the sample of respondents actually achieved. Second, it is interesting to inquire whether there are any differences between the two populations, again as defined by the Ottawa Business Journal sampling frame. Third, are the two samples the same? Finally, what does the picture look like when the very largest firms are excluded? It should be noted prior to reporting the results of these comparisons that in 2003 OCRI (Ottawa Carleton Research Institute) undertook a Task Force on Commercialization under the leadership of Eli Fathi (2003), President of Orbit IQ. The task force defined the problem it studied as follows: “ 1. The ratio of profitable to non-revenue generating technology companies in Ottawa Gatineau is too small. 2. The percentage of technology companies crossing the threshold to become mid-sized (\$50M annual revenues) companies with global leadership positions in the market segment is too small. 3. Too many companies are being purchased at low valuations and eventually turn into precarious satellite R&D labs – partly from difficulties in creating companies. 4. There is too much emphasis on R&D and not sufficient on commercialization. 5. VC investment in Ottawa-Gatineau technology community continues to drop to non-sustaining level.”

Comparison between samples and populations

First, in the year 2000 data there was no statistical significance between the sample and the population sampling frame in age of firm or in number of employees. This was true for both advanced technology based firms and for the supplier firms. In the year 2003 data, there was also no statistical significance between the sample and the population sampling frame in age of firm or in number of employees. Again, this was true for both advanced technology companies and for the supplier firms. A five percent level of type one error was used throughout these tests.

Comparison between 2000 and 2003 populations

There are no significant differences in age for either the entire sample, or for the advanced technology and supplier firms sub-samples. Again, a level of type one error of five percent was chosen for use. Similarly, there were no significant differences for size (as measured by number of employees) for either local or total employees, in either the supplier of advanced technology or advanced technology sub samples. Again, a level of type one error of five percent was chosen for use.

The final tests attempted to take the concerns of the Commercialization Task Force described above into account by excluding all firms with 100 or more employees. When this was done, a significant difference in size appeared between the 2000 and 2003 firms. The means in terms of number of employees for advanced technology companies dropped from 28.46 in the year 2000 to 21.96 in the year 2003, a statistically significant difference at a type one error of five percent.

The means in terms of number of employees among supplier firms also fell, but the difference was not statistically significant. When a similar test is performed of the number of employees for all firms, again a statistically significant decrease in number of employees is found. While data is not publicly available for some aspects of firm operation (notably profitability) in the cluster mentioned in the task force minutes (Fathi, 2003) quoted above, this last result does appear to offer some confirmation for the concerns expressed.

Comparison of 2003 Sample with the 2000 Sample

This section will highlight some of the additional key similarities and differences between the technology firms in this 2003 sample and the technology firms in the 2000 sample.

In the 2000 study, 111 responses were obtained from technology-based firms (26% response rate) and 75 responses from supplier (that is, non-technology) businesses (22% response rate). In the 2003 study, 96 responses were obtained from technology-based firms (16.4% response rate) and 86 responses were obtained from supplier (non-technology) firms (17.4% response rate). Clearly, the response rate is lower than that established three years ago. This is consistent with recent studies of response rates in Canada (Allen, et.al.,2003).

Founding Team and Independence: Comparing 2000 and 2003

The technology firms in the 2000 sample were mainly founded in the Ottawa area (88 percent). The large majority of firms (96 percent) were founded as independent companies, of which most remained independent (79 percent) in 2000. The non-technology firms in the 2000 sample were also mainly founded in the Ottawa region (84 percent) and almost all firms (93 percent) were founded as independent firms, most of which (76 percent) remained independent.

The technology firms in the 2003 sample were mainly formed in the Ottawa area (93 percent) and most were founded as independent companies (94 percent), of which most remained independent (85 percent) in 2003. It should be noted that the percentage of technology firms remaining independent was not significantly different between 2000 and 2003 at a five percent type one error. The non-technology firms in the 2003 sample were mainly founded in the Ottawa region (85 percent). Nearly all firms (97 percent) were founded as independent firms, most of which (90.7 percent) remain independent. This last percentage is significantly different at a type one error of five percent: in the year 2003 a significantly higher percentage of supplier firms remained independent than in the year 2000.

The two categories of groups are different with respect to the use of risk capital. Nearly half of the technology firms in the 2003 sample raised risk capital while less than one quarter of the non-technology firms raised such funds. Both groups do however show a use of financing from business angels. The two categories of firms also appear to differ with respect to the proportion of founders still with their respective firms. Founders for the non-technology firms appear to remain with the firms longer than do founders with technology firms.

The type of organizations the founder/founders worked for immediately before their companies were founded varied on different levels but most of the founders for the technology and non-tech firms came from small firms. The large majority of founders for the technology and non-technology firms worked within 30 miles of the founded company. A majority of the technology and non-technology firms (76 percent of technology firms and 77 percent of non-technology firms) were founded by a team consisting of at least two individuals. For firms in the 2003 sample, 75 percent of technology firms and 68 percent of non-technology firms reported being founded by a team consisting of either two or three founders.

The breakdown of functional responsibility for founders in the 2000 sample is similar to the 2003 sample (see Table 1). The founders for the technology firms in 2000, however, were more likely to come from a General Management position than the founders for the technology firms in 2003. Founders in technology firms in 2003 were more likely to come from Production/Operations and Sales/ Marketing backgrounds than the 2000 sample of technology firms.

**Table 1:
Prior Functional Responsibility of Founders: Comparing 2000 and 2003
Samples**

	2003		2000	
	Technology	Non-Technology	Technology	Non-Technology
Research	19.0%	10.5%	21.9%	15.1%
Technical	29.3%	23.5%	27.9%	22.0%
Production/ Operations	11.6%	9.2%	7.4%	12.7%
Sales/ Marketing	15.1%	24.4%	12.3%	19.5%
Finance	9.6%	9.2%	11.4%	11.2%
General Man.	11.9%	18.1%	19.1%	19.5%

In 2003, the technology firms have a higher proportion of founders coming from a Production/Operations background than the non-technology firms in the same year. This is the opposite of what was found in 2000. The breakdown of the knowledge on which the companies were based was also comparable overall. There were higher proportions of advanced technology and supplier firms in the 2000 sample that stated a source of knowledge from a university and from another company than the 2003 sample. The other areas (Government, Previous Public sector Employer, Personal R&D Activity, and other) were similar in numbers.

Thus, it can be seen that although the 2000 and 2003 samples have some slight differences, they are, overall, similar in terms of company profiles and founder characteristics.

Conclusion of Preliminary Profile Comparison

The large majority of firms in both groups were formed in the Ottawa cluster region and formed as an independent firm - a high percentage remains independent. The two categories of groups are different with respect to the use of venture capital. Nearly half of the technology firms raised risk capital while less than one quarter of the non-technology firms raised such funds. Both groups do however show a use of financing from business angels. The two categories of firms also appear to differ with respect to the proportion of founders still with their respective firms. Founders for the non-technology firms appear to remain with their firms longer than those with technology firms. The type of organizations the founder/founders worked for immediately before their companies were founded varied on different levels but most of the founders for the technology and non-tech firms came from small firms.

Similar to each other, the large majority of founders for the technology and non-technology firms worked within 30 miles of the founded company, before founding it. This indicates homegrown talent and entrepreneurship. The technology and non-technology firms differed slightly in terms of the functional responsibility of the founders in their previous organizations. The technology firm founders were mainly experienced in technical roles while the non-technology founders were mainly in Sales/Marketing roles. The two categories of firms appear to also differ with respect to the distribution and frequencies of sources of knowledge, with universities and another company declining as a source of knowledge between 2000 and 2003.

It is however, apparently accurate to state that the two categories of firms are well matched and provide a reasonable basis for comparison.

Impacts of the Technology Meltdown

The period since mid-2000 to late 2002 was characterized by an economic downturn (the national unemployment rate increased from 6.7 percent in mid-2000 to 8.0 percent by December 2001). The primary effect of this downturn was its impact on technology-based firms, particularly on firms in the IT sub sector. According to the CEO of one Ottawa enterprise: "... in telecom it has really been a depression, but in tech generally its been a real strong recession." This led the authors to examine what happened to the firms in the Ottawa Technology Cluster since this downturn. In this examination, the survival rates of the firms that were included in the research conducted at the height of the so-called "technology bubble" in mid-2000 was studied. Second, the authors investigated what happened to the firms that did not appear to survive.

Each of the firms that responded to the mid-2000 baseline survey was followed until mid-2003 to address the survival issue. The authors utilized the Ottawa Business Journal Directory as a sampling frame for the 2000 study. The 2003 version of this Directory was also utilized as a way of checking which respondent firms from the mid-2000 study appeared in the mid-2003 Directory. Those respondent firms from 2000 that appeared in the 2003 Directory were classified as survivors. Those that did not appear in the 2003 version of the sampling frame were followed up via telephone and Internet contacts.

Comparing Mid-2000 and Mid-2003

Of the 424 technology firms present in the 2000 version of the sampling frame, 230 (54.2 percent) were also among the 768 technology firms listed in the 2003 version of the Ottawa Business Journal Database. Among supplier firms, 209 of the 343 firms (60.9 percent) were listed in both directories. However, changes in listing do not necessarily convey accurate information about business survival rates. For example, some firms may have changed names, lines of business, or location. To explore the actual continuity of firms, most of those firms whose CEOs had responded to the mid-2000 survey were followed up. The results are listed in Table 3, which presents the current status for those firms. Among respondents that were followed:

**Table 2:
2003 Status of Respondent Firms**

	Technology Firms	Supplier Firms
Firms Operating in both 2000 and 2003 with the same name	81 (73.0%)	53 (70.7%)
Firms Operating in both 2000 and 2003t with Name Change	11 (10.0%)	5 (6.7%)
Firms Acquired	4 (3.6%)	0
Inactive Firms	3 (2.7%)	1 (1.3%)
Bankrupt Firms	2 (1.8%)	0
Firms that Moved	1 (0.9%)	1 (1.3%)
No Info	1 (0.9%)	1 (1.3%)
Firms that switched database listings (Supplier vs Technology)	8 (7.2%)	2 (2.7%)
Firms not followed		12 (16.0)
	111 (100.0%)	75 (100.0%)

Table 2 shows that:

- At least 90 percent of technology firm respondents to the mid-2000 survey were still operating in 2003;
- At least 95 percent of the supplier respondents that were followed up here were still operating in mid-2003.

A preliminary discussion, based on 30 detailed in depth interviews, of why the survival rate of advanced technology firms in the Ottawa cluster was so high was presented in Madill, Haines, and Riding, 2003.

Research Results: Examining and Testing the Propositions

This section tests empirically the difference in use and value for linkages between technology firms in the 2003 sample and the technology firms that made up the 2000 sample. The hypotheses being tested are listed below followed by a description of the research findings.

Hypothesis 1: The technology-based firms in the 2003 sample are likely to use more linkages with organizations in their cluster web than was reported by the technology firms in the 2000 research sample.
Hypothesis 2: The technology-based firms in the 2003 sample are likely to value more their linkages with organizations in their cluster web than was reported by the technology firms in the 2000 research sample.

To empirically test the results with respect to use of linkages reported in 2003 and 2000 against each other, a t-test was run with both the summated mean of scores between technology firms in 2000 and 2003 and the individual item scores (see Table 3).

Table 3
Mean Use Scores per Linkage For Technology Firms: Comparing 2003 and 2000

	2003		2000	
	Mean	Sta. Dev.	Mean	Value
Suppliers	3.21*	1.17	3.55	1.34
Service Firms	3.31	1.09	3.20	1.19
Customers	3.45*	1.50	2.83	1.56
Research/Universities	2.00	1.19	1.76	1.06
Research/Government	2.13	1.31	1.94	1.16
Research/Industry	1.92	1.13	1.72	0.94
Firms in Industry	2.34	1.21	2.18	1.21
Subcontractors	3.01	1.36	2.77	1.33
Professional Organizations	2.39	1.20	2.23	1.11
Board of Trade	1.51	0.76	1.50	0.86
Economic Development Office	1.63	0.93	1.53	0.83
Summated Mean	26.85	7.17	24.92	6.36
Mean Difference (2003-2000)	1.93*			

*indicates a significant difference between 2003 and 2000 at the 5% level of type one error.

The t-test comparing summated mean scores for use of linkages between the 2003 sample of technology firms and the 2000 sample indicates that the technology firms in the 2003 sample use significantly more linkages with organizations in their local cluster than did the technology firms in the 2000 study ($t=1.97$, $p=0.05$). The results support Proposition 1. Individual t-tests were then performed to identify the source

of the overall differences between the technology firms in the 2003 sample and 2000 sample. The individual item t-test results indicate that the technology firms in the 2003 sample use significantly fewer linkages with suppliers than did the technology firms in the 2000 sample ($t=-1.97$, $p=0.05$) and use significantly more linkages with customers ($t=2.89$, $p=0.00$) than did the technology firms in the 2000 sample. See Table 3 for these t-test results.

Table 4 presents analogous results for the value each organization reported placing on their linkages with the specific organization types indicated.

Table 4
Mean Value Scores per Linkage For Technology Firms: Comparing 2003 and 2000

	2003		2000	
	Mean	Sta. Dev.	Mean	Sta. Dev.
Suppliers	3.29	1.21	3.53	1.30
Service Firms	3.18	1.10	3.40	1.16
Customers	3.11**	1.49	3.52	1.55
Research/Universities	1.70*	1.02	2.08	1.25
Research/Government	2.01	1.20	2.28	1.41
Research/Industry	1.79**	0.97	2.08	1.23
Firms in Industry	2.36	1.19	2.45	1.31
Subcontractors	2.83	1.33	3.12	1.42
Professional Organizations	2.54*	1.23	2.19	1.18
Board of Trade	1.43	0.60	1.57	0.86
Economic Development Office	1.57	0.84	1.66	
Summated Mean	25.87	6.50	27.66	8.20
Mean Difference (2003-2000)	-1.79**			

*indicates a significant difference between 2003 and 2000 at the 5% level of type one error

** indicates a significant difference between 2003 and 2000 at the 10% level of type one error.

The technology firms in the 2003 sample value significantly less their linkages with organizations than did the technology firms in the 2000 sample ($t=-1.72$, $p=0.09$) (see Table 4). The results directly contradict Proposition 2.

At the .05 level of significance, the technology firms in the 2003 sample value significantly less their linkages with universities as research collaborators ($t=-2.43$, $p=0.02$) than did the technology firms in the 2000 sample. At the .10 level of significance, the 2003 technology firms also value significantly less their linkages with industry research collaborators ($t=-1.89$, $p=0.06$) and customers ($t=-1.92$, $p=0.06$). The tech firms in 2003 do, however, value significantly more their linkages with professional organizations than did the technology firms in the 2000 sample ($t=2.09$, $p=0.04$). Refer to Table 4 for t-test results.

In summary, technology firms in the 2003 sample use significantly more linkages and value significantly less their linkages than did the technology firms in the sample of the 2000 study. Hypothesis 1 is not rejected, while Hypothesis 2 is directly contradicted (except in the category of professional organizations).

Discussion of Individual Linkages: Comparing 2000 and 2003

Table 5 highlights the linkages that were significantly different, in terms of use, between the technology and non-technology firms and directly compares the 2000 results and the 2003 results.

Table 5
Significant Differences at the 5% level unless indicated otherwise in Use of Linkages (Tech vs. Non-Tech Firms): Comparing 2000 and 2003

	Technology – Non-Technology	t	P
2000 Usage:			
	Customers	.90	0.00
	Firms in Industry	.49	0.00
	Subcontractors	.11	0.04
	Research/Industry	.86	0.06
	Professional Organizations	.84	0.07
2003 Usage:			
	Suppliers	.10	0.04
	Customers	.17	0.00
	Firms in the Industry	.22	0.00
	Board of Trade	.75	0.08

**At the .10 level of significance

Differences in usage with two key relationships, customers and firms in the industry, are replicated in 2003. However, differences in usage are found in five other categories that are different in the two years. This appears to indicate that organizations are willing to alter their network usage patterns over time. In the 2000 study, it was established that the non-technology firms valued significantly more than the technology firms their linkages with customers and firms in the industry (see Table 6 below). These results were replicated in the 2003 version of the research. In 2003, but not 2000, it was also found that advanced technology firms valued significantly more linkages with Government Research organizations, and valued significantly less than the non-technology supplier firms linkages with subcontractors and Boards of Trade.

Table 6
Significant Differences in Value for Linkages (Tech vs. Non-Tech Firms): Comparing 2000 and 2003

	Technology – Non-Technology	t	p
2000 Value:			
	Customers	.16	0.0
	Firms in the Industry	.43	0.0

2003 Value:				
	Customers	.71	-	0.0
	Research/ Gov't	.85	**	0.0
	Firms in the Industry	.31	-	0.0
	Subcontractors	.99	8	0.0
	Board of Trade	.72	**	0.0

**At the .10 level of significance.

Discussion and Conclusion

The first research question dealt with the composition of the technology cluster itself over time. First, no significant differences were found in either study between the sample and the sampling frame in terms of size of business or age of firm. Nor were there any significant differences in size of firm or age of firm between the two sampling frames. However, when the largest firms, those with over 100 employees, were excluded, it was found the size of the remaining firms had fallen in 2003 compared to 2000. The response rate also was lower in 2003 than in 2000. The location of founding of the firms studied was primarily local, and this had not altered over time. The percentage of technology firms remaining independent had not changed. However, a higher percentage of non-technology firms remained independent in 2003 than in 2000. The two categories of firms are different with respect to use of risk capital, with a much higher proportion of advanced technology companies reporting access to risk capital. Not surprisingly, a much higher percentage of non-technology firms report their founders are still with their firms. Lerner(2000) and Gompers and Lerner (2004) report that bringing in new top management is frequently a contribution venture capitalists make to firms in which they invest.

At least 90 percent of technology firms respondents in the 2000 survey were still operating in 2003, and at least 95 percent of the supplier respondents that were followed up were still operating in 2003. It is hypothesized that this survival rate of the “technology meltdown” between 2000 and 2003 is much higher than would have been expected prior to the data on survival being collected. Numerous studies have sought to assess how regional collective learning processes contribute to the success of various regional high technology clusters. Recent work in the European context includes papers on Cambridge (Keeble and Wilkinson, 1999), Sophia-Antipolis (Longhi, 1999), Grenoble (de Bernardy, 1999), Pisa, Piacenze and NE Milan (Capello, 1999), Munich (Sternberg and Tamasy, 1999) and Goteborg (Lindholm Dahlstrand, 1999). Keeble and Wilkinson (2000) also includes papers by all the preceding authors as well as Lawson (2000). Pinch and Henry's (1999) analysis of the clustering of the British motor sports industry also draws heavily on concepts of regional collective learning. The Urban Studies special issue of 2004 (volume 41, number 5/6) contains theoretical studies by Cumbers and MacKinnon (2004), Phelps (2004), Maskell and Lorenzen (2004), Benneworth and Henry (2004), Wolfe and Gertler (2004), Simmie (2004), and Cooke (2004) as well as empirical studies of clusters in Stockholm (Power and Lundmark,2004), Ottawa (Harrison,Cooper and Mason,2004), Scotland (Leibovitz,2004),Oslo (Isaksen,2004), and Styria (Todtling and Trippi,2004). Apparently, success includes survival of the individual firms in the cluster during recessionary times!

The results of this research study give a very different impression of the networking and linkage practices of advanced technology firms from those presented elsewhere (Freel, 2000; Ryans et.al,2000). Perhaps advanced technology companies are heavily involved in networking and linking in a global sense rather

than the local sense studied here (Simmie, 2004; Wolfe and Gertler, 2004; Cumbers and MacKinnon, 2004), although the Mitchell, et.al (2005) study found differences only in the greater value placed upon out of cluster linkages with research Universities and Industrial Research partners by advanced technology companies. The results of this study show, however, that advanced technology companies are no more heavily involved in networking and linkages inside of their local cluster area than any other companies in the local cluster. Indeed, they show lower levels of usage of linkages with suppliers, customers, firms in the industry, and Boards of trade than do the supplier firms. Where they differ is that the advanced technology firms place more value on linkages and networking with government research organizations, and less value in linkages with firms in the industry, customers, subcontractors, and Boards of Trade than do the non-technology based firms. It is also interesting to note Simmie's (2004: 1110) remarks about his findings (he studied innovative U.K. firms, where innovative was defined as a firm that had introduced a product new to their market in the last three years): "Finally, the idea that clustering facilitates on-going relationships with other institutions including universities is also not supported by the data. Some two-thirds of the leading innovators did not use external collaboration at all. Among those who did use them, greater importance was attached to national and European collaborators than to local ones." While it is difficult to know what interpretation respondents might put on the ambiguous word "importance", at the very least this result seems to be not a variance with the empirical results reported in this study. Clearly, further research is appropriate. Arguably, the most meaningful result is the alteration in network and linkage patterns among organizations shown in the results. Almost all of the research literature on this topic has been "one-shot" in nature, and it would be easy to conclude that network and linkage patterns, once set, remain largely the same over time. These results show such a view would be incorrect. Indeed, Madill, Haines and Riding (2003) show that one of the principal strategies adopted by firms in dealing with tough times is to build and maintain relationships. In this sense, the results support the underlying dynamic capability, resource-based theory of the firm that underlies this study. The results show that the relationships nurtured and valued change over time as the environment in which the firm is operating alters. This implies changes in the pattern of networking, which this research has found to be the case. From a policy perspective, the results are of value to policy makers and agencies concerned with the development of regional and national innovation policies as they show the relevance of the private sector actors in such development.

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