Towards a Public Policy Planning Framework for High Technology Industry Development: An Analysis of Three New Economy Indicators in the Context of Metro-Manitoba

by

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TOWARDS A PUBLIC POLICY PLANNING FRAMEWORK FOR HIGH TECHNOLOGY INDUSTRY DEVELOPMENT: AN ANALYSIS OF THREE NEW ECONOMY INDICATORS IN THE CONTEXT OF METRO-MANITOBA

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Abstract

Silicon Valley, California, and Route 128, Massachusetts remain today icons of high technology industrial development – ones based largely on innovative ideas, people, and products. In their search for economic betterment, planners and policy makers have often viewed regions such as these to be economic 'Holy Grails'. Still, the successful recipe for creating an economy based on innovative industries such as biotechnology, advanced materials, and microelectronics remains somewhat of a mystery to the two parties. The goal of this research is to aid in this regard by working towards the creation of a public policy framework with which local practitioners may help create the conditions that are necessary to orchestrate such a successful high technology economy in metro-Manitoba.

There were four fundamental research questions that drove this practicum:

(1) What are the high technology firms that drive the new economy?
(2) What are some of the key indicators of high technology industry health that influence the development of new firms, or aid in the retention of existing firms?
(3) What is the present condition of these indicators as measured in Winnipeg, relative to two regional competitors, Calgary and Saskatoon?
(4) How can we combine this new knowledge with urban economic development planning practice to create an informed response that can be initiated by an organisation such as Economic Development Winnipeg?

Using a case study method, we analyse what are arguably the three most important indicators of high technology health (venture capital availability, research and development activity, and educational attainment) and determine how well metro-Manitoba is situated to allow for the development of these types of high technology firms. The case study is situated as a comparative study of metro-Manitoba in relation to both Calgary, Alberta and Saskatoon, Saskatchewan. Key informant interviews were integral to this research, and are listed at the back of this document.

The research concludes with a summary of the findings, and a set of eleven recommendations that local planners may find useful in the promotion of a high technology economy – ones which may also one day form the basis for an informed public policy framework. The recommendations produced are ones that arose directly out of the research questions. In them, we argue for: the creation of an effective advisory group that promotes high technology interests; high technology firms to be categorically identified in metro-Manitoba; the promotion of niche capital funds; the lobbying of pension funds for their inclusion in venture capital pools; the matching of angel investors with entrepreneurs; the lifting of geographic restrictions for LSVCC funds; a restructuring of the Manitoba R & D tax credit strategy; a reorientation of the functions of the University Industry Liaison Office at the U of M; the promotion of R & D partnering between small firms and the U of M; the provision of Provincial bursaries for educators in mathematics and sciences; and the promotion of student and school initiated courses.

Acknowledgments

Though the credit for the completion of a Masters degree is often directed solely to the student, a project of this nature is rarely the work of one individual. In this spirit, I would like to extend my sincere thanks to my committee members, Greg Dandewich and Dr. Christopher Leo, for their time, insights, and wisdom, the latter two of which hopefully made it into this final document. I would also like to extend a heartfelt thank you to my Advisor, Dr. Ian Wight, who stepped in under difficult circumstances and steered me admirably through the process - never letting me forget the overall objectives of the research nor the task at hand.

In a project such as this, it is often the quality of the key informants that dictates the quality of the overall document. I am deeply indebted to the numerous people who agreed to be a part of the primary research undertaken. I would especially like to thank J. Adam Holbrook for his extra efforts during the trying research conducted on R & D performance in Canada.

I would also like to thank the numerous family members and friends who have touched on this project in direct and indirect ways. Too numerous to mention here, you know who you are, and I truly appreciated the kind thoughts and encouragement you offered me. Finally, I would like to thank my wife, Darla McFarlane. Her extraordinary patience and support has been tested during the research and writing aspects of this document, and I look forward to returning the favour some day soon. And yes, I will be home for dinner tomorrow…

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Chapter One

How Can Economic Development Planners Address High Technology Industry Development?

1.1 Purpose

The main purpose of this project is to work towards a public policy framework with which planners and other groups can begin to address high technology [1] industrial development in metro-Manitoba. The research attempts to connect the growth of the 'new economy' [2] industries and their tendency towards locating in certain cities, at certain times, with the proactive planning actions of an urban economic development corporation. The trends in new industry formation have important implications for economic development planners. As the form and nature of economic activities evolve, urban professionals will need to better understand and respond to the dynamics of these high technology firms [3]. Creating the links that merge educational institutions, research facilities, and venture capitalists into a milieux of innovation and progress requires the skills and savvy of urban professionals. Planning for such an industrial future calls for the development and application of appropriate planning interventions, and this research seeks to connect the linkages between the dynamics of high technology industries and the planning knowledge needed to help drive the future economic development of the City of Winnipeg and its larger metro-Manitoba economic region – defined here as those portions of the Province having a predominantly metropolitan character.

1.2 Problem Statement

Metro-Manitoba may be at a crossroads in its economic development. There are two issues in particular. First, while unemployment rates have been generally low over the past five years, and our economic growth (as traditionally measured by changes in GDP) has been at or above the national average for some years, the Winnipeg CMA continues to lose people to out-migration in some key demographic cohorts, and this is expected to increase substantially in the next 15 years. At the same time, the CMA is expected to see a significant rise in those persons who are no longer as actively engaged in the work force, particularly those aged 45 - 65 (KPMG, 1999:41). The problem inherent in these trends in economic development terms is that the city-region must at least maintain its economic prosperity with a shrinking workforce and a general aging of the local population. Successful economic development in the future will be predicated on our ability to retain and employ those people that are most prone to migration - the young and the educated.

Second, Winnipeg has long been known as a city with a stable and particularly diverse economy, with unique strengths in the transportation, manufacturing, and wholesale and retail trade sectors. While there is reason for optimism in the emergence of certain industries such as aerospace maintenance, call centres, and health care, industrial development in new economic sectors is taking more advanced forms, at much greater levels, in many other metropolitan areas of the world. Further to this, 'new' economists such as Michael Porter have begun to suggest that, in effect, too much diversity may be more harmful than helpful in economic development. Porter's contention is that productivity gains are found in clusters (critical masses of industries and their support-industries) where regional specialisation can occur. These two factors, at a minimum, suggest that metro-Manitoba must effectively begin to redefine its role in a new economy if its quality of life, and its economic stability are to remain positive.

New economy industries - such as computer hardware and software development, biotechnology, nanotechnology and certain medical technologies - have emerged unfettered over the past fifty years, significantly altering the character and rapidity of industrial development in many parts of the world, but with particular emphasis in certain metropolitan areas of North America, Western Europe and Japan. The pre-WWII manufacturing era was defined by what has been termed the 'Fordist' economy, made notable by the use of mass production manufacturing techniques to produce standardised, durable goods for mass consumption. As it relates to the location of industry, manufacturers often sought an optimum location and plant size to achieve economies by negotiating close physical access to raw materials, markets, and labour.

In comparison, contemporary high technology industries exist in what has been termed the 'Post-Fordist' economy, the harbingers of which are characterised by the application of knowledge and the processing of information into process modification, products, services, and simple information and its transfer. In emerging industries such as these, it is believed that there is less of a need for a firm to locate where scale economies would be present, and a stronger need to locate where agglomeration economies [4] are possible, aided significantly by the presence of attributes such as an appropriately-educated work force, subcontracting and networking opportunities, venture capital (VC), and high degrees of research and development (R & D) activity, among others.

So-called 'high technology' cities and regions, exhibiting marked positive change in both wealth creation and industrial development terms, include the prototypical advanced technology region, 'Silicon Valley'. This once-rural region between San Jose to the south and San Francisco to the north was the birthplace of the microcomputer industry that first developed and then proliferated in much of north-western California. Other advanced technology 'hubs' of note include the Research Triangle in North Carolina and Route 128 in Massachusetts. These areas appear economically distinct largely because the economic activity that takes place within them is predominantly high technology in its nature.

While urban areas such as these have captured the bulk of high technology industries, most metropolitan areas have not been as fortunate. A fundamental question is why have some metropolitan areas in North America experienced the boom of this modern industrialisation while most have not ? The answer at first glance appears to be relatively simple: cities with the correct mix of business, human, cultural, and location attributes (aspects of an aptly-named innovative capacity) were able to foster development to the point that the synergy created essentially began to feed itself, and industrial structures became comparatively self-sustaining, using knowledge as the main raw material. For example, Silicon Valley developed into an advanced technology area as a result of two formative influences - World War II and Stanford University. It was the presence of this progressive university, its world-class researchers, and millions of dollars invested by the U.S. federal government in new military technologies, that gave this region the impetus for growth. Similar scenarios have been played out in other notorious high technology regions throughout the industrialised world.

A window of opportunity for planners, it appears, would be to identify and develop strategies and processes that nurture those seedbed conditions for development, so that change is more of an organic process, occurring naturally and at its own pace. Research institutions that partner willingly with the private sector, an appropriately-skilled and knowledgeable workforce, a strong VC sector, an opportunistic entrepreneurial class, and focused effort by government, appear now to be the critical factors that these industries may look for when either relocating or starting fresh.

For economic development planning professionals to be able to better guide change, the indicators / conditions mentioned above merit consideration as the benchmarks for assessing the strengths of the local economy, and then crafting a suitable intervention strategy. They represent a critical knowledge nexus in planning for progressive, industrial change. The pattern discussed above - where certain regions are emerging as exemplars in high technology development - suggests less of a problem than a potential opportunity for Winnipeg in particular, and metro-Manitoba in general. It does not suggest that it is a case of 'innovate or languish', when city planners address industrial development issues; it can instead be an opportunity to develop new industrial strengths within an already dynamic economy. The key goal of a high technology industrial development strategy may therefore be less that of managing the economy by decreasing the unemployment rate via job creation schemes, and more a case of adding knowledge-based, high-remuneration positions to the city-region. In other words, planning for this type of advanced industrialisation is not suggested as a quick fix for sagging manufacturing economies, but as a more protracted process of initiating long-term structural change in industrial makeup.

1.3 Research Objectives

There are four specific objectives of this research. First, what the research will target is the generation of knowledge about the strategy-related character of high technology firms. The traditional notion of industry simply producing standardised products for mass consumption has given way to the idea of processed information, in the form of knowledge, being applied as new technologies in the development of new and innovative products and services. Understanding what is and what is not high technology industry is an important first step in beginning to address its development, but is also important for the purposes of this research to help focus on aspects that are relevant to both strategizing and policy-making in the study context.

Traditional economic development studies often justify intervention by analysing numerous socio-economic indicators and using them as a basis for decision-making: indicators such as housing starts, growth in manufacturing shipments, income levels, and marginal changes in the GDP are often measured. As we shall see, these indicators would not be appropriate in profiling high technology activity. Consequently, the second objective of this research is to isolate the pertinent conditions of high technology industrial health. Reviewing both historical location theory and relevant high technology precedents allows us to understand why these firms develop in - or relocate to - the cities and regions they do. Moving from the early work of thinkers such as Alfred Weber and August Losch to scholars of the new economic geography will aid our research in identifying the key indicators that determine the relative health of a high technology economy.

The third objective of the research is to obtain some comparative perspective - in a Canadian, Prairie region context - by measuring those key indicators relative to Calgary and Saskatoon, and reveal the extent to which metro-Manitoba is set to participate fully in the new economy. The choices of Saskatoon and Calgary were made largely because of geographic proximity and urban size (one larger, and one smaller than Winnipeg), and an acknowledgement that the three together share a common, formative Prairies history. If this research is able to identify and assess the relative health of high technology indicators in the Winnipeg context, certain overt strengths and weaknesses could emerge, and from this we may begin to form the basis for an informed planning response.

The final objective of this research is thus to link this improved knowledge of high technology industry with appropriate actions associated with urban economic development planning practice. Planners in a municipal context have often sought to influence industry development through such avenues as the sale of pre-serviced industrial land, hidden or overt property tax concessions for the developer or manufacturer, and water and sewer subsidies (Author Unknown,1995b:3). Measures such as these are an attempt to reduce a firm's costs of doing business in a particular location. High technology industries may offer resistance to this approach, simply because the associated 'factors of production' are no longer the same (Atkinson, R. & P. Gottlieb, 2001:37). A high technology region such as the San Francisco area is the most expensive location in the U.S. in which to do business, yet it is also the undisputed centre of high technology. Indeed, it succeeds largely because of its high costs (Devol, 1999:14). In light of this, this research works towards the development of a planning response that attempts to incorporate: (1) an understanding of the phenomenon of high-technology itself; (2) the relevant public and private actors within the City of Winnipeg, and the wider metro-Manitoba context; and (3) the urban economic development planning professional. Accordingly, the specific research questions addressed are:

1. What are the high technology firms that drive the new economy?

2. What are some of the key indicators of high technology industry health that influence the development of new firms, or aid in the retention of existing firms?

3. What is the present condition of these indicators as measured in Winnipeg, relative to two regional competitors, Calgary and Saskatoon ?

4. How can we combine this new knowledge with urban economic development planning practice to create an informed response that can be initiated by an organisation such as Economic Development Winnipeg (EDW)?

1.4 Rationale for the Research

Perhaps more now than at any other time, cities are the keys to successful economic development (see for example Coffey, 1994). Where once the economic health of the Prairies was shaped largely by the actions of agricultural producers, the regional economy today is powered largely by the activity within our largest cities. In the case of Winnipeg, 80% of Manitoba's economic activity and 65% of the workforce is found within the its metropolitan area (Western Consultants, 2001:11). Further, cities of today act as economic, artistic, creative, and technological hubs in a global web, where metro-Manitoba may have more in common with a city such as Beijing than it does with proximate towns and cities that make up our regional or national market. As high technology enterprise is an overwhelmingly urban experience (see for example Glasmeier, 1991), this research is a necessary step in identifying Winnipeg's position as a city-region in a global economy.

By merely knowing the essence of high-technology location we are not necessarily able to do anything meaningful about it. The study of economic geography offers us theories of the where and the why. Consequently, it tells us why industries locate where they do and how those industries are spatially organised. To initiate and maintain the processes that help guide a city from one type of economy to another requires action - this is the domain of urban planning. Planning today can be seen by some as being... "an interactive process, which brings the divergent objectives of different units into concert" (Alexander, 1992:195). Moreover, Verma (1995:179) notes that the utility of planning theory in general is that it is fundamental in bridging the 'knowledge' of various disciplines, with the 'actions' of planning. In other words, one may derive information from relevant disciplines and build it into knowledge, but one must then know how, why, and if one should act on that knowledge.

An underlying rationale in this research project is that there is a distinct need to articulate what role(s) an economic development planning organisation such as EDW could play in the better-planned development of high technology industry in Winnipeg. Traditionally, efforts in Canadian economic development planning could be described as falling into three broad categories, which for our purposes we label: (1) conservative; (2) mainstream; and (3) radical.

Conservative measures taken by public sector planners are often based on a belief that the dynamics of economic growth should be primarily a function of the market, and the planning role (if any) is seen as one which focuses on improving conditions for business in general, and not intervening to any large degree. Maintaining a pro-business regulatory climate in terms of development approvals and permits, providing publicly-developed industrial land to businesses, and producing media that highlight the relative strengths of one or more communities are examples of this approach (Gertler, 1990:36-7). A more mainstream approach taken by economic development planners seeks slightly more intervention in the workings of the market, recognising that market imperfections may exist, and strategies - such as providing timely employment information or job creation tactics to a pool of unemployed people - are developed (see for example Saunders, 1984). Stronger, more radical intervention strategies privilege less the notion of being a facilitator of economic development in favour of being more of a direct participant. Ideologically, the belief behind this type of intervention is that the business community is one that cannot - or will not - function properly within the local, regional, or international market, and therefore local government efforts are considered necessary. Prime manifestations of this include Crown corporations and - in planning terms - urban development corporations (Gertler, 1990:39).

Closely linked to these three broad ideologies, government planning bodies could occupy one or more of four general roles in relation to developing the economies of cities and regions. These four roles are:

1. **Facilitator**: Here the economic development organisation attempts to streamline the development process and attempts to improve the overall business environment.

2. **Co-ordinator**: In this role, the organisation works with other levels of government, business, and community groups to set objectives and develop implementation strategies.

3. **Stimulator**: This role assumes that the organisation will provide both incubation facilities and industrial premises to stimulate business development .

4. **Entrepreneur**: In this role, a planning body will assume an integral role in (a) identifying available business opportunities, land and buildings, and (b) partnering with the private sector to conduct business as an equal partner (Skelly, 1995:5-6).

If we acknowledge that we are indeed at a crossroads in our economic development, and that we are on the cusp of a new cycle of innovation, the suggestion alluded to here is that perhaps now is the time to consider opportunities for change in the relationships between governments (managing the economy), universities (fostering creativity and imparting essential knowledge), entrepreneurs (seeking new frontiers), and economic development organisations (identifying and responding to local economic concerns) in their goals of fostering an innovative environment for Winnipeg and its wider metro-Manitoba context.

What is the planner's role in all of this ? Planning theorists (see for example: Innes, 1995:184; Friedmann, 1993:482) argue that the effective planner of today is one who does not focus on gathering data and drawing up planning documents as a means to an end. Rather, they are seen as actors in the real world, negotiating change. We may take this to mean that the professional planner of today would be one who orchestrates the actions necessary for an informed and appropriate intervention. The new economy would suggest that economic development planners should deal less with allocating land parcels for industry and more with planning modes such as: the building or working relationships with various levels of government and quasi-public sector interest groups, universities and research institutions; developing and possibly managing incubator facilities; reviewing post-secondary education strategies; and encouraging the development of high quality research parks.

1.5 Research Strategy & Methods

The broad research strategy to be employed in this research is a case study of the high technology industry phenomenon in Winnipeg, recognising that Winnipeg is more than the city proper; it is the Province's metropolitan region. A case study is defined as "an in-depth, multifaceted investigation, using qualitative research methods, of a single social phenomenon" (Feagin, et al, 1991:2). Further, "it provides information from a number of sources and over a period of time, thus permitting a more holistic study of complex...networks and of complexes of social action and social meanings" (Ibid.:6). The case study method provides a sound strategy for this research in that it allows the researcher to focus more on one social entity (Winnipeg) while providing the opportunity to study many complex interrelationships (high technology indicators) and actors (governments, venture capitalists) within that entity.

Within the guiding case study strategy, an array of research methods have been employed to execute this research. In order to articulate relevant regional growth theories, it was necessary to undertake a selective literature review consisting largely of historical monographs. To discover the more recent theories of high technology industry location and development, a targeted literature review was executed, focusing on periodicals in fields such as economics, public administration, management, and economic geography, in addition to urban and regional planning. It was through an analysis of this literature that the author identified the indicators that dictate modern industrial location decisions. The specific high technology indicators selected are organised within the broad groupings of:

(1) Venture capital activity
(2) Research and development activity
(3) Current employment structure and educational attainment of the population

The logical step after successfully categorising the indicators is to provide an appropriate mix of qualitative and quantitative profiling as they exist in the City of Winnipeg and metro-Manitoba. Indicators that lend themselves to quantifying have been researched through the

1996 Canada Census, and through special reports produced by Statistics Canada. In general, the data used in these portions is numerical, and is organised to present Winnipeg data relative to both Saskatoon and Calgary in a compare-and-contrast format. Those indicators not as amenable to numerical classification are researched through studies produced by, and data gathered through, industry associations and government data. Key informant interviews are integral to this research. The nature of such a research project usually necessitates a reliance on quantitative data; typically this is the only data used by other such projects. The interviews and interview methods are very important to this research for two reasons. First, the key informants used in this research possess practical knowledge in their particular field(s) of expertise, and provide substance to supplement the empirical data, and in addition, their values and opinions suggest that the data may be viewed in a different light. Second, in the case of analysing the VC and R & D sectors, standardised and uniform data collection in Canada is either still in its infancy, or is not satisfactory in informing us to the extent required. Key informant interviews thus carry significant analytical weight in this research.

1.6 Study Limitations

This research is an in-depth investigation into the key drivers of high technology industrial development and their relationship to Winnipeg from an urban economic development planning perspective. The use of a case study approach limits the context of the phenomenon under investigation to a discrete entity. Much of the literature on high technology activity focuses on political regions as opposed to cities (or even city-regions), referring more often than not to American states as the political and geographical entity under investigation. This is largely due to the realities of examining empirical data that have been gathered primarily by national and state governments. Out of necessity and desire, this research breaks with this tradition. As we indicated earlier, our findings here suggest that high technology activity is an overwhelmingly metropolitan phenomenon, and increasing the scale to that of the province – while considerably easier - does not fully support this suggestion. This research also duly acknowledges the notion that economic and social activity are essentially without borders, and the findings attempt to relate the high technology phenomenon to the wider metro-Manitoba context where it is applicable.

While concerned with the relationship between Winnipeg's economy and the historical elements of geography, politics, and chance that helped shape it, the focus of this research is very much on the present day, and more so with an eye to the future as it may be influenced by better strategies and good policy. As much as possible, the most recent data will be used, though in some cases, we will be reliant on data that was originally collected during the 1996 Census. Finally, as high technology industries are a relatively complex phenomenon, a less-constrained study would attempt to measure as many indicators of high technology health as possible. Indeed, many similar studies are considerably more encompassing than this one (see for example, Atkinson & Gottlieb, 2001). Data limitations, in terms of both uniformity and availability, as well as project manageability have necessitated that this study focus only on what are considered here, based on the initial literature review and subsequent key informant interviews, as the three most important indicators.

1.7 Document Structure

This project is organised into three parts: high technology industry literature, the case study, and the recommendations for EDW. The first part begins with chapter two, which examines the various methods used to define and measure high technology activities, and arrive at an understanding that articulates the key features of high technology activities, and the core technologies involved. Chapter three is devoted to theories of innovation diffusion, economic polarisation and agglomeration, and literature that illuminates representative high technology precedents, and the key drivers which led to their success. Part two represents the comparative case study portion. It begins with chapter four, which is an in-depth investigation into metro-Manitoba's VC industry - its key people, strategy-related aspects, and relationship to other aspects of the high technology economy. Chapter five is likewise an in-depth investigation into certain aspects of metro-Manitoba's R & D arena. Due to the sheer breadth of this subject area, we have limited the investigation here to what amounts to the most influential aspects of R & D for our purposes. Chapter six is devoted to understanding the educational status of the metro-Manitoba population. In particular, we attempt to investigate how many residents currently possess advanced education in key fields of study, the performance of secondary students in the mathematics and sciences, the key determinants of why secondary students choose particular post-secondary fields of study, and the post-secondary graduation rates in these key fields of study. Chapter seven represents the third part of the research, and includes a summary of findings, in addition to the recommendations that come as a result of the research findings. The document closes with recommendations for further research.

Chapter Two

Understanding the High Technology Economy

Introduction

Historically, there have been conceptual disagreements between researchers regarding an adequate definition of a high technology activity, firm, or industry. This difficulty is compounded for our purposes by the fact that the words 'high technology' are embedded in virtually all products and processes, especially in terms of marketing. When the reader is exposed to the words 'high technology' as applied to razors, car tires, and interior-design schemes, it is understandable that most people have an intuitive yet fuzzy sense of what high technology is, yet few understand what we refer to when we discuss high technology industry. Is a high technology firm one which is involved in the production of computers? Yes and no. It is not if the production of computers is routine assembly from existing parts, but it is considered high technology if the company is involved in the design of a new type of processor. These issues can be debated in virtually ever firm and industry. Therefore, there is a need to define both high technology firms, and high technologies. The purpose of the following section is thus to briefly review some of the past attempts at defining high technology activities, determine the core technologies incorporated by high technology firms, and combine them to arrive at an operable definition for our research.

2.1 Previous Attempts at Defining High Technology Activities, Firms, & Industries

There is little agreement among scholars regarding the best way to explain exactly what a high technology firm is. Rather, there is growing consensus that a standard definition may never be identified (Riche, Hecker, & Burgan, 1983; Markusen, Hall, & Glasmeier, 1986; Malecki, 1984; Weiss, 1983). The term 'high-tech' remains a problematic catch-phrase that conjures up images of space travel, robotics, and computer hardware, and as a result of its ambiguity, is often applied with little discrimination. The confusion surrounding this term for researchers has been compounded by the movement of firms towards what has been termed 'conglomerate economies' [5], and by limitations related to data availability, accuracy, and measurement (Glasmeier, 1991). Definition is further complicated by the fact that virtually all industries will contain high technology activities, but very few (if any) could be considered to have high technology applications in all of their work (Malecki, 1984:263; Baldwin & Gellatly,1998). A review of the literature concerned with formulating an operational and measurable definition of high-technology industry reveals that researchers often – out of necessity - construct definitions that suit their own research purposes (Riche, Hecker, & Burgan, 1983). The following section reviews some of the attempts to define high technology activities. They can be divided into two major categories: (1) un-measurable, and (2) measurable (Malecki, 1984).

2.2 Non-quantifiable Methods

Any definition of high technology that is largely determined by un-measurable methods should be considered subjective (Malecki, 1984). It is generally based on the perceived technical sophistication of a product or process, rather than objective facts. A researcher using such a method will be influenced not only by the availability and accuracy of pertinent information, but also by his or her own knowledge-base, level of scrutiny, and, ultimately, personal bias. A definition of high-technology activities developed in this manner may appear accurate; however, glaring limitations may be present in that no real measurement criterion has been established prior to the researcher's investigation.

As noted by Vinson and Harrington (1979), the Massachusetts Division of Employment Security (MDES) used a variation of this subjective method in their study. They reviewed the U.S. Standard Industrial Classification (SIC) manual and formulated a list of twenty industries believed to be high-technology, based on how technically sophisticated their product(s) appeared to be. This method was also adopted by the U.S. Department of Commerce (1984). Any industry identified in this way is likely to be worthy to some degree, but this represents a crude and simple attempt at a definition. An important trait of most high-technology industries is their innovative quality. Any one product takes at least five years to earn its place on the U.S. SIC manual (Glasmeier, 1991), rendering this method out of touch with new technologies. Further, offering nothing more than a brief heading, the SIC scheme provides the researcher with very little information upon which to make a truly educated decision concerning an industry's high-technology status. Glasmeier (1991) recognises the shortcomings of defining high-technology based on a perceived product sophistication and states that "ideally (she) would identify high-technology industries based on product qualities" (pg. 22), but cites limited data availability and pronounced product diversity within a single firm as reasons why such an approach fails. However, the primary defect remains the fact that this method simply does not offer a working criterion to distinguish between high-technology and low-technology industries and products (Riche, Hecker, & Burgan, 1983; Glasmeier, 1991). In the absence of hard data, it remains a non-quantifiable and impractical means of satisfactorily defining high-technology industry.

More useful attempts have defined high technology by the activities of individual firms. Malecki (1984:262) supports this method and suggests that non-routine activities – as opposed to routine activities of mass-product manufacturing – form the basis for a sound definition. He suggests that there is often a correlation between knowledge-intensive industry and non-routine production processes. Several scholars once endorsed this method (see for example: Vinson & Harrington, 1979; Riche, Hecker, & Burgan, 1983), but this method clearly has flaws. There appears to be no empirical way to determine what a non-routine activity is, and even if it were possible, it is necessary to attempt to become intimately familiar with the workings of individual firms. Further, it is difficult to strictly associate the term 'non-routine' with an advanced knowledge industry. Non-routine activities are likely taking place in all industries, in their early establishment phases especially, but less so once they have matured.

The U.S. Congressional Office of Technology Assessment (1982) provides a more appropriate definition of high-technology industry as being those "companies that are engaged in the design, development, and introduction of new products or innovative manufacturing processes through the systematic application of scientific and technical knowledge" (Riche, Hecker, & Burgan, 1983:51). This definition shares with both Malecki (1984), and Botkin, Dimenescu, and Stata (1982), the notion of high-technology as being closely linked to the degree of innovation, and recognises the need for inputs such as knowledge and technical expertise. This is a relatively good attempt at defining high technology industry. However, until recently, measures such as these - based on perception and 'expert' opinion - remained largely on the fringe of definitions, as they had little in the way of empirical substantiation. Researchers typically eschewed them in favour of more tangible definitions.

2.3 Quantifiable Methods

Researchers may choose a more objective and measurable method to define high technology. Objective methods of defining high technology industries or activities depend on the availability and accuracy of standardised data which, if provided, can be used with relative ease and consistency. Using these methods, researchers may establish criteria prior to data analysis, and each industry is evaluated using the same criteria.

2.3.1 The R & D Intensity Approach

R & D is at the core of high-technology industry. It is defined by De Bressen (1987) as "basic scientific research, applied research, and exploratory development for the purposes of economic application" (pg. 256). Innovative firms often require continual R & D efforts to ensure ongoing economic success through the relatively constant introduction of new products or new iterations of existing products. High technology industries are often categorised using R & D expenditures as a percentage of a firm's gross revenues (sales), and some believe that the relative intensity level of R & D alone can delineate an industry as being high-technology (Committee on Science and Technology, 1990). However, this method can be considered flawed for two reasons. First, this would favour new firms, as they tend to spend a greater percentage of their sales on R & D (Markusen, Hall, and Glasmeier, 1986). Mature firms may spend significantly more in actual dollars, but spend only a small percentage of their sales. This method would suggest that the former is more likely to be considered high-technology, while the latter is not. Second, by using this approach, a researcher may be suggesting that there are no fundamental differences between R & D and high technology (Chabot, 1995). This implies that R & D intensity – regardless of amount – would include firms with high R & D inputs (such as industrial lubricant developers and paper processing companies), but little else that would classify them as possessing high technology attributes (Kodoma, 1991).

2.3.2 The Employment Intensity Approach

It has been suggested that – among other factors – the shift to an information economy, automation, and innovation are partly responsible for the decline in traditional manufacturing employment, while high-technology industries are, assumedly, enjoying steady employment growth (see for example: Blakely, 1994; Malecki, 1984; Markusen, Hall, & Glasmeier, 1986; Weiss, 1983). This would partially explain why policy makers have been so fervent in their attempts to lure high-technology industry to their regions as a means of revitalising their economies (Mier, 1983; Riche, Hecker, and Burgan, 1983). If one accepts this notion, industries with job growth beyond the manufacturing average can be defined high-technology (Technical Marketing Associates, 1979). The logic behind such an assumption (and indeed, its use as a definition) is skewed, in that many employment sectors with strong growth may simply not be reflective of any high technology activities whatsoever (see for example: Weiss, 1983; Markusen, Hall, and Glasmeier, 1983). Further, advanced knowledge industries such as biotechnology today may either have sluggish employment growth as the industry continues to develop, or they may employ few persons relative to R & D expenditures and other factors.

2.3.3 The Human Capital Approach

Many scholars conclude that the human capital component of the labour process provides the basis for the most accurate definition of high-technology (see for example: Glasmeier, 1991; Markusen, Hall, & Glasmeier, 1983; Malecki, 1984; Riche, Hecker, & Burgan, 1983; Vinson & Harrington, 1983; Weiss, 1983, Browning, 1980). Using this approach, high-technology industries are defined by Markusen, Hall, and Glasmeier (1986) as those with greater than the national (U.S.) average of engineers, engineering technicians, computer scientists, mathematicians, and life scientists. This method is popular, and appears to be so because of the ease of gathering data from one source. Despite the early popularity of this method, it too is flawed, in that it (like each method taken individually) is too explicit (Armington, Harris, & Odle, 1983). For example, petroleum refining firms conduct little R & D, may or may not be vibrant in terms of employment growth, but they generally have a high percentage of technical employees. Second, depending on the industry in question, technical staff may have little theoretical knowledge of engineering or other scientific theories (Diwan & Chekaborty, 1991).

2.4 Towards a Definition of High Technology Activities, Firms, & Industries

This research concurs with the findings of previous scholars (see for example: Riche, Hecker, & Burgan, 1983; Markusen, Hall, & Glasmeier, 1986; Malecki, 1984; Weiss, 1983) with respect to the problems of finding a suitable definition for a high technology firm or industry based on a discrete measure. There is simply no one aspect that could be isolated, and measured across all industries, where data is sufficient in scope and depth. However, there is still a need to arrive at a shared understanding of what high technology really is, especially in a policy context. Without a sound understanding of what high technology activities are, discussions regarding the manipulation of its location are "empty and vapid" (Baldwin & Gellatly, 1998:8).

Emerging research practice appears now to have shifted, in that a strict definition of a high technology firm, process, product, or activity is not viewed as a fundamental need in studying the phenomenon. Rather, the suggestion now being put forth is that firms that are active in the world of high technology be defined by a group of shared characteristics which may flow through industries, firms, and people. What may be occurring in one firm may not necessarily be occurring in all firms within an industry. A general set of characteristics also helps explain the activities of firms and industries in which some activities are high technology, and some are not.

Chabot (1995) has developed this idea, and has suggested that high technology taxonomy be restricted to a common set of characteristics that are based on an emerging techno-paradigm. Though he criticises previous 'input' (measurable) and 'output' (un-measurable) schemes that some researchers favour, his efforts could largely be placed in the 'perceived technical sophistication' arena, in that it is still largely a subjective method, and indeed can be seen as a partial compendium. His focus though, is fundamentally different in one regard: the behaviour and organisation of firms (as opposed to simple products and processes) is the defining characteristic that denotes high technology, and in this regard his view may be more satisfactory, and more resistant to criticism.

Chabot lists five definitive behavioural and organisational aspects of activities, firms, and industries to be considered 'high technology'.

Characteristic	Description
1. Manufacturing Inputs	This characteristic indicates that high technology firms are those that spend an 'enormous' amount of capital on R & D relative to other sectors.
2. Business Dynamics	Firms show a tendency towards extreme technological diversification, where mere survival is determined by their ability to remain diverse.
3. Invisible Competitors	The suggestion put forth here is that innovations come in waves, and investments in innovation are usually found in numerous places at once. As a result, competitors may

	be unlikely firms in different industries.
4. Demand Articulation	Firms focus any R & D towards demand-side initiatives. High technology activities are seldom directed towards supply-side initiatives.
5. Technology Fusion	This characteristic implies that technological breakthroughs are essentially minor. Firms engaged in high technology activity are those that successfully combine a number of existing technologies.

Source: (http://www.stanford.edu, 2000)

Chabot's techno-paradigm appears to be intentionally abstract, assumedly because it is oriented towards a set of general characteristics. In a sense, we have returned to where we started, which – despite Chabot's caveats – appears very much to be in the perceived category of analysis. That we have developed an accepted characterisation of high technology firms as opposed to a rigid definition should not present a problem to researchers, so long as the definition is not tied into any measurement scheme. Criticisms regarding definitions likely arose as a result of there being a need to be able to measure certain activities within high technology firms, and when problems arose, the definition tended to be cast aside. For our purposes, we need not use such a definition as a basis for measurement, only a guide for understanding. Chabot's effort is considerably better than many predecessor's attempts in that it is intentionally inclusive, leaving room for new activities and industries to conform, and intentionally vague, allowing researchers to place intuitively, accepted activities that may be excluded from other schemes.

2.5 The Three Core High Technologies

While we have seen that there is a significant amount of research that attempts to define high technology firms and industries (based on their attributes), there is a relative dearth of research that systematically attempts to actually identify what a high technology is, largely because one definition has been almost universally accepted (OECD, 1998). The Office for Economic and Co-operation and Development (OECD) identifies three areas in which new technologies are rapidly emerging: (1) biotechnology; (2) advanced materials; (3) microelectronics; and their associated sub-processes.

2.5.1 Biotechnology

Industry Canada defines biotechnology as the applied use of living organisms (or their components) to make new products or modify existing ones (Industry Canada, 1997:1). Others expand on this definition and suggest that the recombination of DNA and the creation of monoclonal antibodies are the two fundamental techniques used in biotechnology (Feiganbaum & Smith, 1993:108). The U.S. Congressional Office of Technology Assessment provides a similar definition of biotechnology, namely, as "products primarily manufactured using recombinant DNA, recombinant RNA, hybridoma technology, or other processes involving site specific genetic manipulation techniques" (1991:5).

Biotechnology is not truly an industry: it is best described as a series of biological processes used in many industries, including the health, chemical, and agriculture industries (Industry Canada, 1997; U.S. Congressional Office of Technology Assessment, 1991). Pharmaceuticals and diagnostics, seeds, plants, animals, fertilisers, food additives, industrial enzymes, and pollution degrading microbes are some examples of products that can be enhanced or created by the application of this technology (U.S. Congressional Office of Technology Assessment, 1991:3). Although many industries are benefiting from biotechnology, it is the health care field that currently accounts for 90% of global biotechnology activity (Industry Canada, 1997:2). However, growth is expected to rapidly occur in other industries as R & D efforts continue. In fact, the global market for biotechnology-based products is expected to grow from (U.S.) $15 billion to $38 billion between 1995 - 2005 (Ibid.).

2.5.2 Advanced Materials

New materials technology is one of the most pervasive – yet least known technologies – in existence today. Improvements in the interaction between basic science and materials technology, and the development of instrumentation used to study materials has led to the creation of new materials almost daily (Aigrain, 1988:41). Advanced materials science is the diverse area concerned with such discoveries. It is composed of firms who apply science and technology to produce these new, often highly-specialised materials with distinct properties or equipment to process or handle such materials, and it appears to be an innovative, ambitious, and important high-technology area.

At the turn of the 20^{th} century, plastics, wood, and concrete replaced metals to become the most common industrial materials used in North America. A new generation of plastics and other synthetic materials have now emerged to alter the composition of even more products (Newton, 1986:38). Such advanced materials are often able to outright replace traditional materials, and can provide improvements to existing ones, such as corrosion resistant metals, more durable concrete, and electrically conductive and self-reinforced polymers. Science and technology are ensuring that materials become stronger, more durable, and increasingly cost-effective, with the intrinsic properties of all classes of solids - metals, ceramics, polymers, and composites - being better utilised (National Academy of Engineering, 1984:85).

Many new materials are made by combining two or more materials to control strength, stiffness, and other properties. These composites include steel-reinforced concrete, silicon-carbon-reinforced aluminium, and fibre-reinforced plastics (National Academy of Engineering, 1984; Newton, 1986). These composite materials are responsible for improvements in a wide range of products, especially in the aerospace industry. Several models of aircraft use fibre-reinforced composites in air frame sub-structures, where the excellent stiffness-to-weight ratios translate into increased payloads and shorter take-off distances. Furthermore, composites are benefiting the transportation sector, structurally improving rail cars, boat hulls, and motor vehicles (Newton, 1986:39).

Technical ceramics have been receiving attention as an important new material. Whereas traditional ceramics - those used to make dishware, sinks, and floor tiles - are relatively fragile, technical ceramics are considerably more durable. The differences result from the purity of materials and the precision of formulas and firing processes. The introduction of technical ceramics into microelectronics manufacturing has led to significant R & D efforts, with the microelectronics industry funding the bulk of it. The prospects for this new material are considerable. Engineers predict a time when ceramic engines will replace metal engines in cars and aeroplanes (Newton, 1986:41). Other potential applications include cutting tools, such as scissors and surgical saws, and prostheses, such as hip replacements (National Academy of Engineering, 1984:128-30).

2.5.3 Microelectronics

Microelectronics has been defined by one author as "the production and use of highly complex integrated circuits contained on a tiny chip of silicon" (Weil, 1982:8) A more encompassing definition refers to microelectronics bluntly as "a branch of electronics that deals with extremely small components" (Newton, 1986:58). However defined, microelectronics is primarily concerned with the processing, storing, and transmission of information and the use of information in goods and services. As a result, the computer-industry is perhaps its greatest beneficiary (OECD, 1998:10).

Microelectronics is a widely applied and highly advanced technology. The industry began in earnest during the 1950's, first with the development of the transistor, followed by the invention of the integrated circuit (IC). The IC placed hundreds of transistors and other electronic functions on one small piece of silicon. Large-scale-integration (LSI) followed, with many thousands of electronic transistors - enough for a complete computer - etched into each chip (Newton, 1986:8). More recently, very-large-scale-integration (VLSI) became possible, permitting the design of even more powerful data processing systems (Weil, 1982:8). With each reduction in size, these micro-processors have become more powerful and reliable, yet they have often declined in price (Newton, 1986:8). As Malone (1999) explains, this unusual phenomenon was coined Moore's Law by Intel technologist Gordon Moore. Moore graphed the lifespan of the microprocessor to discover that the micro-chip doubled in performance every two years. According to this law, a high-performance micro-processor such as the Intel Pentium chip of 1996, is 10, 000 times more powerful than a chip created 25 years earlier, such as the 4004; yet both were sold for the same price. Furthermore, same chips of a given performance would halve in price every two years. Such a performance-to-price curve is unique to the microelectronics industry and emphasises the complex nature of this fast-paced, dynamic field.

Perhaps the most important aspect of microelectronics is its endless capacity to merge with other technologies. For instance, the telephone and computer industries joined to form telecommunications. Similarly, computers have influenced the manufacturing sector, increasing factory automation and replacing assembly lines with robotics. Moreover, scientists, engineers, and designers are using computer aided design and manufacturing (CAD / CAM) to achieve impressive refinements in design and production. In addition, artificial intelligence and expert systems are emerging that can diagnose disease, prospect for minerals, and trouble shoot mechanical systems. Such innovations, and many others, are closely tied to, and dependent on, microelectronics technology, which has certainly proven to have far reaching influences (Newton, 1986:2-4).

We should note that the new economy, as it is often characterised, would not exist without microelectronics. Its spread to virtually every aspect of modern business machinery led to the development of the personal computer industry, which in turn led to the explosion of the internet as a fundamental communications tool. The rise of e-commerce as an important aspect of virtually all companies' business plans, and the ongoing development of wireless technologies can all be traced back to the origins of the microelectronics industry.

Conclusion

Problems have plagued researchers over the last fifteen years in the pursuit of a universally-accepted definition of high technology firms and industries. Original attempts included measures that appear to be based on assumptions or educated guesses, while other attempts tended to restrict their classification to discrete measures (assumedly so that they could rigorously apply them to large amounts of statistical data). Limitations were noted when the definition would unwittingly exclude or include many key industries. Chabot's thesis is not original, but it does represent advanced thinking about the subject, with a knack for using generalities. He formally eschews previous attempts at defining high technology industries, and essentially characterises any firm or industry that *generally* shows certain behaviours as being representative of high technology. Given that researchers today are less inclined to use a definition as a method to measure activity, this appears to be a valid definition that encompasses the critical points of high technology activity. Chabot's loose definition should be combined with the OECD's generally accepted naming of the three dominant technologies to arrive at an accepted definition for this project. To sum up, high technology activities, firms, and industries are those that are:

(1) based in microelectronics, and / or biotechnology, and / or advanced materials; and,
(2) ones that tend to spend a disproportionate amount of their revenue on R & D; and,
(3) ones where R & D activities are oriented towards demand-side articulation; and,
(4) ones that may have invisible competitors in unknown industries; and,
(5) ones that show predatory behaviour; and,
(6) ones that tend to have consistent, minor technological breakthroughs.

This section satisfies the first objective of our research: we have effectively determined for the reader what high technology activities, firms, and industries are. The following chapter will introduce theories which tell us where high technology firms are, and why they are there.

Chapter Three

Theories & Precedents Relating to the Development of High Technology Regions

Introduction

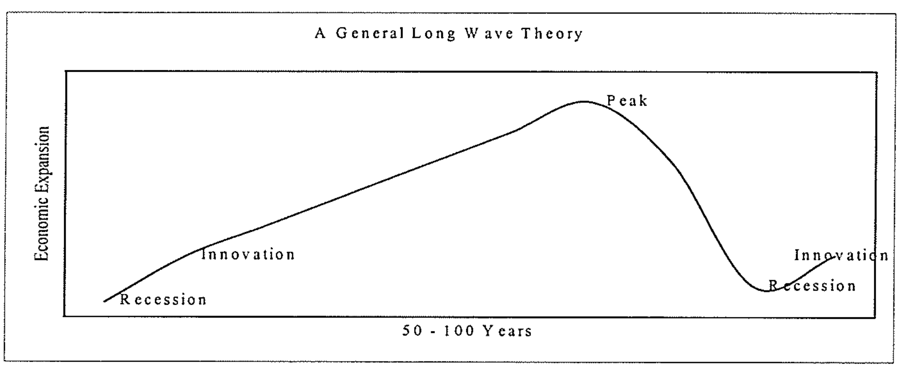
The purpose of this chapter is twofold. First, as the industries that represent the crux of this research are deeply rooted in innovation, we will introduce some key theories that attempt to explain how innovations affect industrialised economies and their firms. In particular, the works of Kondratieff , Schumpeter, and Van Duijn will be discussed. From this, we will also introduce two theories that may outline a process as to how innovative activities diffuse through geographic space, and how this activity may cluster in metropolitan areas. Second, this chapter will introduce three high technology regional precedents - Silicon Valley, Route 128, and the Research Triangle Park. These three are introduced because they are successful high technology economies, and they will aid this research in identifying the key indicators of high technology industry development that we will later apply in a case study context of metro-Manitoba.

3.1 Innovation & the Long Wave & Cycle Theories

Most economists and economic geographers acknowledge the role of technological change and innovation in economic expansion (and the lack of innovation resulting in economic decline), and many see a direct causal relationship (see for example: Mensch, 1979; Van Duijn, 1983; Blakely, 1994; Dobilas, 1996), whether they refer to the invention of the steam engine as a form of power, or the integrated circuit as a form of information processing. Both innovations were critical to the growth of the economies of their day. Modern industry has changed significantly since many of these theories were written, yet they still confer conceptual knowledge of how and why innovation produces structural changes in economic activity.

Though Nikolai Kondratieff was the first economist to truly elaborate a general theory of economic expansion and contraction using economic epochs, he did not note innovation as a causal factor. Kondratieff postulated that all capitalist economies rise and fall in waves of approximately 50-55 years duration (Hall, 1985:7). These waves are best understood when envisioned as beginning with a trough, followed by an upswing, a peak, and then a downswing (see Figure 1). The trough represents a recession that will ultimately demand economic change. Prior to the upswing, investment in infrastructure tends to be high. However, it is not until these investments have spurred others that the long wave begins its upswing. During the peak of the long wave, businesses and industries successfully exploit new innovations that offer new products and new opportunities.

Figure 1



Source: (Author: constructed from readings)

As time lapses, product awareness ensures an increase in competition, and market saturation eventually occurs. As a result, recession and depression often follow, as represented by the declining wave of the cycle (Girifalco, 1991:17-8). Kondratieff identified five eras which demonstrate this long wave dynamic. The first Kondratieff wave is believed to have occurred from 1790-1840, the second from 1840-1885, the third from 1885-1935, the fourth from 1935-1975, and, as a point of debate, we may currently be in the midst of the fifth wave, fuelled largely by the rise of high-technology activities.

Kondratieff did not acknowledge innovation as the direct cause of a long wave. Rather, he concluded that the causal factor was investment in large-scale capital goods, which may or may not have been innovative (Girifalco, 1991:17). However, because capital can not be accumulated without the profits typically (re)generated by innovation, the link between innovation and the long wave appears understated by Kondratieff. In fact, it has become common for economists to identify the cause of Kondratieff's cycle as being technological development, despite his own indifference to this notion (see for example: Hall, 1985:7; Girifalco, 1991:17; Yeates, 1990:33).

As a result, several theorists have since refined Kondratieff's long wave theory. Schumpeter (1939) drew on Kondratieff's work to formulate a similar theory based on shorter waves which he termed business cycles. He argued that two of these shorter cycles could be couched within one of Kondratieff's long waves (Hall, 1985:7) and credited technological innovation as the sole impetus for these cycles. Likewise, Kuznets (1930) shared with Schumpeter the belief that new products are the cause of massive changes in economic growth and decline, which can again be represented by waves similar to those suggested by Kondratieff.

Later, Mensch (1979) argued that there were cycles of approximately fifty years during which the number of innovative products rose and fell, lending further support to an almost universally accepted long wave theory (Girifalco, 199:17).

Where Kondratieff made little mention of innovative activities, and where Schumpeter and Mensch argued that singular innovations and inventions are direct causal factors, Van Duijn posited that long-waves are in fact caused by clusters of innovations that can be self-energising if they occur within a relatively short period of time. Van Duijn's premise is that long waves do exist, and that through history, invention and innovation tend to cluster in time, and that investments in infrastructure associated with these innovations leads to economic growth and expansion. Most importantly, Van Duijn's refinement is the first that indicates that the development of new firms is a significant aspect in this growth scheme (Van Duijn, 1983:58-111).

3.2 The Product-Profit Cycle of Products & Industries

First developed by Vernon (1966), this theory is influenced by the works of both Kondratieff and Schumpeter. Where the latter two were concerned with longer economic cycles that affected the entire economy, Vernon demonstrated that products themselves experienced 6-8 year cycles of growth and decline. This was and is an important concept that runs through industries, though a 6-8 year period vastly overstates product timelines for many high technology products such as software. Of significant interest to our research here, subsequent literature has used this theory to explain the behaviour of firms and industries (Markusen, Hall, & Glasmeier, 1986:41). The theory postulates that as a product or firm progresses through this cycle it experiences four stages of development: innovation, market penetration, market saturation and, finally, rationalisation.

Stage 1	Invention and development of a new product or process. [6]
Stage 2	Patents lapse, competition increases, and firms concentrate on market penetration and sales expansion. [7]
Stage 3	Cost-cutting or the formation of oligopolies is employed. [8]
Stage 4	Rationalisation of activities will occur without innovation [9]

These theories - while differing to some degree in their scope, orientation and causal factors - indicate one significant finding as it relates to our research. Activities, firms, industries, and economies exist, but growth does not exist in a constant state. Rather, the key in each scheme - be it long wave, business cycle, or product / firm cycle - is that innovation and invention directly impacts the changing fortunes of an activity, industry, or economy. What this further suggests to us is that we may be on the cusp of this fifth wave of economic life. The economy of today bears witness to the fact that we are exploiting a cluster of innovations (the integrated circuit, DNA, the internet) and witnessing the growth of attendant firms and industries in response. For our purposes, one of the primary weaknesses that planners may find in these theories is that they are generally temporal, and though obviously designed with the notion of geographic space in mind, they don't address the geographic implications of these waves and cycles directly.

3.3 Growth Pole Theories

The underlying premise of a growth pole [10] theory is that economic growth is highly uneven and tends to develop more strongly and more quickly in some urban areas and regions, thereby polarising growth. Unlike neo-classical economic growth theory [11], where labour and capital flows to urban areas and regions where it is required, growth pole theories suggest that economic growth has a propensity towards 'regional disequilibrium', where there is a tendency for labour, and capital to flow to specific urban areas and regions with innovative activities taking place. Much like Schumpeter's business cycle notion discussed earlier, the impetus for economic growth in these schemes is dictated predominantly by technological innovation and its subsequent diffusion through economic space. However, where Schumpeter and Van Duijn were concerned with cycles of innovation and their effects on *economic* space, and in a *temporal* context, growth pole theories have differentiated themselves by attempting to predict innovation and its effect on economic and geographic space. By this alone, theories of this nature lend more support to planners dealing with the tangible world of economic development.

Francois Perroux (1955) was the first economist to develop a general theory of polarised economic development, though it was subsequently refined by others (see for example: Lausen, 1969:137-61). Richardson (1978:155) suggested that the growth pole process had three distinct stages:

(1) economic concentration at a single point;

(2) diffusion to limited, multiple centres;

(3) diffusion to the periphery [12].

In the first stage, clusters of related, technological innovations lead to the development of a 'motor' or 'propulsive' industry that exploits these innovations in a spatially concentrated geographic area. As a relevant example, Silicon Valley's growth pole was to a large extent made up of the firms exploiting microprocessor technologies (and closely associated innovations), whose locus was the Palo Alto region of California. The introduction of this invention did indeed lead to highly polarised development in this region through the auspices of this technological innovation, largely because knowledge of the invention was - at the time - held by relatively few people. In this model, economies of scale and agglomeration also come into effect, thereby reinforcing the growth and ensuring that this motor industry remained initially concentrated.

During the second stage of this process, the growth pole disperses geographically as knowledge of the invention (or the creation of ancillary inventions) is learned and incorporated by firms in other regions. The effect of this is that now, in addition to the original growth centre, motor industries in secondary centres may develop economically with an ancillary invention, such as Microsoft's sophisticated computer operating system in Washington state, and IBM's personal computer in New York. The final stage is characterised simply by the widespread adoption of the innovation in more peripheral urban areas, and the subsequent economic development that has occurred as a result of it. From the original adoption of the microprocessor as a viable product, economic growth had concentrated in Silicon Valley before dispersing to Washington state and other relevant regions. The microprocessor is now a widely used innovation, and many firms in many regions have helped develop economies using it and its related technologies as a basis for economic development.

3.4 Porter's Industry Concentration Theory

In economic development circles, there is an old theory which has recently become a new theory. As far back as 1909, Alfred Weber, known largely for his role in developing the science of industry location, put forth an inter-firm concentration theory. The theory stated simply that a given firm has economic relationships with other firms who may act as suppliers to the original firm, and others who act as buyers from the original firm. The supporting firms in question either added 'inputs' to the final product (backwards linkages), or bought 'outputs' from the original firm (forward linkages). For example, in the case of the aggregate leather industry, the original firm may be a leather tanner. The input firm(s) could be a series of hide suppliers, while the output firm(s) could be a series of shoe manufacturers. The geographic crux of this theory is that these firms would have a certain economic propensity to locate near one another, in the hopes of creating an economy realised through this agglomeration process. It is supposedly through this agglomeration that regional industry strengths and specialisation occur. This long-standing theory has been tested somewhat successfully using the jewellery (Wise, 1951), furniture manufacture (Hall, 1962), and electronic instruments industries (Martin, 1966) as case studies.

Recently, Harvard economist Michael Porter has renewed significant interest in this basic theory, and has adapted it to help explain how nations achieve industry specialty and international competitiveness. The theory is - as much a theory of agglomeration - a general theory of economic growth, business organisation, and open competition. Porter's target has been largely the nation state as the focus of study (see also, Porter, 1991), but more recently his efforts have been directed to applying the theory to explain metropolitan economic growth (see for example, Western Consultants, 2001). Indeed, the theory is based largely on relationships and other intangibles, and could be considered virtually scale-independent.

The basic premise of Porter's work is that there are four key determinants that dictate an industry's ability to gain competitive advantage. There appear to be few causal assignments within his structure, but instead, he suggests that as these determinants develop in their own right, there is a blurring of causalities and more of a self-perpetuating energy that drives the process. The first determinant is the state of the 'factor conditions', which represents how relevant industries exploit an area's basic strengths in infrastructure relevant to the industry in question, such as highly skilled labour, abundant hydroelectricity, research institutes, or cultural attributes. Porter's second determinant, 'demand conditions', essentially represents the market for an industry's products. He suggests that buyers (which are often supporting industries) have a significant effect on industry where there is pressure on industry to innovate faster and achieve sophistication over rivals. The third component of competitive advantage relates to the extent to which there are equally competitive 'supporting industries'. A classic example of this is the case of IBM, Microsoft, and Intel, parts of which we alluded to in the discussion of growth pole theories. For business reasons now infamous, IBM contracted both Microsoft and Intel to provide key inputs into their business machines. While acting as support industries to IBM in the short-term, these two firms have in fact become world leaders in what are now independent industries, while helping to develop more support industries that now form part of their business web. The final determinant of Porter's scheme is an industry's 'firm strategy, structure, and rivalry'. While complex, the most fundamental aspects of this last portion are essentially an industry's orientation and propensity towards global competition, and the nature of rivalry between similar firms within an industry. Where Weber, and scholars who added to his basic agglomeration theory, (see for example, Oakey, 1985) tended to reinforce the notion of co-operation between firms, Porter has stressed the importance of competition between firms. Far from the approach of government coddling certain firms in an effort to make them national champions, Porter suggests the opposite, in that fierce rivalry between firms encourages significant innovation that will ultimately lead to the development of the entire industry – also for the betterment of each firm (Porter, 1990:71-117).

Porter's most recent approach has been to view metropolitan areas as an important place where the four determinants interchange and industry clusters develop – the geographic manifestation of his theory. Porter defines these clusters as "groups of firms in a given region that - seemingly paradoxically - must co-operate even as they fiercely compete. Clusters encompass not only a number of industry competitors but also suppliers, firms in related fields, specialised educational institutions, and support services that are concentrated in particular locations" www.rouseforum.org, 2001). It appears that a region becomes known as home to a successful industry cluster at the point it becomes internationally recognised. Porter has identified numerous clusters, including entertainment (U.S.), electronics (Japan), and chemicals in Germany (Porter, 1991:66). A recent report has also identified key clusters in Silicon Valley and Ottawa (high-technology), and financial services structures in New York and Toronto (Western Consultants, 2001). Porter has essentially adapted Weber's original thought of industry concentration, but has applied his theory to modern industry and industry structure. His most important contribution to the theory may well be the discussion on the importance of rivalry and competition as a fundamental basis for industry growth.

3.4.1 A Note on Industry Location Theories

The basic premise of industrial location theory is that there are certain factors that dictate where a firm will locate in geographic space. Historically, there have been two main theory streams through which to analyse industrial location: the normative and behavioural approaches. Normative theorists are interested in modelling the factors of production (land, labour, capital, transportation costs) to arrive at an optimum location that represents either the least cost, as promoted by Weber (1909), or maximum profit, as promoted by Losch (1954). Behavioural theorists of industry location reversed the focus of study from the firm (in normative theorising) to the decision maker, who ultimately determines the location of industry. In general, behavioural theorists such as Greenhut (1957) and Pred (1967) were concerned with the way the factors of production are perceived and interpreted by the decision-makers prior to the location decision being made.

Industrial location theory remains relatively staid today, and does not appear employable as an explanatory theory for high technology polarisation. High technology and advanced knowledge industries may have few issues with respect to product weight (software and the products of biotechnical research are two examples that support this notion), and distance to market (where the products of industry may themselves be information, which may be transported through high speed data lines). It is for these reasons that industrial location theory is noted here as background for the reader, but provides no real basis for a study of high technology industrial development.

Conclusion

In this section, we have introduced theories related to innovation and its possible spread through economic and geographic space, and a theory or agglomeration based on competition and co-operation. While we have not delved deeply into these theories, nor suggested them as possible modelling tools, their purpose here was to provide an understanding of the possible effects of innovation on economic systems, and how firms react to the relationships that these innovation-diffusion processes confer. Discussion of long wave economic activity is useful to this research in acknowledging that radical innovations, or smaller, successive innovations with economic value, can have profound effects on economies of all sizes, but that is where their value ends for planners involved in high technology economic development. The simply do not address the issue of innovation, and the causes of innovation, except in a very general manner.

Growth pole theories such as the ones we have introduced also have value in that they go further than the former by outlining a general process of innovation dispersal, and introduce a geographic manifestation into the equation. They are also useful because they introduce the idea that inter-industry firms have a tendency to cluster in separate areas, a key feature of high technology economies. For these reasons alone, theories such as these have relatively more value for planners dealing with actual economic development issues in a high technology context. However, in the context of our research, growth pole theories provide us with little more than a statement that innovations do arise in a certain time and space, and will likely diffuse through an urban or regional hierarchy over time as innovations spread. They, like the long wave and business cycle theories have not adequately addressed the issues of what causes these innovations. They have also not adequately addressed why an innovation tends to occur in one region as opposed to another.

The notion of industry clusters is further developed by Porter in his more recent work, and can be viewed in part as an extension of the growth pole theories. The difference between the two fundamentally rests on three separate aspects: (1) Porter's emphasis on competition; (2) the nature of the firms which share an economic relationship; and (3) the scale of the region in question. In the case of Perroux's growth pole model, firms in *differing* industries share an economic relationship over geographic and economic space, and while there is the notion of innovation mentioned, there are no cause and effect relationships assigned to its development. Porter's notion identifies that competition itself is a basis for innovative activities. Further, he suggests that firms *within* an industry have a tendency to cluster geographically. This clustering is seen to benefit the industry through innovation, and is seen to benefit urban economies through economic development. Finally, where Perroux's work was grounded in regional economics, Porter's recent works have focused on the metropolitan area as the focus of study. The economic relationships espoused in the latter focus on firms within urban areas, and to this end may be more helpful in our overall research objectives.

3.5 High Technology Precedents

Introduction

We have identified some of the key theories that have helped to explain industry location and the development of industry competitiveness. It is important now to begin to narrow the scale from theory to reality so that the reader may see the physical manifestations of these theories. The purpose of this section is introduce three precedents – successful regions that have become synonymous with high technology. These regions are valuable to study because they convey to planners the key relationships and actions that led to successful economic development in these cases. They also present value to this research because they ultimately will define for us some of the key, measurable factors that a study such as this can focus on when applied to our case study context.

It begins with an examination of arguably the two most famous North American examples of high-technology economies - Silicon Valley in California, and Route 128 in Massachusetts. They are important to this research because they demonstrate what is possible in the absence of public domain planning; they are for the most part organic, unbound spatial developments. They also have value in their capacity to reflect that management decisions and inventions are not the sole reasons for success. Employing the Research Triangle Park in North Carolina as the third case emphasises that high technology activities can be developed through economic planning, largely through the auspices of a research park.

3.5.1 Silicon Valley

Despite its longevity, Silicon Valley is arguably still the greatest metaphor in high technology today. Located at the southern tip of San Francisco Bay this formerly productive agricultural region experienced industrial development much later than its Massachusetts counterpart, Route 128. At its birth, Silicon Valley contained few microelectronics firms in the 1950s and did not emerge as a high-technology icon until the 1960s (Saxenian, 1994:1). Its initial growth can be credited to two important and interrelated forces: a unique entrepreneurial spirit and key figures within Stanford University (Saxenian, 1994:20), but its continued success would be better attributed to a collaborative business environment, a highly-educated population, risk-taking, constant innovation, and inventive financing.

3.5.1.1 Understanding The Role of Stanford University in the Region's Growth

Economic development literature today often acknowledges the catalyst role that universities may play in economic development (see for example: Blakely, 1991; Luger & Goldstein, 1997), and Silicon Valley perhaps emphasised that more than any other region. This relationship between educational institutions and local industry was established early, due largely to the efforts of Frederick Terman, an electrical engineering professor at Stanford. Terman provided funding, advice, and space to two of his graduate students, William Hewlett and David Packard, assisting them in commercialising an audio-oscillator (Perkins & Karlgaard, 1991). The subsequent and dynamic success of HP encouraged a modest collection of pre-war technology firms to gather in proximity, forming the "foundation for the region's emerging electronics industry" (Saxenian, 1994:20).

During World War II, firms in the region benefited from research associated with military spending, and while important early on, this was not the most significant aspect in Silicon Valley's development [13]. Instead of simply pursuing these contracts as others did, Terman focused much of his energy on developing the relationships and infrastructure that would bring the defence industry to Stanford, and allow Stanford to bring subsequent technologies of those defence contracts to local industry. Terman's strategy had three aspects : (1) The development of a co-operative, advanced degree program designed specifically for employees of local businesses; (2) the creation of the Stanford Research Institute (SRI) to capture defence contracts; and (3) the development of Stanford Industrial Park as a place to house new firms (Aley, 1997:69). By all accounts, this strategy was highly successful, and by the early 1960s, other, established firms began to relocate in the region and several start-ups emerged in support of them.

In terms of the role that Stanford played in providing the region with highly qualified personnel, one journalist described the institutions' role as "the powerhouse that supplies Silicon Valley with the talent that makes it successful" (Mullins, 1998:32). Gifford is cited by Mullins (Ibid.) as suggesting that Silicon Valley is not fed simply by Stanford, but by the region's entire educational system (Foothill College, UC at Santa Cruz, San Jose State University, and the Xerox Parc research and teaching laboratory), though Aley (1997) argues that "…Stanford is the cause of Silicon Valley". Stanford's relative degree of influence is debatable, but the historical and contemporary contributions made by educational institutions - a precedent perhaps set by Stanford - remain crucial to the region's success and have reoriented economic development planners to strongly consider the role of higher education in high technology industry development.

3.5.1.2 Firm Spin-Offs

In addition to the actions of people such as Terman, and the pioneering role of Stanford in supplying the region with talent and innovations, a highly competitive and entrepreneurial spirit started what is now a common feature of all successful high technology economies – the process of spinning off new firms that are based on the innovations of another firm. This process was to shape Silicon Valley in a profound manner. As an example of this process, William Shockley, a Stanford graduate and one of the inventors of the transistor, founded the Shockley Transistor Corporation to exploit his new invention. With the innovations that came from the ongoing development of the transistor, a number of Shockley engineers left to form their own firms to exploit them (Saxenian, 1994:25). One of these key firms was Fairchild Semiconductor Company, where, in what came to be a pattern, all eight of its founders left to start new ventures based on further innovations in this rapidly developing industry (Rogers, 1984:26). In the 1960s thirty-one (31) semiconductor firms were developed near Stanford University, and most traced their origins directly to Fairchild (Ibid.). This risk taking environment, through the auspices of firm spin offs, continues to be the model for new growth in this and other high technology regions. Saxenian explained the mindset of the region by noting that "Silicon Valley's heroes are the successful entrepreneurs who have taken aggressive professional and technical risks; the garage tinkerers who created successful companies" (1994:31). This environment, and the fact that regional loyalty often exceeds company loyalty, produces this high occupational mobility (Markoff, 1992), which could be another benchmark in identifying high technology activity.

3.5.1.3 Competition, Co-operation, & the Rise of Venture Capital

By the 1970s, with Stanford cementing its influence by developing technologically-savvy graduates and providing inventions that required new firms to commercialise them, the region was flourishing with innovative communications activity, encouraging one journalist to dub the region 'Silicon Valley' (Hoefler, 1971). This rapid growth was in large part fuelled by the emergence of a key mechanism to the entire industrialisation process - VC [14]. Largely an unknown financial entity until that point, by the 1970s VC had replaced the military as the main source of financial backing for innovative activities. By 1974 there were 150 VC firms in the region providing a financial engine for the entrepreneurial spirit that embraced the area. An important feature of the region's venture capitalists is that most were former entrepreneurs themselves. This radically changed the face of business investing, as it allowed them to contribute to (and take control of) their investments by offering advice, management, and solutions where required (Saxenian, 1994:56). In addition to the rise of the VC industry, the use of stock options was another important funding mechanism perpetuated in the region. Given that many firms were spending a large amount of their start-up money on R & D, they often offered stock options to their key employees in lieu of salary. It was not uncommon for a key individual to move from start-up to start-up, taking stock in lieu of salary in each new venture. Stephen Recht, chief financial officer of software start-up NetGravity, explained succinctly why he performed his third stint with a start-up: " I'm betting that one of these companies does well enough that I get a big chunk" (Fox, 1997:52).

In 1997, Silicon Valley claimed 11% of all technical jobs in the United States, while representing only 1% of the population. Furthermore, twenty (20) of the world's one hundred (100) largest high-technology firms are located there (Elstrom, 1997). Its success can be credited to a variety of factors, but this regional growth story is largely one of the influential role of educational institutions, the development of a local VC industry, and the introduction of exceptionally innovative products that led to the creation of many new and dynamic firms and industries.

3.5.2 Route 128

Like 'Silicon Valley', 'Route 128' is an affectionate nickname, and refers to a 65 mile stretch of highway surrounding Boston and Cambridge, Massachusetts. Similarly, the role of universities, the federal government, and World War II played vital roles in Route 128's initial growth and success (Mackun, 1995). Unlike the California case, Massachusetts was already enjoying a wealth of industrialisation during the pre-war period, and contained a large concentration of capital, skill, and technology (Saxenian, 1994:59). Thus, when it came time for the federal government to allocate funds for the development of military technology, the Massachusetts Institute of Technology (MIT) and eastern U.S. businesses were prime recipients.

3.5.2.1 MIT & the Federal Government as Partners in Development

Similar to Stanford's role in the development of Silicon Valley, MIT made important contributions to Route 128's early growth, particularly by taking advantage of federal funding. Much of the funding came to MIT through the efforts of Vannevar Bush, an electrical engineering professor at MIT who was appointed the director of the federal agency, Office of Scientific Research and Development (OSRD). Just as Terman had been a local hero in the west, Bush played a similar role in the east. He "revolutionized the relationship between science and government by funding universities rather than government labs to pursue basic military research" and, as a result, "MIT became the nation's leading centre of research during the war, performing more military research than any other U.S. university" (Saxenian, 1994:13). MIT and nearby Harvard constructed large research labs to attract scientists and technical employees to the area, creating the substantial, highly-skilled labour force needed for high-technology activity. A study by MIT and the Bank of Boston confirms MIT's crucial role in the region's development, reporting that "MIT graduates and faculty had founded 4,000 local companies, employing 1.1 million people and generating $232 billion in world-wide sales" (Judge, 1997), a testament to both MIT and their entrepreneurial achievements.

Although Route 128 has never developed the distinctive entrepreneurial culture that is characteristic of Silicon Valley, its early growth did rely on start-ups. In 1946, the first publicly held VC firm in the U.S. was created, pursuing investment opportunities at MIT (Saxenian, 1994:14). In the 1960s and 1970s, the rapidly growing mini-computer industry established Route 128 as "the nation's leading centre of innovation in electronics" (Ibid.:17), generating more than two thirds of the value-added in mini-computers (Dorfman, 1983).

3.5.2.2 Business Organisation: A Different Culture

Business practices and the productive organisation of firms in Route 128 are much more traditional, perhaps adding to the region's inability to match the success of Silicon Valley. According to Saxenian, Route 128 possesses an independent firm-based system that is typically found in traditional industries such as oil, rubber, machinery, and automobiles, whereas Silicon Valley possesses a more flexible network-based system. Firms in this independent firm-based system perform a wide variety of production activities, value company loyalty and - assumedly - some secrecy, and organise a vertical system of authority and communication. Saxenian describes the limitations resulting from this independent firm-based system:

> "The independent firm-based system flourished in an environment of market stability and slow changing technologies because its leading producers benefited from the advantages of scale economies and market control. It has been overwhelmed, however, by changing competitive conditions. Corporations that invested in dedicated equipment and specialised worker skills find themselves locked into obsolete technologies and markets, while hierarchical structures limit their ability to adapt quickly as conditions change. Their inward focus and vertical integration also limit the development of a sophisticated infrastructure, leaving the entire region vulnerable when the large firms falter" (Saxenian, 1994:9).

Such a system imitates the structure of traditional mass production corporations (Ibid.:70). Firms are self-contained and vertically integrated, limiting the number of spin-offs generated to service and support local firms. Although such a system offers the advantages of scale and stability, it can not adapt to changing markets and technologies. Thus, when the military funding began to slow down, the region had difficulty becoming self-sufficient. Route 128's independent firm-based system created a business climate that is radically different from the co-operation and collaboration common to Silicon Valley. The firms that comprise this high-technology cluster tend to reject any notion of themselves as having a common identity, and cling to their independence despite their obvious spatial relationship. Furthermore, it is not uncommon for firms to hire private investigators to investigate security leaks. Saxenian (1994) describes the business climate in Route 128:

> "Route 128's technology enterprises adopted autarchic practices and structures of an earlier generation of east coast businesses. Secrecy and territoriality ruled relations between individuals and firms, traditional hierarchies prevailed within firms, and relations with local institutions were distant -- even antagonistic. The regional economy remained a collection of autonomous enterprises, lacking social or commercial interdependencies" (pg. 59).

These 'icier' relations are reinforced by a geography that is far more expansive than the dense cluster that typifies Silicon Valley (Ibid.:60). In addition, the lack of social gathering places in the region help to underscore the separation of social-life and work-life, likely influenced by an historically conservative puritan society and its valuing of roots and tradition (Ibid.:61).

Route 128 and Silicon Valley are organic high-technology agglomerations that developed as a result of a number of factors, most notably the influence of research-related World War II efforts conducted at educational institutions such as Stanford and MIT, and the parlaying of that research into commercial products. Although these origins and their technologies may be similar, the two regions reveal some very important differences, and have coped with technological and market changes with varying degrees of success. Despite intense effort, no region in North America has been able to successfully reproduce a high-technology agglomeration as self-sufficient and productive as Silicon Valley. There has been a recent resurgence in Route 128, driven by software, telecommunications, medical technology, and financial services, and future success depends upon its ability to complement Silicon Valley rather than to compete with it (Judge, 1997).

3.6 The Research Triangle Park

Whereas Silicon Valley and Route 128 are naturally-occurring high technology regions, North Carolina's high-technology economy was planned and executed in response to widespread regional-industrial stagnation [15]. Research Triangle Park (RTP) - named for the triangle of land where it is located between Duke University at Durham, the University of North Carolina at Chapel Hill, and North Carolina State University at Raleigh - has flourished into one of the most successful research parks [16] in the world. It encompasses 6900 acres of land (1400 acres still remain undeveloped) owned and managed by the not-for-profit Research Triangle Foundation, and is home to several high-technology corporate giants, including IBM and Data General (Author Unknown, 1999b). This successful model provides a source of optimism for policy makers and planners who are hoping to stimulate their local economies in a similar manner (Luger & Goldstein, 1991:76).

3.6.1 RTP: A Planned High Technology Economy

The RTP was a planned effort, and its initial development and eventual success can be credited to some important industry, business, and academic leaders. One such individual is former governor Luther H. Hodges. Concerned with the amount of skilled labour emigrating from the state, Hodges formed the Research Triangle Committee (RTC) to investigate how the local universities could be utilised to restructure the local economy, a thought we have seen in the cases of Route 128 and Silicon Valley. The committee recommended that the universities should increase their efforts to lure R & D organisations to the region to stimulate growth of high-technology manufacturing and to generate employment opportunities for skilled employees. The important link between industry and educational institutions is a key feature of research park development today; however no attempt to create such an entity (which was still rather obscure at the time) occurred until Karl Robbins became involved in 1957 (Luger & Goldstein, 1991:77).

Despite the help of Robbins and the Research Triangle Foundation's efforts to market the park, it did not attract many R & D organisations until 1965, when two new occupants had a major influence on the park's growth: International Business Machines (IBM) and the National Institute of Environmental Health Sciences (NIEHS). As Luger and Goldstein (1991) explain, "these two occupants served as anchors by putting RTP on the map as a place to locate R & D facilities. A string of R & D branch plants and of large national and multinational corporations and of federal government laboratories followed over the next twenty years" (pg. 78).

An important difference between the previous two precedents and RTP is the latter's bias towards luring large, established companies as anchor tenants. As a result, unlike Silicon Valley and Route 128, new start-ups are not as feasible: it is through innovative activities that arise out of research-universities and small firms where a need exists for start-up firms to commercialise these new activities. Instead of creating development through this technology transfer model, RTP's plan has always been to use the presence of R & D and the university cluster to attract branch plants of major, established corporations, and to this end has been quite successful. This precedent, and the fact it was planned, represents an important departure from the former cases, but it also leaves the fate of the park and the region in the hands of a few very large corporations, as opposed to a large number of small, locally developed firms. Strategies to lure high technology activities (as opposed to developing the conditions necessary for their development) have resulted in decidedly mixed results (see for example: Blakely & Nishikawa, 1992:26-30; Saxenian, 1989:3), and this may have implications for potential planning actions in metro-Manitoba. However, further research, however, is required to better determine the actualities of the planning actions - and factors attributable to chance and innate regional conditions - that contributed to the RTP's success. To determine if such a plan is feasible in a Manitoba context is a worthy option for further research. However, the focus here remains to develop some strategically significant elements of a preliminary public policy framework.

Conclusion

There were three reasons that this research introduced Silicon Valley, Route 128, and the Research Triangle Park. First, while we had to this point loosely discussed the existence of 'high technology regions' as a modern, geographical phenomena, this section clearly sets forth what a representative high technology region is, where they tend to locate, and some of the quirks of firm organisation that set them apart from other industrial regions.

Second, these three examples were introduced to explain some of the differences that set them apart. As we noted, Silicon Valley is reflective of an innovative climate where innovations were turned into new activities by local entrepreneurs with the aid of VC. The RTP was a strategic economic development planning exercise which knowingly used prodigious amounts of university R & D to attract the branch plants of large technology firms. Both models have been successful in their own right, and offer planners two different paths to ponder when defining a high technology strategy.

Third, they were introduced here to isolate the key determinants that could be effectively evaluated in a case study context for the Winnipeg region. The literature review indicated that the presence of research-based universities is essential in the development of most high technology economies, a notion substantiated by others (see for example: Doutriaux, 2000:93, Luger and Goldstein, 1997:127). Further, research universities provide a fertile ground for R & D performance, which, when parlayed into innovative and inventive products and services, often leads to the creation of new firms nearby to exploit them. Universities en masse are the predominant entities which produce the appropriately-educated population that is typically known to undertake high technology activities, whether that be through the performance of R & D, or through employment in new or existing high technology firms. Finally, with respect to Route 128 and Silicon Valley (where small firms dominate, and VC is considered crucial), the literature identified the co-dependent relationship of VC and emerging high technology firms.

VC, an appropriately-educated population, the presence of R & D activity, and the existence of research universities were, in these three cases, the fundamental conditions for the economic development of these high technology regions. One of the key objectives of our research is to take what is known about the development of successful high technology regions such as these, and apply it to a case study of the Winnipeg metro-region. Studies that are similar in intent to this one have typically taken a broader approach in amassing data on indicators of high technology health, and using them to measure how well-developed a region's high technology economy is. Atkinson and Gottlieb's (2001) research focused on numerous, often sketchy high technology indicators, which they in turn used to measure the activities of entire states. Studies such as the former are not useful to planners because they assign no causal or explanatory elements in their measurement. For example, while it is worth noting that there was $250 million of R & D conducted in the state of Florida in 1999, studies of this scope make no mention of who was conducting it, nor what type of R &D was conducted. In reality, it is less important for planners to know the amount than it is for them to know which types of R &D are most likely to lead to the development of new, innovative firms. Thus, an unfocused strategy will not suffice for the purposes of informing local planners. It is for these reasons that this research has rejected such an approach, opting instead for the case study method as an in-depth, viable vehicle for examining the high technology phenomenon in the Winnipeg region.

Chapter Four

The Venture Capital Industry in Metro- Manitoba

Introduction

In the previous chapter, we discussed some of the theories that have helped explain the aggregate growth of economies, and the location and clustering of industry. Further, we examined three representative high technology regions, and determined some of the key aspects that led to their development. The research identified that strong R & D activity, an educated population, and a strong and responsive VC sector are key indicators that shape regional high technology economies. Part two of this research is devoted to conducting an in-depth case study of these three key indicators, as measured in metro-Manitoba, and in a comparative context with Alberta and Saskatchewan.

The objective of this chapter is to determine how effective the metro-Manitoba VC industry is in terms of its ability to act as an integral support industry to innovative, high technology activities. What is it that we specifically need to know about VC to gauge this? VC is a complex industry, and there are many facets of it that have captured the attention of researchers and policy makers. There are also a number of different sets of data that are used by these two groups, which reflect a particular dimension of VC activity that they wish to highlight, including: the total capital under management (aggregate value of prior investments, plus liquid capital currently available for investment), which is often the most cited measure, yet which reveals little about the dynamics of VC; the extent to which investments have been directed to start-up firms versus expanding firms; or average investment per jurisdiction. Studies similar to this one have used VC investments per employed person, and VC investments as a percentage of GDP to offer a comparative perspective between jurisdictions (see for example, Hall, 1999:25). These indicators may all be valid in their ability to shed some light on VC's role in the new economy. However, this research is a detailed study of high technology indicators conducted at the city-region level, and to satisfy the research objectives within it, we must ideally be able to configure data and informant responses to determine: the amounts of VC that have recently been available, and are currently available, for high technology activities; to help determine the extent of high technology activities taking place locally, to which industries did Manitoba VC go; and, to what extent the Manitoba VC industry fulfils the same role as VC does in many highly developed technology regions.

There are five questions that need to be addressed to satisfy these three objectives:

(1) In light of the consistent growth of VC investments throughout Canada (see Figure 2), why do the 1996-2000 investment patterns fluctuate so much in Manitoba, and do the fluctuations tell us anything significant?

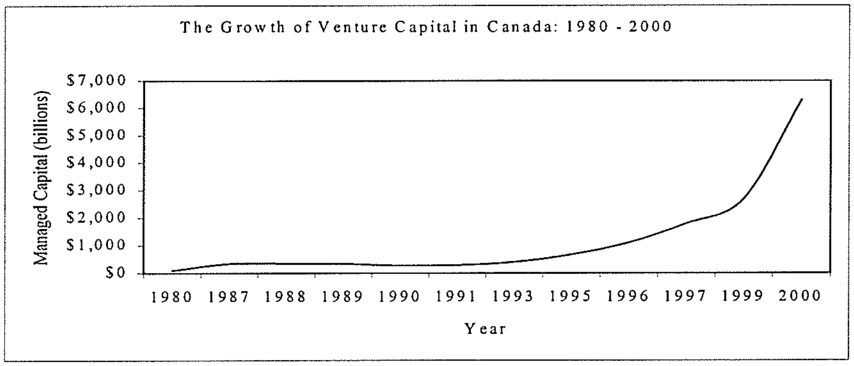
(2) The Manitoba VC industry has more funds available in 2001 than were invested in 2000, suggesting an over-abundance of capital: are there opportunities or threats with respect to having excess supply?

(3) What do the 2000 sector disbursements tell us about the quality and quantity of high technology firms in metro-Manitoba?

(4) Given that we are in a 'global economy' where information and investments are becoming border-less, is a healthy *local* VC industry even important for the development of a high technology economy, or could efforts to develop a high technology economy be better spent elsewhere?

(5) In qualitative terms, how well positioned is the local VC industry to aid in the development of a high technology economy?

Figure 2



Source: Macdonald & Associates, 2001b.

4.1 Why is Venture Capital Important to High Technology Economies?

Based on their most recent annual report on the economic impact of VC, a spokesman for the Business Development Bank of Canada (BDC) indicated there is "...a direct correlation between venture capital investments and the success of young technology companies" (Rè, 2000). Further, the Vice President of Crocus Investments Limited, a Manitoba VC organisation, flatly suggested that "...the new economy can't survive without it" (Cash, 2000:F11). Several studies have also proposed that a direct link exists between venture investing and job creation (for example see: BDC, 1999:5; Atkinson & Gottlieb, 2001:34). VC investments have also been named as an important catalyst for innovation, where the correlation between investments and patents issued in a region was both "positive and significant" (Kortum & Lerner, 2000:691). VC is a worthy indicator because of what appears to be a strong relationship between the infusion of VC and the subsequent growth of R & D spending - another key indicator under investigation in this research. A recent study by the Organisation for Economic Co-operation and Development (OECD) noted that VC investee firms in Canada tended to spend significantly more on R & D than non-investee firms. Among survey respondents, R & D expenditures grew an average of

40% annually after the onset of VC funding. Further, they argue that in 1994, approximately 20% of the top 100 Canadian R & D performers were venture-backed firms (Horsman,1996:110). This figure had grown to 57% by 1998 as referenced in a similar study (BDC, 1999:7). VC appears to be as important to the growth of the new economy as educated and talented people, and is worthy of inclusion here.

4.1.1 What is Venture Capital?

Perhaps the best way to describe VC is this: it is an innovative financing mechanism that often serves the capital needs of innovative firms [17]. VC is not simply high-risk loans, but a sophisticated financing tool where money is given to a firm in exchange for an equity stake in the firm. This exchange is the fundamental difference between VC and traditional forms of debt financing. VC investing differs from commercial banking in other significant ways as well, including: the degree to which the investor becomes involved with the investee company, which typically includes a 'hands-on' management aspect; the scale of the investments, which are often relatively large and may include further rounds of funding; and the time frame for the relationship, which can span decades. In general, all of these relationships between the VC investor and the investee are stronger, closer, and more complex than they are between a chartered bank and a borrower. It is because of these reasons that high technology activities and VC are seen as virtually interdependent.

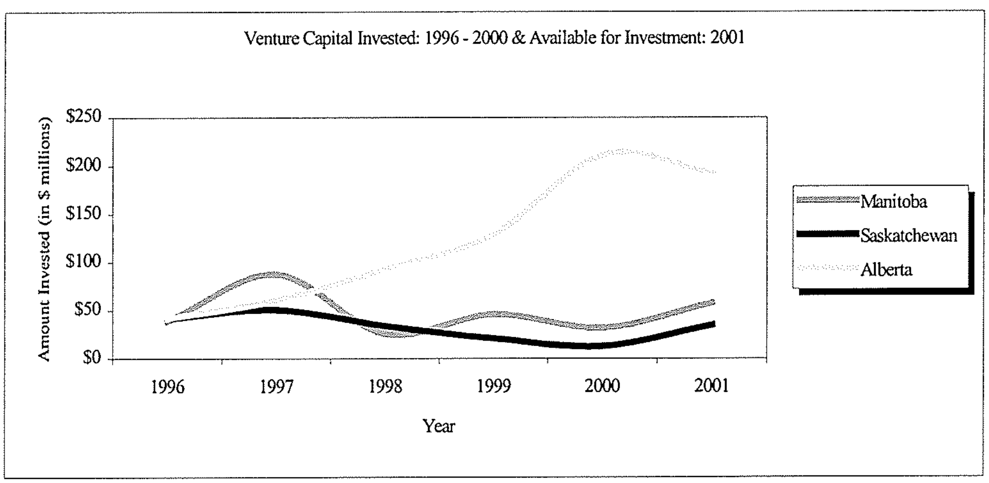
From the investee firm's vantage point, VC may be the only source of capital funding available. Innovative, high technology firms are often those without assets to use as security in financing. The company may exist solely in a business plan, with a simple idea for an unheard of process or product. To this degree, "companies whose assets are intellectual in nature (and hence not particularly good security) need equity capital" (BDC, 1999:1) Having the option of exchanging firm equity for operating funds may be as necessary to the investee as it is opportunistic for the investor. With this process, the firm has few initial worries about producing immediate cash-flow in an effort to pay rents and salaries, and repay loans. A lack of VC for these firms could conceivably destroy many companies in their infancy, but instead affords them peace of mind and allows them to focus entirely on the work at hand (Government of Canada, 1991:5). Finally, some high technology firms and activities have extraordinarily large start-up costs that could not be satisfied by a chartered bank. Where a restaurant venture may require $100 thousand in start-up funding, it would not be unusual for a biotechnology firm to require upwards of $20 million before they could be in a position to draw revenues.

4.2 Manitoba's Venture Capital Industry in Relation to the Canadian Industry

The Manitoba VC industry is small in terms of dollar value, as compared to aggregate Canada, and amongst virtually all other provinces. As little as seven years ago, there was almost no VC available in the City of Winnipeg. As economic conditions, Provincial government policy, and the needs of businesses have changed, the amount of available VC in the City has grown. In September of 1998, there was a cumulative total of $145 million in VC under management throughout Manitoba [18]. The Manitoba figures should be compared to aggregate Canada, where there was $8.4 billion in capital under management in 1998 - the Manitoba portion equates to less than 2% of the Canadian activity. Further, in the fall of 1998, there was $2.4 billion in liquid capital available for investment Canada-wide, and of that, only $33 million was available in Winnipeg (Cash, 1999:B7). In 2000, $32 million was invested in Manitoba, compared to $6.3

billion in aggregate Canada [19]. Emerging or not, Manitoba constitutes a very small portion of Canada's VC market. Manitoba's VC industry has seen earnest development in recent years, and perhaps the most important catalyst for the industry has come from the Provincial government. While divesting itself from direct investing in individual companies, the Province of Manitoba has been crucial to the development of the VC industry through the mentoring of two key funds, and the subsequent provision of 15% Provincial tax credits (in addition to the 15% federal credit) for investors in these two labour sponsored VC corporations (LSVCC) - the Crocus Investment Fund and the ENSIS Growth fund [20].

Figure 3



Sources: 2000-2001 data (Macdonald & Associates, 2001a:28-43); 1998-1999 data (www.cvca.ca); 1996-1997 data (Macdonald & Associates, Interview, 2001).

4.3 Recent Investment Activity & the Issues of Supply & Demand for 2001

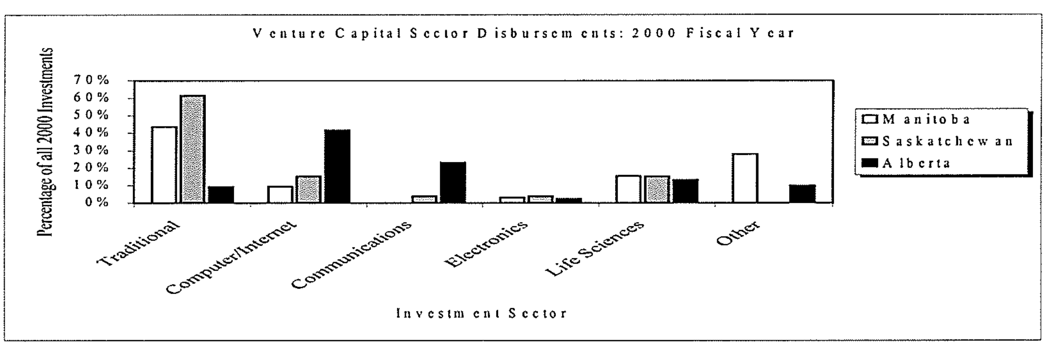
Figure 3 is a compendium of secondary and primary information gathered from separate sources. It illustrates the dollar amounts of VC invested in each province, from 1996-2000, and the current amount available for investment in 2001. The most striking aspect of the data is the extent to which the aggregate amount of Alberta VC investments outpace both Saskatchewan and Manitoba. Although both the investment amounts (see Figure 3) and industry-sector mix data (see Figure 4) suggest that Alberta possesses a relatively booming VC market, the data is highly misleading. Kirk Falconer, Director of Research for Macdonald & Associates, suggests that the invested amounts and general activity levels of the Alberta VC industry are not really the issue, as the Alberta economy will always be larger than both the Manitoba and Saskatchewan economies. However, while noting that there is a good deal of activity in Alberta, he suggests there is a fundamental problem with the Alberta VC market, in that local VC supply is poor in relation to local demand: there has always been a far greater reliance on foreign VC for deals in Alberta. Though the reasons are largely unknown, one key reason for a lack of local investment can be traced to the fact that the Alberta government does not offer tax credits to investors in LSVCCs, thereby seriously negating the desire for 'average' local citizens to invest locally [21]. In the long term such a reliance on national and foreign VC is a highly suspect way of doing business, as these sources are at best far more fickle than local venture capital and will tend to abate much quicker in recessionary periods that local VC would. Further, continuing to rely so much on outside sources of VC means that there will continue to be less pressure to actually develop adequate local infrastructure in the form of diversified, local funds. Pressure may become intense during a down-turn or recession, and it is likely at these points where high technology firms will be at risk of losing a key source of capital, and be most vulnerable (Interview, 2001).

4.3.1 Understanding Manitoba's Fluctuating Investment Patterns

In metro-Manitoba, the most puzzling aspect of the VC data was the investment inconsistency that has taken place over the last 5 years, especially when compared to the phenomenal growth in aggregate Canada, the consistent surge in Alberta, and the consistent ebb in Saskatchewan. Katherine Johnson, Senior Financial Analyst with the Department of Industry, Trade, and Mines (Interview, 2001) suggests that this inconsistency was largely due to the dominance of the Manitoba VC market by two large LSVCCs - Crocus Investment Fund, and ENSIS Growth Fund, respectively - whose investment patterns essentially dictated the provincial pattern [22]. This sentiment is mirrored by both Aiello (Interview, 2001), and Falconer (Interview, 2001) who both indicated that deals involving LSVCC funds can be sporadic, in that government legislation dictates that their capital be expended within certain time frames. As a result, fund managers may hold back a significant portion of funds as they search for better opportunities. Should those opportunities not arise, they must still invest the funds - now in a relatively rushed manner, and seemingly independent of prudent investment sense. In spite of this, the inconsistency that we see in Manitoba should largely be considered a non-factor. More than anything, it is a quirk of the local system.

An important aspect of the data is the amount of liquid VC available for 2001. This represents the effort of VC fundraising over the last year, and consequently what is available for investment in 2001. The data suggests that Alberta is in a relatively good position in terms of supply. In fact, there is a less-than-adequate supply of capital available in Alberta because the investments undertaken during the previous year were greater than the current supply: $211 million was invested in 2000, but the current supply is only $192 million, highlighting the local supply problem. The reverse is true in the case of Manitoba and Saskatchewan, where $32 million and $13 million were invested in 2000, respectively, and $58 million and $35 million, respectively, are available for investment in 2001 in those respective provinces (Macdonald & Associates, 2001a:28-42). Does this then suggest that there is too much VC in Manitoba? A number of key informants were interviewed in relation to this topic of apparent VC over-supply in Manitoba. Ken Bicknell, Vice-President of ENSIS Growth Fund Limited, suggested that their fund had no such supply problem; indeed, there were far more opportunities for investment than there were funds (Interview, 2001). Other informants suggested that - in Prairie Canada generally - there are a great deal of firms seeking funding, but there are few quality proposals among them (Walton, Interview, 2001; Hanna, Interview, 2001). All industry sources interviewed clearly indicated that a glut of available funds at any one time can be seen as a non-factor in determining VC health, and by itself would not indicate that Manitoba is any weaker than other jurisdictions. In fact, the suggestion put forth was that the demand for VC is so high that there truly is "no such thing as an over-abundance of VC in any local market" (Aiello, Interview, 2001), and that securing more funds for VC will never be a wasted effort. Indeed, for many VC firms, it is a constant effort.

Figure 4



Source: Adapted from Macdonald & Associates (2001a:28-43)

4.4 Is Venture Capital Being Invested in High Technology Firms?

Figure 4 shows the total disbursements of VC to all industries in the three provinces during the year 2000. The disbursements to firms have been divided into industry groupings defined by the report's authors, Macdonald & Associates. Based on the data above, it would be false to assume that VC is a vehicle only for high technology firms in a Canadian Prairie context. The data suggests that the majority of venture funding in Saskatchewan, and a significant 44% in Manitoba was not being directed to high technology activities during the year 2000, but instead to more 'traditional' industry sectors [23]. Further, when the 'other' category is included, which, in the case of Manitoba was composed of two media investments and an environmental management investment, and accounted for 28% of all disbursements, 72% of all VC investments were directed towards industries not truly associated with any high technology activity, far more than Saskatchewan's 61%, and Alberta's 20%. Venture funding in Alberta appeared more aligned with the industries traditionally associated with it, in that the majority of VC (80%) was directed towards high technology activities, such as computers and communications. What the data also tell us is - to the extent that VC money is actually getting to the firms most deserving - is the particular high technology industry strengths that exist in the metro areas of each province. Though it would be unwise to come to a conclusion on such a thing merely from these VC investments, the data does substantiate other sources that suggest Alberta's high technology sector specialises in wireless communications and assorted internet industries (see for example: Bergman, 2001:36; Stevenson, 2000:B4), while it also illustrates that Manitoba and Saskatchewan are relatively void of industry specialty (Holbrook, Interview, 2001). Of interest here is one of the high technology categories where Manitoba investments were strong: just over 15% ($5 million of the $32 million invested) of all disbursements in 2000 were directed towards the life sciences sector, composed of medical and biotechnology industries (Macdonald & Associates, 2001a:43).

A review of the investment portfolios of the two largest VC organisations in Manitoba (Crocus Investment Fund and ENSIS Growth Fund), and a private VC firm (Centara Corporation) partially substantiate the findings shown in the graph above [24]. The majority of firms funded by the two labour funds could not be considered to be primarily undertaking high technology activities. In the case of ENSIS Growth Fund, just six of the sixteen largest investee firms appear devoted to what we have defined as high technology activities [25]. The remainder of investee firms are based in a variety of industries such as food manufacture and agricultural supports. Though significantly larger, Crocus Investment Fund is decidedly less oriented towards high technology activities than is ENSIS Growth Fund: of the fifty-seven firms listed in their most recent portfolio, nine are devoted towards defined high technology activities [26], while two investee firms are other VC organisations (Biocapital Investment Limited Partnership, and The Manitoba Science and Technology Fund). Centara Corporation is a fully private organisation (and thereby not bound by geographic-specific investment) that appears finely-tuned with respect to its investment strategies, and represents the closest example that exists in Manitoba to the traditional model of VC firms in advanced, high technology regions. Centara's investment portfolio is small, but very industry-specific; all investee firms are in the IT sector, but none of them are headquartered in Manitoba [27].

4.4.1 The Roles of LSVCCs & History in Determining Manitoba Investments

Key informants queried on Manitoba's propensity towards investment in traditional sectors were asked to identify the extent to which this suggested an expectation of higher returns for investments in traditional firms, or to what extent it suggested that there was simply a dearth of viable high technology firms to invest in. It appears that neither is fully the case, though Bicknell (Interview, 2001) stated that Winnipeg firms typified as 'traditional' were the ones "mature enough to attract venture capital". This suggests that the VC market in Manitoba is somewhat different than it is in most advanced-industry areas: as the theory and precedents introduced in this research have suggested, it is typically the young, unproven firms which are most closely associated with VC investments, which again does allude to either a relative lack of high technology activities in the metropolitan areas of the Province, or simply an unwillingness of the local VC industry to invest in these activities. Johnson (Interview, 2001) indicated that while it does suggest a lack of viable high technology activities to some degree, it is more a reflection on the relative inexperience and attitude of some VC managers in Manitoba, while Aiello (Interview, 2001) added that it has less to do with anticipated returns from traditional industries, and more to do with the fact the VC industry "hasn't built the momentum yet". Manitoba VC managers are typically older, and from traditional banking sectors, while typical new economy entrepreneurs are thirty years of age or under, who "haven't had a culture of limitation around them" (Moffat, 2000:15). This sentiment was echoed in other research as well, with the suggestion that Winnipeg VC managers are far more conservative and averse to risk than their counterparts in Calgary, Vancouver, and Seattle (Kirbyson, 2000:F4), whose VC people tend to be younger than their counterparts in Manitoba (Johnson, Interview, 2001). Falconer (Interview, 2001) introduces a similar train of thought, explaining that - ultimately - local strengths in high technology sectors come from a region's industrial history: money managers typically invest in what they know best, especially when dealing with local funds. The interpretation of both the data and opinions of all three is that VC managers in Manitoba may base their investments in the industries that have a proven track record in Manitoba, and from a particular business perspective. As Johnson (Interview, 2001) indicated, VC managers in Manitoba are only now beginning to understand high technology activities at a sufficiently advanced level to begin investing in them.

4.5 The Venture Capital Culture in Manitoba

In many ways, the Manitoba VC arena appears to be a markedly different 'culture' than some of the VC-entrepreneur dynamics in a prototypical high technology setting such as Silicon Valley or Route 128. Venture capitalists in those regions were often not (and still are not) money managers, but instead wealthy individuals who formed VC companies; ones whose fortunes were earned in a particular industry, who were thus well accustomed to its people and intricacies, and were often very aware of any manageable and unmanageable risks within that industry. In short, they were of the industry they invested in. This is best exemplified in Manitoba by the relationship between Keystone Technologies Incorporated (KTI) and the St. Boniface General Hospital Research Centre. KTI's fund was developed in consultation with the Research Centre officials in an effort to help commercialise key research undertaken there. Successful projects need not search for VC - it is there waiting, and KTI has the right of first refusal on all projects (Cash, 2001c:A4). This appears to be a relatively simple business model, but the important aspect of it is that there is a shared understanding between the two groups as to the expected outcomes of this joint merger. This shared understanding of how VC and its associated industries work together for a common good is forged by knowledge-sharing through communication, and a familiarity that comes from a history together. Based on the successful VC-entrepreneur relationship in prototypical high technology regions, it would be fair to describe their interactions, shared knowledge, and community as a unique micro-culture, and this appears at first glance to be somewhat undeveloped in Manitoba. Reducing any disparities or building stronger relationships between the two appears equally as important as building the supply of capital, and certainly steps could be taken by economic development planners to bring the two parties together to help develop this local culture.

Investing VC in traditional industries such as manufacturing is generally not thought to be the typical use for VC, at least in advanced, high technology regions. With due respect to VC managers, the opinions of key informants also suggest that there may be a need for them to look more closely at true high technology activities such as the ones defined in this study. Investment by the two largest funds in these activities is tepid and scattered: it is one thing for a VC fund to invest in a single firm conducting high technology activities. It is another to make that the basis for most of your investing, as is the case in Alberta. The larger picture that one should keep in view is that - as Porter and others have suggested - critical masses are required in the number and variety of similar firms before a self-sustaining industry cluster can be created [28]. The development of this critical mass / industry cluster helps attract firms to the region, provides the conditions for innovation and opportunity, and may ultimately reduce the risk associated with VC investments in those firms, yet at this point this does not appear to be part of the local VC agenda. The fact that this one international firm opted for Winnipeg because of its cluster (Cash, 2001a:B6), and without incentives, should be a signal to the local VC industry. The agenda for VC has always been to produce returns for investors, and often not to develop an entire economy. This however *is* the agenda of many economic development practitioners. Reconciling the two may prove to be a challenging task.

Further, there is a need to begin discussion of industry specialty as it relates to high technology. As the data and informants have suggested, Manitoba VC managers may be investing in proven Manitoba industries such as manufacturing and consumer goods because these are the region's industrial strengths. It is important to note that there was a time when this rationale was no different in Silicon Valley than it is today in Manitoba. Silicon Valley had no true industrial history prior to the microelectronics revolution, and therefore venture capitalists felt entirely comfortable in electronics investing, because this *was* the industrial history. This suggests that planners involved in advanced industry development should seriously consider a region's history before embarking on any sector-specific strategies. The City of Saskatoon's 'specialty' in high technology activities has always been in biotechnology, in large part because of the formative agricultural research that has been going on there for decades, and which has paved the way for these higher order activities (Holbrook, Interview, 2001). For economic development planners, prior to developing strategies to encourage VC investing in certain activities, an important first step may be to define Winnipeg's specialty in industry terms, and begin to seek out high technology activities that may be found within those industries. Further, research is needed to fully understand what a critical mass of activities really means in high technology, and how achievable a goal this may be.

4.6 The Importance of Place in Venture Capital

These issues raise another key question - in a global marketplace, is local capital even important anymore? Key informants were somewhat divided on this subject. Some suggested that supply and demand are not really important issues in a capital market because VC is a global resource, not a local one. The suggestion was that a VC supply problem in one region would be solved by a surplus in another region, thereby negating the importance of a local VC market altogether (Aiello, Interview, 2001; Walton, Interview, 2001; Hanna, Interview, 2001). In theory, this may be a valid assumption, but two recent articles suggest that Canada's ability to fund large start-up projects with VC was very limited in comparison with the U.S. VC market, and as a result Canadian firms were moving south to capture this funding (see for example: Tuck, 2000:T3; Turner, 2001:60). A recent article suggests that even recently, Winnipeg entrepreneurs may have to make the trek to regions with highly developed VC industries, and cites the example of a cancer therapy whose inventor was unable to secure local early-stage VC. Today, it is a fully public biotechnology firm located in Toronto (Schulz, 2001:A15). Further, if capital will find its way to viable opportunities, why is there a need for local government intervention in Saskatoon, where there is a "very sound research university" (Falconer, Interview, 2001), yet virtually no local VC infrastructure in place, and relatively few investments - from local or foreign sources? It is difficult to envision VC from Toronto and Ottawa making its way to Saskatchewan on a consistent basis: venture capitalists in those two regions find value enough in the high technology sectors located there. Both Falconer (Interview, 2001) and Johnson (Interview, 2001) support this contention. With a lack of outside capital, local money must at least begin to serve local needs. This is a valid thought for Manitoba as well. Indeed, the impetus for the development of LSVCCs in Manitoba was to encourage local investment. Legislative constraints tied to LSVCC funds insist on Manitoba investment, and it is difficult to see how investment would be as strong as it is in the absence of this legislation.

It is quite possible that, in well developed high technology regions, market forces will ensure that VC investments flow to where opportunities exist, perhaps because those opportunities themselves are world-class. It is reasonable on the other hand to suggest that in metropolitan areas where outside capital is not flowing in as anticipated, that ensuring a supply of local VC is a worthwhile proposition, as long as there are ideas, people, and firms that are justified in receiving it. The fact is that there is not a significant amount of local investment in Manitoba that is funded from outside of the Province, nor outside of the country (Aiello, Interview, 2001). Should the desire be to create the conditions that may lead to the development of new economy firms, this leaves planners with two basic choices in relation to local capital. Strategies to alleviate a local supply problem can either (1) focus on attracting foreign VC to local opportunities, or (2) focus on developing the local VC industry to serve local opportunities. We would be unwise to simply assume that investments will always find opportunities. The importance of local people, local government, and the necessary relationship between local money and entrepreneurs should not be ignored in a discussion of Prairie VC.

4.7 The Overall Health of the Venture Capital Industry in Manitoba

Despite identified issues relating to VC managers, supply of VC, and the focus on traditional industries in recent Manitoba disbursements, the overall state of the VC market in Manitoba is somewhat better than what the data suggests. According to Falconer (Interview, 2001), Manitoba likely possesses the strongest VC 'infrastructure' of the three provinces under investigation here, and this is a key to determining long-term VC health. Where the Alberta VC market is dominated by foreign capital, and where the Saskatchewan VC market is essentially government-run, the Manitoba VC market has a variety of large and small, private and labour-sponsored funds, with highly diversified portfolios. More importantly, the Provincial government of the day ensured that it hired the right people to oversee the development of the LSVCC funds, including their legislation and marketing to the public. This is very positive news for Manitoba's VC industry in the long term. At the same time, Falconer (Interview, 2001) also indicated that Manitoba is somewhat over-reliant on the two LSVCC funds, which Bicknell (Interview, 2001) suggests may not be as opportunistic or focused as truly private equity capital. LSVCCs are sponsored by one or more labour groups, and the suggestion has been that a Board of Directors has an implicit say in where funds may ultimately be invested (Johnson, Interview, 2001). If investments are indeed based on a strategy such as this, it would be unfortunate to the extent that deserving firms may miss out on opportunities. Both these implicit investment strategies and the legislated time frame for disbursement are a partial explanation as to why critics have suggested that LSVCC investment returns are poor in comparison to other investment vehicles (Clemens & Iani, 2001:2).

The political agenda of LSVCCs is to stimulate local investment with Manitoba dollars, and to that end, it is a fine model: investors receive generous tax credits while local investees receive needed capital. What should be factored into this, and indeed any economic development strategy that uses direct or indirect subsidies as a motivator, is the hidden costs of such strategies. Osborne & Sandler (1996:3) suggested that 1996 LSVCC tax credits amounted to $470 million throughout Canada. They compare this with the approximately $715 million taken in by the federal government in capital gains revenue, suggesting a windfall of only $245 million [29]. Few would argue that a system based on tax subsidies is truly indicative of a dynamic investment market.

4.7.1 The Need for Local Funds to Diversify & Specialise

As much as Alberta is dependent on foreign VC for local deals, Manitoba is dependent on local VC for local deals. The implications for this reliance are difficult to tell at this point, because both the data and sources suggest that Manitoba shows no glaring weaknesses. Relying so much on 'average' investors assumes that they will always be willing to invest, but clearly, economic forces, government tax policy, and attitudes may change in time. It is conceivable to imagine a time in the future when local investment in these two LSVCC funds will abate and fundamentally, Manitoba may then be seen to be no better off then than Alberta is today. Should either the Provincial or Federal governments reduce or drop the tax credits, what would investment levels in these funds be like in the ensuing years? Similarly, should future returns from Manitoba firms decrease, how would this affect future investment levels in the funds? As Falconer (Interview, 2001) suggested, a well balanced VC market is composed of a great variety of sources. Sooner rather than later, Manitoba must begin to look for alternative sources of VC to help diversify this market.

A fact sheet provided by the Manitoba Department of Industry, Trade and Mines lists accredited VC firms in the Province, and while diverse, the majority of them are clearly oriented towards manufacturing and service industries, and are also oriented towards firms that seek expansion or acquisition financing. Scant few are devoted to either start-up firms or firms involved in defined high technology activities, which - as we have seen - are the true drivers of the new economy. We may just now be seeing local industry specialty in the local VC market suggesting, as Johnson (Interview, 2001) did, that Manitoba VC people are beginning to realise "what real VC investing is", and this bodes very well for high technology start-ups.

Both KTI and the Manitoba Science and Technology Fund Limited Partnership (MSTF) are newer VC funds targeted specifically at high technology activities in their infant stages of growth, though at this point, these funds would be considered exceptionally small ($4 million and $10 million, respectively). Indeed, the average VC deal size in Canada during the year 2000 was $4.4 million (Macdonald & Associates, 2001b:9), suggesting that the former KTI could not have completed one 'average' deal. Recently, the $45 million Western Life Sciences Venture Fund (WLSVF) was developed as an off-shoot from Keystone Technologies Inc (the latter now exists only as part of the WLSVF). Their mandate is oriented towards start-up biotechnology firms in Western Canada, though the fund itself will be managed out of Winnipeg, and assumedly will be more oriented towards local interests (Cash, 2001c:A1 & A4). In addition to these existing funds, ENSIS Growth Fund is planning both a new life sciences start-up fund and a technology start-up fund, while Crocus Investment Fund is building the Manitoba Science and Technology Fund (Bicknell, Interview, 2001).

As we have seen, the largest and most developed VC funds to date are devoted to numerous activities and businesses throughout Manitoba that meet certain investment and community development criteria, but of which most could not be defined as high technology. The development of these new niche funds represents the best opportunity for the local VC market as it relates to high technology firms, but they are either still in development, or are currently under-capitalised. This is a cause for concern. The reality of this scenario is that high levels of VC investing in innovative companies has been occurring for the past two decades in advanced technology regions, and this has partially allowed certain regions to become highly successful, specialised, and well known as places to invest seed capital. The key is for local authorities to recognise that the slow development of these funds represents a potential threat to other goals pursued in the name of the new economy. Local organisations such as Smart Winnipeg and their Exchange District 'Cyber-Village' incubator (Rosborough, 2001:B5), the University Industry Liaison Office and their 'SMARTpark' development (Nealin, 2000:F7), the Manitoba Innovation Network and their 'Innovation Alley' suggestion (McNeill, 1999:B11& B19) are all focused on disparate aspects of the high technology conundrum, and may be at risk of working in vain. VC ties in to each one of these groups and their plans in a significant way. Will the VC industry be on board? Local strategies that would likely be most fruitful would be ones that recognise this threat, and begin to seek methods that would dramatically increase the size of these targeted funds through local, national, or international fund-raising.

Conclusion

Metro-Manitoba should be considered a relatively insular market as it relates to VC: the major internal sources of VC are legislated to not invest in worthwhile opportunities outside of the Province, and external sources of VC have few relationships with local firms. As a result, VC investing in Manitoba firms is fairly reliant on local, subsidised investment vehicles, and there is some concern as to their investment goals, and the long-term viability of any method that succeeds at least partially because of subsidies. We have no true knowledge of the number of firms in existence in metro-Manitoba that could be defined as high technology, but to the extent they do exist, there appear to be relatively few VC opportunities awaiting them that are devoted to the three base technologies we defined previously. A significant effort is required by local partners to help raise more capital devoted exclusively to high technology activities, as is occurring with the MSTF and WLSVF funds, and is expected to be occurring with the off-shoots planned by both Crocus and ENSIS. Manitoba has the strongest and most diverse VC infrastructure in Western Canada (less British Columbia) with which to work: the LSVCC funds are well-managed and strong, and there is a good mix of small private funds and small industry-specific funds. There is little reliance on direct government intervention to make VC available to local entrepreneurs as is the case in Saskatchewan, and this is a very positive aspect. Issues have also been identified with respect to what could be termed a cultural difference between VC managers and local high technology entrepreneurs, but there are suggestions that there is a growing understanding amongst VC managers of what high technology really is, what true VC investing is, and how the two match. Encouraging both VC managers and those creating high technology activities to understand that the two are intimately connected when it comes to high technology industry development, and to then work towards a common goal for the region, is an important proposition. Economic development practitioners are in a unique position to effect change. Typically, they are tapped into both the sources of wealth in a community and decision-makers in the business sector, and possess the skills to build consensus and work towards shared goals for the good of the local economy. Practitioners must begin now to identify how to make this happen.

This research has not addressed the very important issue of 'angel' investing [30], nor the extent to which it is a factor in the Manitoba VC market. Angel investing refers to direct investment in a firm by an individual with high net worth, which was how true VC investing began at its outset. Those involved with angel investing tend to be people within an industry who have made a significant amount of profit from it. The OECD published a report that suggested this informal VC market may in fact have been the largest source of funding for new, start-up firms in the U.S., and potentially as large in Canada in the mid 1990s (Horsman, 1996:105) . This is an important statement, and it is unfortunate that it is functionally impossible to gather data to substantiate this: evidence on the subject is largely anecdotal, and will not be addressed as such in this research. Industry analysts from Macdonald & Associates suggested that in general, informal investing does occur virtually everywhere in Canada, but typically occurs most often in regions with both wealthy individuals and underdeveloped VC infrastructure, such as Alberta (Macdonald & Associates, 2001b:1). Clearly, hard data on angel investing would have an effect on the outcome of any research on VC in Canada. Further research that could assemble such data could be of significant value.

Chapter Five

Research & Development: Spending, Performance, & Key Roles

Introduction

The objective of this part of the research is to assess the ability of the various 'actors' in the local R & D sector to contribute effectively to the development of new firms and an innovative milieux, so that planners may understand R & D relationships and thus incorporate R & D activity into strategies that will help develop a local high technology economy. There are four questions that need to be answered to satisfy this objective:

(1) How relevant is federally-performed R & D in metro-Manitoba, and does it lead to the development of new firms?

(2) What role does the Provincial government play in local R & D?

(3) Are there significant amounts of industrial R & D taking place in metro-Manitoba, and does it offer us any options for strategies?

(4) Is there a role for research universities in an economic development strategy?

To meet this objective, this portion of the research will analyse both statistical data on R & D activity (which provide general estimates of activity levels, measured at the provincial level), and the qualitative local aspects of this phenomenon based on the insight and opinions of key informants within the R & D industry in Manitoba and Canada. The first challenge faced by any person researching R & D is to sift through the myriad relationships of the many funders and performers [31], and the breadth of programs and parties involved in R & D deals to come up with the key information and conclusions that the research warrants. This challenge becomes acute in a research project such as this, where R & D is but one focus. As a result, a researcher must drastically limit the amount of qualitative and quantitative data that is used. However, as planners are concerned primarily with the development of a local economy based on high technology activities, special attention will be paid to the performance of R & D (as opposed to funding). It is the performance in particular that ultimately leads to our desired goals of an innovative milieux, the invention-to-market nexus, and the creation of new firms to exploit these opportunities that R & D may present.

5.1 Limitations of This Research

Any study of R & D is highly complex in its intricacies, yet often vague in the results it produces. Accounting for billions of dollars of economic activity throughout Canada in any given year, it is an enormously large subject area, and when the analysis is reduced from the level of the nation state all the way down to the metropolitan area, it becomes blurred and difficult to track [32]. A fundamental problem encountered is how R & D is defined prior to data even being assembled [33]. Further, at what point does one categorically declare R & D to be no longer occurring, having crossed the threshold from research and into the commercial exploitation of a product? R & D is also legendary in its competitive and secretive nature, and there are serious questions about the reliability of the reporting done, especially by private enterprises (Statistics Canada, 1999a:8). Indeed, due to this secrecy, many key informants are able to offer no more than educated guesses at key aspects of the data. Any assessment of university R & D also has 'serious problems' to the extent that R & D is less an organised activity of a university, and more of a personal activity of institution members (Statistics Canada, 1999d:5). Clearly there will be issues of reliability where data is usually estimated, with differing geographic scales, and where the definition may be subjective amongst data respondents. The reader should keep in mind that all R & D data in this research are informed, general estimates.

5.2 What is R & D?

Research alone is defined as a "…creative work undertaken on a systematic basis in order to increase the stock of scientific and technical knowledge… (Statistics Canada, 1999b:9), whereas development is defined as "... the application of research findings or other scientific knowledge for the creation of new or significantly improved products or processes" (Statistics Canada, Date Unknown:8). Research can be further delineated as being either pure or applied. Pure research is scientific exploration for the purposes of the advancement of knowledge, and as such has no inherent commercial value. Applied research is the application of scientific knowledge and techniques towards products or processes that ultimately have financial returns (Markusen, Hall, & Glasmeier, 1986:14). The development aspect is centred around the idea that the product or process in question leads to some form of prototype development [34]. R & D taken together are the actions that lead to knowledge generation, invention, and the subsequent movement of new and innovative firms into the local economy.

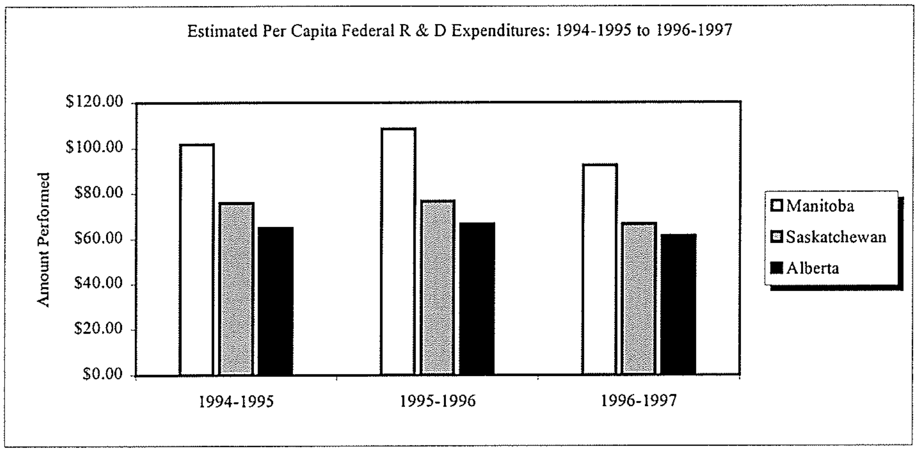
R & D is also a highly knowledge-intensive industry. However, it is not simply a high technology activity, but an activity that takes place in virtually all industries, and in all academic disciplines. The majority of all activity however is within those industries and academic activities in the natural sciences and engineering (NSE) fields, which are defined here as "…disciplines concerned with understanding, exploring, developing or utilising the natural world". (Statistics Canada, 1999a:10). For the purposes of this research, unless otherwise noted, the funding and performing of R & D refers only to the NSE. Indeed, for many reports, social science and humanities (SSH) R & D is no longer measured.

5.3 The Role of the Federal Government in Local R & D

The federal government easily plays the most diverse role within the Canadian R & D arena, and can be most influential in economic regions with less developed industrial R & D infrastructures and activity (Holbrook, Interview, 2001). The federal government is the primary funder in the larger realm of science and technology in Canada, contributing $5.7 billion in fiscal 1996-1997 (Statistics Canada, 1999a:7). Of this amount, approximately $2.87 billion was devoted specifically to R & D in the NSE, second only to the business sector (Ibid.:16). They are a significant performer of local R & D activity as well, accounting for R & D performed through federal departments such as Agriculture, and Fisheries and Oceans, and at federal institutes such as the Canadian Science Centre for Human and Animal Health (virology lab). Nationally, they play the determining role in basic and applied research by funding university R & D through their major granting councils, the Canadian Institutes for Health Research (CIHR), Natural Sciences and Engineering Research Council (NSERC), the Canada Research Chairs (CRC), and for R & D infrastructure, the new Canada Foundation for Innovation (CFI) [35]. (CAUBO, 2000:2)

In total, the federal government doled out approximately $100 million to R & D activities in Manitoba during the 1996-1997 fiscal year. Of that amount, approximately $60 million was performed intramurally ($15 million of which was at AECL), $11 million was given to industry through grants and contracts, $19 million to universities through grants and contracts, and approximately $6 million was given to other groups (Statistics Canada,1999a:18-24) [36].

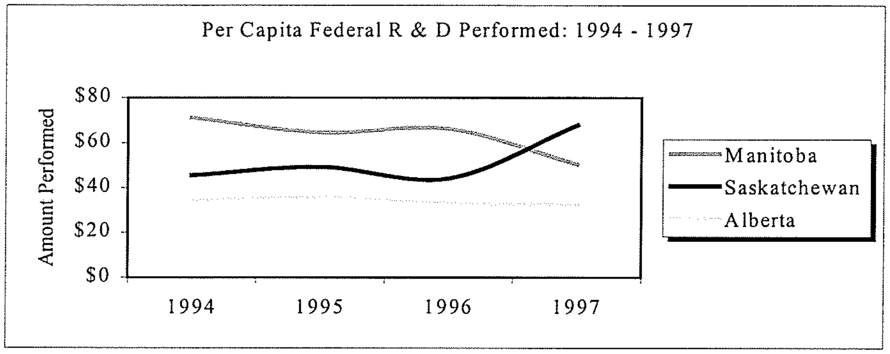
Figure 5



Source: Adapted from Statistics Canada, 1999a.

Their role in Manitoba R & D has changed significantly in the last 3 years, due to the outright curtailment of public activities at the Atomic Energy Canada Limited (AECL) facilities in Pinawa, Manitoba. The AECL received $15 million per year in funding (Statistics Canada, 1999a:30) in 1996-1997, which has all but stopped as the organisation moves to that of a fully private operation (Manitoba R & D Respondent A, Interview, 2001). The data used in this portion of the research do not yet reflect these figures, but both Holbrook (Interview, 2001) and another informant (Manitoba R & D Respondent A, Interview, 2001) suggest that this funding has not been replaced through any new departmental initiatives concerned with AECL [37]. The federal government's departmental presence in metro-Manitoba (after the removal of AECL's $15 million and 150 R & D personnel) is now more limited. Agriculture Canada accounts for the bulk of remaining R & D activity ($40 million) and personnel, with a small presence in Fisheries and Oceans and the National Research Council (NRC), (Statistics Canada, 1999a:30).

Figure 6



Source: Adapted from Statistics Canada, 1999c.

5.3.1 The Federal Government as an R & D Performer

The role of the federal government as a performer of R & D in Manitoba is significant to the extent that it requires the use and employment of highly skilled people in the local economy, which partially contributes to a local innovative milieux. However, as it relates to possible firm development capitalising on inventions and their commercialisation, R & D performed by government is typically high profile in terms of its media portrayal through political press releases, but rarely is it considered to be "cutting-edge stuff" (Holbrook, Interview, 2001), Federally-performed R & D in Canada is instead almost exclusively intended for regulatory and policy purposes, and, with the exception of the NRC's R & D activities, very rarely even undertaken for the purposes of future commercial development (Featherman, Interview, 2001). This finding links well with the existing theory. Both Malecki's (1986:63) and Markusen's (1995) research on the role of government R & D activity suggests that it is unlikely to stimulate much innovative activity through the spin-off of new firms. Markusen suggests that the research culture (non-competitive), personnel systems (relatively good pay as a deterrent to pursuing innovative new ideas), and geographic isolation from other R & D infrastructure (lack of social /

work mixing) are significantly different from the 'research milieux' that surround either corporate or university R & D institutes (Ibid.:3-5). There is also the increasingly important issue of the proprietary rights (intellectual property) issues that often dissuade employees from legally pursuing start-up opportunities.

Given this systemic limitation, the only significant conclusion that this research can draw from the existing theory and key informants is that the federal government-performed R & D in Winnipeg has been reduced significantly in the last four years, and is to be considered generally insular, offering few opportunities for new firm development through the exploitation of new technologies and inventions. In the overall context of the health of local R & D, the federal government as a performer is also to be considered limited in terms of its variety of R & D activity (by sheer dollar value, it is focused today almost exclusively on agriculture-related R & D), but, unfortunately, not its outright dollar value contribution to the local R & D pool.

There is only limited cause for concern in this information, as this research suggests that different types of R & D have very different meanings in the context of local economic development. Though the presence of the federal government's departmental R & D in metro-Manitoba has waned in the last few years, it still constitutes a significant amount of the R & D pool that exists here today. On average, during the time frame referenced above (see Figure 6), metro-Manitoba's share of federal R & D performed was $60.29 per capita, in comparison to the business sector, which provided an average of $72.93 per capita in performance [38]. Should theory continue to hold true, these ratios have potentially negative implications for metro-Saskatchewan, and potentially positive implications for metro-Alberta. This also has possible implications for the recommendations that will arise out of these findings: the greater the reliance a metro area has on federally-performed R & D, the less chance one has of being able to see the benefits through new firm spin-off. In the absence of any explicit or implicit technology transfer mechanisms, it will be potentially more difficult to design a strategy that will reap rewards from federal R & D activity. Further research that would be of potential value to this work would determine exactly what types of R & D activity are taking place within the federal agencies and institutes in metro-Manitoba, the associated Canadian issues with respect to the proprietary rights inherent in federal research, and the destination for the grants and contracts issued by these federal agencies and institutes to private firms [39].

5.3.2 The Role of the NRC in New Firm Development

Table 1 Estimated Per-Capita R & D Expenditures of the Federal Government to Private Industry [40]

	1994-1995	1995-1996	1996-1997	3-Year Average	Rank
Manitoba	$14.16	$14.99	$9.68	$12.94	1
Saskatchewan	$8.87	$11.77	$5.87	$8.84	2
Alberta	$6.57	$8.27	$7.05	$7.30	3

While this research has established the federal government's R & D performance as significant in monetary terms, but with little opportunity for partnering, they also have a small but potentially strategic role as a catalyst for local industry development (see Table 1). The federal government contributes directly to R & D locally through research conducted at one of Manitoba's major research institutes, the NRC's Institute for Biodiagnostics (NRC - IBD), but more importantly as a key technology transfer mechanism through this organisation. Douglas Strang, a Technology Commercialisation Officer for the NRC - IBD (Interview, 2001) indicated that part of the NRC's mandate is to site research institutes that focus on specific technologies, locate them in regions where the research done would help to induce industry-NRC interaction,[41] and aid in the development of spin-off firms that commercialise a technology from the NRC - IBD. Nationally, the NRC indicated that an average of five new firms per year spin-off from activities undertaken by the NRC and industry (NRC, 1999:15), though Strang (Interview, 2001) suggested that the cumulative total from the NRC - IBD in Winnipeg was only four firms since 1992: Innovative MRI Systems (Winnipeg-based); Nir-Vivo Incorporated (Winnipeg-based); Novadaq Technologies Limited (Toronto-based); and MRI Systems (Saskatoon-based) [42]. This should be compared to the case of Saskatoon, where Hinther (Interview, 2001) noted that the NRC-PBI had directly spun off eight firms (of which six are based in Saskatoon) [43], and has helped in the early-stage development work of twenty other biotechnology firms in the Province. Regarding the decided lack of spin-off activity in Winnipeg, Strang countered that the local problem has little to do with a lack of effort by the NRC to help create local firms, but is largely due to two external factors. First, the NRC - IBD relationship with Winnipeg is tied heavily into other public research organisations such as the University of Manitoba and the St. Boniface Hospital Research Centre, where there may be more of a concentration on pure research, or research that becomes commercialised outside of the realm of the NRC - IBD. Second, the inability to help firms spin off is largely attributable to Winnipeg's highly-diversified economy, where there simply isn't enough advanced technology firms with which to do business. He suggested that there is a decided lack of focus within firms in the local R & D community, and general industry activity in "IBD type-activities" in Winnipeg (Interview, 2001). This notion was substantiated in a recent, objective review of the role of the NRC which attempted to assess the 'competency of regions' based on the effect the NRC had as an entry attractor for business locations, start-ups, and patents awarded. Prior to the establishment in 1992 of the NRC - IBD, Winnipeg had six biotechnology firms in existence, and as of 1998 had a total of seven. Prior to the re-establishment of the NRC's Plant Biotechnology Institute (NRC - PBI), Saskatoon had five biotechnology firms, and as of 1998, the City was home to twenty-one [44] (Niosi & Bas, 2000:53).

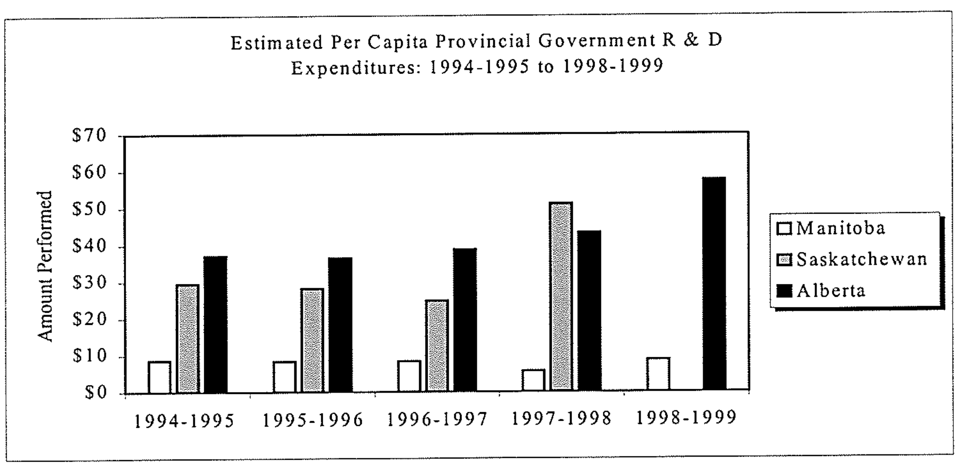
The findings here suggest that there is a different R & D dynamic in Winnipeg than that seen in Saskatoon. The NRC - PBI was one of the first regional NRC institutes developed, and at its re-configuration in 1985 there was already a good deal of local R & D and firm activity taking place in the biotechnology sector: the NRC - PBI simply added to an infrastructure that was in place due to the previous efforts of the University, the Provincial government, and Agriculture Canada (Strang, Interview, 2001; Lowe, Interview, 2001). The quantitative data above (see Table 1) indicates that there was significantly more federal funding to industry in Winnipeg compared to Saskatoon, but as both Strang (Interview, 2001) and Hamblin (Interview, 2001) suggested, it is highly diffused amongst research interests and industry sectors in comparison to Saskatoon's targeted approach. The implications of the findings here are important. First, as this research progressed, key informants suggested that one of Winnipeg's sources of pride - a highly diversified economy - appears in some respects to be a hindrance to the development of a high technology economy. Based on this portion of the research, as it relates to Saskatoon and Winnipeg, it appears that the more highly diversified an industrial base and research specialties are, the less focused the local R & D sector tends to be, and this may have an effect on associated new firm activities. In Saskatoon's case, a relative lack of economic diversification can at least partially help to focus energies on one specific sector. This finding was not an expected outcome. It is something that the reader should keep in mind. It should be of significant interest to other researchers in this field, to what extent a relatively un-diversified economy in a metropolitan setting may actually help lead to industry specialty.

Conclusion

Our background theory indicates that R & D as conducted by government is seen as an unlikely trigger in the development of new firms through the transfer of technological sophistication and inventions to entrepreneurs. Rather, the research results gathered through departmental R & D are often kept internally, and are used for purposes other than economic gain. The limited investigation here suggests that this is very much the case. While the federal government is also highly active through organisations that do attempt to transfer research findings to firms, such as Technology Partnerships Canada, and the Industrial Research Assistance Program, this study focused on the role of the NRC's regional institutes in Saskatoon and Winnipeg, and their stated mandate to help develop companies that commercialise their core technological discoveries. While Niosi and Bas (2000) have provided empirical evidence which shows that Saskatoon's NRC - PBI has been an effective trigger for the development of local biotechnology firms, according to both these data and our key informants, the NRC's role in Winnipeg was limited in its ability to help spin-off local firms based on new technologies. Indeed, only two of the four firms which arose from the NRC - IBD technologies are even located in Winnipeg. More than reflecting a weakness of the NRC or its affiliated programs, informants suggest that there is in fact either a dearth of firms in the City, or a dearth of initiative with which to begin developing firms out of these technologies, and this is the key finding. A significant and related issue was also raised that suggested the diversity of local firms in Winnipeg may in fact be a good part of the reason that there is such limited activity on these fronts. A diversified economy is a desired aspect of any city and region, one which allows for a wide range of economic activities and inclusivity for residents of varying skills and interests. However, this same diversity may take energies away from strengthening one sector of the economy at the expense of others. As seen in the case of Saskatoon, this narrow economic focus is partially attributable to the development of the biotechnology industry in the City. In the attempts to help create an innovative local economy that focuses on technology, organisations such as EDW may need to take into consideration this local diversity and determine to what extent a lack of particular high technology firms may hinder any targeted strategies. Fundamentally though, the implications of these findings as they relate to the overall goal of developing a public policy framework is that both the direct and indirect activities of the federal government in local R & D do not appear to offer a significant number of options with which to strategise. This research must therefore turn its focus towards understanding other aspects of the local R & D system to determine if they offer different possibilities.

5.4 The Provincial Government's Role in Local R & D

Figure 7



Source: Adapted from Statistics Canada, 1999b.

5.4.1 The Three Provinces: Differing R & D Agendas

This research has established that the federal government plays a significant role in local R & D through funding, but to a much smaller degree in terms of its performance. What then is the role of the provinces? In general, the provincial governments contribute a smaller portion of policy, activity, and funds to the R & D arena in comparison to both private industry and the federal government (see Figure 7). This is largely attributable to the provinces' ability to fund R & D with limited revenue streams, the traditional focus on core services, and the acknowledgement by the federal government that innovation, and science and technology policy, are largely matters of federal concern (Holbrook, Interview, 2001). That said, the R & D activity levels of the provincial government in Alberta are significant, and they continue to grow. Though not quoted as official policy, a Policy Analyst from Alberta's Innovation and Science Ministry suggested that "knowledge and innovation are formally recognized within the government business plan", are considered critical to the success of the new economy, and all R & D investments stem from that (Alberta R & D Respondent, Interview, 2001). Adam Holbrook, Associate Director for Policy Research at the Centre for Policy Research on Science and Technology concurs with this notion, and notes that the Alberta government continues to make significant efforts to develop this 'culture of innovation' through R & D investment and promotion - as it is keenly aware of the cyclical nature of the oil industry and its potential for economic decline in the future (Interview, 2001). The Alberta government invested approximately $165 million towards R & D in 1990-1991, and $170 million in 1998-1999 [45] (Statistics Canada, 1999b).

In addition to R & D occupying a significant role in provincial government policy, a separate government department devoted to science and technology, [46] and significant direct investments [47], the government of Alberta ties their R & D strategy into a technology commercialisation policy. The Alberta Technology Commercialisation Network (ATCN) is a coalition of public organisations whose mandate is to commercialise technologies that arise directly out of publicly funded R & D (Alberta R & D Respondent, Interview, 2001). The role of the Alberta government represents an almost ideal attempt towards R & D promotion: by targeting unspecific programs that promote science, and through large matching grants for R & D infrastructure, it appears as though the government views R & D as a vital contribution in the goal of creating a culture of innovation and technological sophistication. In as much as there are a lack of explicit policies that artificially support R & D firms directly, the Alberta government has significant programming and initiatives which truly 'prime' R & D by attempting to bring learning and innovation into everyday policy, and having that lead to industrial R & D and economic development through the development of firms. It is difficult to argue with the success of efforts such as these when one steps back and sees the results.

The government of Saskatchewan represents a unique entity amongst the three. At the outset, there was little reason to believe that R & D would be considered a strong provincial priority in light of their assumed strained economic position. Their direct role in R & D has been surprisingly vibrant, though informants suggested that the levels shown above are no longer indicative of provincial spending habits. Dennis Lowe, a Policy Analyst with the Policy and Strategic Planning Branch of Saskatchewan Economic and Co-operative Development (SECD) indicated that the Saskatchewan government's approach was a limited-time, targeted, and complementary approach to R & D industry specialty. The University of Saskatchewan has had a long and active tradition with agricultural research (Interview, 2001), and this regional expertise was further built upon by the siting of the NRC - PBI in Saskatoon (Holbrook, Interview, 2001) and the significant amount of work undertaken by Agriculture and Agrifood Canada (Strang, Interview, 2001). Over the past several years, both the Saskatchewan and federal governments have invested close to $1 billion in the Province's R & D system to attempt to specifically further this industry specialty in agricultural biotechnology. The Saskatchewan government has committed to two significant upcoming R & D projects, but there is little reason to believe that the levels of funding will continue, and that the Province will continue to rely on the federal government for much of its R & D activity (Lowe, Interview, 2001). To be sure, the Provincial government in Saskatchewan clearly "recognises the role of R & D in both wealth creation, and economic and social development", but their priorities are by necessity tied in to basic services such as health, highways, and education. The Saskatchewan government's lone policy on R & D, the *Research and Technology Commercialization Strategy and Action Plan*, was introduced as official government policy in 1994, but has essentially remained on the shelf since (Ibid.).

5.4.2 A Limited Role for the Manitoba Government

The Manitoba government's direct financial investments in local R & D can be considered to be limited, ranging from a low of $5.78 million in 1990-1991, to a high of $9.97 million (less than $10 per capita) in 1998-1999 (Statistics Canada, 1999b:25), far less than the other two regions under investigation here. In comparison, $7.4 million of the 2000-2001 Provincial budget was expected to go towards tourism development (Minister of Finance, 2000:54). Their main direct contributions lie as a small funder to R & D in the higher education sector, as a small funder to targeted industry groups, and through the Manitoba Innovation Fund

[48], an R & D infrastructure funder. Internally, the Provincial government had the equivalent of four full-time staff members devoted to intramural R & D in 1996-1997. This can be compared to the 543 employed by the Province of Quebec during the same year (Statistics Canada, 1999b:28). Within the government itself, up until March, 2001, there was no departmental presence that dealt explicitly with R & D and associated issues [49]. In the summer of 2001, the Research, Innovation, and Technology division of Industry, Trade and Mines was developed, though little is known about it as yet (Government of Manitoba, 2001). One informant (Manitoba R & D Respondent A, Interview, 2001) indicates that the Division will likely fulfil roles in policy development, co-ordination, and some funding, though no figures have been released which suggest that it has become a greater financial force.

The Province has no explicit policy nor strategy on R & D as it relates to industry or other goals (Manitoba R & D Respondent A, Interview, 2001). However, their unwritten agenda appears to be the stimulation of industry R & D through a relatively aggressive tax credit program (Strang, Interview, 2001). The belief is that lucrative corporate tax credits to private industry are a sufficient enough incentive for local firms to either undertake R & D, or for firms to relocate here for the purpose of undertaking R & D. To meet these objectives, Manitoba's provincial government provides a 15% Research and Development Tax Credit (RDTC) to corporations undertaking defined R & D activities [50] within the Province, and has since 1992 [51]. This is supplemented by a 20% Scientific Research and Experimental Development income tax credit [52] offered by the federal government (SR & ED Directorate, 2000:2), contributing to what some informants have suggested is one of the most generous R & D incentive schemes in the world today (Manitoba R & D Respondent A, Interview, 2001; Holbrook, Interview, 2001) [53].

This is a significant program: the federal aspect of the program accounts for the largest direct contribution to industry R & D, worth approximately $1.4 billion per year (SR & ED Directorate, 2000:2). The RDTC credit represents the Province's only active R & D strategy, financial or otherwise. Though the program is potentially generous, there should be concern as to the overall effectiveness of using a single tax credit as the only economic development tool in the attempt to develop an economy based on a culture of innovation, knowledge, and technological development.

5.4.3 The Problems Associated with Manitoba's R & D Tax Credit Strategy

First, as with any economic development strategy, what are the hidden costs that the taxpayer does not see? An informant within the Department of Finance, Province of Manitoba was asked what the value of these tax credits were in Manitoba, and to what extent these tax credits actually led to more R & D. Unfortunately, as the tax credit is tied to corporate income tax, figures are not released to the public, and are used internally only (Manitoba R & D Respondent B, Interview, 2001). Research that would be of significant value would seek to determine this information and calculate the hidden cost (loss of revenue) of this tax subsidy.

Second, R & D is often a process undertaken by large corporations. As Peter Hamblin, Regional Director for the Industrial Research Assistance Program (IRAP) indicated, one of the fundamental problems with Winnipeg as it relates to R & D is that the economy is made up many small firms, and few large ones, and as a consequence fewer firms are in a financial position to undertake R & D (Interview, 2001). Therefore, the tax credit produces a significant benefit for a handful of large firms in the aerospace and pharmaceutical sectors, but has little effect on others.

This is an important - though expected - finding. Theory that was introduced earlier in this research noted that it is typically the largest of firms that undertake the greatest proportion of R & D (Malecki, 1986:62), yet Winnipeg is characterised by small to medium firms. How will organisations such as EDW begin to address this issue? Though more investigation is required, the findings suggest that there are potential opportunities for R & D resource sharing between smaller firms. Further, research must also be done to determine the possibility of smaller firms, seeking to conduct R & D, avoiding the significant overhead costs by undertaking for-fee R & D work through contractual arrangements with large public or private R & D institutions.

Third, a single tax credit is likewise a less attractive R & D strategy because as one informant suggested, many multi-national firms undertake R & D in Canada because of the tax credits, but the knowledge gained from the exercise is often exported to other regions and countries (Holbrook, Interview, 2001). There are suggestions that the federal government is beginning to look at closing this loophole, but for now it remains (Manitoba R & D Respondent B, Interview, 2001). Again, further research is warranted that would isolate the extent to which this is occurring in Manitoba.

Finally, assuming that there is industry to target, there is concern as to how effective tax credits even are as an R & D stimulator. A recent OECD report suggests that while the Canadian R & D tax credit scheme is one of the most generous today (Guellec & Van Pottelsberghe, 2000:5), it has failed to produce the increase in industrial R & D that it envisioned (Canadian Press, 2000:35), and is not quite as effective in the long-term compared to direct investment in R & D projects by government (Guellec & Van Pottelsberghe, 2000:5). One informant (Manitoba R

& D Respondent A , Interview, 2001) indicated that - overall - industrial R & D in the City of Winnipeg increased somewhat after the onset of the Provincial tax credit scheme, retroactive to 1992, but has since ebbed and levelled off [54]. This should be compared to the situation in Alberta, where industry led R & D in recent years has been approximately double that of Manitoba [55]. In Alberta, there was slightly less direct investment in firms by the Province: on average, they have contributed $2.51 per capita between 1994 and 1998, compared to $2.75 per capita in Manitoba (Statistics Canada, 1999b). Further, there is no provincial R & D income tax credit available for firms. In effect then, the Alberta government is less willing to contribute directly to industry in their R & D relationship, yet the Province still succeeds at inducing industrial R & D at a much higher level through other efforts. When one compares the strategies of Manitoba and Alberta, compared to the relative R & D activity taking place, it would be quite reasonable to conclude that an R & D strategy based on tax credits alone has not significantly invigorated the local business sector into performing more R & D in Winnipeg. Clearly, other factors are required for R & D activities to develop in a region.

Conclusion

The Province's role in the development of R & D in Manitoba is limited, both financially and instrumentally through a lack of initiatives and a lack of presence within government departments, and it is difficult to see how this will change in the near future. The simple fact is that neither Winnipeg nor Manitoba have the revenue streams to compete with Calgary and Alberta (Manitoba R & D Respondent A, Interview, 2001). The Province of Saskatchewan is in much the same position as Manitoba (and indeed, many other provinces), in that they are hampered by a lack of revenue with which to operate. As Lowe (Interview, 2001) explained, the

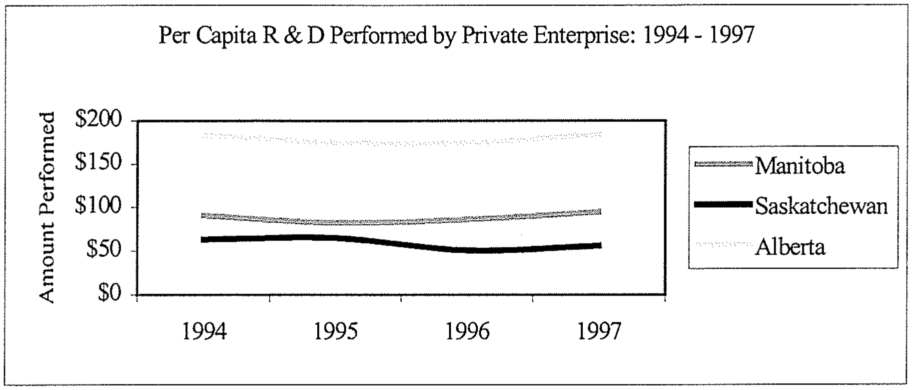
City of Saskatoon has gained international reputation for the biotechnology-related R & D work performed there, and it was a targeted effort based on existing industry strengths and strategic investments that allowed the development of agriculturally-related R & D to happen. It is reasonable to put forth that Manitoba's ability to generate additional revenue will not increase dramatically in the near future, and it is this fact that ultimately prohibits significant R & D strategy. Given that, and including the fact that the lone policy tool in existence today is the 15 % RDTC, there are a limited amount of realistic strategies that the Provincial government could undertake to directly affect local R & D activity. The most reasonable strategy that economic development planners could consider may be a revamped tax credit that is more finely-tuned to the actualities of the local R & D system.

5.5 Industrial R & D in Winnipeg: A Lack of Industries & Small Firms

Introduction

The role of industry in R & D activity can be considered to be the most purposeful of the three so far. Whereas federally and provincially-performed R & D in Canada are characterised by Featherman (Interview, 2001) as primarily for regulatory and policy purposes, industrial R & D is a direct investment in the products and processes that are the basis of a firm's existence: it is the cost of doing business, especially in volatile industries. As Figure 8 indicates, the industrial sector has also clearly been a very consistent performer of R & D in all three provinces, albeit with vastly different amounts of R & D performed.

Figure 8



Source: Adapted from Statistics Canada, 1999c.

A number of key informants were interviewed to help gain a sense of the variety and overall health of industrial R & D activity. Holbrook (Interview, 2001) suggested that, based on his knowledge of Manitoba, it was found in a few key industries, while most respondents were of the opinion that R & D activity in the Winnipeg metro area is much like it is in other urban areas throughout Canada, in the fact that it is concentrated in a relatively few large firms (Strang, Interview, 2001; Manitoba R & D Respondent A, Interview, 2001; Hamblin, Interview, 2001). This concentration is somewhat indicative of advanced high technology regions with a significant R & D presence, but these two issues bear further investigation.

Sidney Featherman, Senior Policy Analyst for Industry Canada suggested that while industrial R & D in Canada can and does take place in a great deal of industries, it is relatively concentrated among a small number of them (Interview, 2001). Empirical data indicates that in aggregate Canada, telecommunications, aircraft and parts, engineering and scientific services, computer and related services, pharmaceuticals, and medicine make up almost 50% of all R & D in Canada (Statistics Canada, 1997b:12). The results of a recent study suggested that the concentration amongst certain industries was even more acute: information technologies alone account for the bulk of industrial R & D in Canada ($5.7 billion), while biotechnology, pharmaceuticals, and advanced materials accounted for $1.7 billion (Niosi & Bas, 2000:62). Featherman (Interview, 2001) further qualified this by adding that these types of industries have virtually no choice but to spend a great deal of revenue on R & D because of the very short product life cycles in their goods and services.

5.5.1 Metro-Manitoba's Concentrated Industry R & D

One informant (Manitoba R & D Respondent A, Interview, 2001) suggested that the R & D activity in Winnipeg does not mirror the Canadian norm as discussed by Featherman (Interview, 2001). Rather, he characterised it as very limited in terms of how many different industry types are performing R & D, and suggested that it could realistically be reduced to a few very active firms in the aerospace (dominated by Standard Aero and Bristol Aerospace), agriculture (dominated by Monsanto), and pharmaceuticals (dominated by Cangene) industries. The total amounts of industrial R & D performed in Winnipeg may appear to be large, but in reality, it is not uncommon for a single large firm in a volatile industry to spend $20 million per year on R & D. What can be seen as a decided lack of diversity in the local industrial R & D arena was compounded most recently by the loss of 175 R & D positions (and an undisclosed amount of R & D spending) when Nortel disbanded its R & D plant in Winnipeg and moved the personnel to Ottawa and Calgary, less than two years after beginning operations (Lett & Cash, 1999:B7 & B12). This closure may have significant ramifications further down the road, as this was the one large microelectronics facility that was conducting R & D in Winnipeg [56]. According to numerous informants there are simply few other firms in Winnipeg where any appreciable amounts of R & D are taking place (Manitoba R & D Respondent A, Interview, 2001; Strang, Interview, 2001; Hamblin, Interview, 2001).

The second aspect of local R & D activity that is worthy of discussion is the degree to which R & D is limited to only the largest of firms. While the City of Calgary does have very large companies undertaking the bulk of R & D activities, they also have a number of small firms - particularly in the wireless technology sector - that conduct large amounts of R & D relative to their revenues, and indeed see it to be as necessary for survival as do the very large firms (Alberta R & D Respondent, Interview, 2001). Evidence from a recent Statistics Canada report reflects this finding: while R & D is still heavily concentrated among large firms, the number of small firms using it as a basic business investment has increased significantly over the last twenty years (Statistics Canada, 1997b:19). Strang (Interview, 2001) offered a simple thought, suggesting that "Winnipeg just does not have enough of those types of firms (small and R & D intensive), but instead a significant amount of small manufacturing companies"; ones that do not typically undertake R & D (Interview, 2001). Hamblin (Interview, 2001) goes on to argue that innovative Manitoba firms who are likely candidates for R & D activity have not yet stepped back and understood how R & D has a role in innovation and business development. What Hamblin is indicating is that innovative firms in metro-Manitoba that may be in a financial position to undertake R & D often do not because they may not see R & D as having an appreciable return on investment in the same way that typical business investments in buildings or additional staff may have. The ramifications for this are hard to assess based on such limited data and informant knowledge. What this does suggest is that much like the VC industry in Winnipeg, there is a conservative culture which surrounds it. Local firms tend to mirror what their competitors are doing, and if there is a belief that R & D is an unwise investment for a SME, this culture may become self-replicating and defeatist.

It is important for future researchers to note that a study of industrial R & D is an exceptionally difficult one to gather either empirical or qualitative results from. At the root of R & D is competition, and the need to 'get there first' is paramount in firms where product iterations are commonplace. Because of industrial R & D's secretive nature, significant difficulties will arise when attempting to either find key informants with detailed knowledge, or gather data directly from firms. Certain divisions of Statistics Canada are the only organisations that are able to frame a picture of industrial R & D, and even then, it is estimated, and based almost exclusively on wide ranging surveys and tax return information. True key informants outside of industry likewise appear few, and their knowledge base - while significant of R & D in general - is diluted by the same factors indicated above.

Conclusion

In spite of the two limitations this research found in the concentration of local R & D, they may be moot points. The most significant aspect of industrial R & D is that it too may be considered insular if it is based exclusively in very large firms, as it appears to be in Winnipeg. In our analysis of federally-performed R & D, this research discussed the findings of Markusen (1995:3-5), and the opinions of Featherman (Interview, 2001) with respect to the limited opportunities for partnering with other actors in the high technology world to commercialise any findings. It was determined from the limited investigation here that R & D in Winnipeg is generally confined to the largest of local firms, typically in the aerospace, pharmaceutical, and agriculture sectors. Similar to the case with federal R & D (where innovations and sophistications are often used internally), there are valid concerns as to the extent that large Winnipeg firms conducting R & D will ever need to build external relationships for the purposes of bringing an invention to light. Without the need to build relationships with local entrepreneurs, specialised business services, and VC firms, there is little need to discuss industrial R & D's role in local economic development in Winnipeg. New products and processes may be developed and even applied locally by these large firms, but this internal process has not altered the economic landscape in any appreciable way through the employment of local people, the use of local entrepreneurship, and the use of local capital. Further, as Holbrook (Interview, 2001) noted, very large firms may often conduct R & D in regions with excellent R & D tax incentives (such as Manitoba), but then export that knowledge (and attendant technologies) to their parent companies and regions.

From the vantage point of the objectives of this research - where there is concern regarding the ability of R & D to help develop new firms and contribute to an innovative economic milieux - these are the fundamental problems with large-scale, industrial R & D. In an ideal scenario, inventions or technological sophistications arise out of research, and find their way into the hands of existing firms or new entrepreneurs for the purposes of commercialising those findings. In turn, existing firms and entrepreneurs seek high risk capital with which to develop this product or process. Where you have very large firms (and often national or multi-national) undertaking local R & D, there is less of a chance that they will require these outside relationships to commercialise their products. By virtue of their size, a great many of these firms have the in-house ability to patent, finance and commercialise their own activities without external contact (Hamblin, Interview, 2001). The larger the organisation, the greater the likelihood that they already possess these services.

5.6 Is There Potential for Universities in High Technology Economic Development?

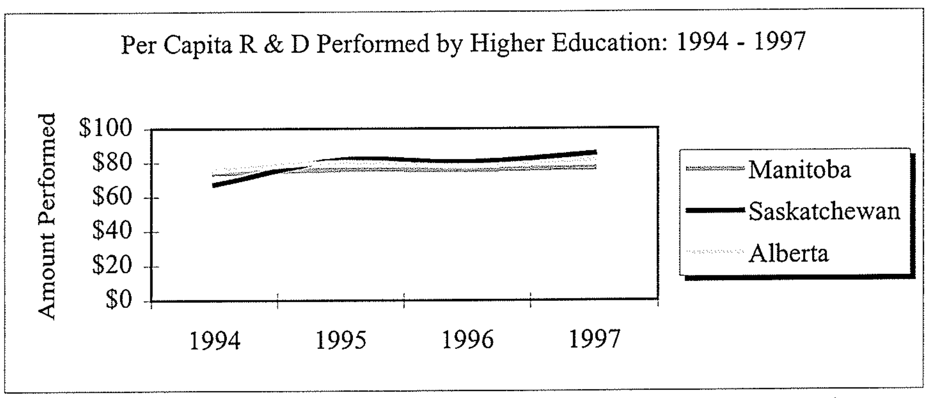
In the case of federally-performed local R & D, this research has determined that there is little opportunity for business development because the research findings are typically used internally, and their commercialisation into wider industry is traditionally channelled through vehicles such as the NRC. The Manitoba government's role is limited both financially and instrumentally. Their primary role appears to be as funder to the higher education system, and as an economic development agent through their aggressive R & D tax scheme (Strang, Interview, 2001). In the case of industrial R & D, the problems inherent were discussed above. All of these appear to leave planners with few options in identifying possible strategic relationships and suggestions for how to even begin to change these scenarios. Our attention thus turns to the university sector.

5.6.1 The Changing Culture of the Research University

The modern research university appears to be redefining some of its core competencies. Where universities were once viewed solely as institutions pursuing and disseminating knowledge, research intensive universities are becoming more entrepreneurial in their attempts to licence technologies and gain revenue through their commercialisation (Author Unknown, 1995 b:B3). There are suggestions that many view this applied research within universities as an improper use of university facilities and public funds, suggesting that pure research and the advancement of science for the general public are the true calling of the research university

(Doutriaux, 2000:94). Amidst this debate, universities are also viewed by planners as potential centre-pieces in economic development strategies for entire regions (see for example: Doutriaux, 2000:93, Luger and Goldstein, 1997:127). Where a large, keystone industry such as Nortel was once seen as (and often still is) a potential catalyst for innovative activities, Holbrook (Interview, 2001) suggests that universities can now fulfil this role by not only graduating a well-educated and skilled work force, but also by using the researchers' intellectual property as the basis with which to form industrial clusters [57].

Figure 9



Source: Adapted from Statistics Canada, 1999d.

5.6.2 The Importance of University R & D in the Development of New Firms

In Canada, university R & D takes on perhaps a greater importance in terms of economic development because a greater proportion of the country's total R & D takes place in research universities. In 1997, university-led R & D accounted for 14.3% of all R & D in the U.S., 14.8% in Japan, and over 21% in Canada (ACST, 1999:7). This situation is much more pronounced in the Province of Manitoba: between 1995 and 1997, approximately 32% of all R & D was performed by the university sector [58] (Thompson, 1999:77-8). This is perhaps the most significant piece of empirical data encountered so far in this research (see Figure 9). The importance of university R & D to economic development planners goes beyond its weighty contribution to the total R & D performed. University R & D represents an ideal nexus where often the most innovative ideas mix with a relatively empty business climate: in these terms, university R & D is the antithesis of government and industry-performed R & D respectively. This is significant because the path from discovery to product is far less clear here than it is with private industry, and this may well provide us with excellent opportunities to develop new firms. As Feller (1994:23) noted, the findings of academic research are rarely directly transferable into ready commercial productions or applications, and they often require significant economic and technical refining. Universities are simply not yet set up, to the extent that large industrial R & D labs are, for this transfer and, as a result, technologies and innovations within universities may be products or processes searching for a home. Ideally, this nexus is where planners, entrepreneurs, and existing firms will mix with VC and set in motion the development of new firms and an innovative business milieux. It is for these reasons that key informants (Featherman, Interview, 2001; Alberta R & D Respondent, Interview, 2001; Holbrook, Interview, 2001; Lowe, Interview, 2001) suggest that economic development planners have the greatest opportunities for industry development with a research university as a key piece of the puzzle.

According to one informant, research universities will become increasingly "crucial" to the successful economic development of regions in a global economy, where people, firms, capital, and knowledge are free to move where they wish (Holbrook, Interview, 2001). A key aspect not noted in any literature is that universities are also deeply rooted within metros and regions, well tied into the social fabric of the community, and are generally not yet prone to leaving the city or region in search of economic opportunity [59]. Again, this becomes more pronounced in metro-Manitoba, where it was determined that: (1) the share of R & D conducted by the research universities is very high relative to the Canadian and world-wide average; (2) there is concern as to both the activity levels and potential for partnering with government R & D; and (3) there is not enough R & D taking place in a variety of private firms and industries. However, the likely success in using a research university for economic development purposes is largely determined by the degree of specialty at the university (Holbrook, Interview, 2001). The development of an economy based on the transfer of new knowledge from the university into new firms to commercialise the inventions is most effective when it is focused - to create the oft-mentioned 'critical mass' of specialised knowledge. When transferred, this critical knowledge mass - all other things being equal - should in theory lead to an assemblage of inter-related firms in a region.

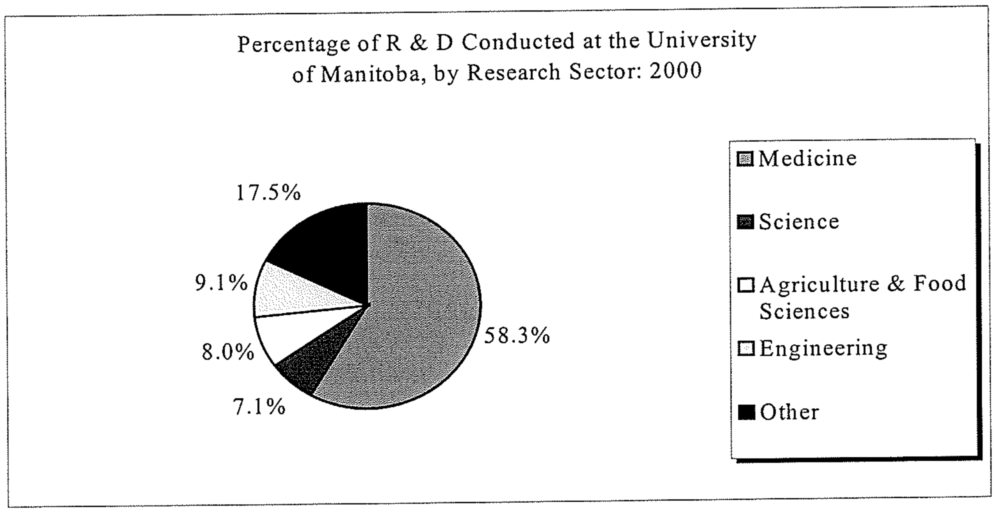
5.6.3 The University of Manitoba

With the transfer of its technology in mind, the U of M developed the University Industry Liaison Office (UILO) in an attempt to commercialise their discoveries, either through the direct creation of firms, or through the licensing of these discoveries to existing or new firms. Jayas (Interview, 2001) indicated that royalties accruing to the University through the licensing of technologies to third parties has increased steadily over the last few years, and were approximately $1.3 million in 2000. Further, Godin (Interview, 2001) noted that there have been nine firms created directly out of U of M research [60], with four more in development [61], which can be compared to the four firms developed directly out of the NRC - IBD technology transfer mechanism. This alone will suggest to us that university R & D is more likely to lead to the development of commercialised technologies and the development of new firms directly out of that research. Most of the firms created out of U of M research are based in the biotechnology sector, which has wide applications in medicine, science, and agriculture. This also brings us back to the original Weberian notion of industry formation with its 'upstream' and 'downstream' industries, and Porter's idea of the industrial cluster based on one specialty and several sub-specialties.

5.6.4 Research Specialisation at the University of Manitoba

While there are valid concerns regarding operational funding cuts to universities in the Province (Gerrard, 2000:A17), R & D performance in the higher education sector has in fact grown 300% in Manitoba NSE sectors over the last 20 years. With few exceptions, performance levels in Manitoba have increased each year from 1979-1980 ($31.6 million) through 1997-1998 ($86.8 million). This is a significant trend by virtue of both its duration and intensity, and it has occurred at approximately the same rate throughout Canada. (Statistics Canada, 1999d:25). In 2000-2001, the U of M is expected to take in just over $90 million in R & D associated income, the vast majority of which will be spent on research in the NSE (Jayas, Interview, 2001). In and of itself, this tells us little of course, other than that funding for university R & D is increasing. Within that figure, a majority (53%) will be devoted to medical research, and between 7% and 9% will be devoted each to Science, Agriculture, and Engineering (see Figure 10). As this relates to our defined three core technologies, biotechnology applications can be found within medicine, science, and agriculture, advanced materials can be found within medicine and engineering, and microelectronics can be found within engineering. Further to this, the U of M has a stated research excellence within medicine in cardiovascular and respiratory sciences, gene technology and cell biology, infectious diseases, neuroscience and mental health, and applied pharmaceutical sciences (University of Manitoba, 2001:1-2).

Figure 10



Source: Adapted from Jayas, personal correspondence, 2001.

Conclusion

R & D as undertaken by the higher education sector has proven to be one of the most consistent performers in Manitoba over the last 20 years, in spite of cutbacks within other areas of the university system. The contribution of university research to all Manitoba-performed R & D is significant, accounting for approximately 32%; considerably higher than most OECD countries, and higher than any other Canadian province, less Saskatchewan. Within that, the U of M has a decided research focus oriented towards technologies and processes that are based in both pure and applied aspects of medical research, many of which may have links to biotechnology applications - a key and still-emerging 21st century technology. Informants and data have suggested prior that both the Manitoba VC industry and the Winnipeg economy in general are perhaps too diversified to maintain proper focus on specific high technology issues. Porter's theory suggests that successful economic development arises through specialisation and the concentration of key firms and attendant business supports. For the first time in our research, the data and informants both suggest that Winnipeg has achieved some sort of specialty in terms of R & D performance in the medical arts, and the development of associated firms. There is a nice fit between this, metro-Manitoba's medically oriented workforce, business-oriented institutions such as the St. Boniface Research Centre, and the development of niche VC funds such as the emerging Western Life Sciences Venture Fund. These links are explored in greater detail later in this research.

This seeming beacon of hope bodes well for economic development professionals, and presents a comparatively stationary target at which to aim. The university R & D sector represents the economic development profession's best opportunity to partner cutting-edge research with the development of new firms. There is however a distinct need for further research to dig deeper and determine to what extent the U of M wants to be in the business of licensing technologies and developing firms. The UILO is dedicated to commercialising research conducted strictly at the U of M. Hamblin (Interview, 2001) indicated that technology transfer offices such as the U of M's UILO are typically at the forefront of this new business culture, but suggested that there is "a genuine lack of understanding outside of the U of M as to what they do, their mandate, and just who they are", a notion mentioned earlier by Johnson (Interview, 2001). University Technologies International is a Calgary-based, independent company which provides technology transfer services to University of Calgary researchers, and other researchers not associated with any university (Alberta R & D Respondent, Interview, 2001; http://www.uti.ca/

link8.htm). This is a highly specialised business service that is fully independent of university ties, but it is clearly inclusive of their activities as well. Given the lack of technology transfer mechanisms in Winnipeg and a lack of understanding of the UILO's function, this appears to be a notion that the U of M and others in the high technology community may wish to investigate further, especially in light of the recent SMARTpark development. It appears reasonable to suggest that the current UILO could reach out to the greater high technology community through such an inclusive business model.

Holbrook (Interview, 2001) suggested that this business culture must be entrenched throughout the university system, and found at the highest levels of the administration for technology transfer to be truly effective. From the viewpoint of this research, there are significant advantages for the U of M to undertake these business activities. First, researchers who have interests that lie outside of teaching are able to explore them and be rewarded with economic opportunity, which may ultimately raise the prestige of the University, help to develop an open culture of innovation and opportunity, and could prove fruitful in instilling this attitude into students. This innovation culture was very evident at Stanford University in the 1970s, where students and professors were occasionally business partners. Second, studies have detailed the problems of retaining highly-educated people in regions with lesser employment opportunities, particularly those with education in the applied sciences, and advanced degrees (Frank & Belair, 1999:5-7). By contributing intellectual property that ultimately spins off new local firms, universities can play a significant role in retaining some of their graduates with degrees in high technology fields of study. Finally, in the face of budget cutbacks, royalties accruing to the U of M - while small today - may eventually go a long way toward the university's plan of relying less on public funding for crucial operational aspects of the university. While Jayas (Interview, 2001) rightly indicated that the U of M provides economic benefit to metro-Manitoba through various means (including the development of new technologies), further research of value could attempt to investigate to what extent the upper echelons of the university administration view the transfer of technology to the local economy as vital.

The financial outlay related to the recent development of the U of M's as-yet-empty SMARTpark appears to suggest that there is a significant interest in developing a business culture at the U of M. The research park is a concept discussed early in this research, and is essentially an industrial park for high technology businesses. Like SMARTpark, most are also located on university grounds [62]. It is interesting to note that there are currently few firms located within the university grounds, which suggests it was developed with the hope of capturing high technology activity, as opposed to providing space for existing firms. Research that would be of value would determine if there would be an incubator function that coddles young firms. Calgary has an incubator for high technology firms (The Technology Enterprise Centre) outside of the university environment as well as a campus-based facility that focuses directly on university-commercialisation firms - the Research Transition Facility (Alberta R & D Respondent, Interview, 2001), but there is currently no explicit high technology incubator in Winnipeg or Saskatoon.

Finally, there is the issue of intellectual property (IP), and what it really means in the context of our research. Virtually all universities today have an explicit IP policy that is either couched within collective bargaining agreements, or found in general university policy. Holbrook

(Interview, 2001) indicated that IP policies functionally come down to a matter of who owns what. In the case of the University of British Columbia, the researcher has no legal rights to their inventions, and in the case of Simon Fraser University, the researcher holds all legal rights and the University none. Jayas (Interview, 2001) suggested that the U of M's policy is "50 / 50", with the U of M and the researcher sharing equally in revenues and ownership [63]. Where the university has no legal interest in IP, the technology may be sold to the highest bidder, in which the benefits of a technology may be lost to the public, the region, and perhaps the country. Where the researcher holds no legal interest, this may seriously hinder the desire and initiative of researchers to undertake this type of research, and thereby leave to chance the discovery being made within another university [64]. While no studies have been done that have empirically determined if certain Canadian university IP policies have been more (or less) instrumental in helping to develop spin-off firms, further research into this is not only warranted, but necessary, and may form the basis for a set of excellent recommendations.

Chapter Six

The Roles of Education & Migration in Determining an Educated Population

Introduction

As it relates to the old economy, labour was often discussed by economic geographers as another equation in their economic modeling: people were considered an input to the production process just as materials were, and large-scale production would locate and relocate depending on availability and relative cost of each. In an economy based on brawn and natural resources, it was easy to both under-value and perhaps under-appreciate forms of knowledge and their role in economic development [65]. This is much less the case in modern industrial economies. The importance of people is underscored when one notes that jobs are following people today as much as people are following the jobs. Florida (2000:24) suggests that those cities and regions with highly educated knowledge workers are the ones that have the capability to lure high technology firms, or grow them from within. Today, people matter more than ever.

This is not to say to say that people were not important to the old economy, for the human capital component has always been an important factor in the location of industry. Stafford's study of the influence of factors for business location indicated rightly that it is the presence of an appropriate work force above all that determines where firms locate (1983:16-8). Where the old and new economies differ is in how the value of this labour component is interpreted. Where manufacturing firms may (and did) require workers with certain skills, high technology firms typically require highly educated people, predominantly with education in the sciences and mathematics, and those with relevant professional designations. The value of labour in the old economy was tied directly to its cost to the production process. In the new economy, value is tied directly to the innovative potential, ideas, and education that the person brings to the development and application of new technologies and processes. Understanding the new economy workforce is a crucial step for planners, and represents the basis of this part of the research.

This part represents the final indicator to be investigated. This research has investigated the R & D function as a form of research capital; particularly how it relates to invention, innovation, and new firm formation, and what opportunities and challenges it presents to the local economy. Likewise, this research has assessed the role of VC and come to understand its relationship to entrepreneurs and high technology firms. The role and function of human capital in the development of high technology economies, and particularly in the creation of an innovative milieux is perhaps the most important indicator, yet also the one whose strength or weakness is most affected by human, environmental, and other forces. These forces also make it the most difficult to understand and effectively measure.

There are three basic and inter-related questions that must be answered to determine: where metro-Manitoba is; how it got there; and - if needed - how it may be altered:

(1) How many metro-Manitobans have post-secondary education in so-named 'high technology' fields of study (which are typically based in the natural and applied sciences and mathematics), and what are some of the contributing factors that explain why there are that many?

(2) In an attempt to understand why some jurisdictions appear to have more persons educated with certain knowledge, how do metro-Manitoba secondary students perform in mathematics and sciences ?

(3) Finally, to understand the link between school and work, are there certain factors that

contribute to secondary students pursuing mathematics and sciences at the post-secondary level?

6.1 The Problem in Identifying Valid Indicators of Educational Attainment

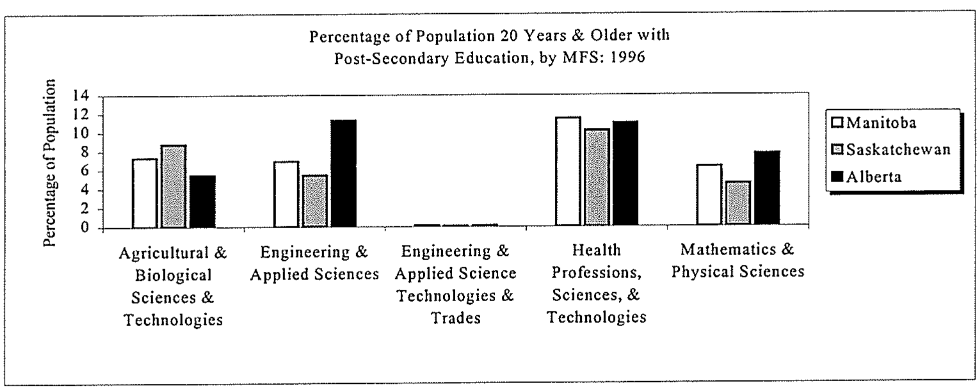
Studies that are similar in both scope and intent to this research have been inadequate in providing any insight into why a resident population does or does not possess the education required for many career opportunities in the new economy (see for example: Hall, 1999:19-20; Atkinson & Gottlieb, 2001:31), mainly offering relatively straightforward data such as the number of persons with a bachelors degree, or the number of engineers per jurisdiction as a representative measure. Unfortunately, these statistics do not reveal to us exactly how this state came to be, by failing to explore issues such as migration and early childhood education as causal factors. The reasons behind this lack of analysis may be the need for brevity on the author's part, but may also be linked to the often problematic study of education itself and the conundrum it presents. When an indicator such as VC is analysed, there are often reasonably clear cause and effect aspects to it that allow us to determine why it performs as it does. For example, the lack of a provincial investment tax credit in Alberta is directly responsible for the limited local VC investment seen in that province. When one discusses education, they are really discussing individuals, and there are relatively few clear cause and effect scenarios which can be isolated as to why a particular state of being came to be. As numerous informants will indicate, there are many factors (home, financial, funding, educators) that may have an effect on a region's educational attainment, but many of these factors themselves are in turn affected by a myriad of other factors. What one often leaves with is more questions than were actually answered. In spite of this inherent limitation, this research is needed to understand the relationship between education and the ultimate development of high technology industries.

6.2 Winnipeg's 1996 Educational Profile

The population of the CMA of Winnipeg is consistently 'less educated' across the education spectrum than either the CMA of Calgary or the CMA of Saskatoon according to data released by Statistics Canada [66]. 1996 Census Canada data indicated that 18.7% of the resident population over age 25 had completed a university degree. Concomitant figures for Saskatoon and Calgary were 21% and 23.5% respectively. The resident population of Winnipeg also attained a lower rate of completion for post-secondary diplomas and certificates: 44.8% of Winnipeg's CMA over 25 attained this level of education or higher, compared to 49.4% in Saskatoon, and 53.7% in Calgary. This trend continues with the number of residents possessing a high school certificate or higher (66.7% for Winnipeg, 69.7% for Saskatoon, and 76.3% for Calgary), and for those residents with less than a grade 9 education: 10.6% of Winnipeg's population over 25, compared to 9.9% for Saskatoon, and 6.2% for Calgary did not attain this (Statistics Canada, 1996b). While illustrative, the data is general, and gives us a only basic sketch of educational attainment. For our purposes, we are most interested in determining the number of residents with degrees that have the greatest likelihood of being applied in industries and firms which focus on high technology activities relating to biotechnology, advanced materials, and microelectronics.

The following chart (see Figure 11) and data dig deeper than the data above in terms of identifying degrees in specific fields of study. The chart represents the number of residents over the age of 20 with completed post-secondary education in five key knowledge areas, also referred to as Major Fields of Study (MFS) [67]. The data is presented at the provincial level, which – as was discussed prior - is a small obstacle to this research. Ideally, it would have been possible to gather this same detail at the CMA level, but it does not readily exist. It would be reasonable to suggest that because the data encompasses the entire Province, a true sense of how it relates to metro-Manitoba is perhaps lost. There is some validity in such a thought, but one must keep in mind that the Winnipeg CMA accounts for approximately 65% of the Province's population, and one must also understand that a greater percentage of people with education in certain fields work in the City of Winnipeg. For example, just over 83% of Manitoba's residents with engineering and applied sciences degrees, and approximately 82% with mathematics and physical science degrees worked in Winnipeg in 1996 (EDW, 2000:40). The reader must keep in mind the degree to which Winnipeg dominates Manitoba when reviewing the data.

Figure 11



Source: Statistics Canada, 1996b.

What the data tells us is that metro-Manitoba's resident population in 1996 was also less educated statistically in so-called 'high technology' fields of study in comparison to Alberta (with the exception of Health Professions) [68], and more educated relative to Saskatchewan (with the exception of Agricultural and Biological Sciences). Behind these 5 MFS, there are a significant number of secondary and tertiary classifications of MFS, which - due to their breadth - will not be reviewed here in detail. However, of particular interest is the Engineering and Applied Sciences classification. In this group, the percentage of Alberta residents with degrees in fields such as Mechanical and Electrical Engineering was significant.

6.2.1 Factors Influencing Winnipeg's Education Profile

The questions in all of this of course are, does the data effectively show us how ready the city-region is to undertake high technology activities, and does it tell economic development planners what they need to know to develop any strategies that relate to the encouragement of the new economy? John Harper, a Labour Market Analyst for Manitoba Education, Training and Youth suggested that both the CMA-level data introduced earlier, and the data from Figure 11, essentially tell us only one thing. The statistics here are - unemployment notwithstanding - less a reflection of a propensity towards education, and much more a reflection of the educational requirements of Manitoba's current industrial base, which he also indicated was comprised of generally older workers than either Saskatoon or Calgary (Interview, 2001). Harper's thought on this was correct because, as noted above, the data does not indicate where a resident received an education - only which education the resident possessed. In this sense, the data do not reflect this propensity towards educational achievement as was hoped. What it does accurately shows us is: the number of residents who have either migrated in with a specific education; or those who migrated here and then received the education; or those who were born here and acquired that education.

The notion that these data are reflective of the education needs of the current industrial base was also reiterated by an informant from the Council on Post-Secondary Education (COPSE), who concurred with Harper's analysis and conclusion, but suggested that the data are also influenced by another sub-factor. The opinion expressed was that Manitoba has traditionally had less people with a university education than many other urban centres largely because of both the strength and diversity of the local economy. They indicated that the choice to go on to college or university is influenced by a large number of factors, but that the degree to which there are available job opportunities in the local economy, that do not require a post-secondary education, has a significant effect on enrolment rates at both the college and university level (Manitoba Education Respondent, Interview, 2001). In other words, the more job opportunities that the economy presents to those not in post-secondary school, the lower the enrolment rates at colleges and universities. To debate this point, and to delve into the myriad factors that determine college and university enrolment are beyond the scope of this research, but it will be assumed that it is partially correct as a minimum. In support of this, it is worth noting that the number of students graduating from Manitoba universities with bachelor and first professional degrees has dropped consistently from 5,112 in 1994 (Statistics Canada, 1996a:149) to 4,520 in 1998 (Statistics Canada, 2000:147), while the unemployment rate has been relatively stable for the past number of years.

In hindsight, the key informant responses were adequate to the depth of the questions posed (keeping in mind the difficulty in ascribing singular causes to complex problems) but it is difficult to see how this one causal factor would have such a significant effect on the educational profile of the Province. Further, in accepting their response, this project would have to assume that good employment opportunities that do not require post-secondary education would affect enrolments in all fields of study somewhat equally, which means that the question of why the population of metro-Manitoba is less educated than that of Alberta hasn't truly been answered, and only indicates that, on average, there were fewer persons with post-secondary education in most high technology fields of study in comparison to metro-Alberta.

6.2.2 The Implications of the Current Structure

Despite the limitations that the data ultimately presents in explaining the contributing factors in Manitoba's educational profile, it does suggest two inter-related points. First, assuming that the education levels of the resident population do reflect the educational requirements of Manitoba industry, it indicates that metro-Manitoba's industrial base is one that - in general - currently requires a less educated work force than does Alberta's, and as was discovered in the analysis of both the VC and R & D sectors, it reiterates that Winnipeg likely does have fewer high technology firms than Calgary. Second, it has immediate implications for any potential strategies that could be undertaken by organisations such as EDW, because it also indicates that metro-Manitoba, and Winnipeg in particular, are likely not as prepared as other centres for planning initiatives that would attempt to attract high technology firms to the City, unless those strategies were accompanied by attendant strategies that attempted to attract the appropriately-educated persons to fill the necessary positions. Despite knowing this, these conclusions alone only place this research alongside the similar studies previously noted (Hall, 1999:19-20; Atkinson & Gottlieb, 2001:31), and we have as yet no understanding if the key informant's responses alone are adequate. We similarly have no knowledge of the potential for change if the responses are correct. There is therefore a need to expand this research, and investigate other indicators that are more helpful in revealing if metro-Manitoba has an appropriately educated population to undertake high technology activities.

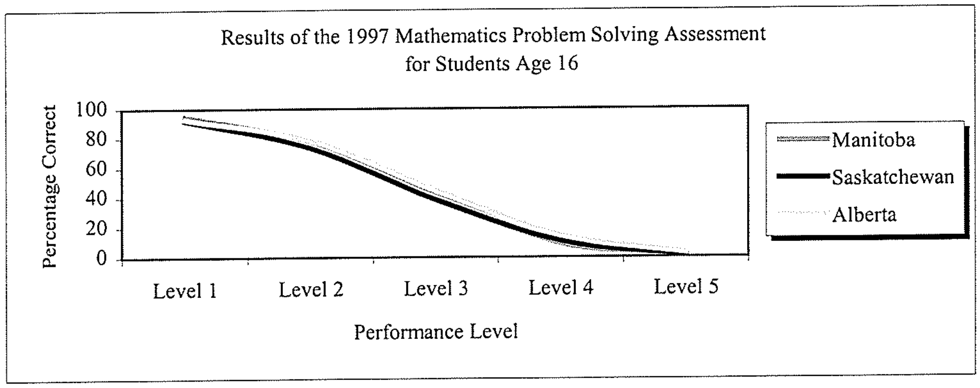
6.3 The Need for Further Indicators

Given that the data is reflective rather than diagnostic, it is insufficient in properly profiling the educational capabilities of the Province, and the question then becomes: by what indicator(s) can one effectively measure the preparedness of the metro-Manitoba population to undertake employment in high technology industries? Richard White, a former U.S. congressman and current CEO of a political lobbying group for Silicon Valley firms suggested that the question as to whether or not the workforce of the 21st century will be ready for the challenges it may pose will be found in the educational achievement and potential of school-age children (Feeder, 2001:F16). How our younger students approach and succeed in the study of mathematics and sciences may in itself be a valid indicator of how many people in a jurisdiction will have applied this knowledge in further study 5 – 10 years from today. Based on White's statement, there are various education indicators that could be analysed to obtain a sense of this. For example, for each jurisdiction a researcher could measure the number of dollars spent on education per student, the number of children per teacher in mathematics and science classes, or the ratio of computers to students in classroom settings. These may all serve some purpose, and more than likely have an outcome that is meaningful, but these would not necessarily go to the heart of the problem. In that many careers in the new economy are based in core technologies such as biotechnology, advanced materials, and microelectronics, and that they find their roots in mathematics and sciences, an indicator that focuses closely on these subject areas would be of the greatest value. If this research is able to either isolate (1) the causal factors of excellent secondary performance in these subject areas, or (2) why some jurisdictions show a performance increase over another, economic development planners may be in a position to use these findings as a basis for decision-making and strategising.

6.3.1 The SAIP as an Indicator of Science & Mathematics Ability

The School Achievement Indicators Program (SAIP) is a nation-wide assessment technique employed by the Council of Ministers of Education (CMEC) to allow educators, the public, school administrators, and government education employees to determine how well students are doing in certain subject areas. The results of these tests have implications for possible changes to curriculum, staffing, funding, and other school matters. Mathematics content [69] and problem solving [70] tests were most recently administered in 1997 [71], and both written assessment [72] and practical task assessment [73] for science were administered in 1999. Students were evaluated according to their ability to answer questions whose difficulty is categorised in terms of 'performance levels'. For example, a level 1 mathematics student at age 16 should be able to solve relatively simple mathematics problems, the range of which is determined by the test's creators; a level 2 student should be able to solve an incrementally more difficult problem, and so forth. The most difficult problem solving would take place at level 5. Understandably, the higher the level (the more difficult), the less the number of students that will solve that problem. The expectation prior to analysing the data is that the results would help us determine if metro-Manitoba is performing significantly better or worse than other jurisdictions, and in concert with key informant interviews, what the reasons were for that performance. This review was also undertaken with the assumption that secondary performance in the mathematics and sciences has some as yet undefined connection to a student's propensity of studying similar subjects at the post-secondary level.

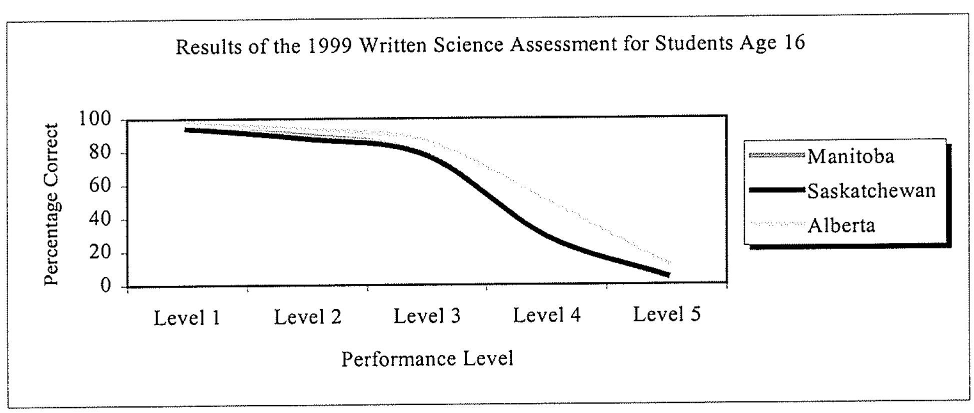
Figure 12



Source: CMEC, 1997b.

Overall, amongst children 16 years of age, Alberta students scored higher in each performance group in mathematics problem solving than did both Manitoba and Saskatchewan, though – as the graph indicates - not by decidedly large margins (see Figure 12). The differences were most obvious in the more difficult levels 4 and 5. Alberta's children were scored at 14.6% and 2.9% [74] for levels 4 and 5 respectively. Manitoba's respective scores were 9% and 1.3%.

Figure 13



Source: CMEC, 2000.

As we saw in Figure 12, the results from the mathematics problem-solving portion of the 1997 SAIP essentially indicated that students in the three provinces tested very similar in terms of their outcomes, with only a slight tendency for Alberta's children to test higher in level 4 and 5. In the case of the written science assessment (shown in Figure 13), the differences between Manitoba and Saskatchewan were almost indistinguishable throughout the five performance levels. Alberta's children tested higher in levels 3 through 5, reporting percentage scores of 85.8%, 49.8%, and 11.8% correct, respectively. This should be compared to Manitoba's respective scores of 78%, 28.7%, and 4.5%. Though it will not be profiled here in great depth, the results from the previous written science assessment (1996) are remarkably similar, especially as it relates to the differences between Alberta on the one side, and Saskatchewan and Manitoba together on the other.

6.3.2 The Determinants of the SAIP Results

We know what these data are designed to illuminate for those in the education system, and for our purposes we had hoped to determine if metro-Manitoba fares better or worse than either Alberta or Saskatchewan in these tests to any significant degree. The answer to this question, as we saw above, is essentially no: there are few differences between the three provinces in terms of how they have scored, the validity of which is added to by the inclusion of the 1996 written science assessment findings, which are remarkably similar (CMEC, 1997a:27-36). According to a Manitoba informant, there are few identifiable causal factors (innate in students, or entrenched in the school administration or teacher process) that are responsible for student performance (or lack of) on standardised tests, and only anecdotal evidence that suggests that one school is any more or less effective than another at teaching mathematics and science effectively. Jean Britton, Senior Analyst with Manitoba Education, Training and Youth further suggested that these scores - while representative of student ability to a small degree, and representing the only realistic way of objectively determining it - are not in general a great indicator of a student's ability in mathematics and science, and there are therefore few causal factors that should be identified and used as a basis for strategising [75]. Rather, Britton suggested that the results of SAIP tests are determined by a myriad of factors such as a students interest, socio-economic status, home life, parental achievement, and many others. Most importantly, the results may be less indicative of a student's ability, nor the effect of these various factors on them, and more a reflection of how closely provincial curricula matches the questions typically found on these tests (Interview, 2001; Clark, Interview, 2001; Saskatchewan Education Respondent, Interview, 2001).

6.3.3 The Role of Differing Curricula & Secondary Initiatives on the Results

In consideration of the responses, a natural question that flows from the SAIP data is to what extent the differing curricula of the three provinces would have an effect on even the marginal differences between these test scores. For its part in all of this, respondents were relatively straightforward in their response to this question. Two informants were of the opinion that the curricula were essentially the same (Britton, Interview, 2001; Clark, Interview, 2001) and the Saskatchewan informant indicated that they were "functionally identical" (Saskatchewan Education Respondent, Interview, 2001). The coming together of curricula to achieve both a uniform knowledge base and expected outcomes has been occurring for some time in Western Canada. Known as the 'Western Canadian Protocol', it establishes expected outcomes for students in Alberta, Saskatchewan, Manitoba, the North West Territories, and British Columbia.

While the data and informants have supported the irrelevance of curricula content in the findings, the defining difference noted above was that Alberta schools generally follow their curricula more closely than Manitoba or Saskatchewan do.

In her assessment of the test's worth and results, Stella Shrum (Interview, 2001), Program Manager for Alberta Learning, suggested that there are specific reasons why Alberta may consistently test higher in the mathematics and sciences. There was due acknowledgement that there is much more of a 'culture of testing' that occurs in Alberta, caused in part by extensive media coverage and provincial school policy that stresses the importance of these tests. However, Shrum noted that expected outcomes for students in mathematics and science are highly specific, and that both the curricula and student materials are structured in such a way so as to ensure that educators actually teach the curricula, a thought about Alberta's education philosophy also noted by a key informant in the Saskatchewan education system (Saskatchewan Education Respondent, Interview, 2001). What no informant was able to identify during the course of this research was whether more or less strict adherence to a prescribed curriculum is simply preparing students to perform well on specific testing, or whether this strict adherence is actually contributing to a better education in the mathematics and sciences that is in turn reflected on test scores. This is a matter that is of interest here, and that should warrant the attention of researchers in the education field.

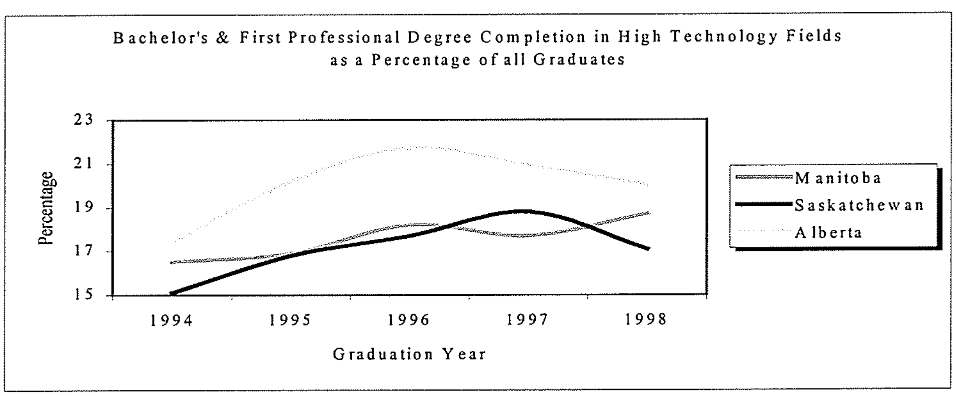
Shrum also indicated that the performance by students, and particularly the interest in science and mathematics is likely encouraged to some degree by initiatives run within schools which are oriented towards encouraging careers in both fields. One such effort in Alberta –

described as a "major initiative" - is the introduction of 'streamed' courses [76] in pure and applied mathematics at the senior high level, the purpose of which is to allow students to hone their skills and knowledge in more applied and theoretical courses (CMEC, 1998:9). Further, initiatives are also encouraged which see industry associations and community groups speak to students on a regular basis about mathematics and science-based careers. Both the Saskatchewan informant (Interview, 2001) and Britton (Interview, 2001) indicated that there were few initiatives of this sort taking place in Saskatchewan or Manitoba schools, the relative lack of which, both suggested, was part of an education philosophy that differed somewhat from Alberta. This philosophy is one which espouses a 'whole-child' philosophy that does not stress mathematics and science knowledge to any greater degree than other subjects, co-operative behaviour, or other life skills[77]. As Shrum suggested, it is likely that these types of initiatives are responsible to a very small degree for performance, but the connection is murky and largely indefinable. Where it may be most effective is as an encouragement to further studies in mathematics and sciences (or associated disciplines) at the post-secondary level (Interview, 2001). Again, we see what may be a direct or indirect factor in student performance, but in the absence of cause and effect studies to either substantiate or refute this, it essentially becomes a moot point. Given the responses by the informants in each of the three provinces (where each to some degree debunked the value of the SAIP mechanism, and debated whether performance in mathematics and sciences is considerably different between jurisdictions) initiatives of this sort may hold some value for policy-makers, and it is certainly something that should be kept in mind by organisations such as EDW.

6.3.4 SAIP: Conclusions & the Link to Post-Secondary Schooling

The conclusion that we may reach from these data, and from the opinions of key informants, is that a single test score on a standardised test (even across many years of testing) is: (1) not necessarily the most effective measure of evaluating ability in mathematics and sciences (though it is grudgingly accepted as the best there currently is); and (2) that the actual test scores do not effectively demonstrate that one school, one division, one province, or one educational philosophy is any better than another in creating mathematics and science literate children. However, the most important finding from the data is the fact that the differences in performance between these three jurisdictions are very small, which essentially leaves us with one conclusion: in spite of any initiatives, the three provinces appear equally adept in graduating secondary students with similar grasps of science and mathematics. A more important outcome of this research is the recognition that both of these conclusions may very well be meaningless if those students who did excel did not go on to pursue post-secondary education in fields of study associated with those two disciplines. A natural question then becomes, why do students choose particular paths in post-secondary education?

Figure 14



Source: Statistics Canada, Education in Canada (1996, 1997, 1998, 1999).

Figure 14 shows the percentage of all students graduating from post-secondary institutions with a bachelor's or first professional degree in what has been termed 'high technology' fields of study, from 1994 through 1998. As we determined, there were few differences between provincial curricula, nor how secondary students performed in the standardised SAIP tests between the three provinces. Yet when we look at the number of students who have enrolled in, and subsequently graduated from university [78] in 'high technology' fields of study [79], we see that a greater percentage of students from Alberta universities graduated with these types of degrees in comparison to Saskatchewan and Manitoba, and considerably more so from 1995 through 1997. Clearly, there must be some intervening reason(s) that affects why more students in other jurisdictions go on to pursue high technology fields of study at university.

As the 1996 Census data material introduced earlier indicated, Manitoba has fewer high school graduates compared to both Alberta and Saskatchewan. A 1995 report released by Human Resources Development Canada (HRDC) documented the ensuing activities of students who either did (or were supposed to) graduate from secondary school in 1993. The data in Table 2 (below) indicate that – among this sample of students – fewer Manitoba students are even finding their way to university or college, compared to the other two provinces. The reader is reminded of both the COPSE informant and Harper's (Interview, 2001) comments regarding employment opportunities in the Manitoba economy and the effect they may have on why prospective post-secondary students in Manitoba may not go on to further studies.

Table 2 Percentage of High School Graduates in Post-Secondary Education or Training Two Years After Graduation [80]

Province	Men	Women	Total
Manitoba	67.5%	73.5%	70.5%
Saskatchewan	77.5%	84.0%	80.8%
Alberta	74.9%	75.1%	75.0%

6.4 Factors Influencing a Student's Pursuit of a University Education

To begin to answer the problem posed above, a number of key informants in the education system were queried on what it is that 'pulls' students into university, and what the factors are that determine the fields of study that they choose. This line of questioning was introduced to determine if there were any factors that we could isolate as being relevant to our objectives. For example, if it was common for students to pursue post-secondary studies in those fields in which they had the highest marks in secondary school, planners could attempt to determine if education strategies that focused on improving mathematics and sciences testing may lead to more university students pursuing these fields in university [81].

The responses from key informants suggested that there are a great number of factors (some personal and some environmental) that ultimately determine if a student will proceed to university, and what that student will pursue in university. For example, Clark suggested that parental accomplishment and expectation, in additional to natural ability carry significant weight (Interview, 2001) in a student's education choices. Britton felt that peer reference and program accessibility were strong factors that encouraged students to pursue particular streams, while others stressed the possibility of high remuneration and societal needs for particular occupations (Shrum, Interview, 2001), socioeconomic status, and quality of educators in secondary and post-secondary school (Saskatchewan Education Respondent, Interview, 2001).

6.4.1 Local Industry as a Non-Factor in Student Choice

One of the assumptions carried into this research was the sense that the employee needs of local industry would be a significant factor in determining what prospective post-secondary students studied, largely because of the increased likelihood of landing employment soon after graduation. The subsequent thought was that any efforts made by planners to increase the number of high technology firms would in turn lead to an increased enrollment in associated fields of study, which would further increase the demand for education in high technology fields. Brian Stimpson, Associate Dean of Engineering at the University of Manitoba suggested that with the exception of very large firms such as Nortel - there does not appear to be a great deal of evidence that suggests students pursue particular fields of study based on the likelihood of finding employment with local firms, especially as it applies to engineering. Rather, he indicated that students entering studies in university typically look at the 'bigger picture' of national or international employment, and do not assume that their workplace will necessarily be where they have attended university (Interview, 2001). This notion was substantiated by both Clark (Interview, 2001), an informant from Saskatchewan (Interview, 2001) and Britton (Interview, 2001). The caveat given by both Britton (Ibid.) and Stimpson (Interview, 2001) was that Winnipeg has no very large firms (that require very specific skills) such as Nortel that would have this effect on students. This too may warrant further investigation. To what extent very large organisations impact student choices in post-secondary education could have greater or lesser implications for economic development initiatives, especially in regions where there are an abundance of large firms, and ones where there a dearth of them.

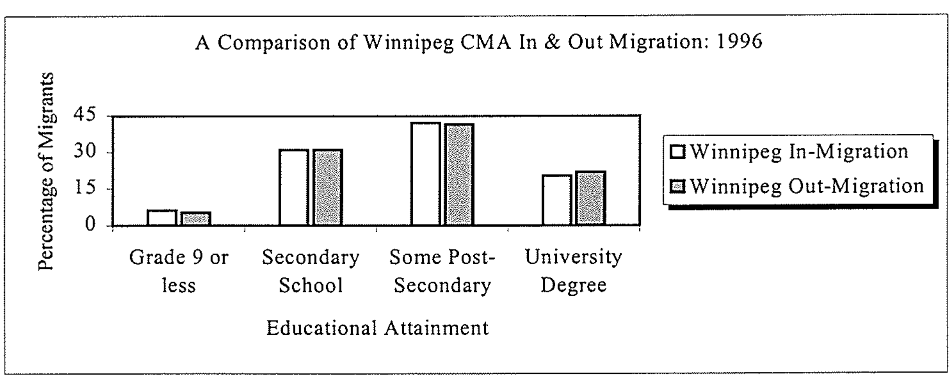
As we have found throughout this discussion on education, there does not appear to be any absolutes or certainties when it comes to identifying factors that determine either performance in or outcomes of education. In this case, the respondents suggested that there is no one single contributing factor on which we can focus, underscoring just how personal is the choice that students make, and all of the possible influences that may factor into those choices. However, where there was consensus amongst all respondents was the issue of student interest, and its affect on what students studied in post-secondary schooling. All suggested that it is typically what students found most interesting in high school that went a long way in determining whether or not they would ultimately pursue this through university (for example: Clark, Interview, 2001; Stimpson, Interview, 2001; Harper, Interview, 2001; Shrum, Interview, 2001). This notion was substantiated in a recent survey of graduating Manitoba secondary students, where just over 35% indicated that pursuing subjects of interest was their primary goal at university (Manitoba Education and Training, 2000:16). It is this fact more than any other that we must focus on.

6.5 The Effects of Migration on a City's Education Makeup

Though we have attempted to limit our indicators to those that focused on VC, R & D, and education, it would be appropriate to spend a small amount of time discussing migration, its connection to education, and its role in either helping or hindering a high technology economy. Studies have detailed the effect that migration may have on local, regional, and national economies (see for example: Florida, 2000; HRDC, 1999; Global Television, 1999). Excessive out-migration may be harmful to local economies if those who are leaving possess more skills, knowledge, and experience than those that remain, or migrate in. The conclusion of other researchers suggests that more educated people are likely to move than those less educated (Rosenfeld & Atkinson, 1990:18-20), and that the more specialised a person's education and training, the greater their geographic scope tends to be when considering a move (Luger & Goldstein, 1997:109). This of course has implications for planners addressing high technology development with its attendant education demands.

Migration is important for us to acknowledge for our purposes because it may hinder or help any efforts planners make in addressing post-secondary education in the name of the new economy. For example, effective strategies that saw post-secondary graduation rates in the engineering, and natural and applied sciences increase may be rendered fruitless if those graduates leave the City, Province, or country. Similarly, if Winnipeg's in-migration pattern indicated that many more new residents possessed the skills that are required, there is much less of a need to undertake those same strategies, and that energy could instead be applied elsewhere.

Figure 15



Source: Statistics Canada, 1996b.

According to the most recent Census of Canada, the Winnipeg CMA is faring relatively well in this regard (see Figure 15). Winnipeg had a net loss of only 80 persons age 15 and older during the period 1991 – 1996 [82]. While there were net gains in some groups of people with certain levels of education, the one group that gained less people than it lost were those with university degrees. There were 11,545 who left the CMA during the referenced period with a degree, and 10, 730 who migrated in with one. This represents a net loss of 815 people (or 163 per year), though it is not possible to determine what types of degrees that they held. In what has come to be a common scenario, Saskatoon fared much worse, with a net loss of 2,655 degree-holders, while Calgary fared much better, with a net gain of 12,680 [83]. What we may conclude from this, is that if we simply compare Winnipeg to Saskatoon, we find Winnipeg to be in a relatively good position in terms of migration. When we compare the data to Calgary, we see clearly that their subsequent efforts to build a new economy may already have been bolstered significantly without direct effort, simply because more educated persons are moving there. Economic development planners in metro-Manitoba must determine if the status quo provides a sufficient base for attendant strategies, or if the issue of in-and out-migration needs to be addressed, and, given its preponderance in economic affairs, it would be difficult to see how it could be ignored. Addressing migration will be an exceptionally large task, simply because myriad factors such as local salary levels, taxation issues, career opportunities, quality-of-life, and many other factors come into play.

Conclusion

The overall purpose of this section was to determine – in terms of education - how ‘ready’ metro-Manitoba is to undertake high technology activities. As we have noted prior, scholars have linked a region's likelihood of nurturing high technology firms to - in part - how many people have post-secondary education in the fields of study associated with the sciences and mathematics.

In general, we found that people in Manitoba had a lesser completion rate for high school and for university than those in Alberta and Saskatchewan did. Specifically, we found that Manitoba had a greater percentage of people with post-secondary education in 'high technology' fields of study compared to Saskatchewan, and a lesser percentage than Alberta. This fact was influenced by a number of factors, including the older average age of the Manitoba population and the types of industry found in the Province, which - according to key informants - seemingly demand less education than industries in Alberta do. In effect, this told us more about the local industry make-up than it did about the innate possibilities of educational achievement in the local population. In an attempt to dig deeper, we examined how Manitoba students performed in standardised mathematics and science testing relative to the other two provinces and found – aside from the slight fallacy that a single test score could truly represent aptitude and potential achievement – that Manitoba students generally performed as well as students in the other two provinces. In spite of this, fewer students in Manitoba went on to post-secondary education, and of those who did graduate from post-secondary education, a lesser percentage graduated with degrees based in the mathematics, and natural and applied sciences. From this, key informants indicated that - ability and intelligence being constant - a great number of factors influence whether or not students go on to post-secondary education, and what fields of study they choose. In the final analysis, Manitoba students appear just as adept at mathematics and science at the secondary level, and the conclusion drawn from both data and key informants is that the interest to pursue these fields appears to be lost when it comes to post-secondary education.

Though it would be simple to suggest as some have (Author Unknown, 2000a:20-2) that 'more education is needed' in metro-Manitoba, based on the findings here, this would not necessarily be true. Rather, we must acknowledge the views of the key informants who have suggested that it is the lack of interest in pursuing degrees in these fields of study that is ultimately affecting university graduation. Stimpson (Interview, 2001) noted that interest in these fields is ultimately 'lost or found' within secondary school, and suggested that this may fall on secondary teacher's shoulders, through no fault of their own. According to Stimpson, it is not uncommon for secondary educators to be teaching subjects such as mathematics and science without having the proper training or background (Ibid.), a notion also substantiated by Britton (Interview, 2001) and a Saskatchewan education informant (Interview, 2001). The problem is largely due to the fact that people with backgrounds in engineering, mathematics, and applied sciences are often employable as is, and many either do not pursue further degrees in education, while those that may, simply do not teach. This fact, and the problems stemming from it have been officially recognised by the Saskatchewan government in just the past few months.

In an effort to have more educators in the workforce with specialty in (among others) mathematics, physics, and chemistry, Saskatchewan Education will institute a bursary program in 2002 to address this very issue. Education students with a declared major in one of those fields would qualify for bursaries provided by school divisions (in turn provided to them through Saskatchewan Education) while they attend university, in return for 2 years of service within that school division. This program is also mandated to apply to existing educators who would return to university to upgrade their qualifications in return for guaranteed service periods (Neill, 2001:1-2). While not necessarily unique, this is a valuable plan that directly addresses the key problem noted by the key informants. If student interest in these fields of study is indeed won or lost in secondary school, efforts should be made to ensure that educators genuinely wish (and are genuinely able) to teach these subjects, and that their interest is in turn transferred to students. Clearly this would need to be a long-term commitment for the benefits to translate into increased enrolment and graduation in certain post-secondary degrees, and a longer term commitment yet to see how this in turn would affect any other aspects of the new economy, but it is certainly attempting to tackle the issue at its roots. However, a program such as this again raises the issue of whether or not subsidies of any sort are worthwhile endeavours in the long term. In this case, we would suggest that it is worthwhile only because by doing so, we are not creating an environment that is not capable of sustaining itself - only urging it on. Further, this program may be effective because it does not directly remunerate educators differently based on their qualifications (which could create unwanted equity and union problems for a service such as education), but is instead placed as an incentive prior to service. Though this is a relatively small program ($1 million for the 2001-2002 provincial budget), it appears to be a very valid way to directly promote a new local economy. Further research that merits attention in this regard would determine what percentage of educators in Winnipeg are instructing classes in these fields without the proper qualifications (or interest), before considering this for metro-Manitoba.

Informants had indicated that within the school divisions themselves, efforts could be undertaken to further help develop student interest both in these subject areas and in career choices that may come from these subjects. In particular, both Stimpson (Interview, 2001) and

Shrum (Interview, 2001) stressed that industry associations and other groups in Alberta have a long-standing tradition of working with schools in terms of introducing students to career choices in engineering, mathematics, and the sciences. The viewpoint of industry associations, especially in Alberta, is that their presence in secondary schools is necessary because of assumed employment needs in the future. To be sure, industry associations do have a presence in Manitoba schools, but the opinion offered by Stimpson in citing the Association of Professional Engineers and Geoscientists of the Province of Manitoba (APEGM) is that the relationship is simply less than it is in other jurisdictions. Further review and discussion illuminates the fact that there are few industry associations based in Winnipeg that are in the realm of high technology industry. It is reasonable for us to suggest here that the efforts of planners could be well spent on helping to build relationships that bring interested industry and education parties together in a meaningful way.

The Minnesota High Technology Association (MHTA) is a highly functional coalition of industries and industry personnel, who in many ways appear to mimic a planning body in their efforts. Coalescing out of a disparate group of associations (the Minnesota High Technology Council, the Minnesota Software Association, the Minnesota Internet Services Trades Association, and the Upper Midwest Java Association), the MHTA represents hundreds of companies in the state, and in addition to having a presence within the secondary education system, typically issues position papers on matters of economic development, legislative changes, education and educators, and other issues that relate technology development to broader public policy. Their mandate clearly focuses on information technology, which alone will not address the wider range of technologies and firms that we have included in our definition, but the MHTA represents a point of departure for planners in Manitoba. It is also clear that Manitoba does not have the sheer number of high technology firms that the state of Minnesota does, but the structure and purpose of such a body are well in line with the emphasis this research is ultimately proposing.

Chapter Seven

Towards a Public Policy Framework for High Technology Industrial Development

7.1 A Note to Planners Regarding the Limits of the New Economy

Our initial objective was to illuminate for the reader exactly what high technology industries and firms are, and why they should be considered different from any other industries and firms that have come before them. Though we have not addressed it in any detail during this research, there is little to suggest that so-called high technology industries are any better at solving any of the difficult problems that cities and city planners face while pursuing strategies for this new economy. At a minimum, the high technology economy is one that demands a highly educated workforce, as it demands access to capital, as it demands access to knowledge obtained through research, as it demands entrepreneurship and innovation. These five assets - as qualities of people and places - are not distributed easily and equally to all members of society, and as governments, industry, and other proponents of the new economy move forward in their quest for more economic growth, it is easy to foresee that as many (if not more) vulnerable members of society may get left behind. The poverty rate among Canadians as defined by Statistics Canada [84] has in fact increased from 13.1% in 1979, to 17.2% in 1997, even as the much-vaunted growth in GDP has continued for the country as a whole (Silver, 2000:1).

Second, when economies grow, land and housing prices are often soon to follow, forcing many people out of the city due to a lack of affordable housing, possibly creating a problem that is now worse than the one the economic growth has 'solved'. Similarly, pollution and traffic congestion are often by-products of unfettered economic and urban growth, and while we could make a case that advanced knowledge industries are ones which likely create little pollution, this doesn't necessarily negate the associated problems caused by associated economic growth. The San Jose, California region today has been the recipient of fifty years of urban and economic growth, and today planners face significant hurdles in undoing the 'benefits' of economic growth: a lack of reasonably-priced housing, pollution, and increasing traffic congestion (see for example, Newman, 2001:52-75). Our research has not delved deeply into the side effects of high technology economic growth, but these are no less important issues for planners to face. Though we would not go as far as to suggest that one must succeed at the expense of the other, as a region and as a society, it may be wise to step back and decide not so much if we can promote a new economy, but if we should, in the absence of planning for its effects fifty years from now.

7.2 Summary & Recommendations

Within our scope, this research has identified for the reader what high technology industries and firms are, and whether they differ from more traditional firms. At the outset of determining what is and what is not a high technology industry, the assumption was that one could easily identify what it was that makes them distinct. Much scholarly work was done in the 1980s and 1990s that attempted – often in vain - to show us that these firms could be easily defined by using a discrete measure (or even a combination of measures). None proved universally accepted by the scholarly audience interested in high technology industries. Two Canadian researchers substantially changed how high technology was even viewed, suggesting simply that high technology industries did not exist, but high technology activities within firms and industries did (Baldwin & Gelatly, 1998). However, the most satisfying description of what a high technology firm / activity was found in a research paper by Chabot, where the author eschewed virtually all previous attempts at defining it, and stated simply that firms known as high technology had *tendencies* towards large R & D expenditures, predatory competition, competitors in each and every industry (based on degrees of innovation, and not on products), and successive iterations (and hence short time lines) of technological innovations. The OECD (1998) identified microelectronics, advanced materials, and biotechnology as the three core technologies which act as the basis for more or less each technological innovation seen in the last five years. When we take Chabot's loose definition of high technology, and combine it with the OECD's statements, we can in fact come to a reasonable conclusion as to what a high technology firm is, and does.

The second objective of our research was to identify the key triggers that essentially 'make high technology go'. Planning for high technology cannot be accomplished by issuing permits for firms, and planners must be in a position of knowing the drivers of the new economy before they can begin to address it. We had discussed previously that traditional firms often sought optimal locations based on the correct mix of land, labour, and access to capital. High technology economies often arise where we see a confluence of technological innovation, creativity, VC, research, and highly educated persons. Though we now see examples of this in countries such as Japan and Scotland (Silicon Glen), and in metro-regions such as Ottawa-Hull and Boston, Massachusetts (Route 128), the classic example of this is still Silicon Valley. Silicon Valley grew to prominence largely because of Stanford University, its huge defence-spurred R & D budgets, its pioneering role as an agent of technology transfer, and its willingness to adopt a business culture that saw the development of cutting-edge firms often started together by students and professors. VC became the final critical element in the relationship that brought these idea-rich, cash-poor ideas to market. While there are a number of other factors that come into play, as this example and others reveal, it is the mix of VC, R & D activity, and the collection of people with a technical education that are the key place-centred indicators helping build these innovative regions.

The third objective of the research was to find out how developed these key drivers of high technology development were in a metro-Manitoba context, situated comparatively with Saskatoon, Saskatchewan, and Calgary, Alberta. The general method undertaken to assess Winnipeg's potential for high technology activities was a combination of secondary data analysis, and primary research conducted through a series of open-ended, key informant interviews. The final objective of our research was to take what we had discovered, and make appropriate recommendations that would be a step towards a framework with which planners and policy-makers could conceptualise what is involved in planning for high technology firms and creating an innovative milieux in their cities and regions.

7.3 Economic Development Winnipeg's Legislative Constraints

A small, yet key aspect of our research here is to articulate what role an organisation such as EDW could play, and the reader is drawn to the discussion in the first chapter regarding the various roles that economic development practitioners play in urban economic development. EDW is one of a number of planning entities that have an interest in, and hope for the creation of an economy that is built on innovation, knowledge, and local resources. Depending on the planning entity in question, it would have been reasonable to assign lesser or greater tasks in the making of this new economy depending on their own particular legislative situation. We can not reasonably propose a role here for EDW greater than facilitator, given: (1) the funding arrangement between the City and the Province, and EDW; (2) the legislative and financial constraints on EDW; (3) the roles played by the senior levels of government in the arenas that this research enters; and (4) the likelihood of an organisation such as theirs actually affecting change without similar legislative and policy-making powers.

EDW's role in Winnipeg is diverse in terms of its marketing strategies and information sharing, but in our view here its most important competency is its ability to mobilise local people and resources into avenues of action. Planning in this environment is tantamount to relationship building and the subsequent steering of those relationships towards goals that are politically achievable, non-redundant, and financially responsible. Creating partnerships where none existed will be a long-term and invaluable process in building a high technology future for Winnipeg and metro-Manitoba.

Recommendation #1 Establish Key Partnerships

The first and likely most important recommendation that can be proposed here is one which would require conceptualisation before any of the other recommendations could be dealt with in a rational and strategic manner. While we are hesitant to suggest that another institutional / organisational structure be constituted to deal with an issue, the reality is that there is a need to form some sort of fixed or fluid coalition to represent the public interest, and other groups, to actually address these recommendations. There is in existence in Manitoba today a number of non-profit groups, government departments, research organisations, operating agencies, and interested persons who are all in their own way attempting to deal with a piece of the high technology puzzle. To demonstrate this, Table 3 (see below) indicates some of the noteworthy organisations and to what extent they appear to focus on the aspects of the high technology conundrum that we have identified as important. An 'x' indicates that their stated mandate addresses some of these key issues, technologies, and indicators.

Table 3 Existing Manitoba Organisations Involved in the Promotion of a High Technology Economy

Organisation	Education	R & D	New Firms	VC	All Technologies
SMARTpark [85]		X	X	X	X
Manitoba Innovation Network [86]	X		X		
Economic Innovation and Technology Council [87]	X	X	X		
Smart Winnipeg [88]					

From the hindsight gained through this research, these groups - through their visions, mandates and activities - may be unable to focus on the issue of high technology as broadly as it has been investigated here. By this, we refer to our definition of high technology as necessarily addressing (1) the three core technologies introduced at the outset of this research, and (2) what we have defined as some of the key needs for (and measures of) innovative industry, such as R & D propensity, the use of and exposure to VC, and an educated and technologically-sophisticated population. Some organisations such as MIN and Smart Winnipeg appear too sector-focused (expending their energies almost exclusively on the development and promotion of the information technology sector), while Smart Winnipeg (the Cyber Village) and the SMARTpark Development Corporation (SMARTpark) appear to be more process-focused (where their goals are oriented towards the creation of industrial districts). We are not suggesting that any of these organisations are not effective bodies in planning for change, but they each exist to serve a particular purpose, and their purpose is not necessarily ours.

Our planning mode here suggests that any coalition of interests that is formed attempt to address the issue of high technology broadly (as opposed to focused), view the factors and actors as part of a non-hierarchical web, wherever it is possible to do so (as opposed to assigning value, and interacting with them independent of each other), and resist the temptation to subsidise the relocation of new business enterprises. We know that planning for high technology involves recognition that innovative thought, human capacity for invention, and a strong knowledge base are the core needs of a city in this case. However, many attempts have been made by policy-makers and planners where high technology activities are transplanted into urban areas with the expectation that growth will be inevitable, but - the RTP notwithstanding - this rarely is the case (Cooke, 2001:37).

As an example of our suggested approach, simply proposing an education strategy that graduates more people with computer science certificates, diplomas, and degrees from local colleges and universities is singular, and represents a means to an end. From our vantage point, we would propose that this group seek strategies that promote a science-based education as a starting point, but without a fixed outcome. We are not proposing to solve employment problems as much as we are proposing to develop a local milieux based on knowledge and the innovative capacity of individuals and their institutions. Similarly, we would not discuss VC as a facet of the local financial system, and we would not speak of it only in terms of 'having more VC'. Rather, we would view it as one of the key lubricants of the new economy, one embedded with links to the entrepreneurial community, the people within it, and the products of the R & D sector. R & D similarly can't be discussed without addressing the question of who is providing the R & D funding, whether the students of today will be the researchers of tomorrow, and who will ultimately turn that R & D into the innovations that society values.

Such a coalition should be conscripted with an advisory and advocacy status, as opposed to having legislative and financial capacities. We argue this because of the revealed nature of the indicators that we have studied, and the apparent role-entrenchment found in their institutions, modes of delivery, secrecy, and bureaucracies. In the case of R & D, the senior levels of government, the business community, and the higher education sector, all carry significant weight in determining the R & D character of metro-Manitoba, but all have considerably different agendas, roles, and powers. As we discussed earlier, the federal government plays a very large role (strategically and financially) in Canadian science and technology policy, and there may realistically be little that a local organisation could do except to lobby for the affecting of policies that would direct R & D resources towards the Winnipeg region. Similarly, in the example of education, the Province alone holds sway over policy, planning and curriculum development, while the school divisions, schools, and individual educators are the sole deliverers of the programs. We can see no legislative role here that would change this fact. Finally, firms in volatile industries view R & D as a basic business investment, and their actions are predicated on their beliefs in the value of R & D more than their willingness to do so. Promoting these efforts is a satisfactory aim in this case.

We should not overly concern ourselves with changing these power structures, as much as we should try to bring these interests together and strategise a common goal that benefits the region. Any coalition that is struck should include representation from the organisations, agencies, departments, and firms which now do their work within the realms of secondary and post-secondary education, research, VC, and economic development. EDW may have difficulty in finding co-operation amongst the business-led R & D sector and VC industry in metro-Manitoba. Skills will be required to encourage representatives from these two groups, who – in the course of this research – gave the impression that their role in high technology development did not necessitate significant partnering and goal-making.

Recommendation #2 Identify the New Economy Firms in the Region

As a precursor to further recommendations, there is a distinct need for EDW to develop and execute a method to identify how many high technology firms are in existence in the Winnipeg CMA. As we noted throughout this research, this research did not endeavour to categorically identify those firms within Winnipeg that we would consider to be 'high technology', largely because researchers have moved away from this type of research. We noted previously the problems involved in categorically identifying entire firms as being 'high technology'. We have identified and measured some of the key factors in high technology development, but we have not identified the firms currently here. This is necessary because, although we have been able to identify traditional industry strengths, and existing R & D strengths, planners would be wise to investigate if Winnipeg has developed a likewise significant amount of any particular high technology firms. To this end, we will suggest here that EDW incorporate at a minimum the working definition of high technology firms espoused here and, using their existing knowledge bases, develop methods to identify how many firms meet this criteria. It may be of value to inquire if other cities have been successful in creating a method to gather this information, and if it meshes with our definitions.

7.4 Winnipeg's Venture Capital Market

To sum up, our research found that a city or region's VC market is a key factor in the development of a high technology economy. High technology firms are often those which have difficulty in attracting start-up capital through traditional mechanisms such as banks, and VC may thus be the only source of capital for firms of this nature. Our findings on this indicator's health in Winnipeg were in some ways expected, and in some ways surprising. Winnipeg's VC industry is relatively insular, in that it is concentrated among two large LSVCC funds, fuelled by local investors who receive a significant tax credit from both senior levels of government. There are not a significant amount of funds coming from outside of the Province into Winnipeg firms. While informants suggested that the Manitoba VC market is generally considered to have a good infrastructure relative to a province such as Alberta (Falconer, Interview, 2001), it is tainted by the fact that a great deal of funds are invested in firms that are not considered high technology in their orientation. This clearly reflects one of two things. First, there is the possibility that the managers of these funds face barriers to investing in high technology firms. This may be due to what one informant suggested was a lack of awareness on the part of VC managers as to what constitutes true high technology activities (Johnson, Interview, 2001). Second, this may reflect the fact that there simply are not enough local high technology firms to invest in, though it is unlikely that this is a dominant factor, as we shall see.

Recommendation #3 Focus on Niche Funds

The fact that there is in existence today the Manitoba Science and Technology Fund Limited Partnership and the Western Life Sciences Fund (which is headquartered and managed out of Winnipeg), and that the ENSIS Growth Fund Limited has made clear their intention to develop Life Sciences and Technology-specific funds, suggests that there are a number of high technology firms in the City, or there is the expectation that there will be. Judging by the VC funds in existence above, and our other findings, it is also likely that a great many of them are based in the life or medical sciences. We noted earlier that niche funds are necessary in Winnipeg's VC market. For our purposes, these funds are the most important aspect of the local VC market, and are either very under-capitalised or are not yet in operation. EDW, and any coalitions that they form, must identify how they may play a role in the successful capitalisation of these funds. The suggestion put forth here is that EDW should utilise their presence in the Winnipeg business community and aid in the promotion of these funds in an effort to ensure their capitalisation.

Recommendation #4 Discover Hidden Sources of Venture Capital

'More VC' was in the statements of each key informant interviewed as it relates to the Winnipeg market. Pension funds are – next to the chartered Canadian banking systems – the holders of the greatest amount of wealth in Canada today. Money from pension funds is invested in a great many ventures, including real estate, stocks, and bonds, and they are invested in the perceived name of safety. Contributing to VC funds has not been a high priority for Canadian pension fund managers since the early 1980s, when less than adequate returns left some managers wary of further investing. This attitude largely remains today, in spite of the returns experienced in many VC deals. This culture is the antithesis of the U.S., where 50% of all VC funds are composed of pension fund resources. In Canada, the corresponding 1998 figure is closer to 6% (Author Unknown, 2000b:3). The reasons for this can be distilled down to the previously noted issue in the 1980s, a general perception that VC investing is not in the interest of pension fund investors, the perception that there are not enough resources (personnel) in pension funds management to devote to the hands-on method of VC investing, and the potential bad publicity as a result of possible losses (Author Unknown, 1999a:27-33). In a word, fear. However, such fear can be potentially calmed by the pooling of funds, and placement into the portfolios of existing VC managers who are well versed in VC investing. We will recommend here that EDW or a new coalition identify pension funds in metro-Manitoba (and Canada) that are not currently investing in venture-type situations, and we will further recommend that any coalition stage meetings with pension fund representatives in order to begin an exchange of ideas.

Recommendation #5 Free VC Funds from Geographic Restrictions

Numerous informants suggested that Canada's system of personal taxation seriously negates both the ability and desire of many people to invest in higher-risk ventures. It is anticipated that any efforts (other than lobbying) undertaken by EDW or any coalition to reasonably effect changes to the provincial or federal system of personal taxation would be fruitless. However, LSVCCs were created to encourage local investment while offering the investor a significant investment tax credit. We noted previously that legislation dictates that funds must be disbursed within certain time frames, and that this has caused some questionable investing. Further, the legislation that gave rise to the LSVCC funds (which currently dominate Manitoba's VC market) dictate that a very small percentage of these funds may be invested outside of the Province. Depending on the performance of the Manitoba firms receiving investment, this may seriously negate the ability of these funds to create significant profits. While we are not advocating a significant change to this system - assuming a lack of worthwhile local investments - allowing a greater percentage of these funds to be invested where investment sense dictates, may in turn create more profit (assuming the foreign investments were wise). This in turn may create more wealth for the individual Manitoba investor, which may lead to more local investment in the long term. The secondary effect of this would be that the local LSVCC industry would in turn be able to acquire more wealth on its own.

Recommendation #6 Identify Winnipeg's Angel Investors

Numerous key informants within the VC industry had suggested to us that VC firms and funds saw little need in actually pursuing investment opportunities, as there were always more opportunities coming forward than there were funds available to invest. However, informants also suggested that the quality of many proposals coming to them were suspect. We would suggest here that VC firms could be brought closer into the innovation mix by working directly with entrepreneurs, in potentially identifying innovative technology opportunities, and helping to develop new firms far in advance of actual capital requirements. As Falconer (Interview, 2001) and Aiello (Interview, 2001) both noted, traditional venture capitalists (angel investors) [89] are typically industry experts more than they are money experts, having earned fortunes in a given industry. Their greatest strength is often the ability to adequately assess the likelihood of success and failure prior to investment. We suggest here that EDW and any coalition formed begin to identify angel investors and entrepreneurs with technology interests, and establish a forum where these two groups may better relate.

7.5 Metro-Manitoba's R & D Sector

At the outset, we attempted to understand the role of R & D in helping to create high technology firms, and determine how planners could affect any sort of change. The research specifically sought to determine how the performance of local R & D may be linked to the development of new ideas, inventions, and the creation of new, high technology firms. This was achieved by examining the dominant 'roles' performed by the federal and provincial governments, local industry, and the Province's foremost research university, the University of Manitoba.

In general terms, we discovered that R & D as performed by the federal government in Manitoba has been reduced dramatically with the curtailment of activities at the AECL site in Pinawa, Manitoba. Independent of this fact, federally-performed R & D was viewed by most informants as having little applicability to the direct creation of novel inventions and processes, and has little transferability to entrepreneurs who may in turn commercialise these findings through the aegis of start-up companies. One of the exceptions to this norm is the NRC and its role (as part of its larger mandate) in helping to develop new technologies and firms through their technology transfer mechanism. This research determined that the NRC facility in Saskatoon was considerably more successful than its Winnipeg counterpart in helping to develop new firms [90]. In fairness, a good part of the reason for this success lies outside of the NRC, and can be found in Saskatoon's research history, and its many programs, personnel, and structures focused on biotechnology.

The provincial government of Manitoba has a very limited role in R & D, both as a performer and in other ways as well. Though we have established that government R & D tends to have little applicability in the development of new firms, the Manitoba government conducts a very small amount of R & D, as compared to both Saskatchewan and Alberta. Manitoba has as of yet no explicit policy with respect to the encouragement of R & D, and the lone policy tool in use is a R & D tax credit. We debated earlier the usefulness of a single tax credit to essentially lower the cost of doing R & D, and the associated perils.

Recommendation #7 A Very Taxing Problem

Given its limited revenue streams, we support the Government of Manitoba's contention that R & D is best encouraged through this tax credit, but the suggestion being put forth here is that the tax credit become more reflective of the actualities of local R & D. The Manitoba government provides a 15% tax credit to firms conducting R & D in Manitoba, which combines with a federal tax credit to produce a tax advantage that many countries cannot match. In spite of this, metro-Manitoba has not developed into the R & D hub likely envisioned by policy-makers. Given that informants in both the VC and R & D sector have suggested that local strengths in industry often parlay into strong research strengths, we would suggest here that the Manitoba government review this situation, and modify what may be a 'scatter-gun' approach, and increase the credit for firms that are:

(1) actually based in Manitoba, which we think would at least begin to stop the exporting of knowledge [91];

(2) based in technologies which have a strong history in, and thus greater likelihood of success in, the local economy; and,

(3) small and medium-sized, to aid those firms that may wish to conduct R & D but who are unable to do so.

Regarding the second aspect of this recommendation, our research found existing research and industry strengths in both agriculture and medicine. Increasing the allowable tax deduction for firms conducting R & D in those fields has two bases for justification. First, we are providing subsidy for firms that are based in Winnipeg and Manitoba, as opposed to artificially enticing firms that may not be here for any other reason than an attractive tax credit. Further, given that the industry in question has a strong history in Manitoba, any results of this R & D may be more easily commercialised locally, given that there is an extant business milieux (support firms, legal services, etcetera) that understands the subtleties of the agricultural and medical / life sciences industries. Regarding the third point, informants have suggested that R & D in Manitoba was dominated by very large firms, but that there is a distinct need for firms of all sizes in highly-competitive industries to undertake R & D. Both Strang (Interview, 2001) and Hamblin (Interview, 2001) had indicated that small firms in Manitoba generally do not have a true appreciation for the benefits that can be seen through the performance of R & D, and while alone will not solve this dilemma, the manipulation of this tax credit to favour small firms in this respect may begin to address this problem.

The role of universities in economic development became a matter of great interest to economic geographers around the time that Stanford University began spawning high technology firms in the 1970s, and interest has remained constant since. Accordingly, we attempted to determine the role of university-performed R & D in Manitoba, and the potential this research may afford economic development planners. We discovered that university-led R & D is more predominant (as a percentage of all R & D performed) in metro-Manitoba than in all other provinces in Canada, except Saskatchewan, and that nearly 60% of all R & D performed is in the medical and life sciences. Further, both the key informants and existing literature suggested that university R & D offers the most potential for the development of new firms. Historically, a university's raison d'être is not the development of companies, but the dissemination of knowledge. This often presents an ideal opportunity where innovations and inventions require a company or entrepreneur (from within or outside of the university) to commercialise this knowledge. It is at this confluence where we are most likely to see the mixing of ideas, entrepreneurs, and VC turn into new firms.

Earlier, we examined the NRC and its success in spinning off new firms, and noted that only four firms have been developed directly from research at the NRC in Winnipeg, through their technology transfer mechanism (and that only two of those firms are based in Winnipeg). The U of M's UILO office is similar in intent to the NRC, in that it attempts to take research findings and develop them into licensed technologies or new firms. By sheer numbers alone, the UILO is more successful than the NRC in this task. Nine firms have been established through their office, and another four are in the process of starting-up through their Venture Box program [92]. The UILO exists solely to exploit and commercialise technologies and inventions that come from research conducted at the U of M.

Recommendation #8 Rethink the Industry Liaison Function

The UILO at the U of M represents the 'business face' of the university, and by extension, it represents the U of M's presence at this nexus of innovation, VC, and entrepreneurship that we have discussed. However, key informants had suggested earlier that there is a genuine lack of understanding as to what the UILO does, and how it fits in to the bigger picture of technology commercialisation in the City of Winnipeg (Johnson, Interview, 2001;

Hamblin, Interview, 2001). The recommendation put forth here is that the UILO's success rate may be increased, and their regional presence made more purposeful if it became more reflective of an organisation that existed for the benefit of all research undertaken in metro-Manitoba where there is a possibility for commercialisation.

Earlier in this research, we discussed a private firm, University Technologies International Incorporated. (UTI), based in Calgary. UTI provides a for-fee service to all researchers, fulfilling all of the functions that the UILO does (licensing, patenting, access to capital, commercialisation-potential reviews). The fundamental distinction of course is that they are not limited to servicing one university. Their clients include other universities, research hospitals, and any other person or organisation with research findings that have commercial potential. The UILO could become a true regional business development agent that commercialised the research findings of the U of M, the St. Boniface Research Centre, the limited R & D-based findings of the universities of Brandon and Winnipeg, and others. Existing small and medium-sized firms in metro-Manitoba who are undertaking R & D, and who may have a technology with commercial potential (or may have purchased the rights to one) may also not have access to these specialised services, and may benefit greatly from this type of business structure.

Recommendation #9 Become an R & D Broker

One of the issues that this research discovered was that R & D is most-often undertaken by very large firms with seemingly unlimited financial resources. However, we know that R & D is considered (by Chabot and others) to be a basic function of all firms who are found in highly competitive industries, especially industries such as software development which tend to have exceptionally short product time-lines, and constant product iterations. Our research also discovered that key informants within the R & D realm felt that Winnipeg had many such small firms, but that the 'culture' of these firms was not oriented towards R & D as a basic business function. Further, one of the great hurdles that many small firms face – independent of desire - is the ability to actually conduct R & D, as the costs associated with full-time facilities, researchers, and equipment may be onerous for many. According to Jayas (Interview, 2001), the U of M undertakes research-for-fee for approximately 100 firms; many of which are based in Winnipeg. What we suggest here is that the previously-noted coalition take a lead role, and essentially act as an R & D broker between researchers and research departments at the U of M on the one side, and small, innovative firms that seek to undertake R & D, on the other. There is also a need to identify and encourage those firms in the business community who may see value in, and would benefit from, an R & D arrangement such as we have articulated above. Caution is urged here as we do not know the extent to which the various research departments within the U of M have either the desire or the time to increase the amounts of research-for-fee arrangements they undertake. Further discussion is warranted between the U of M and EDW to determine this and other facets of the U of M's potential role before proceeding.

7.6 Education in Manitoba

Our research attempted to discover if metro-Manitoba possessed a labour force that was prepared to undertake innovative and high technology activities. Research of this nature presents a great challenge to scholars, and it is doubtful that any one or two education indicators can truly satisfy the research objective in this case. Through data analysis we determined that in general the population is statistically 'less educated' than both Saskatchewan and Alberta. This is so because of Manitoba's relatively poor high school completion rates, number of persons with a diploma or certificate, and number of persons with a university degree. Key informants suggested that there were two key contributing factors here; that the average age of the work force was older (suggesting that less education was needed in the past), and that both the diversity and positive performance of the Manitoba economy allowed many to eschew post-secondary education in favour of employment. However, in analysing statistical data focusing on the percentage of persons with degrees considered amenable to high technology activities, Manitoba fared generally better than Saskatchewan and generally worse than Alberta.

Results of the most recent SAIP were employed to determine if Manitoba secondary students were scoring below or above both Saskatchewan and Alberta's children in mathematics and sciences. Though we should be cautious of basing any action on a single test score, in general Manitoba students performed near enough to students from the other two provinces to suggest that they were fundamentally 'equal'. In an attempt to connect this factor with university education, we analysed university graduation rates in key fields of study. We learned that Manitoba fared generally better in this regard than did Saskatchewan, and generally worse than Alberta. Though not expected outcomes of the research, key informants suggested that neither the needs of local industry, nor the performance of secondary students, has a direct effect on what secondary students pursue in post-secondary education. A great number of other factors (socio-economic status, parental and peer influence, student interest) affect the education choices of students, and specifically, the desire of the student to pursue subjects of interest was given considerable weight by secondary data and informants.

It would be easy at this point to simply recommend a raft of programs that boosted student performance in mathematics and sciences as a remedy to this problem, but these would be recommendations that did not arise out of the research findings. The actual findings of our research do not necessarily suggest that 'more' is needed, or that students must improve their performance. Given its weight as a determining factor in post-secondary education choices, there is a need for us to discuss recommendations which would maximise student interest, with the hope that it leads to increased post-secondary enrolment in these fields. There appears to be no quick fix here, but informants suggested that a student's interest in a particular subject matter is either won or lost in secondary school, and the problem should begin to be addressed at this point.

Both Britton (Interview, 2001) and an informant from the Saskatchewan education system (Interview, 2001) have suggested that their respective provinces have struggled to ensure that secondary educators who teach in mathematics and sciences have the appropriate background to teach it effectively, and thus develop student interest. The reality of the secondary school system in many parts of Canada is that it is difficult to entice those with a degree in mathematics or sciences to become educators, often because people with degrees in those fields are employable without the Education portion of a combined degree. An informant within the Saskatchewan Education system has described the extent of this problem throughout the Prairies and northern Ontario as " chronic and significant", and that it exists in urban as well as rural areas (Saskatchewan Education Respondent, Interview, 2001).

Recommendation #10 Teach the Teachers

What we would first suggest in this regard is a program that is in some ways related to the initiative that the Saskatchewan government will introduce in 2002. Saskatchewan Education has set aside $1 million dollars for a program that - among many other things [93] - offers pre-service bursaries to 5 post-secondary Education students per year, which are provided to students with a declared major in certain mathematics and science-related fields of study. The bursaries are provided to offset the costs of the degree pursuit and, in return, graduating educators must provide two years of service within the granting school division. The findings of our research suggest however that such an initiative would need to be much more focused than the Saskatchewan example, and yet broader in its delivery [94]. We will argue here that such a program is necessary, but in the context of our research should only focus on the delivery of pre-service bursaries in mathematics and sciences in exchange for return service. The initiative proposed by Saskatchewan Education provides a pool of money that school divisions apply for and, upon receipt, administer. There are no provisions that ensure that the most needy school divisions apply for this; it is an option available to school divisions only if they see value in it. We would therefore suggest that such an initiative in Manitoba be run through a Province-wide body such as the Department of Education, Training, and Youth, which would be entrusted to ensure its delivery to each school division and school where the need exists.

We can foresee that this sort of recommendation would likely face resistance at some levels simply because the costs associated with it are direct, and the results accruing from it may be decidedly indirect. Further, it may be a number of years before we would be able to see any concrete results, and even then, they would reveal themselves at the post-secondary level. In our discussions with key informants in the education field, the synopsis was that it is difficult to cite causal relationships between external factors and student performance. In this vein, critics may argue that such a program may or may not achieve its expected outcomes, and if it does, it may have more to do with other attendant factors than it does an expensive program. This hypothetical concern may be valid, but if student interest is indeed a weighty factor in post-secondary enrolment, the societal and economic costs associated with not attempting initiatives may be greater.

Recommendation #11 Promote Self-Directed Learning

The second recommendation that we are putting forth here is that school-initiated courses (SIC) and student-initiated projects [95] (SIP) must be better promoted - or perhaps mandated as part of the curriculum - to secondary students, and at a formative age. If student interest is a key factor, allowing students the opportunities to satisfy academic curiosities may reap long-term rewards. Two of the key informants interviewed noted that secondary schools and students within Manitoba have the opportunity to pursue SICs and SIPs, respectively, but that neither is well-promoted within many schools and school divisions in Manitoba (McFarlane, Interview, 2001; Britton, Interview, 2001). Much of this is attributed to the fact that the onus is on educators to develop and monitor the courses on top of often-hectic existing work schedules, while some can be attributed to our earlier finding that there are many secondary educators teaching mathematics and sciences without the proper backgrounds, and may thus not feel entirely comfortable designing courses in these subject areas. (McFarlane, Interview, 2001).

There were 1,264 SIP courses and 55 SIP [96] courses approved by the Department of

Education, Training, and Youth for the 2000-2001 school year. Of the 1,264 SIC, 109 SIC were related to either mathematics or natural and applied sciences, with the vast majority relating to multi-media computer work, and internet publishing. Of the 55 SIP courses, three were related; two in advanced internet usage, and one in advanced science (Manitoba Education, Training, and Youth, 2000:1-48). It is clear from these data that the SIC mechanism is not one that is currently oriented towards mathematics and sciences, nor do students appear to initiate many credit courses through the SIP mechanism. According to McFarlane (Interview, 2001) the SIPs are often sought out and undertaken by the brightest of students, but the lack of SIPs is more attributable to a lack of promotion for the student who has the initiative, but either does not have the guidance or the confidence to pursue this further.

7.7 Regrets

The recommendations produced in this chapter were in direct response to the objectives of the research, and the questions that those objectives produced. As a result, the successful application of these recommendations may produce some positive results in metro-Manitoba's education, R & D, and VC sectors, and these in turn will (1) hopefully orient planners and groups with an interest in high technology development towards common goals, and (2) help in the development of locally-created high technology firms. These recommendations will not however turn Winnipeg and metro-Manitoba into a high technology utopia: this research and these recommendations are but a corner of a larger collage. Discovering the bounds of Winnipeg's innovative milieux, and developing a fully-realised public policy framework, is out of the reach of research such as this. While we focused our efforts on three key indicators of high technology health - which we feel suitably framed a capacity for innovative activities - we have not in fact come to know the true health of high technology in Winnipeg as we had hoped. There are far too many aspects of society, education, human interest, and economy that this research was unable to adequately cover. For example, we have not adequately addressed the entrepreneurial character of the region in question, nor have we fully analysed the current structure of high technology industry in Winnipeg. These two examples, and others, require full investigation before researchers could adequately prepare a true public policy framework.

7.8 Considerations For Further Research

We have identified, throughout this research, where there exists a need for further research, and we will not expand on those particularities here. Some we expect will be undertaken by EDW as they move towards their aims, and we hope that some will be addressed by future researchers. The nature of case study method creates a demand on the researcher to conduct an in-depth investigation into a single phenomenon, while incorporating the myriad factors that impact on the subject of the case study. In doing so, we may focus too closely on too few variables. It would be worthwhile for future researchers to challenge this problem with a different research strategy. The work of Atkinson (2001) represents a good framework to begin with, though further research for planners would need to be considerably more in-depth to tap the roots of the issues. Similarly, an excellent option for future research would be a geographically-comprehensive study of high technology indicators in a Canada-wide context. Space and time limitations did not allow us to situate metro-Manitoba outside of a Prairie-region context, and it is likely that we would have gained a better appreciation for Winnipeg's particular situation if we had widened the lens.

While we did begin to address the role that migration plays in determining a region's suitability to undertake high technology activities, we did not explore it to the extent that we would have liked. There is at present a dearth of statistical data that illuminates exactly who is leaving the region and province, and who is entering. It is important that planners dealing with high technology know how many educated persons we are losing. We do know that during one five-year period, the Winnipeg CMA lost more persons with degrees than it gained, but that is where it ends. Research that will be of value will study this phenomena over a much longer period of time, and will attempt to determine the exact education and knowledge that migrants take with them when they leave and when they arrive.

Conclusion

The raw materials that orchestrated the ebb and flow of old economies do not orchestrate the new economy. Far from it in fact. As we discussed at the outset, industries and industry development were often predicated on the availability of and accessibility to raw materials considered crucial to the production process. Firms therefore located and urban economies grew where access to these raw materials were either most abundant or cheapest. And as we saw: coal, steel, and the rise of Pittsburgh, Pennsylvania. We should remember however that the classic land (proximity and price), labour (skilled and cost-effective), and capital (financial) mix that economies such as these were based on has shifted, but it has not left us. Indeed, we are still very much concerned with land (vibrant urban centres), labour (educated and innovative), and capital (human, research, and venture). As we see now: Stanford University, VC, and the rise of Silicon Valley.

Economic place makers must too understand these shifts from brawn to brain, from standardised to innovative, from water supply to R & D, from capital to human capital, and develop further strategies outside of the ones noted here that may help develop their local economies. Strategies aimed at business recruitment were (and are) ones that attempted to artificially lower the cost of doing business through property tax holidays, subsidized water and sewer rates, and other techniques. Lower cost is simply not as important to many of the modern industries we have discussed (see for example: Armington, 1986:3; Beck, 1995:6, Knight, 1995:26). As Devol noted, the San Francisco region is the most expensive location in America in which to do business, yet it remains the undisputed "high technology champion" (1999:14). Software firms have almost no locational restrictions, yet as Castells noted, a full 20% of all U.S. software firms are located in California (1989:66). Something is certainly keeping them there.

Planners who deal in effective strategies are realizing that high technology firms are often 'willing to pay the price' to be in highly innovative and exciting centres. They have begun to let go of policies and promotions that emphasize the low cost of doing business in a locality, and are beginning to re-formulate policies that address education and skills for current and future citizens (Atkinson, 2001:2). Economic development practitioners will have to decide if they want to continue to subsidise business relocations, or if they wish to attract and keep highly educated people and have the firms follow them. This has great implications for those who can and do have an impact on the quality of life in metro-Manitoba. Cultural amenities, a diversity of lifestyle choices, high quality living areas and quality restaurants are now of central importance in creating the conditions that keep our educated people at home (Markusen, Hall, & Glasmeier, 1986:174; Florida, 2000:11). Indeed, place matters as much now as it ever did.

End Notes

1 For the purposes of this research, the term high technology is used interchangeably with the terms advanced technology and advanced knowledge.

2 The 'new economy' is a somewhat loose term that is employed by various researchers. In general terms, it refers to an economy based on new types of activities, firms, and industries, and can incorporate new modes of business organisation and philosophies. In the context of this research, it is used interchangeably with the phrase high technology economy.

3 In the context of this research, the word 'firm' refers to an individual business, while 'industry' refers to the aggregate sum of those firms.

4 This refers to the notion of clustering: the massing of like industries proximate to human resources and ancillary services that represent an important infrastructure for such industry (Leborgne & Lipietz, 1988). These types of industries, their workforces and their inter-firm dynamics have often-profound locational propensities, that have often tended to favour some cities and regions over others.

5 A business enterprise consisting of widely diversified companies.

6 Patent costs and other start-up expenditures result in excessive pricing to recoup costs. Profits are reinvested in R & D to streamline products and processes, or to invent new ones. Employment growth is attendant, and typically features the hiring of skilled personnel and managerial staff (Chapman & Walker, 1987:111; Markusen, Hall, & Glasmeier, 1986:41).

7 At this juncture, firms typically standardise production and locate where the costs of production (especially labour) are lower. Employment growth still occurs, but only in managerial and sales personnel (Markusen, Hall, & Glasmeier, 1986:42-3).

8 Cost-cutting is a response to profit loss or an attempt to earn market share. Oligopolies are formed when competing firms collude for the purpose of restricting output, hence raising prices (Markusen, Hall, & Glasmeier, 1986:43)

9 Acceptable rates of return can no longer be achieved. Imports have penetrated the intensely competitive market, and new innovations and firms have begun to replace the need for the product / firm altogether. As a result, many firms are forced to close their doors (Massey & Meegan, 1982:22). Should this occur, production of a product often becomes concentrated in a few locations, typically those with the lowest production costs, and the firm may also undergo product diversification in order to survive (Markusen, Hall, & Glasmeier, 1986:44).

10 The term growth pole refers to what Amos (1996:9) describes as an "integrated industrial complex", which is described as a concentration of related industry groups, led by one propulsive industry. This term should not be confused with the term 'growth centre', a high growth region, which in Richardson's estimation is the geographic manifestation of a growth pole (1978:164).

11 Neo-classical economic growth theory postulates that national economies with regional economic distress would eventually return to a state of equilibrium under the guise of 'factor mobility', which is essentially the movement of people (labour) and investment (capital) to areas of economic need.

12 In this case, periphery does not necessarily refer to a rural area. Instead, it refers to regions that have few economic relationships with the growth centres.

13 In fact, the bulk of federal war-needs contracts went to eastern-U.S. firms (Saxenian, 1994:21).

14 Venture capital is a term which refers to the investment of money into a firm in exchange for firm equity.

15 According to the U.S. Bureau of the Census (1959, 1963), the region's employment base was concentrated in declining low-technology and low-wage manufacturing industries, with only 3.3% of employment occurring in high-technology sectors, compared to the national average of 10.3%.

16 A research park is "...a high-quality, low-density physical development where there is significant interaction between academics, researchers involved in research and product development, and commercial organisations and entrepreneurs" (Blakely, 1994:310) Further, they typically have a strong "role in aiding the transfer of technology and business skills between the university and industry tenants" (www.siue.edu, 1999). A research park is a real-estate

venture, and may be a non-profit or for-profit entity that may or may not be owned or managed by a university (Ibid.).

17 This is not to suggest that VC is not an applicable source of financing to all industries, because indeed it is. In advanced high technology regions, it is simply that there have been so many innovative firms using VC that it has come to be identified so closely with these types of firms.

18 VC activity in most industrialised countries is a highly metropolitan, and highly concentrated phenomena, and this is true in the case of Manitoba. Winnipeg accounts for approximately 90%-95% of all VC activity in the Province, with a very small percentage taking place in smaller urban centres such as Portage la Prairie, and Brandon (Aiello, Interview, 2001; Bicknell, Interview, 2001; Johnson, Interview, 2001; Falconer, Interview, 2001).

19 To further place both Winnipeg and Canada in the proper context, the projected amount invested by U.S. VC firms in 2000 (based on first quarter projections) was $90 billion (Kennedy, 2000:D8) Indeed, a single *firm* in Silicon Valley - 'Greylock' currently has $2.2 billion under management (Turner, 2001:64)

20 To be eligible for additional tax credits from the federal government, The fund's managers must abide by rules to guarantee a federal tax credit to investors. Investments must be geared towards small and medium-sized enterprises (SME's) with assets of $50 million or less, and the investor must hold the investment for a minimum of eight years (Horsman, 1996:113)

21 It is important to note that the lack of a provincial tax credit for LSVCC investing does not infer that investments by any individuals do not occur. Year 2000 contributions to the VC pool in Alberta by individuals constituted 57% of all new funds raised, largely through the auspices of private, independent funds.

22 Crocus Investment Fund Limited is by far the largest VC fund in the Province, accounting for $200 million in capital (Crocus recently purchased Vision Capital Fund, which added to Crocus' previous portfolio value of $170 million) ENSIS Growth Fund Limited is also a substantial source of capital, accounting for $40 million.

23 The traditional sector as defined by the report's authors includes manufacturing, construction, and miscellaneous.

24 It is important to note that many VC organisations do not make public their actual investments. These three represent the Winnipeg based firms that do.

25 EKG Solutions Incorporated, Modern Digital Communications Incorporated, Momentum Healthware, NIR-VIVO, SpectraWorks Incorporated, Vansco Electronics, Websar Laboratories.

26 IMRIS Incorporated, Bioforma Research & Consulting Incorporated, Biovar Life Support Incorporated, Diaspec, eZedia Incorporated, Online Enterprises Incorporated, OpTx Corporation, SLMsoft.com Incorporated, Vivencia Biotech Incorporated, Medicure.

27 Chrysalis-ITS Incorporated, Electrophotonics, Loran Technologies Incorporated, Microbonds Incorporated, Texar Software Incorporated.

28 There are indications that we may now be seeing the emergence of a true aerospace cluster in the Winnipeg metropolitan area. Elbit Systems Limited, an Israeli aerospace electronics and software firm, recently began operations in Winnipeg in the hopes of acting as a support firm to may of the City's existing aerospace firms (Cash, 2001:B7-8).

29 Their research appears understated: not included in their calculations are taxable revenues from expanded or new businesses, and from employment gains. Further research would attempt to include all possible ramifications of a strategy based on tax subsidies.

30 Also known as informal investing.

31 'Funding' refers to what groups (governments, business, higher education, and others) pay to have someone conduct R & D. 'Performing' refers to the R & D work actually executed. For example, the Federal government may fund a total of $2 billion in a given year, and of that amount, $300 million may be performed directly through their departments, which is also referred to as intramural R & D. Research may also be performed by industry, public research organisations, individuals, and higher education, defined here as "all universities, colleges of technology and other institutes or post-secondary education, whatever their source of finance or legal status. It also includes all research

End Notes (continued)

institutes, experimental stations and clinics operating under the direct control of, or administered by, or associated with, the higher education establishments" (Statistics Canada, November, 1999:5)

32 Virtually all data relating to R & D is produced by either Industry Canada or Statistics Canada, and is rarely discussed at the metropolitan level. Further, Canada is one of the few remaining countries in the OECD that still attempts to measure R & D activity.

33 A $1 million federal research grant to a firm may be reported as a $1 million R & D investment from the government's point of view. However, the firm may use 20% of that grant for administrative costs, and 30% for necessary capital purchases. In reporting this income, only 50% of the grant may be listed as true R & D. The federal government has thus reported a $1 million R & D expenditure, and the firm has reported a $500 thousand R & D investment.

34 While we have roughly defined what R & D is, for the purposes of this study, the following activities - as delineated in Section 37 of the Income Tax Act - are not considered in measuring R & D: "(i) market research and sales promotion, (ii) quality control or routine analysis and testing of materials, devices or products, (iii) research in the social sciences or the humanities, (iv) prospecting, exploring or drilling for or producing minerals, petroleum or natural gas, (v) the commercial production of a new or improved material, device or product or the commercial use of a new or improved process, (vi) style changes, or routine data collection." However, routines such as design and engineering, computer programming, and secretarial work that are in support of R & D activities are considered. (Statistics Canada, Date Unknown:8-9)

35 There are approximately 50 federal programs in existence today that tie into R & D, either directly or in partnership with others (see for example, www.strategis.ic.gc.ca)

36 Saskatchewan received a total of$68 million in 1996-1997: $42 million intramurally; $6 million to industry; $18 million to universities; and $2 million to others. Alberta received a total of $174 million in 1996-1997: $84 million intramurally; $20 million to industry; $68 million to universities; and $2 million to others.

37 The data does not include what we would assume to be significant amount of R & D funding at the now-operational Canadian Science Centre for Human & Animal Health.

38 These numbers should be compared to Saskatchewan ($53.64 per capita – federal R & D, versus $47.01 per capita – industrial R & D) and Alberta ($33.28 per capita – federal R & D, versus $146.35 per capita – industrial R & D)

39 Earlier, we discussed the role of the U.S. federal government and the development of sophisticated technologies by innovative firms in California during World War II. Why should the role of the government be any different in that case? The boom created in California during the 1950's was the result of defence contracts being offered to firms conducting R & D based on wartime technologies. As a result of the time-urgency issue, contracts were awarded (proprietary rights and all) to private firms in an effort to speed up the process. Wartime inventions often become modified consumer products after the cessation of fighting. This was a significant factor in the development of the microelectronics industry.

40 This table represents the dollar value of R & D funding that private businesses received from the federal government. While it includes funding associated with the NRC, it involves other programs and agencies that are not discussed in this research.

41 There are 16 NRC Institutes and 4 NRC Centres throughout Canada, though 12 of the 20 are located in Ottawa.

42 According to Strang (Interview, 2001), the focus of the NRC - IBD is not so much to develop location-specific spin-off firms, but to aid in the development of Canadian-based firms that are focused on the four key technologies of the NRC - IBD: biosystems, spectroscopy, informatics, and magnetic resonant technology.

43 Aventis, GNC Bioferm, Bioriginal, Plant Genetic Systems, Fytokem, and Performance Plants.

44 A similar gap was found between Saskatoon and Winnipeg when the number of U.S. patents awarded were analysed (Niosi & Bas, 2000:55).

45 Saskatchewan did not report in 1998-1999.

End Notes (continued)

46 Alberta Innovation and Science.

47 Part of Alberta's provincial strategy is a $30 million (annual) competitive R & D program called the 'Innovation and Science Research Investments Program'. A small portion of this program is specifically aimed towards funding groups interested in the simple promotion of science (Alberta Science and Research Authority, 2001:14-6).

48 The Manitoba Innovation Fund is a 5 year, $35 million (total) matching fund used in conjunction with the Canada Foundation for Innovation (Manitoba R & D Respondent A, Interview, 2001). The CFI's purpose is to provide R & D infrastructure funding in the hopes of reducing the overhead costs associated with R & D that often must be paid for directly out of other grants. Developed in 1998, this funding would not show up in the statistical data used here.

49 Until they blended with the Department of Industry, Trade, and Mines, the Economic Innovation and Technology Council was to some degree tied into the Provincial government. Their role was essentially to advise the Province on matters of science and technology, and to act as facilitators amongst business, education, and the private sector.

50 As per Section 37 of the Income Tax Act.

51 The Province of Saskatchewan provides the same level of Provincial income tax credit, while the Alberta government provides no Provincial income tax credits.

52 For companies with less than $200 thousand per year in income, the federal credit is 35%.

53 An informant in the Department of Finance, responsible for administration of the tax credit, was asked to what extent these tax credits affected the amounts of R & D undertaken in the Province. As this information is based on income tax data, it is considered confidential, and was made available.

54 Further research of value would gather information regarding industry-performed R & D prior to 1992 (in adjusted dollars), and attempt to determine exactly how successful this program has been in stimulating industrial R & D activity.

55 Aggregate industry in Alberta performed an average of $146.35 per capita between 1994-1997. In Manitoba, the corresponding figure was $72.93 (Statistics Canada, November, 1999). See Figure 8 for further details.

56 While the R & D dollar figures for Nortel - Winnipeg were not available, Nortel is Canada's largest R & D performer by far. In 1997, Nortel performed $3.2 billion of R & D in Canada. The firm closest to Nortel in terms of spending performed $420 million (Author Unknown, 1998:97).

57 As we discussed earlier, the role of the university in economic development came to prominence in the case of Stanford University and its role in the development of Silicon Valley, and indeed the entire microelectronics industry (see for example: Saxenian, 1985:22; Aley, 1997:68; Saxenian, 1994:25). Similar thoughts were echoed with respect to MIT and Route 128 (Judge, 1997), and Duke University, the University of North Carolina, and North Carolina State University's role in the success of the Research Triangle Park (Luger & Goldstein, 1991:80).

58 Lowe (Interview, 2001) suggests that this figure may be as high as 48% for Saskatchewan.

59 It is important to note that while the Province of Manitoba has more than one university that conducts research, the U of M conducts virtually all of the university R & D discussed in this research.

60 Diabex, Molecular Research Reagent Incorporated, Cronus Biopharma, Medicure, Fermion, Coretech, Biovar, Genesense, and Norzyme.

61 MyoNova Medical Incorporated, teraPAC Systems (telecommunications), Brasitar Biotechnologies Limited (biotechnology), and First Choice Health Products Limited (neutraceuticals).

62 Saskatoon has a highly successful research park (Innovation Place) in place today. Regina has recently built a research park on their campus as well.

63 The University of Calgary and the University of Saskatoon both have revenue sharing built into their IP's.

64 For further information on this topic, see Rank & Brochu, 1999.

End Notes (continued)

65 One U.S. report suggested that only 20% of Americans actually make things for a living anymore. The other 80% of workers are engaged in information generation, providing services, or engaging in research and design (Hall, 1999:18).

66 It is important to note that these data - and all education data included from the 1996 Census of Canada - are reflective only of the level of education attained by members of the resident population(s) of the CMA(s) on the day of the Census. The data does not indicate where the resident attained this education, and thus has less value in many ways than an analysis of the number of degrees, diplomas, and certificates that may have been attained in Winnipeg's educational institutions. The data offer us no real connection to any aspects of the education system in their province of education, nor of any relevant non-education factors of the city where the education was received. However, the data is still useful in portraying some generalities.

67 These knowledge areas are referred to by Statistics Canada as Major Fields of Study, which are a predominant discipline (or area of learning, or training) of a person's highest post-secondary degree, certificate or diploma. The structure consists of 10 major categories: Educational, Recreational and Counselling Services; Fine and Applied Arts, Humanities and related fields; Social Sciences and related fields; Commerce, Management and Business Administration, Agricultural and Biological Sciences / Technologies; Engineering and Applied Sciences; Engineering and Applied Science Technologies and Trades; Health Professions, Sciences, and Technologies; and Mathematics and Physical Sciences. Due to their nature, the first five are not considered in this research. Further, within each MFS, certain secondary classifications have been removed that are not applicable to high technology activity. For example, in the case of Health Professions, Sciences, and Technologies, the classifications of Nursing, Dentistry, Surgery, certain specialised Medical professions, and the Psychiatric fields have been removed. Similarly, Civil Engineering has been removed from the Engineering and Applied Sciences. While clearly all involve advanced knowledge, certain MFS such as these likely have few applications to the development and use of advanced materials, biotechnology, and microelectronics.

68 As noted previously, this MFS does not include Nursing, Dentistry, Surgery, certain specialised medical professions, or the Psychiatric fields.

69 Mathematics content is not reviewed in this research.

70 In mathematics, problem-solving consisted of the application of skills in the use of numbers and symbols, the ability to reason and construct proofs, the pursuit evaluative strategies, and the ability to make inferences from databases.

71 The most recent mathematics SAIP was conducted in 2001, but the results of the testing have not yet been made public.

72 In the science portion, written assessment outcomes were determined by 16 year old student's knowledge of the nature of science, science concepts, and the relationship of science to both technology and societal issues.

73 Practical task assessment in science is not reviewed in this research.

74 These figures represent the percentage of students who correctly solved the problem(s).

75 A respondent in the Assessment and Evaluation Division of Saskatchewan Education intimated that an educator's evaluation through tests and one-on-one contact is perhaps the best indicator of student achievement (Saskatchewan Education Respondent, Interview, 2001). However, the respondent also acknowledged that this is most valid for a school, and less valid for a division or a province. The reasoning is that each educator - regardless of curriculum - tests and marks differently than the next, and a thorough assessment of each educator's techniques would need to be factored into any student assessment methodology.

76 Streaming refers to the diversification of courses (and students) into specific streams, such as the applied and pure mathematics mentioned above (in comparison to general mathematics). In this case, students who excel at mathematics may elect to enrol in specialised classes that may have more applicability in some post-secondary faculties. The disadvantage of this is that some students can 'stream' themselves out of university entrance. In some countries such as Japan, streaming is done by school administrators early on in high school, and effectively determines which students will be streamed into advanced mathematics and sciences, and which students will be put through the more general courses (Clark, Interview, 2001).

End Notes (continued)

77 Britton (Interview, 2001) indicated that science fairs are still quite common in Manitoba schools. Many Manitoba school divisions have what is known as 'student initiated projects (SIP) and 'school initiated courses' (SIC), which allow both individual students and educators to pursue special projects and courses. McFarlane (Interview, 2001) noted that a significant number of students are unaware of these options because they are not well promoted.

78 Please note that these figures do not include community college graduates, or diplomas and certificates earned from universities.

79 For the purposes of this research, we have included the following fields of study in the 'high technology' designation: agriculture, biology, zoology, engineering, medical studies and research, pharmacy, chemistry, geology, mathematics, computer science, and physics. The following fields of study were removed from this designation: household science, veterinary medicine, education, physical education, architecture, landscape architecture, forestry, dental studies and research, nursing, rehabilitation medicine, history, languages, economics, geography, law, political science, psychology, social work, sociology, and other.

80 Includes certificates, diplomas, and degrees.

81 In an unpublished report that focused on University of Manitoba students, Britton (Interview, 2001) found that secondary students who had high marks in certain subject areas did not necessarily score as well in those same subject areas at the university level. Further, she found that secondary students who performed poorly in certain subject areas did not necessarily perform poorly in those same subject areas at the university level.

82 The reader should note that the data tell us how many people migrated into the CMA and migrated out of it, from 1991 to 1996. While it tells us definitively that the CMA retained these residents during the five year period, it does not tell us if the out-migrants simply moved just out of the rigid CMA boundaries, or elsewhere within the province.

83 This research acknowledges that more is not necessarily better when we speak of migration. Indeed, rapid in-migration may produce many unwanted benefits such as exorbitant housing costs, traffic problems, and pollution to name just a few. These issues however will not be addressed in detail in this research.

84 Statistics Canada's current measure of poverty is defined by income in relation to the Low Income Cut Offs.

85 The SMARTpark Development Corporation is the body charged with overseeing the development and operation of SMARTpark at the University of Manitoba. This corporation is perhaps the broadest organisation in terms of its encompassing all three key technologies that we have discussed. Its mandate is to encourage university-industry R & D linkages, help develop new firms, and provide the physical space that firms require.

86 The Manitoba Innovation Network is a non-profit organisation whose mandate is to nurture and develop the infrastructure and relationships necessary to help encourage information technology as a fundamental process found in all aspects of life, and in terms of the development of new firms.

87 The Economic Innovation and Technology Council (EITC) was established in 1992 to act as an arm's length advisory council to the Department of Industry, Trade, and Mines on matters of technology commercialisation, innovation, and any economic development related to them. The EITC has now dissolved, and has been incorporated into the Division of Research, Innovation, and Technology, couched within the Department of Industry, Trade, and Mines. Their mandate and organisational structure is still relatively unknown.

88 Smart Winnipeg was established to help create 'technically-enabled communities', and is directly supported by the City of Winnipeg and the Province of Manitoba. Perhaps their most well known strategy has been their promotion of a 'Cyber Village', a plan to create an information technology district through the use of vacant commercial space in Winnipeg's Exchange District.

89 It is regrettable that the scope of this research did not permit us to further investigate angel investing as a form of VC investing. Angel investing represents VC investing as it originally developed - the direct investment of cash in high risk ventures by individuals of high net-worth, typically in industries that they know very well. Due to its exceptionally private nature, it is a difficult subject area to research, but as Horsman (1996:105) noted, angel investing may very well be more important to start-up firms than the forms of VC that are documented in this project. There is a distinct need for this research to be undertaken if economic development planners are to truly determine the state of Winnipeg's VC market.

End Notes (continued)

90 There is no NRC facility in Calgary, Alberta.

91 The current legislation dictates that the R & D simply be performed in Manitoba, and not that the R & D performer be based in the province.

92 The Venture Box program appears to act as a quasi-incubator for new innovations and new firms. In effect, technologies, researchers, and firms coming through the Venture Box program receive special benefits, such as access to VC, business planning, marketing, and legal aspects related to the incorporation of firms and the patenting of technologies.

93 The "Teacher Recruitment and Retention Initiatives" program introduced by Saskatchewan Education goes considerably beyond a bursary for post-secondary Education students studying mathematics and sciences. The program includes programming money for special needs resources and educators, and part-time educational upgrading for educators in many subject areas, to name two additional aspects.

94 It is unfortunate that this research was not able to properly identify even the rough numbers of educators in metro-Manitoba who are teaching these subject areas without the appropriate educational background. Data of this sort is not kept in any of the three provinces, as the decision regarding which educator teaches a particular subject typically rests with the Principal of each school. Further, some educators may be teaching these subjects full-time, while some may only be teaching as little as one course.

95 This program was introduced in 1975 in an effort to allow schools to incorporate local educational needs while still employing provincially-mandated curricula. The onus rests with the individual school to initiate (or initiate along with the student) these courses, with only an obligation to report the course to Manitoba Education, Training, and Youth.

96 These do not include any 'adult education' courses that may have been run through a particular school.

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