RURAL ECONOMY

A Nutraceutical Industry: Policy Implications for Future Directions

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Project Report 98-02
AARI Project #970747

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Executive Summary

The development of any new industry faces a number of barriers. The interest in developing a nutraceutical/functional food industry in Alberta needs to focus on a range of issues associated with the ability to develop the financing, management and knowledge base to permit the development of such an industry. Others, however, have developed new industries where none existed before, and the purpose of this case study is to a) improve understanding of the process of developing a new industry, and b) attempt to draw lessons from the experience of new industry development elsewhere.

This study presents a review of literature concerning the development of new industry, and focuses on the roles best performed by public and private agencies in fostering new industries, particularly associated with the agriculture and agri-food sector. Main conclusions are that primary elements of infant industry development are

- Learning-by-doing,
- R&D, and
- innovation and spillovers.

Proprietary learning is fundamental for gaining experience and reducing production cost, but learning spillovers exist across all the industries. Implications from this review on research include:

1) Size of investment in the new technology is critical and very large initial investments can make a new industry very difficult to establish. If capital is a critical constraint, pioneer industries that require small capital inputs may be preferred.
2) The existing market structure and minimum efficient scale are critical factors in determining the potential success of the new industry. For example, if one or two other competitors are already in the market, the potential new entrant must consider the strategic implications of entering the market. Market entry of another firm may not be possible at the most efficient scale due to limited total demand. One implication of this would be a potential entrant would enter if demand is expected to grow allowing the entrants to operate at the most efficient scale in the future.
3) Dynamic Scale economies, learning by doing, can create an industry competitive advantage. The first firms into the market retain a competitive advantage over later entrants into the market. High spillover of this learning to the rest of the industry erodes the competitive learning advantage. This suggests three possibilities. (1) Where learning remains proprietary (i.e. low spillover), the firm has an incentive to invest in the optimal (profit maximizing) level of learning. This may or may not be the socially optimal level of education or skills training depending upon the conduct of the firm in the market. (2) Where high spillovers exist, there may be little incentive for firms to invest in education and training due to the public good aspect. (3) Where high spillovers exist, individual firm strategy may revolve around either continuous innovation as the competitive edge or recognize that these new products will gradually become commodities and this will require a different future strategy to remain competitive as the industry or service sector matures (e.g. high volume, lowest cost).
4) Another positive side associated with spillovers may be the development of external economies of scale. That is, other sectors may directly and indirectly benefit from these spillovers in human capital, R&D and innovation.
5) Some research suggests that spillovers occur and have impact across national boundaries. Thus, policies that promote international networking and knowledge exchange (i.e. easier spillovers from international countries to the domestic sector) will have positive social benefits. Example of such policies at the University level might include:
    i) Creating several prestigious academic positions in functional food/nutraceuticals for visiting scholars (i.e. rotate the scholars through these different positions and provide high levels of research funding support to attract the best talent in the world).

ii) World-recognized conferences held in Alberta that bring the best expertise in the world to Alberta.

6) University research stimulates industry research but the converse may not be true. Positive spillover effects exist between industry sectors and Universities. Spillovers from University R&D induce more spending on "local" industry R&D, but the converse is not necessarily true.
7) Successful industry R&D may be done by any sized firm but commercialization of the research may require significant financial resources.
8) Private R&D may be subject to spillover and to the extent that this spillover becomes a public good, arguments for public support for R&D can be made. Canadian results from the 1980's suggest that the social rate of return to R&D varies from 20% to 26%. Social rates of return to agricultural research in the US are estimated to be in the range of 35% with higher returns reported for basic research A large portion of the social return results from spillovers of R&D from one sector to another sector.
9) Infancy periods for new industries can vary from 5 years to 20 years with the longer periods required for those industries or sectors that have high technology requirements.
10) Domestic pioneer industries may find it extremely difficult to catch up to incumbent firms when technology is rapidly changing and competitor firms aggressively develop and adopt these new technologies. This suggests that being among the first entrants is very important. Being among the first firms in a growing industry is important in determining market share. Innovation is a key component in maintaining a competitive firm.
11) Spillovers of R&D and experience occur in several different ways and not all firms benefit equally. Firms benefit from the R&D expenditure of other firms. However, to remain competitive with the firms doing research, these firms still need to do their own research. That is, the direct effect of spillovers from firm 1 to firm 2 has a negative impact on the profits of firm 2. This competitive effect may explain why many firms in the same high technology industry conduct R&D. However spillover impacts appear to have an overall positive impact on the industry. For example low technology sectors benefit from the spillover impacts of R&D conducted by high-technology sectors.
12) Basic research has as high, and possibly a higher, rate of return to business and society than does applied research.
13) Human capital is a key component in innovation and technological change.
14) Private firms invest more in R&D when they retain more of the benefits (i.e. the returns are higher).

These observations and generalizations from the literature lead to a number of policy implications for development of a nutraceutical industry in Alberta. These policy issues and impacts include the following. There is a need:

a) To investigate and understand the capital requirements for functional foods and nutraceuticals.
b) To evaluate the market growth potential in domestic and international markets.
c) To determine the optimal level of public support in training and education, for industries identified as having high spillovers from learning by doing. It appears important to identify whether functional foods and nutraceuticals will be a sector with high spillovers or whether most of the learning remains proprietary.
d) For a selective role for the public sector to determine the value of spillovers (external economies) and develop programs that lead to optimal levels of R&D and human capital. There appears a sound basis for policies or other activities that encourage spillovers in the local economy.
e) To understand the international dimensions of spillovers. To the extent that these exist, domestic public support will benefit firms and people in other countries. Similarly, domestic

industry will benefit from international experience and R&D.

f) To encourage public support of research at Universities and other public research institutions. Universities need to encourage interaction between researchers and industry and allow the movement of researchers between private business and University. This may become increasingly important if more basic research is conducted by the private sector in the future. Similarly, business firms need to interact with research and education institutions.

g) To encourage the process of commercialization of innovations by reviewing investment regulations and changing these regulations as appropriate to allow investments to be made in selected industries.

h) To encourage public support for co-funding private research, with the level of public support related to the social value not captured by the private firm. However, results need to be measured.

i) To recognize the time lags in research/development programs. The results of any public support program, either positive or negative, may take over a decade to evaluate. If a decision is made to provide some form of support, then patience will be required before the *ex post* benefits can be evaluated. There is a high return to public research and the optimal level of private research may below the social optimal level. However, the literature reviewed provides no guidance on how to allocate public research funding across sectors. How does the government pick winners or should the government even try? Will functional foods and nutraceuticals be a winner economically? Furthermore, does supporting the functional foods and nutraceuticals draw resources from other sectors, or will it have other detrimental (or positive) impacts on other sectors?

j) It may be necessary to evaluate the current industry structure of the sector, target sub-sectors with few competitors, and evaluate the potential growth rate in productivity for domestic firms. This is especially important if domestic firms are not among the first to enter the sector of the industry.

k) To the extent that functional foods and nutraceuticals are high-technology industries, each firm in the industry should be conducting active R&D programs.

l) To recognize and encourage public support for basic research, associated with evidence of very high pay-offs to basic research.

m) To encourage firms to engage in R&D activities, society need to continue to evaluate alternative ways of retaining private ownership of R&D research. This does, however, need to be matched against the social cost of these policies.

The study also discusses several methods for evaluating science parks. These include input measures such as expenditures on R&D, intermediate measures such as patents or output measures such as number of innovations or new products. The general overview of the literature suggests that successful research parks have strong linkages to local universities, conduct research, employ scientists and in general have a strong positive impact on the local economy.

The process of industry development was examined through a case study of the development of a biotechnological-oriented research park known as Innovation Place, located in Saskatoon, Saskatchewan, Canada. Innovation Place is associated with the University of Saskatchewan, and was developed jointly by the Government of Saskatchewan, the University of Saskatchewan, and by industry. The roles played by government, university and industry in the development of Innovation Place are outlined, and the case study follows the development of Innovation Place, chronicling the evolution of the research park from concept to its current stage. The issues of costs, benefits, and their distribution are raised in the final discussion of the evolution of Innovation Place. Innovation Place has a major impact on the local economy. However other measures such as the number of innovations generated or the social return on the public investment have not yet been evaluated.

The case study on Innovation place raises many questions about Science Parks and their potential role in fostering a functional food and nutraceutical sector in Alberta. These questions include:

- Which way does causation between a science park and a pioneer industry run? Could a successful nutraceutical/functional food industry be the basis for a successful research park or would a research park help assist with the development of a successful nutraceutical/functional food sector?
- Would knowing more about successful/unsuccessful research parks help us to understand how we are best able to develop successful nutraceutical/functional food sectors?
- What is the best way to understand the basics for industry development? Would more studies of research parks be the answer, or should a serious quantitative analysis of one park (such as Innovation Place) be attempted?
- What does the University of Alberta and the Province of Alberta want to achieve in the nutraceutical/functional pioneer sector? Are we developing a high-tech research sector, a high-tech food manufacturing/processing sector, a relatively low-tech food manufacturing/processing sector or all of the above?
- Where does Alberta have a potential comparative advantage in this pioneer sector?
- Will the taxpayer benefit from public support of a nutraceutical/functional food sector?

These are critical questions that need to be asked and at least partially answered by policy makers, Universities and industry.

The review of the literature does suggest that research parks can be successful at transferring technology between research universities and industry. However, mechanisms such as research consortia, joint ventures or contract research are alternative ways of encouraging research spillover impacts. Indeed, non-research park firms may have as many linkages to a research university as research park firms. These same non-research park firms may also employ as many graduates from the local post secondary educational institutions as research park firms.

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Introduction

The formation of new industries is an important economic phenomenon, and a driving force that propels industrial development and heralds economic growth. It is important to understand the fundamentals of new industry development in order to understand how industries start and grow. This is the main purpose of this review: In this paper, we seek to clarify the economic process of industry growth, in particular the growth of new or infant industries. The approach adopted is to examine and review relevant literature, both theoretical and empirical. The study seeks to analyse the formation and growth of new industries or economic sectors in order to understand how the industries emerge, to assess whether substantial differences exist between infant and mature industries, and to delineate leading factors determining the performance of new industries. The purpose is to provide information on which to base industrial policy.

This project is structured as follows:

Part I: Growth and Development of New Industries

Part II: Growth and Development of Research Parks

Part I includes a literature review and theoretical study of infant industries, and presents models of infant industry development in terms of the effects of a new entrant on the price, cost and output of the industry. This section discusses factors related to the development of new industry, including economies of scale, learning-by-doing, research and development, and spillovers. Empirical studies of infant industries are reviewed. A range of issues are reviewed but particular attention is given to research and development (R&D), spillovers, human resource development, and the roles of Research Universities in providing training and inducing industrial R&D. The main results of the theoretical and empirical discussions are then applied to policy implications for new industry development. Alberta has been identified as having good potential to develop new industries and business clusters in energy and mining, forest products and agriculture and food. The development of value-added agri-food and fibre products has attracted interest from both industries and government, and has been viewed as a new opportunity for boosting economic growth. The Government of Alberta has undertaken a value-added initiative, and the University of Alberta has established a research centre for nutraceuticals and functional foods. Policy applications to Alberta value-added agri-food industries are identified.

Part II reviews the literature on research parks and their role in infant industry development. Then a case study of the development of Innovation Place Research Park, a research park, is presented. Innovation Place has focussed primarily but not exclusively on agricultural technology and it is located near the University of Saskatchewan.

Part I: Growth and Development of New Industries

Survey of Theoretical Studies of Infant Industry

The competitive model of firm entry is described first. Problems with the model are briefly discussed. Newer models of industrial organization theory are then presented. These ideas include economies of scale, barriers to entry, learning by doing, research and development and specific assets.

The Effect of Entry on Price, Cost and Output

Firm entry plays an important role in the determination of market price and output in the theory of industrial competition. Entry has been defined in different ways. Some have defined it as the birth of a producing unit, a new plant or a new firm. Others have defined it as a new legal entity, which may be a birth of a new plant, but it could also be a new firm as a result of merger or acquisition. Entry, in this context, refers to the former case, that is any movement of firms into a market which involves the use of productive capacity not in the market prior to that movement (Johnson, 1986).

Market entry occurs not only as the result of new firm formation, but also from diversification of firms already in operation elsewhere. The common characteristic is that all are new participants to the market for the goods or services they are producing. Merger or acquisition is not at issue. The effects of entry on the market price and output can be explained in terms of assumptions of a market in pure competition. In a perfectly competitive market, there is no impediment to entry, and there exist a large number of buyers and sellers who are fully informed about the market. The producers of the homogeneous goods face identical costs, all sell their products at one price, the market price, and all aim to maximize their profits.

Now we assume that because of the change of consumers' preference, there is an increasing demand for the product, so that the market demand shifts to the right. In the short run, this causes the price to increase and output to expand. The rise in price attracts new entry into the industry to compete for the positive economic profit existed in the current firms. New firms continue entering until the market supply curve shifts to far enough to the right to permit price to decline to its original level. At this point no firm can make a supernormal profit, and there will be no new entrant since it would face a negative profit. A new equilibrium is determined.

The traditional model stresses the role of entry in the process of market equilibrium. However, perfect competition need not exist. In an infant industry, for example, the firm that first enters the new market may have the characteristics of a natural monopoly. Continuing entry will have different effects on the price, cost and output of the industry as compared to perfect competition. The original model has to be modified to adjust to the change. Initially, there is only one firm in the market earning a monopoly profit. This positive economic profit encourages other firms to penetrate the market. The process continues until price is forced down to minimum average cost. At this point, economic profits are zero, and each firm produces at minimum efficient scale. Minimum efficient scale is the smallest scale at which a plant or firm may achieve the lowest attainable unit cost (Bain 1956). The results of market entry without impediment are that both price and cost will fall, and total industrial output will increase. The faster the entry, the steeper will be the slope of the time paths of the falling price and unit cost (Devinney 1987).

The conventional microeconomic model just described has been attacked by the modern theory of industrial organization. The model needs to be modified so as to adjust to the disequilibrium caused by the existence of numerous barriers to entry.

The Barriers to Entry

In an infant industry, a new firm's decision to enter the industry is primarily driven by the excess profit exhibited by the incumbents. On the other hand, there are additional factors that influence the decision of potential entrants. In this section, we discuss these factors and the reaction of the incumbents in responding to the entry, especially actions designed to discourage new entry into the industry. Features of the industry or characteristics of the players that tend to impede entry are called barriers to entry. A large number of studies have emphasized various aspects of the topic. Examples are Grossman (1990), Krugman (1987), Oster (1994), Bain (1956) and Mueller and Tilton (1969). Factors discussed below include economies of scale, learning-by-doing, research and development, product differentiation, and specific assets.

1. Economies of Scale

A technological characteristic of production is called an *economy of scale* if, by expanding the scale of operation to increase the volume and capacity of production, the cost of per unit of output falls. Economies of scale, however, cannot exist at all possible levels of scale. A common situation is that the decline in unit cost will stop at its minimum efficient scale, and once this point is reached, further increases in scale will neither reduce nor increase the unit cost of production. Minimum efficient scale is important in analysing economies of scale, because it determines the minimum size of the production for a plant to operate efficiently. It also indicates the market share required for a firm to enter the industry at a low cost level[1]. Bain (1956) points out that entry becomes less attractive as (i) the minimum efficient scale becomes a larger proportion of total industry output, and (ii) the rise of unit cost becomes steeper as scale is reduced below the minimum efficient scale. His argument is that the barrier is related to the perception and reaction of potential entrants, as well as the incumbents. These reactions may affect price, cost and output. For example, the new firm may enter at a scale that is less than the minimum efficient scale, and small enough not to affect the prices and market shares of the established firms. In such a case, retaliation against it from competitors is unlikely. But the entrant will have to produce at an inefficient scale at high unit cost. In another case, the new firm may enter at the minimum efficient scale or larger. This will affect the market shares of the established firms, and the situation will become more serious when the scale of the new entrant is a relatively large proportion of the entire market. Unless the incumbents give up their shares in the market to the entrant, that is unlikely, the excess supply will drive the post-entry price for the industry to be less than the pre-entry level. There are two possible results: one is that the new entrants and the incumbents suffer the lower price and produce at the current level of output, the other is that one or both of them will try to recover the price by reducing the production to the suboptimal scale. In either case, they experience a loss of profit, which makes further entry less attractive.

In the case that new firms enter at a less than the minimum efficient scale, there are some strategies for the low-scale entrants. They may charge premium prices to compensate for the higher cost, and seek to obtain these premia through product innovation and by developing a niche market for the products. Or they may choose a plant location close to their markets so that costs are lowered. This is a common among companies. They may build many small scale plants at different locations, instead of one large centralized plant. This strategy is especially suitable for high bulk products for which the cost of transportation is a big concern. In the other case, in which new entrants are able to produce at the minimum efficient scale or larger, they have to compete with incumbents against the loss of profit. A strategy for both new entrants and incumbents in this case is to increase the demand for the product by expanding and diversifying their markets. From this point of view, this may explain why for many industries, their focus of market development has been changed from domestic to global business.

In addition to the percentage effect of scale economies, Bain (1956) also points out that the capital requirement effect of economies of scale is another barrier to be considered. Fixed capital investment is necessary for the formation of a new firm. This investment includes spending on plant construction, machinery equipment, and research and development, etc. For some industries, this forms a serious financial barrier for the potential entrants.

2. Learning-by-doing

Learning-by-doing refers to the improvement in efficiency gained by a firm through experience in production. It has been observed in many different industries, and was first conceptualized by Wright 1936, and studied by others including Gruber 1994.

Learning by doing is a dynamic process, in which current output affects its future cost as well as investment and production decisions. On the other hand, it is analogous to the static economies of scale discussed earlier since the average cost falls with increased output. Therefore learning by doing has often been referred as *dynamic scale economies* (Grossman 1990). The learning by doing referred to above is internal to the firm because, in order for the firm to realize cost reduction, it has to conduct production activities itself to gain the experience. Learning by doing can be either proprietary or spillover. In the case of proprietary learning, the experience a firm gains from its production process is kept private. Thus, the firm first entering a new industry gets a reward for its effort of learning, which

[1] Some studies indicate that minimum efficient scale is quite different among industries, and food industry usually has considerably smaller scale requirements than other manufacturing industries such as steel, automobiles, aircraft, etc.

is the cost advantage it preserves over its subsequent competitors. Thus, learning by doing creates a barrier to new entrants, comparable to economies of scale[2].

Learning by doing is often an important strategy for a dominant firm. The dynamic process of learning economies makes it possible for a pioneer firm to capture an advantage of over producing in an early period and cost reducing in later period. To achieve the object, the firm may adopt the pioneer's pricing policy (Scherer and Ross, 1990) to keep its price low initially so as to stimulate rapid expansion of demand for its products.

The pioneer advantage of learning cannot last forever. The learning curve eventually levels off, and cost reduction finally disappears. In addition, the development of science and technology stimulates new design and invention, leading to a new learning curve. The advantage to the firm of learning is limited where spillovers are present, and spillover learning has been found to be common in many industries.

Where spillover is present, learning by doing becomes a public good, and is external to all the firms inside and outside of the industry. Firms that enter the industry late can benefit from the experience of incumbents through the diffusion of knowledge. They may be able to produce at a reduced cost and to achieve productivity gains. Learning by doing is less of a barrier to entry in this case. Lieberman (1984) indicates, in a study on learning by doing in chemical processing, that its effect on deterring entry is very small as the result of rapid diffusion of technology. Other studies (Fudenberg and Tirole 1983 and Dasgupta and Stiglitz 1988) support this view.

Another important finding is that proprietary learning handicaps market competition, and spillover learning improves welfare and efficiency. These results imply that government assistance may be needed to achieve the socially optimal level of learning by doing.

3. Research and Development

In the studies of economics of infant industry, research and development (R&D) has been considered as one of the most important topics in terms of both theory and policy implications. Although the term R&D is often utilized in innovation related activities, there is a conceptual difference between research and development according to the nature of the R&D. Research can be either basic or applied. As defined in Hall (1994), the main objective of basic research is "to obtain a more complete understanding of the subjects under study, whereas applied research is directed primarily towards a specific practical aim, or for possible uses for the existing finding of basic research". Development involves technical work of "producing new or improved materials, products and services, including the design and development of processes and prototypes" (Hall 1994). Basic research is primarily conducted by universities and academic institutes, and is largely publicly funded. The Economist (1997) suggests that up to 80% of basic research in rich countries is conducted by Universities. Industry, government or university conduct applied research. In most cases, development is conducted by industry. In North America in 1993 companies and governments supplied 57.6% and 39.6% of the total research funding respectively however companies, government and higher education institutions spent 70.3%, 10.8% and 15.7% of all R&D funding respectively (Economist 1997).

Although research and development are correlated among different organizations, research done by universities, due to its nature, is more likely to diffuse to industries. A survey study by Nelson (1986) found that university research is an important source of industrial innovation, especially in the area of biological science. Another study by Jaffe (1989) on the effects of academic research concludes that university research significantly affects corporate patents, particularly in those high-tech areas such as medical, electronics, optics, and nuclear technology. It also induces industrial spending on R&D, but not vice versa, therefore improvement in university research system will stimulate

[2] For more discussion of the proprietary case, see Spence (1981).

innovation as well as productivity in the industries.

R&D is often regarded as a barrier to entry. There are several reasons. First, R&D impedes a potential entrant from entering the market for its initially high sunk or irreversible cost, as mentioned previously in the case of economies of scale. Some evidences suggest that economies of scale are not necessary in the discovery of new ideas, and small firms may do better in innovation, but substantial scale is normally required to commercialize (Oster 1994). Second, an investment decision on R&D involves substantially more risk than other business strategic decisions with respect to the uncertainty in new technology. Finally, investment in R&D is necessary in order to retrieve experience from learning by doing. To the extent that spillover in learning exists, and that experience has characteristics of public good, firms that conduct R&D will invest less to avoid free riding by other firms. Spence (1984) indicates that the effect of an increase in spillovers is three-fold: It reduces a firm's incentive to invest in R&D. It reduces the R&D required to achieve a given level of cost reduction. And, it increases total economic surplus.

Because of the public good status of R&D, some kinds of compensation are necessary in order to elevate the incentive of a firm to invest in R&D and innovation. In practice, a patent is one of the systems of protection. With a patent, "the inventor is invested with a property right which entitles him or her to claim a financial reward from any commercial use of the invention" (Hall 1994). With a patent in hand, an innovating firm has monopoly power over its innovation for a fixed period of time, which grants it the right to use the invention exclusively, to sell it or license to others for using it. Therefore, a patent enables the firm to recover the R&D costs. On the other hand, a patent also imposes restrictions on competition, and blocks the diffusion of new technology.

Apart from the patent system, other methods to encourage investment in R&D are the award system and the contractual mechanism (Tirole, 1988). The implementation of the award system involves the designation of a clearly defined project and the award of a fixed amount of money or "prize" to the first firm or institute that completes the project. Once the prize is granted, the innovation becomes a public good. In comparison with the patent system, an advantage of the award system is that there is no monopoly produced over the innovation. But the system is much less adopted than the patent system for a few reasons. The first is that it is very difficult for the government to perceive all the information about the invention and its demand in advance, and to determine the value of the prize in order to motivate the researchers properly. So in practice, it is possible that the award is resolved after the innovation takes place. The other reason is that the system implies competition at the research level, which does not necessarily produce the optimal amount of innovative activity (Tirole 1988). Another alternative, which is easier to implement, is the contractual or procurement mechanism. The government or firm chooses one or a number of firms or institutes, and contracts with them for certain R&D activities.

4. Product Differentiation

Product differentiation refers to consumer's preference for one or more particular products over many others which are heterogeneous and close substitutes. It is "propagated by differences in the design or physical quality of competing products, by efforts of sellers to distinguish their products through packaging, branding, and the offering of auxiliary services to buyers, and by advertising and sale-promotional efforts designed to win the allegiance and custom of the potential buyer" (Bain 1956). The product differentiation advantage of established firms has often been considered as an obstacle for a new firm to enter an industry. One simple reason is that these efforts make it possible for buyers to realize the distinctive properties of the products and to become their loyal customers. When a new firm enters this product differentiated industry, consumers who prefer existing products are unlikely to switch to new and unknown product about whose quality they are uncertain. Also, the established firm may have some power to control price because of the product differentiation advantage. Due to customer's loyalty to the product, the firm may be able to raise the price to above minimum costs without losing many customers or attracting new competitors. On the other hand the firm may also drop its price to lure more buyers, and to retaliate against the potential entrant as well. The product differentiation disadvantage of a new entrant results in a disadvantage in price and cost. On the other hand, in the case of an infant industry, the advantage of being the first entrant in a market and holding a pioneering brand is an attractive benefit to early entrants.

5. Specific Assets

Assets are necessary for any production activity. Asset may refer to tangible goods such as production facilities and equipment, or intangible goods in the forms of skilled labour and management, patents, relationships with suppliers, distributors and customers, and product reputation. An asset is said to be specific to a market if it can not be easily applied to other markets. Oster (1994) stresses that specific assets enable a firm to serve the market and to earn a rate of return. But more importantly, for those already established firms, specific assets also deter potential entrants. Oster concludes that the bigger the size of the firm, and the more specific the functions of the assets, the more the firm will commit to threaten new competitors in order to maintain its position and share in the market.

Cost and Benefit Analysis and Productivity Measurement of an Infant Industry

An industry's progress from infancy to maturation is a period during which the production activity of the firm or industry appears, then achieves a competitive position in the international market. Different industries have different experiences in this period. Some may pass it in a few years, and others may never reach maturity. The length of the infant industry period is determined by the performance of the industry, which is associated with production technologies, marketing strategies, policies the government, and the like.

To assess the performance of an infant industry, Bell, Ross-Larsen and Westphal (1984) implement a framework that connects social cost benefit analysis to productivity measurement. The social cost benefit analysis is necessary in the assessment of infant industry. The reason for this argument is that the start-up cost in these industries is usually higher than the same kind of cost spent in an established and matured one. Society has to bear the cost for fostering the industry either through subsidies or by paying higher prices (Jacobsson, 1993). Thus the social cost and benefit of developing an infant industry should not be ignored.

The general purpose of social cost benefit analysis is to estimate the net present value of an economic activity, which is the discounted value of the difference between the gross benefit and cost (Bell et al. 1984). The neoclassical theory of production specifies that productivity is related to the state of technology, the resources used during the production process, and the efficiency with which these resources are utilized. In this sense, the growth of productivity can be attributed to factors such as technological change, scale of the production, and improvement in production efficiency, which is the movement towards technical efficiency of resource use from inferior positions. Productivity growth can be achieved through many different channels. These include:

- reducing cost through technological efforts such as learning by doing, R&D and innovation
- achieving economies of scale
- improving product quality and the efficiency of input use
- training the work-force or developing human capital
- introducing new products or accessing new markets.

Many of these factors are also barriers to entry for a new firm. On the other hand and most importantly, they are also the impetus to productivity growth and the method for new firms and industries to overcome the impediments of entry and to become competitive. These issues are discussed in more detail in the Appendix.

Summary

New industry, also called infant industry, is an important transitional phase of industrial development. Issues of entry, that is the formation and evolution of infant industries, are considered key determinants of the successful evolution of an infant industry. In this section, theoretical models of infant industry are studied in terms of the effects of entry on determining the price, cost and output of the industry. The results of a new entrant are that in the equilibrium, the price is adjusted so that it equals to the minimum average cost, and each firm produces at its minimum efficient scale. The discussion of industrial behaviour is also conducted through a comprehensive survey of factors affecting the industry. These include economies of scale, learning by doing, research and development, product differentiation and specific assets.

Survey of Empirical Studies of Infant Industry

The studies of infant industry development are not limited to theoretical models. Numerous economists have devoted their efforts to empirical research or case studies at firm or industry level to better understand the development and evolution of a firm or industry. The empirical survey presented here draws from the criteria discussed in the previous section. Thus, the focus is on empirical studies dealing with the evolution of infant industry in terms of the number of firms and price and output over time, size and age effects, length of infancy period, market pioneer advantages, effects of learning by doing, R&D, spillovers, human capital development. Selected research findings related to Canadian industries are reported.

The Evolutionary Model and Time Path of Infant Industry

Available literatures deals with the nature of the evolutionary process, and the influence of the initial entrant pattern on the ultimate number of firms, price, output as well as the market structure when the industry is mature. Klepper and Graddy (1990) present an evolutionary model of new industries using annual data on the number of firms, output and price for 46 new products of consumer, producer and military goods from the date of their initial commercial introduction through 1981. They argue that the history of a product shows a pattern of three stages: Stage one starts with the first commercial introduction of a new product, and the period extends to the point until the number of competitors in the industry stops growing. The second stage is the period in which the number of existing firms declines, so that the net entry is negative. It follows by stage three of zero net entry, a period in which the number of firms stabilizes. To demonstrate the path of number of firms, the model is also able to illustrate the paths of price and output over time. In stages 1 and 2, price declines and output increases, and both percentage changes of price and output decrease over time. In the last stage both tend to level off and remain stable.

The time path has important implications. The fact that price shows a declining trend suggests that learning by doing plays an important role for both incumbents and new entrants to reduce the cost and to innovate products to better quality. As the number of firms declines and eventually stabilizes when the industry reaches its maturity, the range of cost and quality for a product down, suggesting that only those incumbents who produce high quality and are cost efficient can survive. The increase in output is mainly due to the reduction in the number of producers, the expansion of capacity of the incumbents and the increased demand for the products. In addition to these findings, the authors point out that the market share tends to stabilize over time. All these findings imply that firms' early experiences are important in forming the market structure of the industry in later period.

The Size and Age Effects of Infant Industry

Some economists emphasize the relationship between growth processes and the size of an industry. An example is Audretsch and Mahmood (1994). Based on manufacturing data collected from U.S. Small Business Administration, they test the hypothesis that a new firm is likely to produce at a sub-optimal scale when it first starts, and that reaching the output level of the minimum efficient scale is one of the primary motives driving a firm. The study found that a firm's start-up size tends to be positively related to the likelihood of survival, and negatively related to the rate at which the firm grows. Thus the bigger the firm when it is established, the easier to subsist, and on the other hand, the slower for it to grow. By contrast, the extent of scale economies has the opposite effect on the likelihood of survival and the rate of growth. The bigger the minimum efficient scale, the higher the growth rate in order to reach the scale, and the harder to actually reach it and to survive. Other factors that positively affect likelihood of survival and firm growth are capital intensity and market growth. In recent years, studies have examined the relationship between firm growth and its current size and age. Examples are US and Canadian studies by Evan (1987 a, b), Dunne, Roberts and Samuelson (1989), and Baldwin and Gorecki (1990). The common conclusion is that growth is negatively related to both the current size and age. Das (1995) attributes this negative relationship to at least two factors. Larger firms experience more constraints on fast growth than small firms and with age there may be fewer gains or growth opportunities available from learning by doing.

The Length of Infancy Period

Jacobsson (1993) cites three reasons for being concerned about the length of the infancy period. First, the longer the period, the higher the cost of production due to various impediments of entry. Either the firms have to bear the cost themselves, or the society has to foster them in the form of subsidies or higher prices. Therefore, the length of the period is related to the total social cost of fostering the industry. Second, assessment of industry performance requires both costs and benefits to be time discounted. The longer the period, the greater the total benefits may be reduced by discounting. Third, knowledge of the anticipated length of the period is advantageous for continuous monitoring of the progress and for policy reformulation.

One method of measuring the infancy period is proposed by Bell et al. (1984) is related to unit cost of production, import price and growth rates of productivity for the industry and foreign competitors. Since many infant industries receive government assistance or protection until they reach the maturity, another method of determining the infancy period depends on how long the government imposes protection on the industry. By these measurements, a Taiwanese industry that produces engine lathes passes the infancy period in five years (Jacobsson 1986). Balassa (1975) claims a period of five to eight years of protection for infant industries is required. Case studies of South Korean engineering industries which produce integrated circuits, machining centres, computer numerically controlled lathes and hydraulic excavators indicate that about twenty years are required for these hi-tech industries to shift from starting-up to being internationally competitive (Jacobsson 1993). Two decades seems long, but the same learning period is also observed in developed countries (Porter 1991), although industries with simple products need less time to reach maturity.

In a technologically dynamic environment, industries devote more efforts to gain productivity and competitiveness in the international markets, which makes it more difficult for an infant industry to increase its productivity at a rate greater than its mature competitors. This is likely why the infancy or learning period is prolonged in technology-based industries.

The Market Pioneer Advantages

The order of market entry plays an important role in determining the market shares in both consumer and industrial goods industries (Robinson and Fornell 1985, Robinson 1988). A competitor in a certain market is identified as a market pioneer if she is the first to develop the product or service in the market, an early follower if she enters a growing market, or a dynamic or a late entrant if she enters a more established market situation. Market share advantages of pioneers are attributed largely to consumer's high perceptions of quality and broader product lines than later entrants, and less to product patents or to advertising and promotional spending.

Learning by Doing, R&D and Spillovers

Case studies on different firms and industries cite evidence indicating that learning by doing is a widespread phenomenon, contributing substantially to the increase in production efficiency, the reduction of production cost, and the growth of productivity. The phenomenon is even more prominent in infant industries and industries equipped with rapidly developed technologies. Spillover is another important source of learning when there is a knowledge externality, and empirical results reveal that learning spillovers exist in all the industries studied. Lieberman (1984) indicates that spillover is robust across all of the chemical processing industries they studied. Furthermore, it accounts for a larger share of cost reduction than the proprietary learning. But the extent to which spillover is captured is different in various industries. Irwin and Klenow (1994) show that firms in semi-conductor industry learn three times more from an additional unit of their own cumulative production than from an additional unit of another firm's cumulative production. On the other hand, spillovers between firms within a given country are about as much as between firms in different countries. This implies that spillovers have gone out of the national boundary in scope, attributing to the rapid development of advanced technology in communication around the world. Another empirical study examines learning by doing in the American rayon industry. In its early stage of 1920-1938, the industry consisted of DuPont, the industry leader, the American Viscose Company (AVC) and a mix of six early followers. The empirical tests reject the hypotheses that firms benefit equally from their own experiences and that spillovers have symmetric effects on firms across the industry. The estimation results state that DuPont has a large and significant own learning parameter but the spillover parameter is insignificant, indicating that as a technical leader, it mainly relies on its own research and development. On the other hand, spillovers are significant for AVC and other firms, and there exist considerable differences in their abilities to benefit from learning by doing.

The effects of R&D and spillovers have also been studied by Jaffe (1986), who assumes a stable relationship among a firm's own R&D investment, other firm's R&D spillovers and the firm's production of new and economically useful knowledge. The latter usually leads to the formation of firm's patents and the generation of profits, which would also be reflected by the firm's value in stock markets. Jaffe's results indicate that for U.S. firms with average R&D expenditures, individual firm patents increase with increased R&D expenditures but over half of the increase in a firm's patents arise from the spillover effects from the increased R&D expenditures by other firms. The effects on profit and market value of other's R&D spillovers are two-fold: One is the direct effect, which is estimated as a reduction in both profit and market value. The other is the indirect effect via its interaction with the firm's own R&D, which increases the economic returns of that firm. On average, the net effect of spillovers is estimated to be positive: Those who invest more than average in research will have a higher return, and those who invest less will have a lower return. Jaffe (1986) estimated the accounting rate of return on private firm R&D at 27%.

Learning and application of R&D are the most important sources of productivity growth and industrial development. In the previous section, research has been classified as basic research and applied research. Depending on the sources of financial support, R&D can be funded either by private companies and industries or by the government. Do they play equally important roles in contributing to the explanation of productivity growth? This question was investigated by Griliches (1986). Two findings are that the stock of R&D capital contributes significantly to the explanation of cross-sectional differences in productivity, and there is little evidence of a decline over time in the rates of return to R&D investments during the 1960's and 1970's. Another important finding is that the basic research component of R&D has premium rate of return, and contributes more to productivity growth than does applied research. The other is that the privately financed R&D is more effective than the federal government funded research in enhancing private productivity and profitability at the firm level. Putting the last two results together, we may say that firms or industries that invest a larger proportion of their R&D expenditure on basic research will show larger increases in productivity.

Although individual firms and industries may fund and conduct basic research, a majority of it is funded and carried out in universities or non-profit and government research centres. A university is considered both a disseminator and a creator of public knowledge. Nelson (1986) used a survey to examine the role of university in supporting technical advances. Industry regards chemistry, material science and computer science as highly relevant fields for training scientists. Computer science and metallurgy are fields in which university research is especially relevant to technical change in industry, and biology and biological sciences applied to medicine and agriculture as fields that are closely connected with related industries in both research and training. Furthermore, regression analysis of this survey data presents a significant and positive relationship between university research and the quantity of industrial R&D, suggesting a linkage between university research and industrial productivity through the spillover effect.

Extending from the story of "Silicon Valley" and other case studies in which university research geographically spills over to local commercial innovation, Jaffe (1989) has also studied the effect of academic research by focusing on the empirical analysis of this phenomenon. The results support the existence of commercial spillovers from university research. The direct effects appear to be different in each technical area, with drugs and biology showing the strongest influence. The causality relationship between university research and industrial R&D reveals that university research significantly affects local industry R&D but not vice versa. The finding confirms Nelson's (1986) result that spillovers of university research induce more spending on industry R&D and advance industrial productivity. Moreover, the results can be applied to explain the phenomena that firms or industries prefer to support local universities and that many industrial R&D labs are located near universities and research institutes to take advantage of the geographical spillovers.

R&D Spillovers in Canadian Industries

Most of the empirical results that have been presented reveal the important roles of learning by doing, R&D and spillovers in promoting infant industry development, and in enhancing productivity and competitiveness of industries in general. While most of them are based on US data, there are also findings related to Canadian industry. One is a study by Bernstein (1988), who focuses on assessing the impacts of intra- and inter-industry R&D spillovers on the cost and structure of production of several Canadian industries. Intra- and inter-industry R&D spillovers refer to R&D spillovers between rival firms within the same industry and between firms operating in different industries, respectively. Their effects on the cost and structure of production are two-fold: One is the cost reducing effect. The other is the factor biasing effect, i.e. the effect on changing proportions of factor demand inputs. Spillovers also imply the existence of difference between the social and private rates of returns to R&D investment. The social rate of return is higher than the private rate of return.

The results suggest that the effects of intra-industry spillovers differ between high-technology and low-technology industries. The latter use R&D spillovers from rival firms as a substitute for their own demand for R&D capital. For firms in high-tech industries, elasticities are complementary, indicating that these firms tend to invest more in their own R&D activities in response to an increase in R&D spillovers from their rivals. Bernstein (1988) estimated the social rate of returns to R&D as varying from 19% to 26% during the period 1978 to 1981. Further discussion on this study is included in the Appendix.

Human Capital Development and Innovation

Human capital development contributes substantially to the productivity and competitiveness of an economy. Bahk and Gort (1993) decompose learning into organization learning, capital learning, and labour learning, and show that a relationship exists between human capital development and firm-specific learning-by-doing. US data for 1973-1986 are used to estimate that capital learning continues until the fifth or sixth year after the birth of plant, and organization learning lasts at least ten years, implying that new entrants have to invest in learning and the benefits take time to develop.

A few studies have stressed that there is a strong complementary relationship between human capital development, innovation and technological change. One of the studies is Baldwin and Johnson (1995), which indicates that innovation, human capital development and high quality products and service, as firm strategies, are highly complementary, and play important roles in influencing the training decisions of firms. Using Canadian data for the 1984 to 1988, the authors conclude that training

- Is positively related to a firm's innovation capability, to the emphasis the firm places on the value of labour skills, and to the quality of products.
- It is also positively related to the size of the firm and the growth of the capital-labour ratio.

Innovation is found to be the most important characteristic of a competitive firm. A survey study by Baldwin, Gray and Johnson (1995) reports that approximately 92 percent of Canadian shipments were produced in establishments using advanced computer-based manufacturing technologies in 1993. The use of advance technology leads to an increased demand for a highly educated and skilled workforce, and a need for more training and more investment expenditure in human capital. This confirms the finding by Baldwin and Johnson (1995) that innovation and technology are complementary with human capital development.

Different firms have different operations and strategies. Some firms are very successful, others are struggling just to survive. A Canadian study by Baldwin (1995) reviews the results of a survey which aimed at uncovering strategies that differentiate more successful firms from less successful ones. Baldwin points out characteristics and strategies commonly possessed by the firms that are more profitable, productive and competitive. These are R&D capability; access to new markets, especially export markets; frequency of new product introduction; acquisition of new technology; controlling production costs; and making use of government programs which provide R&D and export assistance. A conclusion is that innovation is the most crucial determinant of success among all of the factors.

Traditional Agriculture Research

The USDA (1995) conservatively estimates the social rate of return to public agricultural research in the U.S. has been at least 35%. This particular study reviewed the conclusions of numerous research studies on R&D in the agriculture industry. All public agriculture R&D research had a common range of reported rates of return of 40% to 60%. Basic research had a reported common range of 60% to 90%. Interestingly, the rate of return to education at the primary farm level was estimated as 30% to 40%. Private research had a common range of 30% to 40%. None of the studies reviewed extended beyond the time period 1985. While these rates of return appear to be overly high, they do indicate the high social rates of return to basic and applied research. Also this same review showed that private firms invested more in R&D when more of the R&D benefits were retained by the firm.

Implications for a Nutraceutical and Functional Food Centre

Functional Foods and Nutraceuticals are proposed as a potential pioneer industry in which Alberta could excel. This section briefly explores the food industry in Alberta, defines functional foods and nutraceuticals and applies the conclusions from the literature review to policy implications for developing a functional food and neutraceutical sector.

Applications to Alberta Value Added Agri-Food Industries

The performance of Alberta's agriculture, food and beverage industries is important to productivity growth and economic development for the province. However, recent decades have brought new pressures for the agri-food industries. One of the challenges comes from trade liberalization. With new and emerging trade arrangements, more international movement and market opportunities are created for agri-food products. But at the same time, there is also more competition among the industries in both the domestic and global scopes. There is a perceived trend that consumers demand for food and beverage is shifting to high quality, wholesome and natural products due to increased concern about the health, safety and environment. However there is a potentially conflicting consumer objective for food that is quick to prepare and low cost. This shift may result in a flat or even reduced demand for some products, and creates more opportunities for value-added production and expanded markets for niche and differentiated agri-food products. Changes in population and income also affect Canadian agri-food industries. The Canadian population is growing more slowly than world population, and percentage of personal disposable income spent on food and beverages shows a declining trend. This suggests stronger competition among the producers for the limited domestic market, and an emerging view that the export market has more potential for development.

Currently, Alberta food and beverage industries are mainly comprised of a few subsectors, including meat slaughtering and processing, dairy, fruits and vegetables, bakery, feed and beverages. With about 30 percent share of the value added of the whole industries, the meat sector, mainly beef and pork processing, is the dominant one. There has been a fundamental change in the production structure of the Alberta meat processing industry, which is toward higher concentration and larger facilities serving a wider range of geographical area. With North America as the main market, the industry has been identified as competitive in comparison to sub-sectors and the same sectors in other provinces. However, it also has weaknesses. The demand for red meat has been static in North America possibly due to changes in consumer preferences, and there is a need for product innovation as well as market expansion to other areas of the world, especially to Asia. The focus seems to have been on low cost and basic commodity processing, and there are fewer activities producing high quality and consumer-ready products. More efforts in the production of high value added products are being sponsored by the provincial government. R&D activities, product innovations, development of pioneer industries/sectors that can increase output for both domestic and international markets are current initiatives.

Functional foods and nutraceuticals are seen as one potential pioneer (i.e. infant) industry for Alberta. (Toma and Bouma 1996). The market for these products have been growing in the US, Japan and western Europe, it is still a new market in Canada and much of the rest of the world, implying a need for R&D for products in this area.

A Nutraceutical or functional food is "any food or food ingredient considered to provide medical or health benefits, including the prevention and treatment of disease"[3]. A nutraceutical refers to potions or pill type products made from natural food ingredients. Functional foods are food items usually with added food components that confer this health benefit. Existing Alberta functional foods include oat fractionation for beta glucans (health purposes) and the cold buster bar (enhanced performance). Non-food industrial uses are products, derived from agriculture, for the purpose of

[3]This definition is from"Nutraceuticals/Functional Foods. An Exploratory Survey on Canada's Potential". By Food Focus. Toronto, Ontario. For Agriculture and Agri-Food Canada. June, 1995.

pharmaceuticals and industrial uses.[4].

Alberta value-added agri-food industries in Nutraceutical/functional foods and industrial new uses are in their infancy. However, there is pressure to development of the new industry. The urgency comes from the pressures and the opportunities faced by the industry. These include

- the need for the industry to develop new business strategies in order to face the challenges from trade liberalization and more competitive global economic conditions
- the current and expected shift of consumer preferences toward health from food and the desire for foods to be help prevent disease or improve the quality of life.
- the small size (early infancy) of the present industry in Alberta or Western Canada
- the more advanced state of the industry in Europe, parts of Asia and United States
- the lack of knowledge concerning the potential health benefits of select food components
- the implied but rarely stated assumptions that this demand will increase with rising income essentially causing a shift in demand towards quality foods (i.e. less emphasis on low cost)
- the implied but rarely stated assumption (or prediction) that consumer tastes in high income countries are undergoing a substantial structural change (versus a shift) in demand and this will lead to a rapidly growing market in functional foods and nutraceuticals.
- the recognition that in selected high income countries, in particular Canada and the United States, the proportion of the population in higher age groups such as seniors is increasing and this expected to cause a structural change in demand (i.e this relates to the point up above)

Considerable resources are required for the development of value-added agri-food industries. These include agricultural raw materials, access to technology, capacity for innovation, R&D, human capital development, and availability of capital resources. Alberta has abundant and cost-efficient supplies of raw materials such as livestock, grains and oil seeds. However, there are fewer efforts devoted to R&D and innovation in this sector, although these have been identified as important to the competitiveness and success of high knowledge based value-added industries. Literature cited above suggests that the best solution to this problem is the commitment to R&D and innovation from industry, the universities and research institutes as well as the government. In addition, there is a need for greater private and public linkage, collaboration and strategic alliances in order for agri-food industries to evolve from basic processing to value-added technology supported industries. The R&D activities by the industries are necessary for new product and process design, improvement, distribution and marketing. The universities are the primary source of basic research, and provide industries with training and research, and induce more private R&D through spillover effects as well. Thus, collaboration between industries and universities can be viewed as a channel for the industries to innovate, to access technology, to diffuse knowledge and to improve the development of human resources, which are the fundamentals for industries to develop value-added products and to improve productivity and economic growth. The role of government is also essential in encouraging and funding R&D, and funding and establishing programs and policies to stimulate more private R&D activities.

The essential question from an Alberta public perspective becomes what should be our industrial policy with respect to pioneer industries and in particular functional food and nutraceuticals? Using trade protection and barriers to help the industry grow are not viable solutions from the Alberta government perspective because:

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[4] More information on Alberta nutriceuticals/functional foods and industrial uses can be found from “Changing Course! The Value-Added Agri-Food & Fibre Strategy for Alberta”. By Toma & Bouma Management Consultants in Association with the George Morris Centre, April, 1996.

1) Generally economic research has found inconclusive evidence of the benefits of such programs and in general trade theory suggests that free trade is preferable;
2) The World Trade Organization, of which Canada is a member, essentially prohibits erecting tariffs or trade barriers to support industry;
3) The federal government is responsible for trade policy, and;
4) The Alberta or Western Canadian market is small and if any significant economies of scale are exhibited by this pioneer industry, the firms will need access to international markets to achieve minimum efficient scale.

Theoretical and Empirical Policy Considerations for a Nutraceutical and Functional Food Industry in Alberta

1) Size of investment in the new technology is critical and very large initial investments can make a new industry very difficult to establish. If capital is a critical constraint, pioneer industries that require small capital inputs may be preferred.
   a) Policy Implication: Investigate the capital requirements for functional foods and nutraceuticals
2) The existing market structure and minimum efficient scale are critical factors in determining the potential success of the new industry. For example, if one or two other competitors are already in the market, the potential new entrant must consider the strategic implications of entering the market. Market entry of another firm may not be possible at the most efficient scale due to limited total demand. One implication of this would be a potential entrant would enter if demand is expected to grow allowing the entrants to operate at the most efficient scale in the future.
   a) Policy Implication: Evaluate the market growth potential in domestic and international markets.
3) Dynamic Scale economies, learning by doing, can create an industry competitive advantage. The first firms into the market retain a competitive advantage over later entrants into the market. High spillover of this learning to the rest of the industry erodes the competitive learning advantage. This suggests three possibilities. (1) Where learning remains proprietary (i.e. low spillover), the firm has an incentive to invest in the optimal (profit maximizing) level of learning. This may or may not be the socially optimal level of education or skills training depending upon the conduct of the firm in the market. (2) Where high spillovers exist, there may be little incentive for firms to invest in education and training due to the public good aspect. (3) Where high spillovers exist, individual firm strategy may revolve around either continuous innovation as the competitive edge or recognize that these new products will gradually become commodities and this will require a different future strategy to remain competitive as the industry or service sector matures (e.g. high volume, lowest cost).
   a) Policy Implication: Some level of public support can be justified in training and education for industries identified as having high spillovers from learning by doing. There is a need to identify whether functional foods and nutraceuticals will be a sector with high spillovers or whether most of the learning remains proprietary.
4) Another positive side associated with spillovers may be the development of external economies of scale. That is, other sectors may directly and indirectly benefit from these spillovers in human capital, R&D and innovation.
   a) Policy Implication: Again, this may suggest a selective role for the public sector to determine the value of these spillovers and then develop programs that lead to optimal levels of R&D and human capital.
   b) Policy Implication: Public support for policies or other activities that encourage spillovers in the local economy.

5) Some research suggests that spillovers occur and have impact across national boundaries.
   a) Policy Implication: Domestic public support will benefit firms and people in other countries.
   b) Policy Implication: Domestic industry will also benefit from international experience and R&D. Thus policies that promote international networking and knowledge exchange (i.e. easier spillovers from international countries to the domestic sector) will have positive social benefits.
      i) Example of such policies at the University level might include:
         (1) Creating several prestigious academic positions in functional food/nutraceuticals for visiting scholars (i.e. rotate the scholars through these different positions and provide high levels of research funding support to attract the best talent in the world).
         (2) World recognized conferences held in Alberta that brings the best expertise in the world to Alberta.
6) University research stimulates industry research but the converse may not be true. Positive spillover effects exist between industry sectors and Universities. Spillovers from University R&D induce more spending on "local" industry R&D but the converse is not necessarily true.
   a) Policy Implication: Public support of research at Universities and other public research institutions.
   b) Policy Implication: Universities need to encourage interaction between researchers and industry and allow the movement of researchers between private business and University. This may become increasingly important if more basic research is conducted by the private sector in the future.
   c) Policy Implication: Business needs to interact with research and education institutions.
7) Successful industry R&D may be done by any sized firm but commercialization of the research may require significant financial resources.
   a) Policy Implication: Government review investment regulations and change these regulations as appropriate to allow investments to be made in selected industries.
   b) Policy Implication: Large domestic or international firms may be the best equipped groups to commercialize many of the innovations and ideas developed in Alberta.
8) Private R&D may be subject to spillover and to the extent that this spillover becomes a public good, arguments for public support for R&D can be made. Canadian results from the 1980's suggest that the social rate of return to R&D varies from 20% to 26%. Social rates of return to agricultural research in the US are estimated to be in the range of 35% with higher returns reported for basic research A large portion of the social return results from spillovers of R&D from one sector to another sector.
   a) Policy Implication: Public support co-funding private research with the level of public support related to the social value not captured by the private firm however results need to be measured.
9) Infancy periods for new industries can vary from 5 years to 20 years with the longer periods required for those industries or sectors that have high technology requirements.
   a) Policy Implication: The results of any public support program, either positive or negative, may take over a decade to evaluate. If a decision is made to provide some form of support, then patience will be required before the ex post benefits can be evaluated.
   b) There is a high return to public research and the optimal level of private research may be below the social optimal level. However, the literature reviewed provides no guidance on how to allocate public research funding across sectors. How does the government pick winners or should the government even try? Will functional foods and nutraceuticals be a winner economically. Furthermore, does supporting the functional foods and nutraceuticals draw resources from other sectors or have other detrimental (or positive) impacts on other sectors.
10) Domestic pioneer industries may find it extremely difficult to catch up to incumbent firms when

technology is rapidly changing and competitor firms aggressively develop and adopt these new technologies. This suggests that being among the first entrants is very important. Being among the first firms in a growing industry is important in determining market share. Innovation is a key component in maintaining a competitive firm.

   a) Policy Implication: Evaluate the current industry structure of the sector, target sub-sectors with few competitors, and evaluate the potential growth rate in productivity for domestic firms.

11) Spillovers of R&D and experience occur in several different ways and not all firms benefit equally. Firms benefit from the R&D expenditure of other firms. However, to remain competitive with the firms doing research, these firms still need to do their own research. That is, the direct effect of spillovers from firm 1 to firm 2 has a negative impact on the profits of firm 2. This competitive effect may explain why many firms in the same high technology industry conduct R&D. However spillover impacts appear to have an overall positive impact on the industry. For example low technology sectors benefit from the spillover impacts of R&D conducted by high-technology sectors.
    a) Policy Implication: If functional foods and nutraceuticals are high-technology industries, then each firm directly in the industry should be conducting active R&D programs.
12) Basic research has as high and possibly a higher rate of return to business and society as does applied research.
    a) Policy Implication: Public support for basic research.
13) Human capital is a key component in innovation and technological change.
    a) Policy Implication: Public support for some level of education and training especially as this relates to spillover impacts.
14) Private firms invest more in R&D when they retain more of the benefits (i.e. the returns are higher).
    a) Policy Implication: Continue to evaluate alternative ways of retaining private ownership of R&D research. However this always needs to be matched against the social cost of these policies.

Part II: Growth and Development of Research Parks

The review of literature in Part I evaluated pioneer industries and the role of various activities such as R&D in the development of pioneer industries. Two considerations were apparent from this review. First, a major impact of R&D is derived through spillovers from Universities to private industry. Second, spillovers of human capital and R&D from one firm to another firm or even to different sectors may have very high social benefits. This suggests industrial policies that promote spillovers in the domestic economy may have very high social rates of return. At the same time, encouraging spillovers may also reduce the private return to human capital investment or R&D investment. Research parks may, in part, be a public sector response to promote spillover impacts and also provide a level of public support that results in the optimal social level of R&D and education.

Therefore, Part II briefly provides a framework for evaluating research parks. This framework is derived from the academic literature and would provide a basis for conducting future work on research park evaluation. Next, a case study on the Saskatoon Innovation Park is presented. This case study is mainly descriptive since measurement data on this research park are not available and financial resources limited our ability to collect this data.

Research Parks Evaluation

Science Parks are property based initiatives usually located close to a place of higher learning. A Science Park has formal and operational links with a University, other higher education institution or research centres. It is designed to encourage the formation and growth of knowledge based business. Other organizations normally reside on site. The research park has a management function which is actively engaged in the transfer of technology and business skill to the organizations located on site (Monck et al.,1988).

Historical Development

Science Parks in North America and Europe were established, at least in part, to commercialize findings of scientific research in Universities and government research centres. Also they were considered a means to rejuvenate local and national economies and this gave rise to a concept of establishing science parks or innovation centres. Among the most successful science parks in the USA are Route 128 in Boston, Silicon Valley in California and the Research Triangle Parks in North Carolina. The most successful science parks in Great Britain are Cambridge Science Parks at Cambridge and Heriot-Watt Research Park at Birmingham (Monck et.al 1988). The research park at Stanford University, the first research park, was established in 1951.

The growth of these Science Parks is commonly associated with links to leading academic institutions. Growth of Route 128 is associated with Massachusetts Institute of Technology (MIT) and growth of Silicon valley is associated with Stanford University. Similarly, growth of the Cambridge Science Park is associated with Cambridge University and that of Heriot-Watt Research Park is associated with Heriot-Watt University (Monck et.al 1988).

Clearly evident, in reviewing the home pages from various research parks, is the fact that local governments view them as a means of economic development. Commonly quoted information about the park is the physical research area, the number of firms at the park, total employment, the relationship with the local universities and the names of selected tenants. Local interest has led to an increase in science parks in North America and elsewhere. By 1993 approximately 143 research parks were planned or under construction in North America. This included 15 in Canada (Anonymous 1994)[5]. Luger et al. (1991) indicates that up to 50% of the research parks in the U.S. fail and 50% of

5 Various internet world wide web sources gave similar types of estimates. Another source indicated the U.S had over 140 research parks (Thuermer, K.E. April 1997. Maximum R&D. World Trade. p 70-78).

the surviving research parks change their focus. Regions with small populations, without research universities and without large government sponsored research laboratories had an even lower probability of developing a successful research park.

Research Park Evaluation Indicators

The growing interest in the study of innovation and technological change stand in contrast to the availability of adequate statistical data (Kleinknecht 1993). Acs et al (1993) suggests three major aspects of the innovative process to measure technological change:

1) Measure of inputs in the process, such as R & D expenditure or share of the labour force accounted for by employees involved in R & D activities.
    a) R & D reflects only the resources devoted to producing innovative output, not the amount of innovative activity actually realized. This indicator has a number of drawbacks. R & D is input and not an output in the innovation process. There are often problems in accessing the firm level data (Kleinknecht et al. 1993).
2) An intermediate output such as the number of inventions which have been patented.
    a) Patents are types of intermediate output (Kleinknecht et al.). It reflects new technical knowledge, but it does not indicate whether this knowledge has a positive economic value. It is important to draw a distinction between invention and innovation: Invention is an idea, a sketch or model for a new or improved device, product, process or system. Innovation in the economic sense is accomplished only with the first commercial transactions involving the new product process system or device. Little is known about what firms do with their patents, or what is the share of patents translated into commercially viable products. Only those inventions, which have been successfully introduced in the market, can claim that they are innovations as well. Patents do not capture all of the innovations actually made.
3) Direct measure of innovative output
    a) It involves counting the absolute number of innovative outputs of firms as published in trade journals, managerial assessment through surveys on number of innovations, identification of innovation by consulting experts and/or identification of major innovations from historical references/journals. The main assumption behind this measure is that firms/industry always wish to publicize their findings or innovations in order to commercialize into the wider economy. Different methods are mentioned to collect innovation output from industries or firms. Each of the methods has its strengths and its drawbacks.

These measures attempt to evaluate how successful research parks have been in developing and commercializing new ideas. Other measures used by local authorities relate to measures of economic impact on the local economy. These measures include the number of firms, total employment or other measures of economic impact. Luger et al. (1991) identify three stages in economic development for research parks. These are

1. Incubation
2. Consolidation
3. Maturation

Success criteria for incubation could be the number of firms established at the research park. Consolidation criteria could be the total payroll or number of new jobs created. Maturation success measures would be the induced changes in the economic structure of the region.

Jowitt (1991) argues that there is a confusion in the role of science parks, whether the primary purpose is job generation or developing a high tech output. The problem of regional economic growth and the development of high-tech research and manufacturing have become increasingly inter-wined and in the process confused. Regional economic growth and job are distinct from high technology development and may even be in conflict.

Empirical Research on Research Parks and Innovation

Netherlands innovation research indicates that innovations per employee decreases with firm size, small firms produce higher innovation output per unit of R&D and quantity of R&D is positively correlated to firm size. (Kleinknecht et al. 1993). Ireland innovation research found 0.4 innovations per thousand employees in companies with less than 20 employees and 0.08 innovations per employee for firms with over 100 employees (Cogan 1993). Monck et al. (1988) assessed the performance and impact of firms located in science parks in Great Britain by comparing the performance of high-tech firms located at science parks with those high-tech-firms not located in science parks. Indicators of input sides and output sides of technological process were used to assess technological performance of firms located at science parks. For input indicators, proportion of "Qualified Scientists and Engineers" (QSE) and "percentage of turnover of firms invested on R & D activities" were used. Firms in science parks were found to be employing a higher proportion of qualified scientists. Twenty-eight percent of science park firms invested more than 40% of their turnover in R & D activities as compared to 15% for off-science park firms. Actual R&D links, personnel links, student/graduates employment and trial sponsorship with the nearby University were similar between park firms and off-park firms.

Using output indicators showed 28% of firms on science parks lodged a patent in the prior two years compared with only 19% of off-park firms. Another output indicator, new products launched, showed:

- that the likelihood of a firm launching a new product is not associated with increasing QSE employed.
- firms with low and middle levels of expenditure on R & D are associated with high rates of new product introduction, but high levels of R&D expenditure are associated with low rates of introduction of new products in markets and this difference may be a reflection of the youth of these firms.
- the likelihood of a firm bringing a new product to the market was correlated with its likelihood of having filed a patent in the last two years however, 55% of firms without any patents in the last two years had launched new products. This suggests that patenting alone is not a perfect indicator of technological development.

Some observers of research parks have concluded that technological change was best promoted by the existence of giant corporations. This conclusions was possibly drawn from success of Silicon Valley due to presence of Hewlett-Packard and Fairchild, Route 128 of Boston due to presence of Digital Equipment and Research Triangle in North Carolina due to presence of IBM. Direct measures of innovative activity in the US indicate that small and new enterprises, as well as incumbent large corporations, make important contributions to innovative activity. The relative innovative advantage of large versus small firms does not appear to be constant across industries but depend upon market structure characteristics, scale economies, the technological opportunity, class of the industry and the firm size distribution. (Acs and Audretsch 1993).

Other research challenges the common perceptions that research parks are successful due to the presence of universities or other related companies. Studies by Stewart (1993) in Great Britain and by Van Dierdonck et al.(1991) in Belgium and the Netherlands found that majority of firms located in park did not mention the availability of external technological resources as an important determinant for their location decisions in the parks. Similarly Vedovello (1997) from his studies on British science parks, also concluded that geographical proximity between universities and firms is not an important influence on the existence or strength of links at least for those related to the research activity established between University and industry. Park firms were found to be engaged in informal linkage activities with university, whilst in terms of formal linkage such as employment of academics, sponsoring trial, student project links and the employment of graduates, off-park firms have equal or greater number of links (Steward, 1993). Luger et al. (1991) also found similar results while assessing the impact of the Research Triangle Park in North Carolina. It was found from these two studies that science park tenants mentioned the "prestige image" of being located inside science park is the most important determinant for their location decision, rather than prestige of affiliated universities. Van Dierdonck et al. concluded that the argument of science parks advocates, that geographical proximity will stimulate inter-organizational information flow, might be based on a biased understanding of the relation between physical distance and communication.

Another suggested advantage of science parks located in proximity to a university, access to recruiting graduate students from the affiliated university, has also been challenged. Van Dierdonck et al. (1991) reported there is a modest flow of personnel from university laboratories to industry, but very little in the reverse direction. The Luger et al. (1991) study on three successful US research parks, namely Utah, Stanford and Research Triangle Park, also found that a high proportion of the workforce has been recruited from outside the region, except in the case of Utah Park. Similarly Van Dierdonck et al. (1991) also could not detect a recruitment bias towards the local university in their study of Belgian and Dutch science parks.

Science Park Conclusion

Several methods for evaluating science parks were discussed in this section. These include input measures such as expenditures on R&D, intermediate measures such as patents or output measures such as number of innovations or new products. The general overview of the literature suggests that successful research parks have strong linkages to local universities, conduct research, employ scientists and in general have a strong positive impact on the local economy. However, science parks are not required for individual firms to develop high-tech businesses. Further, some researchers suggest that the perceived benefits of science parks may be less than are commonly attributed to them. Many alternatives such as research consortia, joint ventures and contract research can be used to stimulate technology transfer between universities and industry. Local authorities need to be clear on the objectives of a research park. Is it to develop technology or is it to generate general economic development and employment? These two objectives may be in conflict with the socio-economic base existing in the region. The next section presents a case study on the Innovation Place research park located in Saskatoon, Saskatchewan Canada.

Research Park Case Study: The Growth and Development of Innovation Place, Saskatoon, Saskatchewan

Objectives of the Study

This case study examines the historical roles of persons and institutions in the development of a research park in Saskatoon, Saskatchewan, known as Innovation Place. This research park is widely seen as an example of a successful attempt at a university related research park, one that houses several businesses that could be considered part of a pioneer industry. From this case study, the first objective is to identify policies that assist new industry in developing and to highlight policies that hinder development. Second, this case study relates research park activities and results back to the literature review and conclusion in Part I of this study.

Case Study Methodology

The methodology used in the case study is a qualitative survey conducted in person, by phone, fax and email. It is based on interviews of tenants at the research park, representatives from the Saskatchewan government including Saskatchewan Opportunities Corporation and the Department of Economic Development and Cooperation, and the President of the University of Saskatchewan. It also includes interviews conducted with representatives from the City of Saskatoon, to determine the extent and nature of involvement by the city in the development and operation of the research park. This case study discussion should be interpreted with caution. A large portion of the information presented in this section was provided by respondents that have a vested interest in promoting this research park. The authors have no reason to doubt the sincerity or the accuracy of the responses/information reported here, but we did not have the resources to conduct an independent assessment of Innovation Place.

A further source of information used for the case study is written material including the Innovation Place website (http://www.innovationplace.com/), historical issues of local newspapers, and promotional materials from Innovation Place, the City of Saskatoon, Saskatchewan government agencies and economic impact studies conducted by the University of Saskatchewan.

Innovation Place Description

Innovation Place is a 120-acre research and development park located in Saskatoon, Saskatchewan, near the University of Saskatchewan. The park describes itself as the largest research park in Canada and one of the 20 largest in the world. It is home to approximately 100 tenants with more than 1,500 employees, housed in 21 buildings. A listing of tenants in included in the appendix. Innovation Place is considered by the survey respondents to be a centre of agricultural biotechnology in Canada, and a recognized biotechnology address internationally. In addition to agricultural biotechnology, tenants conduct research in computing and communications, natural resources and environmental sciences.

Innovation Place is not an infant or pioneer industry, but is in the commercial real estate business. It arose based on an agreement signed 20 years ago, in June of 1977, between the University of Saskatchewan and the Government of Saskatchewan. Innovation Place is, however, a specialized commercial landlord, catering to advanced technology firms, and not all companies that desire to rent space at the park are eligible to become tenants. It is a research park. Eligibility for tenancy is based on the kind of business carried on, and whether or not the firm is deemed to add value to the research park.

According to sources at the University of Saskatchewan, the concept behind the park was developed by the former president of the University of Saskatchewan, L. F. Kristjanson, and one of the buildings at the park is named in his honor. He saw the park as a collaborative environment where researchers and scientists from the University and other research institutes could work together. It was believed that the sharing of ideas would have a synergistic effect and contribute to the creation of more new and commercially viable research ideas. Several research institutes were already in operation at or near the University of Saskatchewan, so the idea was an expansion of an existing phenomenon. The concept is one that has become known as *technology clusters*. The most famous of these in North America is Silicon Valley. It also grew out of ideas conceived at Stanford University, ideas whose commercial fruition has taken place in Silicon Valley. Thus, as discussed in the prior sections, there appears to have been a conscious effort to promote R&D and human capital spillover effects in Saskatchewan.

Many of Innovation Place's tenants fit the economist's definition of infant industries. Others can be considered pioneer industries, or companies that are working in fields of research not previously explored or producing products not previously available for an existing market. Most of these are in the agricultural biotechnology industry and are developing and producing new vaccines, innoculants, or strains of plants. The tenants range in size from small start up companies to major international firms. In addition, there are well established international companies represented at the park whose businesses are unrelated to agriculture biotechnology, such as Xerox Canada.

The participants questioned had difficulty determining the reasons for the success of Innovation place however they were in agreement that this research park was a success. There are examples of other research parks that have not been as successful. This growth in Innovation Place is attributed to a myriad of factors. These factors are explored in the following sections of the report.

History

In 1977, the University of Saskatchewan (the University) and the Government of the Province of Saskatchewan (Saskatchewan) formally agreed that Saskatchewan be granted an 84 year lease of land immediately north of the University, in order to establish a research and development park. Construction on Innovation Place began in 1979, and the first tenants moved into the park in 1980. At that time two buildings representing 170,000 square feet made up the park. The number of tenants has grown to at least 100 by 1997. (Figure 1).

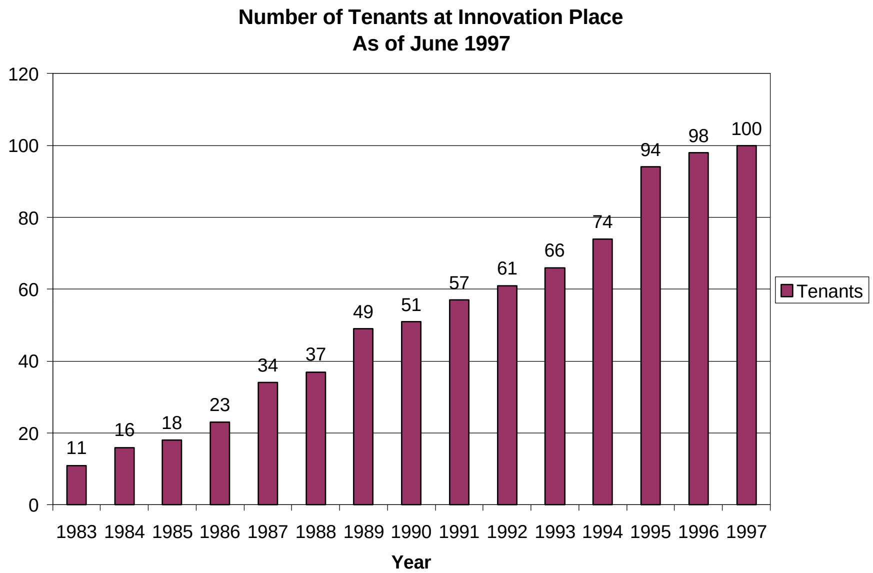

Figure 1: Tenants at Innovation Place (Source: Innovation Place)

Since its inception, Innovation Place has been owned and run by a provincial crown corporation. The Saskatchewan Opportunities Corporation (SOCO) was established in 1994 with a mandate is to "facilitate economic growth in Saskatchewan through investment in viable businesses and infrastructure which supports the development of business."[6] SOCO acquired the assets of Innovation Place from the Saskatchewan Economic Development Corporation (SEDCO) in 1995, which SOCO replaced as the province's economic development investment agency. The two agencies have similarities, but SOCO is a more narrowly focused organization.

Tenants can rent existing space at Innovation Place, have SOCO build facilities to be leased on a long term basis, or sublet land and build their own facilities. Of the 21 buildings currently at the park, tenants have built five.

Role of Government

In the mid-1970's, representatives of the University of Saskatchewan conceived the idea of a research park adjacent to the University which would create an environment for collaborative research. It was also viewed as a means to commercialize technology developed through research being conducted at the university and associated institutions. At the same time, the provincial government was planning to develop a provincially owned industrial park with a view to attracting new businesses, diversifying the Saskatchewan economy, and creating employment. When presented with the university's idea the government recognized its merits and entered into an agreement with the university which gave the government an 84-year lease on the land which now houses Innovation Place. Under the management of the provincial crown corporation, construction began in 1979 and the

6 SOCO Internet Home Page (http://www.gov.sk.ca/soco/)

first tenants moved into the park in 1980 and 1981.

The first three tenants of Innovation Place were all crown corporations. They were the Saskatchewan Potash Corporation, Sask Comp (an information technology company), and Saskatchewan Research Council (SRC). SRC remains a tenant today, but the other two were privatized and have moved to other locations.

In early days of Innovation Place, and some argue still, the return on investment from renting space at the research park was not sufficient to attract a private investor. Perhaps the largest role the government played in the development of the park is that they did not demand a market rate of return, and this allowed the park to grow and develop. Innovation Place is and has always been profitable but not as profitable as other commercial real estate ventures. A private investor would probably not have entered into the venture to build this particular research park because the return on investment was simply not there. Using the terminology from prior sections of this report, the governments of Saskatchewan used public moneys to enhance spillover impacts and possibly increase the level of R&D closer to the socially optimal level through below market rate lease arrangements.

A second role that the government played in the development of Innovation Place was to fund agricultural research through its various grant programs. These grant programs supported much of the research conducted at Innovation Place in the early days, and resulted in innovations that have since been patented and commercialized. Without this funding, the companies conducting the research may have had to look for an alternative sponsor or sold their inventions to a larger research company with better financial strength. Either way, there is no assurance the technology and the jobs would remain in Saskatchewan and or in Canada.

A provincial office of Saskatchewan Economic and Cooperative Development is located at Innovation Place. While it does not play an active role in running the research park, it is considered by the respondents to be an asset to the park tenants. The department's sector specialists work closely with the tenants to help them secure financing, deal with regulatory issues and contribute to policy development for the Department of Economic and Cooperative Development.

Role of University

The University contributed the idea that led to the development of Innovation Place, and there are more than two dozen research related spin off companies whose genesis can be traced back to the University. Many are tenants at the research park. The oldest of these is SED Systems, a telecommunications company that grew out of the University's Space Engineering Department in 1965 and specializes in developing high-technology hardware and software systems for space, satellite communications, and defense applications.

The University of Saskatchewan has a strong foundation in technology transfer. This is due, in large part, to its Faculty of Agriculture and to related research institutions located at the University. When the Government of Saskatchewan decided to set up an agricultural college in 1912, the President of the University of Saskatchewan, Walter Murray, convinced the government that the college should be a part of the university. His philosophy was that farmers needed to be educated in more than just agriculture, and having the Faculty of Agriculture a part of the university system would achieve that goal. The University of Saskatchewan was the first university in Canada to include agriculture as a faculty, and it changed the way the institution saw itself. In the respondents' opinions, it became a more applied and problem-oriented institution. Many of the discoveries made are actually taken to the field where farmers test them, and people with technical concerns are encouraged to take them to faculty at the University of Saskatchewan for help. This form of technology transfer helped the administration see research differently, realizing that, whether fundamental or applied, research has practical applications for everyday life. The commercialization of these technologies in turn leads to a return on this research investment.

As part of the College of Agriculture, the province also set up the provincial laboratory at the University. This lab employs several scientists and technicians who work at the university but who are employed by the province. Much of the research they do is done in conjunction with the researchers employed by the university, so there was a sharing of information even before Innovation Place was started.

Related agricultural research institutes already active at or near the University of Saskatchewan in the mid-1970's included Agriculture Canada, the National Research Council's Plant Biotechnology Institute, and the Veterinary Infectious Diseases Organization (VIDO). University President Leo Kristjanson and his Vice-President of Research at the time, Blaine Homeland, wanted to create a community of scientists and researchers working together. They believed that such a community would create a synergy between university research and the commercialization of the discoveries made. The university took the idea to the provincial government and the government bought into it. The concept of a research park fit well with the mandate of SEDCO, which was to diversify the Saskatchewan economy and attract new businesses and related employment to Saskatchewan.

Although the University was instrumental in the creation of Innovation Place, the University has not been an active player in management of the research park, except through its role in the Management and Advisory Committee, discussed in more detail later. The role of the university has been one of contributor of intellectual capital. Many employees or executives from companies at Innovation Place hold adjunct positions with the University, act as external examiners on graduate committees, and do joint research with academic staff. University faculty members are advisors on research matters with Innovation Place tenants. The proximity of Innovation Place to the University creates a synergy that might not likely exist if the research park was located at a greater distance from the University.

Role of Industry

The role of industry in the development of Innovation Place has always been one of tenant. No financial support for the development of Innovation Place has come from private sources. Some tenants have built their own facilities on-site rather than rent from Innovation Place, or have had the facilities built for them on a long-term lease agreement, but these are the exception.

The decision to locate at Innovation Place has been based on the facilities available and the proximity to other researchers doing similar work. For example, Innovation Place has built infrastructure that supports agricultural biotechnology research. It allows small firms access to facilities that would normally be available only to large research firms with strong financial backing.

Work done at the National Research Council's Plant Biotechnology Institute, VIDO, and Agriculture Canada has been successful, and this success has attracted other similar businesses to the area. Management at Innovation Place expresses the belief that the past successes of institutions at or near Innovation Place have been the result of the synergy created by having like organizations working in proximity to one another, and that this synergy has attracted other tenants to the research park.

Another factor that has affected companies' decisions to locate at Innovation Place is the proximity to test markets and end user markets. As stated earlier, many of the innovations coming from the University of Saskatchewan and private companies at Innovation Place are tested on farms in the area. Saskatoon is centrally located on the prairies. When products are ready to go to market, Innovation Place represents a good location for feedback from end users.

Industry has not played a direct role in the management of Innovation Place except as part of the Management and Advisory committee. Tenants have also had input through annual surveys of the Chief Executive Officers (CEO's) of all the tenants at the research park. These CEO's have responded to the surveys with suggestions for needed facilities, new management initiatives, and generally concerning future directions for research park policy. This feedback has allowed the park's management to build the right facilities at the right time.

Services Provided by Innovation Place

Respondents attribute Innovation Place's success to providing the right kind of services to its tenants. The services available from Innovation Place have given the advantages of being part of a big company or institution like a University to small companies that are tenants at the park. Services provided by the park that go beyond the kind of services available from an office complex include:

- audio visual equipment,
- display cases,
- growth chambers,
- network,
- meeting rooms,
- a park newsletter,
- recreational facilities,
- rental of green spaces,
- reception area rental,
- storage space,
- tenant related events, and
- a listing on the world wide web.

Included with the rental of meeting rooms is audio-visual equipment including slide projectors, overhead projectors, and a TV/VCR. A LCD panel that can be used with a Mac or a PC computer for use in presentations to larger groups is available for rental. There are also display cases in the Galleria and Atrium buildings that can be rented to display a company's products or information about services. Other features of Innovation Place include:

- Growth chambers, for growing plants or storing materials in a controlled environment, can be rented. This is an important service, because construction and maintenance of these facilities is often too costly for a small firm.
  - There is a high-speed network based on Asynchronous Transfer Mode (ATM) technology, the result of a strategic partnership between the provincial phone company and Innovation Place. This allows tenants high-speed access to the Internet and to other tenants in the park without paying toll charges.
  - Meeting rooms of various sizes, in various buildings are available to the tenants for rental.
  - A monthly newsletter is produced, and features articles about the research or services of one or more tenants plus information pertinent to all tenants. This newsletter is mainly circulated in Saskatchewan, but some copies are mailed internationally. The newsletter is a means of advertising for the tenant companies, an alternative that may not be accessible to individual tenants doing their own marketing.
  - Recreational facilities are available for use by tenants' employees. Facilities include squash courts and fitness equipment, a ball diamond, sand volleyball courts, and access to the river valley trail system in Saskatoon.
  - There are also green spaces for outdoor activities and gatherings, and an indoor reception area on the main floor of the Galleria building that can be used by tenants without charge.

Finally, Innovation Place arranges social events for its tenants from time to time, some of which are designed to showcase the talents of the tenants in the park, others that are simply for social interaction among tenants.

The services provided by Innovation Place other than the office space allow companies access to facilities and events that many small companies would not normally be able to afford.

Services not directly provided by Innovation Place but contributing to the appeal of being located there, include seminars organized by tenants, and open to other tenants at the park. These seminars are often a major attraction, because presenters are often prominent researchers, attracted by the ability to conveniently visit numerous biotech firms in Saskatoon.

Buildings at Innovation Place are organized around, or include, large open spaces. Proponents of the research park contend that these architectural features contribute to the collaborative concept of the research park. These open spaces tend to inflate lease rates at Innovation Park, because it is space that no one pays for directly. While it seems impossible to measure the effect, the concept is seen as important part of Innovation Place because it is believed to contribute to exchange of ideas among people who are employed at Innovation Place.

Tenants of Innovation Place

Most tenants at Innovation Place can be classified as pioneer companies (see appendix). They are working in areas that have not been well developed or where the technology is constantly changing such as information technology and transgenic plant breeding. As such, the capital requirements of such an industry are high and would prevent many infant companies from getting up and running if they had to build all their own facilities.

While Innovation Place has come to be known as a research address in the field of biotechnology, there are also tenants in the fields of information technology, pharmaceuticals, and other business. Of the 94 plus organizations and companies which call Innovation Place home, 68 percent are privately owned; 24 percent are publicly owned; with the remaining 8 percent a combination of public and private ownership.

Approximately 52 percent of the more than 1,400 employees of Innovation Place are employed by publicly owned companies. The remaining 48 percent are employed by the private sector. An estimated 38 percent of Innovation Place's total employees work in the Information sector; 26 percent in the Environment sector; 18 percent in the Agriculture sector; and 18 percent are employed in other sectors.

Management Structure

Innovation Place is owned and operated by the government of Saskatchewan through its crown corporation SOCO. The management of Innovation Place is subject to decisions made by the board of directors of SOCO, which has decision-making authority with respect to the funding of new infrastructure. In addition to the Board of Directors, a management advisory committee, made up of representatives from the park’s tenants, its management, the Government of Saskatchewan and the University guides management of the park.

The board of directors of SOCO seldom rejects recommendations of the management of Innovation Place and historically the park has received the funding applied for. In addition to the board of directors, Innovation Place has a Management Advisory committee composed of representatives from the park’s tenants, government, park management and the University. While this committee does not influence day to day management decisions, its purpose is to chart the future direction of the research park.

As part of the original lease agreement between the province and the university, the University of Saskatchewan maintains veto power over who can be allowed as tenants of the park. The reason for this veto is a desire to see that the park remains a true research park. The original proponents of the research park idea did not want to bring in tenants that might depart from this view, or that would allow the area to move toward becoming a light industrial area or a manufacturing site. The definition of manufacturing is somewhat vague, because as part of bringing new products to market, some manufacturing is done, but it is believed important to the integrity of the park that a new company does not have manufacturing as its focus.

Innovation Park Evaluation

An independent assessment of Innovation Place was beyond the resources of this study. When Innovation Place was queried about other science park measures such as number of innovations, number of research scientist, number of patents, number of University of Saskatchewan graduates employed etc. they were unable to provide any data. However, the University of Saskatchewan has commissioned economic impact studies. A discussion of these results is presented next.

Economic impact assessments of Innovation Place have been conducted in 1991, 1993, 1995 and 1997. This assesses the total estimated economic impact of the spending by firms at Innovation Place on the City of Saskatoon and the province of Saskatoon. The 1997 study used a multiplier of 1.43 for the city and 1.65 for the province (Innovation Place Newsletter, April 1998). Results of the economic impact are reported in Figure 2 and show an estimated city impact of $146 Million in 1997. The number of full time equivalent employees in 1997 was estimated at 1559 people directly employed at firms located at Innovation Place.

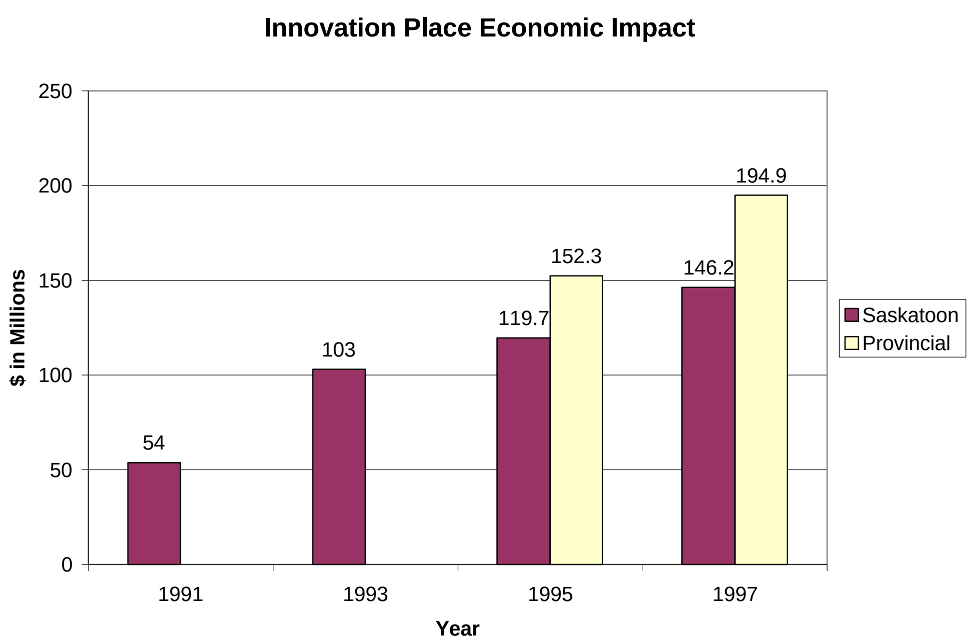

Figure 2: Economic Impact (Source: Innovation Place)

It should be noted what it is that this economic impact does not measure. It does not in any way measure the public input and social return on investment in Innovation Place and other public dollars associated with Innovation Place. It does not measure the number of innovations to arise out of Innovation Place or the economic impact of these new innovations nor does it measure other inputs such as number of scientist or total quantity of R&D spending. It is simply an attempt to measure gross impact to the city/province, and lacks the input data that would permit a cost-benefit analysis of Innovation Place.

Conclusions and Recommendations

The respondents to the survey were very positive about Innovation Place and its success. However more critical measures of its true success need to be developed. This research park appears to have been very successful in promoting spillover impacts using some level of public support. The public support has been in the form of providing facilities below market rates and in providing funding for research. Specific roles for government, universities and industry are identified next.

Role of Government

Research parks are expensive to build but can attract businesses that create employment and other economic benefits for an area through technological innovation. The extent to which technology is diffused and adopted is central to the question of whether the research companies and the parks they inhabit are successful or not. Government involvement in the creation of a research park is necessary to the extent that these projects tend to have a low return on investment, inadequate to attract a private investor. While a private investor would focus on private returns of an investment, government may take into consideration such benefits as job creation and other social benefits.

Establishing a research park also takes time. Research is not only a capital and labor intensive process, but often requires a great deal of time before successful results can be shown. The success of technologically innovative companies depends on this slow process, and so does a research park that houses them. Innovation Place, although viewed by some as an overnight success, has been building for twenty years. Many of its tenants have been working in agriculture biotechnology for as long or longer than that and are just now achieving a level of production that gives them some stability. The funding agency for the research park has to be committed to a long-term investment.

The high capital, time and labor requirements of research make it prohibitively expensive for many firms. Many companies that conduct a significant amount of research are large, international firms. While it is important to the long-term stability of a research park to attract some of these “names”, it is also believed important to promote local research and development in start-up and spin-off companies. Governments can play a second important role in supporting a research park by providing funds to small, independent or University-related research companies.

Role of the University

The University of Saskatchewan provided the land for Innovation Place, and the location of the land adjacent to the University may have had some bearing on the degree of success achieved by Innovation Place and in helping to promote spillover benefits. Proponents of this view suggest that proximity is needed in order to get the desired synergy between researchers in private industry and universities. If a University has land that can be used to house a research park, that land may be crucial to the success of the research park.

A successful research park needs successful research and this requires people qualified to do that research. Graduates from applied sciences are needed, but so too are graduates from the fundamental sciences such as biotechnology, physics, biology and chemistry. The University must be producing enough graduates of the right quality and level of education to supply a steady source of labor to work on research. To this end, the University has to be in tune with the demands of the labor market and develop a curriculum suited to these firms.

In addition to offering the right programs, the University needs to be doing the right kind and quantity of research in order to produce patentable technologies that will be the seeds of new companies. This intellectual capital is necessary to keep new innovations developing. The University also has to create an atmosphere where its researchers are encouraged to look for marketable opportunities for their innovations.

A University may contribute to the success of the research park by participating in research being conducted at the park, either on an advisory basis or by taking an active role in conducting the research. Cross appointments between the university and industry might facilitate this participation.

Role of Industry

The consensus of most associated with Innovation Place is that management of a research park is best assumed by an entity that is not subject to political will or interference. That management role is probably best assumed by a crown corporation or a private company. Tenants and management at Innovation Place attributed at least some of the success of that research park on the relative disinterest of the government, and the opposition parties in the legislature, since the park's inception in the early 1980's. This lack of interest is believed due, in part at least, to the good (and non-controversial) management that has occurred at the park.

Just as the university must keep in touch with industry and the changing needs of the private sector, industry needs to be aware of the research and development being conducted at universities. When commercially viable innovations coming out of a university are ready to be taken to the market, industry needs to be there to support the transition to a commercial environment and sometimes take over that transition.

Industry tenants at research parks are involved in governance through bodies like Innovation Place's Management Advisory Committee, and to provide feedback through surveys. Such devices give the park's management the feedback it needs to build the right facilities, institute the right policies, and chart a course for the park's future.

It is important for a research park to fill a niche and stick to that market. If other commercial real estate owners and developers in a region see a government supported research park as being competitive or predatory in their market, the opposition to the park will likely be its undoing. The absence of political interference referred to earlier would not be possible if constituents saw themselves competing with the government for market share.

Further Study

Asking *why* Innovation Place has become a success is a several-part question. First, has it been a success when it has obtained below-market returns on its rental of real estate to technology tenants? Second, how does one assess those other benefits, product creation, new industry development, employment expansion? Third, is it possible to estimate those other benefits, and compare them with the costs and foregone returns from establishing and operating the research park? Fourth, is there some public role that might be considered the responsibility of government in bringing new knowledge into being? Fifth, and if public support is crucial, why in Saskatoon compared to any other city in the world that is associated with a reasonably major university?

For all of these reasons, assessing the impact of Innovation Place is difficult. During the 1970's, respondents indicated that many university-related research parks were built throughout North America, but proponents of Innovation Place argue that few others have been as successful[7]. How might it be possible to develop a better understanding of the degree of success, and the reason for this success? One possible area for further research is to examine the relationship between a research park's success and its physical proximity to a university. It might also be possible to measure other outputs from a research park besides its estimated economic impact. What are the numbers of innovations developed at the park? How much is spent on R&D?

The assessment of research parks could be furthered by broadening the scope of the survey, and perhaps attempting case studies of other research parks and universities, to assess views of what

7 Respondents to the survey indicated that many research parks were built in the 1970's. Other information sources suggest that very few research parks were built in the 1970's. For example, Thuermer states that only 20 R&D parks operated in the United States prior to 1982; however by 1997 there were nearly 140 parks.

has contributed to research parks located elsewhere. It may be especially useful to conduct a survey at research parks with widely different perceptions of success, in order to look for differences in their development and management. In addition, companies (including large firms) who reportedly considered locating at Innovation Place and decided against it, could be interviewed to see what their rationale was for not locating there.

Innovation Place has created an image of success and continued growth. The reasons cited for this are many, and some of the cited reasons appear, to the economist at least, as naïve.[8] It may well be, however, that the image of success is Innovation Place's strongest claim to future growth and development. The viability of public investment in research parks is an unresolved issue, in part perhaps because its role in harvesting the benefits of research and development is not well understood. But it is clearly deserving of more study.

Implications for a Nutraceutical and Functional Food Centre and Industry In Alberta

The review of the literature on research parks and the case study on Innovation place raises many questions about Science Parks and their potential role in fostering a functional food and nutraceutical sector in Alberta. These questions include:

- Which way does causation between a science park and a pioneer industry run? Could a successful nutraceutical/functional food industry be the basis for a successful research park or would a research park help assist with the development of a successful nutraceutical/functional food sector?
- Would knowing more about successful/unsuccessful research parks help us to understand how we are best able to develop successful nutraceutical/functional food sectors?
- What is the best way to understand the basics for industry development? Would more studies of research parks be the answer, or should a serious quantitative analysis of one park (such as Innovation Place) be attempted?
- What does the University of Alberta and the Province of Alberta want to achieve in the nutraceutical/functional pioneer sector? Are we developing a high-tech research sector, a high-tech food manufacturing/processing sector, a relatively low-tech food manufacturing/processing sector or all of the above?
- Where does Alberta have a potential comparative advantage in this pioneer sector?
- Will the taxpayer benefit from public support of a nutraceutical/functional food sector?
These are critical questions that need to be asked and at least partially answered.

The review of the literature does suggest that research parks can be successful at transferring technology between research universities and industry. However, mechanisms such as research consortia, joint ventures or contract research are alternative ways of encouraging research spillover impacts. . Indeed, non-research park firms may have as many linkages to a research university as research park firms. These same non-research park firms may also employ as many graduates from the local post secondary educational institutions as research park firms.

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8 For example, a "Saskatchewan syndrome", building on the 'spirit of community' that exists in Saskatchewan, was cited by respondents as *the* reason for the success of Innovation Place.

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Appendix: Additional Information, Figures and Tables

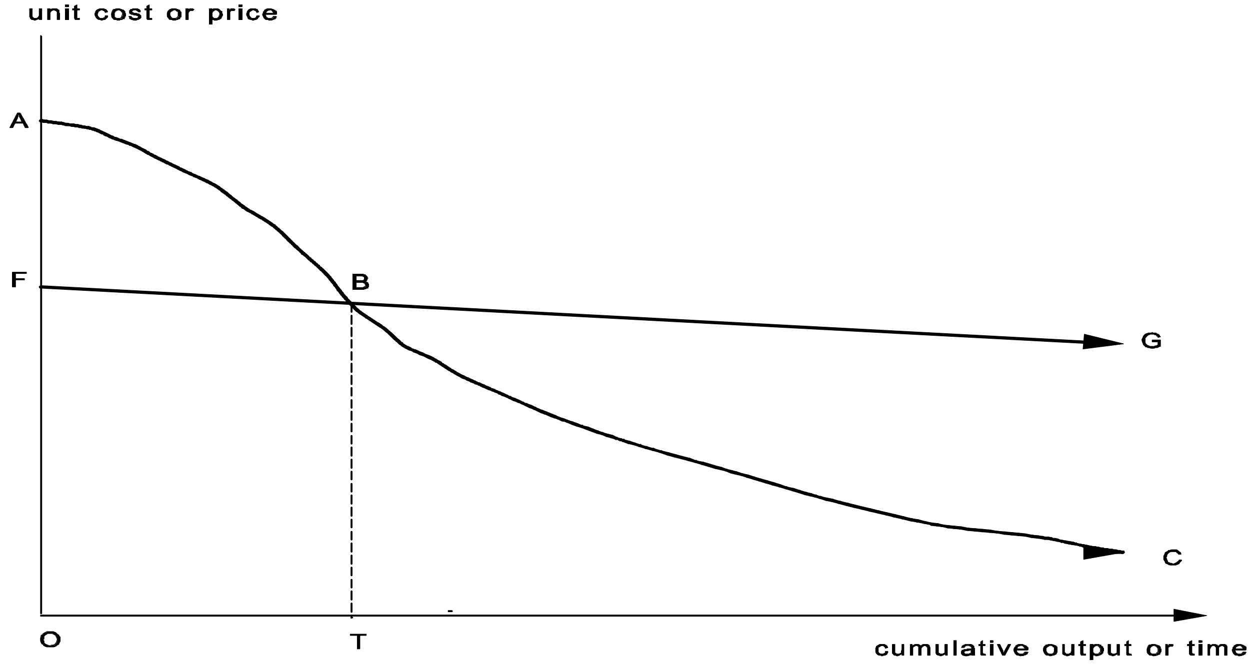
Infant Industry Discussion: Evaluating Benefits

The general purpose of social cost benefit analysis is to estimate the net present value of an economic activity, which is the time discount of the difference between the gross benefit and cost. As defined by Bell and et al. (1984), “the social cost of developing an infant industrial activity is equal to the cumulative discounted value of the difference between domestic and import costs from the initiation of production to the time of maturation, when domestic production and import costs are the same. The gross social benefit includes, correspondingly, the cumulative discounted value of the difference between domestic production and import costs after the time of maturation, when the average domestic production cost is lower than the import price.” Bell et al. (1984) also interpret the cost and benefit graphically. In figure 1, path ABC represents the unit cost of production of the infant industry. Assuming that with the improvement of productivity and technological efficiency, the unit cost is reducing, the path has a decreasing trend. FBG is a path for import price, or unit cost of the homogeneous product. At the cross point B, where the two are equal, the industry achieves maturation. Bell et al. explained the horizontal axis from two directions: cumulative output and time. It is these two different interpretations that make it possible to relate the analysis of cost and benefit of infant industry to the measurement of productivity growth when assessing the performance of the industry.

If the horizontal axis is interpreted as the cumulative output, areas FAB and CBG represent the gross undiscounted social cost and gross benefit of developing the infant industry, respectively. The net benefit is calculated as the difference of the two after they are time discounted to their present values. In order to yield a positive net benefit, the gross benefit has to be large enough to recover the cost, which may be realized if the unit production cost can be reduced below the unit cost of import fast enough. Thereby, a short infancy period is important for keeping the discount effect on the total benefit at the minimum (Jacobsson, 1993).

Another alternative of interpreting the horizontal axis is to treat it as time. By doing so, Bell et al. not only illustrate the length of infancy period, which is OT, furthermore, they are also able to measure the growth rate of productivity of the infant industry at each time point, which is the negative value of the slope of path ABC. An assumption implied in this idea is that the price of each input does not vary over time. Since ABC is the average cost of producing one unit of product, the negative value of the slope for ABC denotes the derivative of output minus the derivative of total input with respect to time t, which defines the rate of change of total factor productivity. Similarly the negative value of the slope of path FBG represents the growth rate of total factor productivity of foreign competitors if assuming a constant exchange rate. From the point of view of productivity measurement, unless the productivity of the industry grows faster than its foreign competitors, the net social benefit of developing the infant industry cannot be positive, neither can the industry ever reach to its maturity. To the extent that cost benefit analysis is difficult to measure for most of firms or industries, productivity measurement provides valuable information for evaluating the performance of an infant industry. It is also useful in measuring the length of an infancy period, a process period from starting a new business to becoming internationally competitive.

Figure 1



Source: Bell, Ross-Larsen and Westphal (1984)

Social Rates of Return to Investment in Canada

Bernstein (1988), assessed the impacts of intra- and inter-industry R&D spillovers on the cost and structure of production of selected Canadian industries. Intra- and inter-industry R&D spillovers refer to R&D spillovers between rival firms within the same industry and between firms operating in different industries, respectively. Their effects on the cost and structure of production have two impacts: One is the cost reducing effect. The other is the factor biasing effect, i.e. they change the proportions of factor demand inputs. Spillovers also imply the existence of difference between the social and private rates of returns to R&D investment. Bernstein derives the elasticities of unit cost and factor demand with respect to both intra-industry and inter-industry R&D spillovers and the social and private rates of returns of R&D investment as well by estimating the marginal rates of intra-industry and inter-industry spillovers. The results, as summarized in Table 1, reveal some important findings. They are: (1) In industries such as aircraft and parts, electrical products and chemical products, which have been classified as being of high technology intensiveness by the Science Council of Canada based on R&D expenditures as a proportion of sales (Gertler, 1991), the unit cost decreases more compared to other industries in response to an increase in the intra-industry spillovers. On the other hand, in response to an increase in the inter-industry spillovers the unit cost decreases relatively less in these hi-tech industries, and more in those technology less intensive industries. But overall inter-industry spillovers play a much greater role in reducing average cost of production relative to intra-industry spillovers, since the magnitude of elasticities with respect to inter-industry spillovers is much bigger for every industry studied; (2) The elasticities of factor demand for R&D capital input with respect to inter-industry spillovers are all negative, indicating that firms in each industry benefit from the efforts of other industries, use them as substitutes for their own R&D investment. Those industries which have smaller propensities to spend on R&D, such as food and beverage, pulp and paper and metal fabricating benefit even more from the inter-industry spillovers since their elasticities are more elastic. However, the effects of intra-industry spillovers are different. For firms in relatively low technology industries, they tend to use R&D spillovers from their rival firms of the same industries as a substitute for their own demand for R&D capital. For firms in high-tech industries, their elasticities are complementary, indicating that these firms tend to invest more in their own R&D activities in response to an increase in R&D spillovers from their rivals. Overall with much larger elasticities, the substitutionary inter-industry spillovers are dominating across all the industries; (3) The social rate of return is quite different from the private rate of return in each industry due to the existence of intra- and inter-industry spillovers, and is higher in those three high tech industries.

Table 1. R&D spillover elasticities and social rate of returns of R&D investment in some Canadian industries, 1978-1981.

	Food and Beverage (10)[1]	Pulp and Paper (27)	Metal Fabricating (30)	Non-electr. Machinery (31)	Aircraft and Parts (32)	Electrical Products (33)	Chemical Products (37)
Elasticity of unit cost with respect to intra- and inter-industry spillovers							
intra-ind. spillovers	-0.058[2]	-0.052	-0.051	-0.049	-0.079	-0.110	-0.126
inter-ind. Spillovers	-1.117	-0.941	-0.973	-0.957	-0.814	-0.546	-0.524
Elasticity of factor demand for R&D capital input with respect to intra- and inter-industry spillovers							
intra-ind. spillovers	-0.672	-0.338	-0.856	-1.288	0.539	0.541	0.368
inter-ind. Spillovers	-5.771	-6.502	-5.096	-3.651	-3.874	-3.644	-3.540
Marginal rates of intra- and inter-industry spillovers and social rate of returns of R&D investment							
marginal intra-industry spillovers	6.45%	7.16%	6.45%	5.53%	9.23%	11.91%	12.5%
as % of social rate of return	32.2	35.1	32.0	28.6	40.1	46.2	47.3
marginal inter-industry spillovers	1.94%	1.65%	2.12%	2.2%	2.18%	2.24%	2.31%
as % of social rate of return	9.7	8.1	10.5	11.4	9.5	8.7	8.7
social rate of return[3]	20.01%	20.43%	20.19%	19.35%	23.03%	25.77%	26.43%

Notes:
1. Numbers in the brackets in this row are two-digit Standard Industrial Classification (SIC).
2. These are average percentages based on a 1 percent increase in the spillover variable.
3. Computed as the sum of the private rate of return which is 0.1162 plus the marginal intra- and inter-industry spillovers.
Source: Bernstein (1988).

Questions Used to Guide Innovation Place Case Study

Questions for Innovation Place Interviews

Administration, U of S, and Government

1. Where did the idea for innovation place get its start? A government initiative or a university initiative that was appealing to government? Was there any interest on the part of industry at the outset?
2. What was the economic climate in Saskatoon at the time? Employment, consumer spending, office space for lease, etc.?
3. What was happening at the U of S? Was the idea conceived by an individual, a department, a faculty, or the university administration? Why? Was it driven by a research program that was showing promising results for technology transfer, or by the need for research programs that that would produce something commercially viable at the post university stage?
4. How is policy for Innovation Place set? Recommendations to boards? from whom?
5. Why are there two boards - what is the rationale for separating capital projects from management and administration? Do the two boards have common members? Are tenants of Innovation Place represented on one or both of the boards?
6. What support does Innovation Place receive from the city of Saskatoon? What about Regina, PA, Melfort, etc.?
7. Any idea how many grads from the U of S are employed at IP? What degrees are most commonly sought? What level - i.e. PhD, Masters, Bachelors?
8. What is the relationship between the University and local businesses? Does the University seek funding and ties mainly with local industry and government or with large industry and federal government?
9. What are criteria for tenants to be considered for Innovation Place? Have potential tenants been denied? Why? Why does the U of S have veto power, rather than province or existing tenants or IP administration?
10. Is there a long term plan for Innovation Place? Can it reach a maximum size? Is there a maximum number of tenants?

Tenants

1. Why Innovation Place? Why Saskatoon? Remote location, questionable accessibility by air, etc.
2. Is there synergy in having like businesses surrounding you?
3. Do you do any collaborative work with other tenants of the park? What kind?
4. Is there a tendency for staff to move from one business to another within IP?
5. Are new businesses in the park often spin-offs of other businesses in the park?
6. How many U of S grads employed here? From which disciplines? What level of degree?
7. Do you feel you have a part in charting the future for Innovation Place? Do you have input into policy for the park?
8. How does tenancy at Innovation Place differ from any other research facility or office complex? How is it the same?
9. To an established tenant is it important that the U of S maintain its veto power over new tenants?

Current Tenants at Innovation Place

A listing of tenants is on the Innovation Place Internet Home Page (http://www.innovationplace.com/). The firms are listed under agriculture, environment, information or computing technologies, pharmaceutical/medical and other. The listing demonstrates that the companies at Innovation place include not only research firms, but also support services and various government agencies. The listings for 1997/98 are below.

Agricultural Related Companies

AdCulture
AgriFood Equity Fund
Agrium Inc.
Ag-West Biotech Inc.
AgrEvo Canada Inc.
BASF Canada Inc.
Biolin Research Inc.
BioProducts Centre
Bioriginal Food & Science Corp.
Biostar Inc.
BioWest Inc.
Canadian Value Added Cereals Consortium
Canamino Inc.
Canodev Research Inc.
Canola Council of Canada
Dow AgroSciences
Fytokem Products Inc.
Harvest Foods Ltd.
Health of Animals Laboratory
Limagrain Canada Seeds
Monsanto Canada Inc.
Performance Plants Inc.
NRC - Plant Biotechnology Institute
Philom Bios Inc.
Plant Genetic Systems (Canada) Inc.
Prairie Plant Systems
POS Pilot Plant
Prairie and Northern Wildlife Centre
Sask. Canola Development Commission
Sask. Canola Growers Association
Sask. Food Processors Association
Sask. Nutraceuticals Network
Sask. Pulse Crop Deveopment Board
Sask. Veterinary Medical Association
Sask. Wheat Pool, Ag. R & D
System Ecotechnologies Inc.
U of S Department of Crop Science & Plant Ecology

VIDO
Western Ag Innovations Inc.
Western Grains Research Foundation

Environmental Related Companies
Canadian Environmental Technology Advancement Corporation
Clayton, Sparks & Associates Ltd.
Clifton Associates
E. K. Sauer Consulting
M.D. Haug & Associates
National Hydrology Research Centre
Sask. Environmental Services Centre
Sask. Environment and Resource Management - District
Sask. Environment and Resource Management - Fisheries
Sask. Environment and Resource Management - Regional
Sask. Environment and Resource Management - Wildlife
Vemax Management Inc.

Information/Computer Technology Related Companies
Advanced DataSystems Ltd.
Autodraft Technical Centre, Ltd.
Axon Development Corporation
BDM Information Systems
D. Black & Associates Visual Communication
Digimax
Digital Planimetrics Inc.
Envista Technologies
Hypercore Technology Incorporated
LGS Group Inc.
MALLnet GLOBAL Corp.
Northern Lights Internet Solutions, Ltd.
Nursing Systems Inc.
Profit Systems Inc./Epsilon Consulting
QCC Communications Corporation
Randco Software Corporation
SaskTel
SED Systems Inc.
Slipstream Software Systems Inc.
Telecommunications Research Laboratories
Traxis Inc.
TriNexus Technologies Inc.
Xerox Canada Ltd.

Other Companies
Boffins Cafe
Canadian Institute for Radiation Safety
Cochrane Engineering Ltd.
CIBC
Crown Investments Corporation - Asset Management Division

D. Rosten Enterprises Inc.
Garven and Associates
Gauley & Company
GENESIS Architecture & Engineering Inc.
Hitachi Canadian Industries
HutchTech Consulting Inc.
Information Desk
Innovation Place Administrative Offices
Ives Temporary Services
K 3 Kensulting Inc.
KPMG
PCS (Technical Services)
PolyTest Laboratories International Inc.
PRIDE Canada
Royal Bank of Canada
Sask. Accelerator Laboratory
Sask. Economic & Co-operative Development
Sask. Highways & Transportation
Sask. Research Council
SunWest Food Laboratory Ltd.
Trimension Group

RESEARCHER - BIOGRAPHICAL DATA

LEROHL, Mel

Post-Secondary Education and Training Relevant to Proposal:

Institution	Field Specialisation	Degree/Diploma	Year
Michigan State University	Agricultural Economics	Ph.D.	1965
University of British Columbia	Agricultural Economics	MSA	1962
University of Alberta	Agriculture	B.Sc.	1960

Relevant Professional Experience (begin with present position):

Dates	Position or Function	Employer	Location
1971 – present	Professor	University of Alberta	Edmonton
1965-71	Economist	Agricultural Economics Research Council of Canada	Ottawa

Research Activities

Title	Date

Canada-U.S.-Mexico-Argentina Trade in Beef. AARI. Completed in 1996/97.
An Assessment of the Value of Soil Attributes in Agricultural Production in Alberta. AARI. (With E. Smith, Agriculture Canada)
BC Market for Alberta Potatoes. AARI and Potato Growers of Alberta. (With M Veeman, K Chen)

Relevant Articles Published in Refereed Journals and Other Relevant Works in the Last Three Years

M.L. Lerohl. 1997. *The Impact of South American Integration on the North American Beef Industry.* AARI Final Report: AARI Project #940515.

M.L. Lerohl. 1996. Short and Intermediate Term Effects on Alberta Beef Producers of Canada-U.S.-Mexico Freer Trade**. AARI** AARI Final Report: Project #920191.

Kevin Dunlevy and Mel Lerohl. 1996. An Examination into British Columbia Market Opportunites for Alberta Table Potatoes. Draft Report for AARI/PGA.

M.L. Lerohl and G.C. van Kooten. 1995. Is Soil Erosion a Problem on the Canadian Prairies? *Prairie Forum*. 20:1:107-121.

Miranda, Mario J., Frank Novak and Mel Lerohl. 1994. Aggregate Acreage Response in the Canadian Prairies Under the Western Grains Stabilization Program. *American Journal of Agricultural Economics.* 76:2:270-276.

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RESEARCHER - BIOGRAPHICAL DATA

Unterschultz, James R

Post-Secondary Education and Training Relevant to Proposal:

Institution	Field Specialization	Degree/Diploma	Year
University of Alberta	Finance	Ph.D.	1996
University of Alberta	Agricultural Economics	M.Sc.	1991
University of Alberta	Agriculture	B.Sc.	1980
University of Alberta	Economics (Honours)	B.A.	1977

Relevant Professional Experience (begin with present position):

Dates	Position or Function	Employer	Location
Oct. 1994-present	Assistant Professor	U. of A.	Edmonton
1987-1989	Regional Farm Economist	AAFRD	Vermilion
1980-1987	District Agriculturist	AAFRD	Alberta

Research Activities

Title **Date**

Extensions to Niche Markets for Fresh Canadian Pork in the Pacific Northwest: A Case Study (With M. Veeman):.

New Instruments for Co-ordination and Risk Sharing Within the Canadian Beef Industry (With F. Novak) 1997-98.

Flexible Pricing and Payment Alternatives on Canadian Wheat Board Pooling for Wheat (With F. Novak) 1996-98.

Relevant Articles Published in Refereed Journals and Other Relevant Works in the Last Three Years

Kim, R.B.Y., J. Unterschultz, M. Veeman and P. Jelen. 1997. Analysis of the Korean Beef Market: A Study of Hotel Buyers Perspectives of Beef Imports From Three Major Sources. Agribusiness: 4: 445-455.

Unterschultz, ., K. Quagrainie and M. Vincent. Evaluating Quebec's preference for Alberta Beef Versus US Beef. Agribusiness. 13: 457-468.

Kuperis, P., M. Vincent, J. Unterschultz and M. Veeman. 1997. Staff Paper 97-03. Niche Markets for Fresh Canadian Pork in the Pacific Northwest: A Case Study.

Novak, F. and J. Unterschultz. 1996. Simple Risk Measures When Hedging Commodities Using Foreign Markets Markets. A Note. Journal of Futures. 16: 211-217.

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