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Development and Acquisition of New Technologies in the Food-Processing Industry

Canada

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in the Food-Processing Industry

Research and Analysis Directorate
Strategic Policy Branch

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DEVELOPMENT AND ACQUISITION OF NEW TECHNOLOGIES IN THE FOOD-PROCESSING INDUSTRY

Donald A. West*

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Preface

Innovation is positively related to the use of advanced technologies and contributes to the technological competitiveness of Canada's food-processing industry. It is an important component of business and technology strategies of firms. Innovators are more likely to have research and development programs than non-innovators but production groups, suppliers and others are also involved in the innovative process. Innovators are at least as concerned about most impediments as are non-innovators; non-innovators are relatively more concerned with a lack of financial resources. Government programs are widely used but are not generally considered to be highly important. Larger plants and foreign-controlled plants tend to be more innovative. Rates of innovation and innovative activities also differ by individual food industry.

This study describes the process of technological change in Canada's food-processing industry, its importance, and the factors influencing it. The study is part of a joint project of Agriculture and Agri-Food Canada and Statistics Canada.

The objectives of the project are:

1. To assess the level of technology use in the Canadian food-processing sector and its constituent industries;

2. To examine the demand for new technologies in relation to factors such as the need for new and better products, cost reduction and government regulation;

3. To examine the supply of new technologies in terms of domestic and foreign sources, and research and development effort;

4. To understand the process of technological change at the plant or firm level, including the methods used by plants or firms to identify technology needs and opportunities as well as impediments to change.

An earlier document (Baldwin, Sabourin and West 1999) reported on the use of advanced technologies and business practices in the industry, their impact at the plant level, and the implications of their use for industry structure and performance, including the industry's international competitiveness. A third draft report (West, 1999), examines the implications of the results for technology policy.

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Highlights

- Innovation is a key element of the technological prowess of a firm and industry. It is the result of an innovative process that involves activities ranging from basic research to the implementation of a new process or commercialization of a new product.

- This study examines the innovative process as practiced in the food-processing industry. The emphasis is on process innovation, either alone or in conjunction with a new product. The study considers the influence on innovation of structural factors such as plant size, country of control and individual food-processing industries, as well as the influence of the business strategies and practices of firms. In addition the study looks at the impediments to innovation and related government programs.

- Data for this study were obtained from Statistics Canada's comprehensive 1998 Survey of Advanced Technology in the Food-Processing Industry (SIC 10), a survey undertaken in co-operation with Agriculture and Agri-Food Canada. Information was obtained on the use of advanced technologies, innovation, and related plant characteristics and activities. Results focusing on the use of advanced technologies and business practices are presented in an earlier report (Baldwin, Sabourin and West 1999). Policy implications are discussed in a third report (West 1999).

Innovation and technological competence

- Technological competence is related to the use of advanced technologies, and is reflected in international technological competitiveness. It is achieved through the use of a range of business strategies and practices of which innovative behaviour is a key element. But plants differ appreciably in their level of innovation and the strategies and practices employed.

- The importance of innovation is indicated by the fact that process innovators are more likely than non-innovators to use advanced technologies and to consider themselves to be technologically competitive with their United States counterparts.

- In the three years preceding the survey, 60% of all plants made at least one process innovation and 19% made seven or more. Innovation rates differ by industry, plant size and country of control.[1] In particular, the other, fruit and vegetable, and dairy industries lead in making innovations of most types. Larger plants and foreign-controlled plants are more likely to have made innovations, especially process innovations.

- Innovation takes place within a broader framework of business strategies and practices. Innovators are more likely to use product and process development practices such as benchmarking. Innovators emphasize both general business strategies and specific technology strategies, including an emphasis on the improvement of existing technologies as opposed to more radical change, and the use of skilled personnel.

The innovative process

- Process innovation involves obtaining information on innovative opportunities, acquiring it, or if not available, developing it. Technology that is purchased may require significant adaptation to plant requirements, an important part of the innovative process. The innovative process employs both internal resources and external sources. The use of external sources indicates the importance of technology transfer to innovation and the technological competence of the industry.

  - The most commonly used internal source of information and contributor to the development of new technologies is the production unit (engineers and staff). However, the research and development (R&D) units also are important—two-thirds of plants report an R&D program, mostly in-house. Head office is a widely used internal source for all three activities, especially information.

  - External sources for innovative activities are the sector market (suppliers, customers, other processors), the technology services market (industrial research firms, consultants and service firms) and the non-market (publications, trade fairs and conferences, industry associations, universities and government organizations). Technology is basically knowledge. Therefore, it is difficult for creators of technology to control its use fully and the markets are imperfect; 'spillovers' are common, especially for the more generic forms of knowledge. Spillovers occur for all three categories of external sources but especially the non-market sources. They contribute to technology transfer but are a deterrent to private R&D because they reduce returns to investments.

  - Suppliers are by far the most used external source of information, technology development and technology acquisition. While significant, the least used is the public or quasi-public sector (governments, institutes and universities). Usage rankings of those external sources that are applicable to all three innovative activities are the same. This finding suggests that these activities are at least broadly complementary. Sources located outside Canada are especially important for technology acquisition and generic information.

  - Process innovators are much more likely than non-innovators to participate in all of these activities.[2] This statement is not surprising but it does emphasize their importance to successful innovation. The more interesting results are that process innovators are especially more likely to obtain information from trade fairs and conferences, to make use of the production group for technology development, to have an in-house R&D program, and to acquire new technologies from suppliers. They also are more likely to use foreign-based sources than are non-innovators.

  - Foreign-controlled plants are more likely than Canadian-controlled plants to participate in all these innovative activities. The major reason is their much greater use of foreign-based sources. In particular, they are much more likely to develop new technologies and to do so internally through related plants located outside Canada. Foreign-controlled plants clearly are an important mechanism of international technology transfer.

- In almost all cases, plants with 250 or more employees are by far the most likely to undertake these innovative activities and those with 10-19 employees are the least likely. There is relatively little difference among the mid-size plants. Apparently, the largest size plants are the most likely to have the resources or anticipate sufficient benefits to engage in many innovative activities. Larger size would be a factor in the greater use of these activities by foreign-controlled than Canadian-controlled plants. There also are differences among the individual food-processing industries in participation rates in the innovative process. The industries that lead in use of advanced technologies tend to be the leaders in carrying out several innovative activities. In particular, the fruit and vegetable industry and the other industry are the most likely to use each of the three methods of introducing new technologies (buy, adapt, develop). Along with the dairy industry, they are the most likely to have an R&D program. Given the relationship between process innovation and technology use, this broad result is not surprising.

Innovation and human resources

♦ New technologies can decrease the requirements for some skills while increasing the need for others. Not only are special skills required to acquire, adapt or develop new technologies, new skills may be needed for their implementation, operation and maintenance. Managers report that the effect of adopting new technology is more often an increase than a decrease in skill requirements.

- Having skilled personnel is one of the leading technology strategies for both innovators and non-innovators. However, specific human resource strategies and practices differ between innovators and non-innovators and by plant size and industry characteristics. These differences emphasize the contribution of human resources to innovation.

- Except for production and supervisory staff, process innovators have a more educated staff than non-innovators. Innovators are more likely to use science, engineering and technical staff in implementing new technologies. There is no difference between innovators and non-innovators in using external sources of expertise as opposed to having professionals and technicians in-house.

- Innovators put more emphasis on strategies to increase skill levels than do non-innovators, including training, recruitment and innovative compensation packages. The key training areas are worker safety and product quality, followed by technical skills and computer training. Basic language and literacy skills and basic numeracy skills are the least commonly offered training; they are the least plant-specific.

- Larger plants put more emphasis than smaller plants on increasing skill levels of employees and using training to do so. Likewise, foreign-controlled plants put greater stress on these human resource activities than do Canadian-controlled plants. Industries that are the leading users of advanced technologies (dairy, fruit and vegetable, and other) tend to lead in the emphasis placed on improving employee skills.

- The effects on total employment at the plant, firm and industry levels depend on changes in labour productivity and changes in output resulting from lower costs and improved quality and service. Managers report that productivity improvement is an important result of adopting advanced technologies. Clearly, improvements in productivity, quality and service also are a function of employee skills.

Impediments to technology adoption

♦ Although the adoption of advanced technologies results in appreciable economic and operational benefits, some plants have not adopted them and many have adopted only a few. Impediments to technology adoption can occur in six areas: financial justification, financial resources, management, human resources, external support services, and government policies, standards and regulations. Given the close relationship between the use of advanced technologies and innovation, especially process innovation, these also are possible impediments to innovation.

- In the food-processing industry, financial justification is the most important impediment to advanced technology adoption. The key factor is the cost of buying, leasing or developing new technology, but other costs and revenue factors also are important. A lack of access to financial resources is the second most important impediment.

- Management, human resources and government all fall in the mid-range of importance as impediments. While more managers consider them to be of low importance, 25-30% of managers consider them to be of high importance.

- Innovators and non-innovators agree on the importance of these impediments. However, there are significant differences in the absolute percentages of plants rating some impediments as highly important. In particular, non-innovators put much more emphasis on a lack of financial resources than do innovators. Perhaps surprisingly, however, it is the innovators who put more emphasis on five of the impediments than do non-innovators - small market size, cost to develop software, lack of capabilities to evaluate new technology, training difficulties and food safety. These latter results may be partly explained by the 'learning by doing' model of innovation and technology adoption.

- Unlike the adoption rates of advanced technologies and the innovation rates, each of which mostly differ in consistent patterns by plant size, country of control, and industry, impediment ratings of plant managers do not. The characteristics of these groups associated with technology use and innovation apparently do not apply as strongly to impediments, although there are some exceptions. For example, foreign-controlled plants are more concerned than Canadian-controlled plants with impediments to implementation and benefits of innovation and less concerned about the cost and management of the acquisition and development process.

Role of government

- In view of the benefits of technological change to the economy and the impediments to it, governments offer a range of programs and services. The study identifies 13 programs in four areas - R&D, investment, human resources, and markets. Some programs provide financial support and some provide facilities or services. Their contribution or effectiveness is indicated by usage and ratings of importance by users.

    - Government programs are widely used by food processors. Eighty percent of plants make use of at least one program. The top four programs in terms of use are market information services, tax incentives for machinery and equipment, training programs, and R&D tax credit. They are used by 62-64% of plants and cover the four program areas.

    - However, every program is considered by substantially more users to be of low importance than high importance. Programs that are both widely used and considered to be very important are tax incentives for machinery and equipment, R&D tax credit, R&D grants, and training programs. The programs considered to be most important tend to be financial in nature.

    - Process innovators are more likely than non-innovators to use government programs and to rate their importance more highly. In comparing innovators and non-innovators, there appears to be only a weak positive correlation to the differences in use and differences in the importance attached to government programs.

    - Foreign-controlled plants are more likely than Canadian-controlled plants to use government programs but are a little less likely to rate their importance highly. There is no pattern to these differences with respect to type of program or level of use. In broad terms, the results are consistent with the reputed advantages of multinational firms.

    - Larger plants are more likely to use government programs than smaller plants, although there is little difference in the mid-size ranges. There is no consistent relationship between plant size and importance attached to programs; a few are positively related, a few are negatively related and in some cases the mid-size groups give the highest ratings.

    - Industries differ in the rate at which they participate in government programs and in the importance they attach to them. Whereas relative usage rates are much the same across industries, this is not the case for the importance attached to them. No consistent relationships between importance and use of programs, impediments or technology use are evident across industries.

Conclusions

- R&D is a key to the creation, adaptation and acquisition of new technologies but all parts of the firm make significant contributions, especially the production group. Suppliers are the most common external source of information and development as well as acquisition. Technology transfer takes several forms, domestically and internationally; it is at least as important to technological progress of the Canadian food-processing industry as intramural R&D.

- Innovators are more likely than non-innovators to be technologically competitive internationally. They also are more likely to engage in all of the innovative activities and to use foreign-based sources. This finding emphasizes the importance of these activities to successful innovation. In addition, they are more likely to be concerned about impediments to innovation, to use government programs and to consider that government programs are highly important. For non-innovators, a lack of financial resources is a key impediment to innovation. The relative lack of concern for other impediments by non-innovators may reflect their lack of experience in innovation.

- Foreign-controlled plants are more likely to be innovative than Canadian-controlled plants and to use foreign-based sources in all phases of the innovative process. Although they are more likely to use government programs, they are more concerned about only a few impediments and to rate the importance of only a few government programs more highly. Larger plants are more likely to be innovative than smaller plants and some industries more than others, but concern about impediments, use of government programs and importance of government programs show little relationship to plant size or a consistent industry pattern. These structural results explain some of the diversity in plant innovation rates and innovative behaviour. They also indicate a diversity of needs with respect to government programs. However, multivariate statistical analysis is needed to separate and to measure the independent effects of these structural variables on innovation.

- The results of this study, along with those on technology use (Baldwin, Sabourin and West 1999), should be helpful to firms in the industry in evaluating and improving their technological competence. As discussed in West 1999, they also should be of use to government policy makers and program administrators in their efforts to facilitate technological change in the food-processing industry.

Highlight Endnotes:

[1] Plant size is measured by employment and five size groups are used: 10–19, 20–49, 50–99, 100–249 and 250 or more employees. Countries of control are Canada, the United States and other, although most results distinguish only between Canada and foreign. Seven industries are defined, largely corresponding to the three-digit SIC-E system: bakery, cereal, dairy, fish, fruit and vegetable, meat and other, where the other industry is the oilseed, sugar and confectionery, and other SIC-E industries. See Baldwin, Sabourin and West 1999 for details.

[2] The use of innovative activities by non-process innovators is not an anomaly; probably all firms would have at least investigated the possibilities and made some type of innovation in the not too distant past. (Also, some process non-innovators are product-only innovators.)

1.0 Introduction

The introduction has three sections:

- Background
- The survey
- Outline of the study

1.1 Background

The use of advanced technologies contributes to the economic performance of a firm, industry and economy by increasing productivity and by contributing to improved products and services. Technological change includes both the creation and the transfer of new technology. Understanding the process of technological change is thus important in the development of strategies for a firm's success and in the development of appropriate public policies to support improvements in an industry's technological competence.

The food-processing industry uses advanced technologies in areas such as processing, process control, packaging, quality control, information systems, and inventory and distribution. However, technological prowess is more than just the use of advanced technologies. The effective use of new technology depends on effective associated business practices. In addition, technological competence requires a range of innovative activities and skills.[3] Effective procedures for developing, acquiring and implementing new knowledge, processes, machinery and equipment are essential features of technological change. Firms in the food-processing industry differ in technology use, technology strategies and level of innovation (Baldwin, Sabourin and West 1999) and are expected to differ in the ways that they achieve their technological goals.

As noted by Stoneman (1996), Schumpeter identified three stages in the process of technological change: invention - the generation of new ideas; innovation - the translation of the invention into marketable products and processes and diffusion - the spreading of the new products and processes across the potential market. But this process is not linear: there are many feedback loops as problems are encountered and as knowledge gained at one stage is fed back to a previous stage. Nor does one stage automatically lead to the next. At each stage there is a selection process that is heavily influenced by expected rewards. Few ideas or inventions end up as commercial products or processes. Indeed, 'innovation' is often used to describe the overall process of technological change, not just one stage. Innovation, in the broad sense of doing something new, can be global (the first use in the world or the economy) or local (the first use in the unit of observation such as a plant, firm or industry) (Stoneman 1996, Tassey 1994).

In this study, innovation is used in the broad sense; that is, it includes invention (in the form of knowledge, plans and documents as well as machinery and equipment), the translation of the invention into a new product or process, and its diffusion. Also innovation is considered in the local sense. Thus a plant undertakes a process innovation if it adopts a production method which may be used by others but, from its own perspective, is new or significantly improved. The method may involve changes in production procedures or distribution systems. A process innovation may be intended to produce new or improved products, which cannot be produced using conventional methods, or to increase the production or delivery efficiency of existing products. Similarly, a product innovation is the commercial adoption of a new good or service. While firms can be innovative in many dimensions - products, technology, management, human resources - this study focuses on product and process innovation, especially the latter.

This study considers five characteristics of the innovative process:

- the relative importance of the development of new technologies versus their acquisition
- the role specific innovative activities play in process innovation
- the difference between individual firm activities versus collaborative activities
- the impediments to new technology adoption
- the role of government technology-related programs

In addition, differences in rates of innovation and specific innovative activities between Canadian-controlled and foreign-controlled plants, large and small plants, and the individual food industries are of interest. These several characteristics are relevant to firms in assessing their technological competence and planning technological change. They are also relevant to the assessment and development of public technology policies and programs.

Our interest in sources of new technology and joint activities of firms reflects the fact that process and product innovation typically involves a combination of inputs from sources both internal and external to the firm. The ability to create or acquire knowledge is a crucial part of the process. Internally, R&D departments, management, production and engineering units all participate in the creation and acquisition of new technologies. Externally, while some technology markets function well, the transfer of knowledge among firms incurs significant problems of appropriateness; that is, it is difficult for the creators of knowledge to capture its full value. The 'spillovers' associated with innovation are thus an important mechanism of technology transfer, domestically and internationally. They also influence firm structure and give rise to business arrangements such as joint ventures, and institutional structures such as research institutes (Baldwin 1999).

This study was guided by hypotheses or expectations based on previous studies of the manufacturing industry referred to throughout the paper. In particular, it was expected that technologically advanced plants in the food-processing industry would be more likely to be recent innovators than other plants. The degree to which a plant/firm adopts new products and processes and the specific ones it adopts were expected to be a function of the way in which the plant identifies, obtains and implements them. New products and processes can be developed internally or with others, or purchased. Both the level of innovation and the methods used were expected to be influenced by plant size, country of control and industry.[4] They also were expected to be influenced by and affect the human resource activities of the plant. In addition, financial and other impediments were expected to influence innovative activities.

1.2 The survey

This study is part of a larger project on technological change in the food-processing industry (SIC 10). Data for the study were obtained from the Survey of Advanced Technology in the Canadian Food-Processing Industry, conducted by Statistics Canada in 1998. The survey is unique in its focus on the food industry and its comprehensive coverage of it.

The questionnaire was developed with the help of experts in research establishments, universities, governments and industry. The questionnaire consisted of ten sections: general firm and plant characteristics, the production environment, business practices, advanced technology adoption, skill development, technology development, competitive environment, effects of technology adoption, impediments to technology adoption, and the importance of government programs in this area. For reasons that are discussed in following sections, the rate of adoption of advanced technologies and innovation were expected to be influenced by the country of control, the plant size, and the type of products produced (industry). Therefore the population was stratified by these three variables. Three ownership categories (Canada, the United States, and other) were used. Four employment size categories were used: 10-19, 20-99, 100-249 and 250 or more employees. Plants with fewer than 10 employees were not surveyed because of cost constraints. Seven industries (bakery, cereal, dairy, fish, fruit and vegetable, meat and other) were identified.[5] The population distribution of Canadian food processors across each of these three stratification variables, and selected operational and performance characteristics, are discussed in Baldwin, Sabourin and West 1999.

The survey was conducted in three stages. First, each sampled unit was contacted to determine the name and mailing address of the person who should receive the questionnaire. Second, the questionnaire was mailed to the respondent, who for the most part was the plant manager. Third, follow-ups were done by telephone interviews.

A sample of food manufacturing plants was randomly drawn from a frame of Statistics Canada's Business Register representing the Canadian food-processing population. Overall, 1345 establishments were surveyed and 1018 were found to meet the study's selection criteria. The overall response rate for those qualifying was 83.9%. Response rates across each of the three stratification variables - size, industry, and country of control - also were high (Table 1).

Table 1. Survey Response Rates

Stratification Variable	Completed	Response Rate
	number of plants	percentage
Number of Employees		
10 – 19	206	82.1
20 – 99	408	83.8
100 – 249	145	89.0
250 or more	95	81.2
Country of Control		
Canada	666	83.0
United States	108	85.0
Other Foreign	80	90.0
Industry		
Bakery	129	80.6
Cereals	133	85.3
Dairy	105	86.1
Fish	110	82.7
Fruit/Vegetables	101	89.4
Meat	137	85.6
Other	139	79.9
All	854	83.9

Unless otherwise specified, the data presented in this report are population estimates. They are a percentage of plants, which are derived using the appropriate establishment weights to convert sample results to population values.

Some questions asked managers to rate the importance of an activity, characteristic or result on a scale of 1 to 5, where 1 is not important and 5 is extremely important. In this document, answers to such questions typically are summarized by the percentage of plants that report a score of 4 or 5. This procedure is convenient and captures the essential result.

1.3 Outline of the study

There are eight chapters in the study. Chapter 2 describes the level of innovation in the food-processing industry and provides the links between innovation and the use of advanced technologies, technological competitiveness, practices and strategies. Chapter 3 then examines the relationships among the ways that plants buy, adapt, or develop new technologies, and the methods used to develop and to acquire the new technologies. Chapter 3 also compares the innovative activities of recent innovators with those who have not made a recent innovation. Chapter 4 examines differences in innovative activities between Canadian-controlled and foreign-controlled plants, large and small plants, and individual food industries. Chapter 5 investigates the human resource implications of technological change. Chapter 6 evaluates impediments to innovation. Chapter 7 looks at the importance of government programs and services for innovation in the industry. Chapter 8 draws some conclusions from the study.

Chapter 1 Endnotes:

[3] For example, innovative firms in the manufacturing sector put more emphasis than non-innovative firms on strategies for improving performance in areas such as management, human resources, marketing, financing, government programs, and services and production efficiencies (Baldwin and Johnson 1995).

[4] For example, studies of all manufacturing have found that the levels of innovation and research and development differ by industry and are related to plant size and country of control (Baldwin 1997a, Baldwin 1997b, Baldwin and Da Pont 1996, Baldwin and Gellatly, 1998).

[5] In alphabetical order, the seven major industries, as defined by their respective SIC 4-digit industries, are:

Bakery - biscuits (1071) and bread and other bakery products (1072)
Cereal - cereal grain flour (1051), prepared flour mixes and cereal foods (1052), and feed (1053)
Dairy - fluid milk (1041) and other dairy products (1049)
Fish - fish products (1021)
Fruit and vegetable - canned and preserved fruits and vegetables (1031) and frozen fruits and vegetables (1032)
Meat - meat and meat products (except poultry) (1011) and poultry products (1012)
Other - vegetable oil mills (except corn oil) (1061), cane and beet sugar (1081), chewing gum (1082), sugar and chocolate confections (1083), tea and coffee (1091), dry pasta products (1092), potato chips, pretzels and popcorn (1093), malt and malt flour (1094) and other food products (1099).

2.0 Innovation and Technological Competency

Innovation is a key element of technological competency. Technological competency is rooted in the overall strategies of the firm for dealing with the challenges and opportunities presented by its economic and market environment. For example, rapidly changing consumer preferences would imply the need for new product development while intense price competition would put more emphasis on new processes to enhance productivity. The adoption of business practices (such as continuous quality improvement, benchmarking and just-in-time delivery) influences the need for new technology, the effectiveness with which it is used and the way that it is obtained. Thus technological competency is more than the use of advanced technologies and includes effective innovative behaviour.

This chapter describes the level of innovation in the food processing industry and examines the relationship of innovation to the use of advanced technologies, technological competitiveness, business practices and strategies. It thus indicates the importance of innovation to the firm and places innovative activities in the context of overall firm behaviour. It also provides the linkage between technological competence as examined in the first phase of this overall study (Baldwin, Sabourin and West, 1999) and the behaviour of innovators and non-innovators.

Innovators are plants that made a major product or process innovation in the three years preceding the survey (1995-1997) and non-innovators are plants that did not done so. While 'non-innovators' may well have made innovations in the past and may be engaged in some innovative activities, recent innovators are expected to be more active in this regard as well as more successful. We are particularly interested in process innovation because it is expected to be the most directly associated with the use of advanced technology.

This chapter on innovation and technological competency has six sections:

- Product and process innovation rates
- Innovation and use of advanced technologies
- Innovation and technological competitiveness
- Innovation, technology strategies and business strategies
- Innovation and business practices
- Summary

2.1 Product and process innovation rates

Product and process innovations are of three types:

- Product only
- Product requiring a process innovation
- Process only

In the three years preceding the survey, nearly 70% of establishments made a major product innovation of some type and 60% a major process innovation of some type. Of course, many introduced more than one innovation and more than one type. For example, 31% made seven or more product innovations and 19% made seven or more process innovations. One reason for the greater popularity of product innovation is that new products are more easily licensed than new processes. Information asymmetries make it relatively difficult to obtain returns to process innovations other than through own-firm production (Cohen and Klepper, 1996).

Innovation rates differ by individual food industry, size of plant and country of control

(Baldwin, Sabourin and West, 1999, and Table 2A). The 'other', fruit and vegetable and dairy industries lead in most categories of innovations. The bakery industry is among the leaders in product innovation but trails in process innovation. By these measures, larger plants are more innovative than smaller plants, especially for process innovations. Foreign controlled plants are a little more likely than Canadian controlled plants to make product innovations and much more likely to make process innovations. To some degree, these industry, size and control differences are interrelated. For example, foreign controlled plants are larger on average than Canadian controlled plants and industries differ with respect to plant size and degree of foreign control as well as products produced and technological opportunities.

Table 2: Incidence of Product and Process Innovation in the Last Three Years

	Type of Innovation					
	Product-only (a)	Product-process (b)	Process-only (c)	Any product (a or b)	Any process (b or c)	Any innovation (a or b or c)
	percentage of plants[a]					
Food Industry	51	53	36	69	60	72
Sub-Industry						
Bakery	58	51	20	75	52	75
Cereal	44	39	38	59	54	65
Dairy	58	58	40	74	63	78
Fish	32	51	26	61	59	65
Fruit & Vegetables	56	54	41	76	60	77
Meat	47	50	39	61	58	66
Other	64	66	50	81	73	83
Plant Size						
10 - 19	39	39	21	56	43	58
20 - 49	52	50	30	72	57	74
50 - 99	53	53	42	71	64	77
100 - 249	56	62	44	74	70	78
250 or more	60	74	60	81	81	84
Country of control						
Canada	50	52	34	68	58	71
Foreign	59	62	55	75	75	80

[a] Percentage of plants making at least one innovation. Any one plant could make more than one type of innovation.

2.2 Innovation and use of advanced Technologies

While major product and process innovations would not necessarily require the use of advanced technologies, the adoption of such technologies would imply the introduction of a significant innovation. In fact, 95% of process innovators use at least one advanced technology while 77% of process non-innovators do so. In addition, 40% of process innovators use 11 or more of the 61 advanced technologies identified in this study compared to only 11% of process non-innovators. The results are similar for all innovators and non-innovators (Table 3). This similarity of results for process innovation and all product and process innovation is not too surprising given that 83% of all innovators made some type of process innovation. The converse is that advanced technology users are likely to be innovators.[6]

Table 3. Use of Advanced Technologies, by Type of Innovator and Non-Innovator

Number of Technologies	Process[a]		All Types[b]		All plants
	Innovator	Non-innovator	Innovator	Non-innovator	
	percentage of plants				
None	5	23	6	28	12
1 - 5	27	45	29	46	34
6 - 10	28	22	29	16	25
11 or more	40	11	36	10	29
	100	100	100	100	100
At least one	95	77	94	72	88

[a] Process only or product requiring process innovation.
[b] Process only, product only or product requiring process innovation.

Additional evidence of a relationship between innovation and advanced technology use is provided by a multivariate regression analysis which finds that process-only innovation is strongly positively associated with the adoption of advanced technology in the food-processing industry, holding other factors constant (Baldwin, Sabourin and West 1999).

Of course, the motivation for process innovation is to improve plant performance. Plant managers confirm that the adoption of new technologies has positive economic effects, especially through increased productivity, improved products and improved regulatory compliance (Baldwin, Sabourin and West 1999).

2.3 Innovation and technological competitiveness

Food-processing plants that are considered by their managers to be more technologically advanced than their United States counterparts, are more likely to be users of advanced technologies than those considered by their managers to be less competitive.[78] Therefore, given the positive relationship between technology use and innovation, it would be expected that innovators would be more likely to consider themselves to be more technologically competitive.

Survey results indicate that this is the case. For example, 27% of process innovators believe they are technologically more competitive compared to 15% of process non-innovators.

Although there is no difference with respect to those who consider themselves to be less competitive, a relatively small proportion of innovators consider that the question of technological competitiveness is not relevant to them (Table 4).[9] These results indicate the importance of understanding the factors influencing innovation rates, especially in the context of international competition.

Table 4. Technological competitiveness by type of innovator and non-innovator

Technological Competitiveness	Process[a]		All types[b]		All plants
	Innovators	Non-innovators	Innovators	Non-innovators	
	percentage of plants[c]				
Less Competitive	25	26	26	25	26
Equally Competitive	33	26	32	25	30
More Competitive	27	15	26	14	23
Not Applicable	14	33	16	36	22
	100	100	100	100	100

[a] Process only or product requiring process innovation.
[b] Process only, product only or product requiring process innovation.
[c] Percentage of establishments giving a score of 4 or 5 on a 5 point scale where 5 is the use of technology that is much more advanced than that of competitors in the United States.

2.4 Innovation, technology strategies and business strategies

The priority a firm places on innovation is established by the competitive environment and strategies it follows to respond to its environment (Teece 1994). Threats of new competitors and the unpredictability of competitor and consumer actions are among the major sources of uncertainty faced by food processors. Price, quality and service are thus areas of intense competition and key features of competitive strategies (Baldwin, Sabourin and West 1999).

The development and implementation of effective competitive strategies require competencies in the areas of marketing, production, management, human resources and technology. These competencies are generated by both general and specific business strategies. While all strategies are interrelated - for example, innovation priorities will be heavily influenced by marketing strategies - those that most directly related to innovation are technology and human resource strategies.

In this study, plant managers were asked to evaluate the importance of several general and specific technology strategies. There are four general strategies:

- using technology developed by others
- improving existing technologies and processes
- creating new technologies and processes
- accessing R&D facilities

By far the most highly rated strategy, considered to be very important by 67% of all plants and 75% of innovators, is the incremental one of improving existing technologies and processes (Table 5). These results suggest that much process innovation focuses on relatively small improvements.

About 43% and 41% consider that using others' technology and developing new technology are highly important strategies, respectively, indicating that technology transfer is as important to firms as new technology development. At the same time, technology transfer is relatively more important to non-innovators than innovators, perhaps reflecting the costs and risks of undertaking developmental activities. The strategies of creating new technologies and accessing R&D facilities are about twice as important to innovators as non-innovators (Table 5). However, R&D facilities are not the only means of developing new technology (next chapter).

Table 5. Importance of general and specific technology strategies, by type of innovator and non innovator

Strategies	Process[a]		All Types[b]		All Plants
	Innovator	Non-innovator	Innovator	Non-innovator	
	percentage of plants[c]				
General strategies					
Using technology developed by others	47	38	45	39	43
Improving existing technologies/ processes	75	54	73	48	67
Creating new technologies/processes	49	28	47	25	41
Accessing R&D facilities	35	16	34	11	27
Specific strategies					
Use of advanced technologies	47	28	45	24	39
Product innovation	60	37	58	30	51
Research and development	42	27	41	22	36
Use of skilled personnel	62	51	62	48	58

[a] Process only or product requiring process innovation.
[b] Process only, product only or product requiring process innovation.
[c] Percentage of establishments giving a rating of 4 or 5 on a 5 point scale with 5 being extremely important.

There were four specific technology strategies evaluated by plant managers:

- use of advanced technologies
- product innovation
- research and development (R&D)
- use of skilled personnel

Half the managers (51%) consider product innovation to be very important and 39% the use of advanced technologies. Product innovation is somewhat more common than process innovation. Thirty-six percent consider that R&D is a highly important technology strategy, which is in line with the emphasis placed on having access to R&D facilities. As would be expected, innovators put much more emphasis on these specific strategies than non-innovators.

Innovation requires people with appropriate skills to introduce them. In addition, new ways of doing things and doing new things have implications for the number of people employed in various capacities and their respective skill levels. It is not surprising, therefore, that managers put considerable emphasis on human resource strategies. In the context of specific innovation strategies, 58% emphasize the importance of skilled personnel, the highest percentage of the four specific technology strategies and the one with the smallest difference between innovators and non-innovators.

The relative emphasis placed on the individual general and specific technology strategies not only differs between innovators and non-innovators, it also differs by individual industry, plant size and country of control. With respect to the specific strategies, the other and fruit and vegetable industries put the most emphasis on product innovation, the dairy and fruit and vegetable industries on advanced technologies, and the fruit and vegetable industry on R&D. The cereal, dairy and the other industries lead in emphasis placed on skilled personnel.

Larger plants tend to give greater importance to all of these strategies. Foreign-controlled plants are a little more likely to emphasize them than are Canadian-controlled plants (Baldwin, Sabourin and West 1999). These relationships of strategies to industry, plant size and country of control are broadly consistent with the differences among them in innovation rates.

2.5 Innovation and business practices

Business strategies are implemented in part by business practices. This study identified a number of practices in three areas, listed in order of use: product quality, materials management and distribution, and product and process development (Baldwin, Sabourin and West 1999). The first two areas are essentially operational in character. Some require process innovation, including the use of advanced technologies.

Process and product development practices are clearly part of the innovative process with the objective of effectively and efficiently developing and implementing innovations. They also use innovative means such as computer-aided design and process simulation to do so. The use of development practices such as rapid prototyping and concurrent engineering, along with management practices such as total quality management, have increased the linkages among the stages of the innovation process, strengthening the feedback loops (Tassey 1994). In the food-processing industry, continuous improvement and process benchmarking are the two leading product and process development practices (Table 6).

As might be expected, innovators are much more likely than non-innovators to use all of the process and product development practices included in this study (Table 6). For both process innovation and all innovation, the largest difference between innovators and non-innovators is in the use of continuous improvement followed by process benchmarking,[10] the two practices most used by both groups as development tools.

The incidence of use of advanced product and process development practices is positively associated with plant size. Also, foreign-controlled plants are more likely to use them than are Canadian-controlled plants. The other, fruit and vegetable, and dairy industries are above average in the use of these practices (Baldwin, Sabourin and West 1999). These results are consistent with the structural patterns of technology strategies, innovation and the use of advanced technologies.

Table 6. Use of product and process development practices, food-processing industry

Practice	Process[a]		All Types[b]		All Plants
	Innovator	Non-innovator	Innovator	Non-innovator	
	percentage of plants				
Rapid prototyping	18	7	17	4	13
Quality function deployment	33	16	31	15	26
Cross-functional design teams	25	8	22	7	18
Concurrent engineering	23	5	20	4	16
Computer-aided design	24	8	22	8	18
Continuous improvement	70	43	67	38	59
Process benchmarking	43	19	41	15	34
Process simulation	20	11	19	8	16
Process value-added analysis	33	15	30	13	25
Other	1	1	1	1	1

[a] Process only or product requiring process innovation.
[b] Process only, product only or product requiring process innovation.

2.6 Summary

Technological competence requires innovative behavior. Innovation is positively associated with the use of advanced technologies and international technological competitiveness. Innovation is thus important to a plant's success. The results of this study help us to understand better why some plants are more innovative than others.

The priority placed on innovation is reflected in business strategies and more specific technology strategies. Innovators place more emphasis on the importance of all the general and specific technology strategies than non-innovators, although the difference varies by strategy. Plants tend to emphasize incremental change in technology, indicating that relatively small innovations can have an important cumulative effect. They also stress the use of technology developed by others, emphasizing that technology transfer as well as the creation of new technologies is important. The results also indicate that improving employee skill levels is an important part of technology strategies.

Rates of innovation and the effectiveness with which firms use new technologies are influenced by the business practices followed by the ways a firm implements its strategies. In particular, the innovation process can involve the use of advanced technologies in the area of product and process development. Innovators are more likely than non-innovators to use all of the product and process development practices identified in this study, especially continuous improvement and benchmarking.

Innovation rates in the food-processing industry differ by individual food industry and are somewhat higher for larger than smaller plants and a little higher for foreign-controlled than Canadian-controlled plants. The use of advanced technologies and business practices and the priorities placed on general and specific technology strategies differ in consistent patterns by industry, plant size and country of control. These structural factors thus help to explain some of the variation among plants in innovation rates.

Chapter 2 Endnotes:

[6] In terms of advanced technology users, 65% of those plants using at least one advanced technology are process innovators while only 25% of plants using no advanced technologies are process innovators. In addition, the greater the number of advanced technologies used by a plant, the greater the likelihood that it is an innovator (Appendix Table A1).
[7] Managers were asked to compare their production technology with that of their most significant competitors in the United States using a scale of 1 to 5 where 1 was less advanced and 5 was more advanced. The data reported herein are the percentages of plants giving a rating of 4 or 5.
[8] This relationship did not hold at the industry level (because United States plants also vary in technology use).
[9] The corollary result is that more competitive plants are much more likely to be process innovators (73%) than process non-innovators (27%). Also, for technologically less competitive plants, a smaller percentage (59%) are process innovators and a large percentage (41%) are not.
[10] Benchmarking is a way to learn from the experience of others and thus a way to learn about the existence and potential of new technologies, necessary information for innovation. Continuous improvement means an ongoing effort to do better as opposed to periodic drives.

3.0 Innovative Activities

In this study, innovation refers to the commercialization of substantially new products and processes. Innovation is a response to the identification of a product market opportunity or the need for an improved method of carrying out a production, distribution or management process. It requires the capability to identify and to monitor sources of ideas and information and the ability to create or to acquire the technical means to implement them in the form of new products and processes.

Innovation is thus a knowledge-based activity. The knowledge is generated internally or externally and combined with existing knowledge and other resources to produce new products and processes. The required knowledge can be embodied in machinery and equipment and take the form of plans, designs and reports. It is also found in the expertise of basic and applied scientists, engineers, production workers and managers.

The traditional view of the role of knowledge creation in the innovation process has been a linear one. An R&D unit generates, or obtains from outside the firm, scientific information and uses it to develop a new product or process to be given to engineers and production units to implement. The overall process can involve basic and applied research, design work and pilot plant production. More recently, the roles of non-R&D groups have been more fully recognized. The new view is that the knowledge-creation process is more circular in that new approaches often originate with the production and engineering departments. The R&D unit then does the work necessary to understand the scientific principles involved and provides this information to the engineers and production people for implementation. If this is a common approach, focussing only on R&D as the source of innovation would overlook key parts of the process and lead to erroneous conclusions.[11]

No firm can rely solely on knowledge generated internally. External sources include other firms and public or semi-public organizations. Tassey (1994) identifies a 'technology infrastructure' that supports the innovative activities of firms. This technology infrastructure is comprised of elements such as generic technologies, infra-technologies, standards, scientific and technical information and testing methodologies. In any case, whatever approach the firm uses internally to generate innovations, innovation will depend crucially on acquiring and incorporating knowledge from outside the firm. An understanding of the role and relative importance of knowledge/technology transfer in the innovation process is thus required.

Technical knowledge can be transferred through market and non-market mechanisms. The latter are much more important for the transfer of knowledge than for the transfer of most goods. It is difficult to control the flow of ideas and information. People talk to each other and read scientific and technical publications. They also use practices such as reverse engineering to learn how a product is made. Markets (including contracts and licenses) are used for machinery, equipment and services, but even here prices may not reflect full value. Transfers in which a buyer pays less than the good (knowledge) is worth produce a 'spillover', the difference between the value to the recipient and the price paid. International transactions can result in international spillovers. Joint ventures and consortia are ways to minimize spillovers (and spread costs and risks).

McFetridge (1995) identifies the following sources of domestic spillovers. In each case, the assumption is that the benefit received is not fully compensated:

- imitation - product and process imitation could take place as a result of independent R&D (duplication is less costly than the original R&D), reverse engineering, licensing, hiring the innovator's employees, publications, patent disclosures and conversations with the innovator's employees. In addition (or alternatively), the innovator may charge less than the innovation is worth to the user to reduce the incentive for imitation.

- complementarities and interdependence - the innovation stimulates or makes possible the development of new products or processes in other industries. A 'generic' innovation is one for which this is especially true.

- subsequent innovations - current innovators utilize the knowledge embodied in the stock of past innovations. Innovation is a cumulative process.

- demonstration effects - the cost and risk of adopting a new technology is reduced if the experience of early adopters can be accessed.

- learning experience and incubation - employees learn skills transferable to other firms, perhaps their own.

As indicated, spillovers are not limited to the innovator's own industry. Transactions and linkages with suppliers and customers also can produce spillovers.

Of course, firms also obtain technology from foreign sources. Technology is transferred internationally in embodied form (trade in goods) and in disembodied form (plans, papers, meetings). Traditionally these transfers have occurred at arm's length (through the market) or internally (intra-firm). Intra-firm transfers are more likely to be used the greater the investment required to make the transfer, that is, the higher the transaction cost. Intra-firm transfers thus are often associated with novel, complex and non-codifiable technologies. Additional transfer methods include licenses and joint ventures. In each case, spillovers can occur and the choice of method would be influenced by the desire to minimize them (McFetridge 1995). Mergers and acquisitions are also used.

International transfers of technology also result from the international use of R&D itself. Alliances, consortia and networks are ways that firms reduce duplication and attempt to internalize domestic and international R&D externalities (McFetridge 1995). Foreign direct investment also is a method used to maintain control.

In brief, given that technological competence is an important business strategy of a firm, its implementation involves a number of activities. First, information on technological opportunities must be obtained. Then, a decision is needed on whether to buy, adapt or develop the new technology, and each of these options can be achieved in more than one way.

This chapter examines how food-processing plants/firms carry out these steps and the interrelationships among them. The focus is on process innovation, that is, the adoption of a technology new to the plant or firm where technology is defined broadly to include the technical means and know-how required to produce a product or service. Technology takes the form of equipment, materials, ingredients, processes, blue prints and knowledge.

External sources of technology and knowledge are classified into three groups corresponding to the primary way in which knowledge is obtained from them:

- the sector market - the suppliers of goods and services to the firm, the firm's customers, other processors and joint ventures/alliances. Technology is transferred from these firms in several ways but primarily in the form of, or associated with purchases of machinery, equipment and other products and services.

- the technology services market - consultants, industrial research firms and private institutes. The technical knowledge generated by these firms is market-priced but primarily transferred in the form of information and advice as opposed to equipment.

- the non-market - non-market sources of generic, non-rivalrous knowledge including private organizations (industry associations) and information-based sources such as publications, trade fairs and conferences. It also includes public or semi-public organizations, namely universities and government research organizations. For some purposes public organizations might be considered a separate category since technology transfers from them can involve various forms of technology and involve payments, contracts and joint undertakings. In addition, the role of these organizations is of particular interest to public policy.

Technology can be transferred through market mechanisms but only imperfectly with the result that spillovers occur. Spillovers are associated with all of these categories but especially with the non-market group.

This chapter on the innovative process has three main sections:

- Overview of innovative activities
- Differences in activities between innovators and non-innovators
- Summary

3.1 Overview of innovative activities

This section provides an overview of innovative activities in the food-processing industry as a whole. It focuses on technology development and transfer domestically and internationally. This sections has five parts:

- Information on new technologies
- Methods of introducing new technologies
- Development of new technologies
- Acquisition of new technologies
- Relationship among innovative activities

3.1.1 Information on new technologies

Innovation requires obtaining and assimilating ideas and technical information. Depending on firm priorities, the information sought could focus on new products, new technologies or more basic scientific developments.

Food-processing firms give top priority to the systematic collection or monitoring of information on new products, closely followed by information on new technologies. Fifty-three percent of plant managers rate information on new products as highly important and 49% rate information on new technologies as highly important. Fewer participants (33%) stress information on new scientific developments this highly. In addition, 37% consider that the systematic collection of information on skilled personnel is very important. These scores indicate that the emphasis is on applied knowledge.

Information can be obtained from internal (within the firm) or external sources. In each case, the sources can be located within or outside Canada. This part examines the relative importance of these sources.

Internal sources

Internal sources of ideas and information include head office and related plants. About two-thirds of food processing plants get ideas for new technologies from head office and one-third from related plants. These figures indicate that being part of a multi-plant firm is an advantage in learning about technological opportunities (Table 7).[12]

More specifically, internal sources of ideas are departments or groups such as research, development, design, production engineering, production staff, technology watch group and sales/marketing. By far the most important internal sources of ideas for the adoption of new technologies are production staff and the sales/marketing department. They are each used by nearly two-thirds of plants, while about half of all plants get ideas from research and development groups, respectively. This result supports the non-linear model of innovation discussed above. However, only 18% of all plants use technology watch groups, a formal way to co-ordinate efforts and facilitate intra-firm diffusion (Table 7).

These internal sources also are channels for the international transfer of knowledge although in this regard they are relatively unimportant. About 10% of plants obtain ideas from head offices and related plants located outside Canada, respectively. Production staff are among the least important international transfer mechanisms, although their ideas may contribute via the research, development and design groups (Table 7).

Table 7. Internal sources of ideas for new technologies, domestic and foreign

Source	Location		
	All locations	Canada only	Foreign[a]
	percentage of plants		
Head Office	64	55	9
Related Plants	34	24	10
Functional Unit:			
Research	46	34	13
Development	46	35	12
Design	33	22	11
Production Engineering	42	32	10
Production Staff	65	60	5
Technology Watch Group	18	14	4
Sales/Marketing	62	51	11
Other	3	2	1

[a]In this and other tables (unless otherwise specified), foreign is not foreign only. Relatively few plants use foreign sources exclusively.

External sources

As discussed above, external sources of technology are classified into three groups: the sector market, technology services market and the non-market.

Sector market plants are the leading sources of information. About two-thirds of the plants obtain technical information from suppliers (65%) and customers (61%), and nearly half (47%) from other processors (Table 8). The transfer of ideas and information is thus closely associated with purchases and sales of machinery, equipment and other goods. These transactions would include associated services. Spillovers would be involved - presumably a relatively high proportion of the information flow from customers and perhaps other processors.

Non-market sources also are important, especially trade fairs and conferences and publications. Trade fairs and conferences are used by 60% of plants. Universities and governments are sources of ideas for only 28% of plants (Table 8). This relatively low use may reflect the relatively basic or generic nature of university results compared to the industry's emphasis on applied results. Of course, these sources are more important than this result would indicate in that much of the information obtained by industry from publications, trade fairs and conferences would originate with them.

Table 8. External sources of ideas for new technologies, Canadian and foreign

Source	Location		
	All locations	Canada only	Foreign
	percentage of plants		
Sector market			
Suppliers	65	39	26
Customers	61	39	21
Other processors	47	29	18
Technology services market			
Industrial research firms	23	16	7
Consultants and service firms	43	32	12
Non-market			
Publications	53	26	27
Trade Fairs, conferences	60	25	35
Industry associations	39	24	16
Universities	28	20	7
Federal or provincial research organizations	28	24	3
Other	2	1	1

While in all cases domestic sources are used by more plants than foreign sources, the latter make an appreciable contribution. The most frequently used external foreign-based information sources are trade fairs and conferences followed by publications and suppliers. These results, especially the importance of the non-market sources, indicate that international spillovers contribute significantly to technological change in Canada's food-processing industry.

Relationship between internal and external sources

The results indicate that internal and external sources of information are of more or less equal importance. Internally some 60-65% of plants obtain ideas from head office, production staff and sales/marketing staff, while externally about the same proportion obtain ideas from suppliers, customers, and trade fairs and conferences. Since external contacts would require knowledgeable plant or firm personnel, it might be expected that plants that are more active internally would also be more active externally.

3.1.2 Methods of introducing new technologies

Having learned about a new technology, there are three basic methods of introducing it:

- buy it ready to use
- buy it and adapt it to plant requirements
- develop it

Purchases (of equipment, documents, blue prints, or designs) are part of the process by which new technology is disseminated among plants/firms within and across industries and transferred from one country to another. The adaptation of purchased technologies and the creation of new ones imply a design and engineering and/or research and development capability.

Both the opportunity to buy new technologies and the ability to either adapt or develop new technologies are important to the food-processing industry. Any one plant could, of course, use more than one method of introducing new technologies and survey results indicate that this is the case. Fifty-nine percent of plants buy ready-to-use process technologies and 50% adapt purchased technologies to their own use. The latter are acquired mostly from unrelated firms. Forty-six percent develop their own process technologies, either within their own firm or with other firms (Table 9).

Table 9. Methods of introducing new process technologies, by source

Methods	Geographic Source		
	All locations	Canada only	Foreign
		percentage of plants	
Buy ready to use	59	27	32
Adapt purchases			
from all firms	50	26	23
from unrelated firms	33	13	19
Develop new technology			
by own or other firm	46	30[a]	17
by own firm	41	31	10
with other firms	29	16	13

[a] In this and similar tables, this percentage refers to firms that do development work in-house and/or with other firms but only in Canada.

The importance of international technology transfer is indicated by the significant role that foreign sources play in the introduction of new technologies to Canadian plants. Foreign sources are relatively most important for purchases of ready-to-use technologies and technologies requiring modification when the purchases are made from unrelated firms; in both cases more plants use foreign-based sources (exclusively or as well as Canadian-based sources) than rely solely on Canadian sources (Table 9).[13] The importance of foreign sources for new technology no doubt reflects the small size of the domestic food processing machinery and equipment industry; the global machinery and equipment manufacturers are located in other countries.

Although acquisition is the leading method for introducing new technologies, nearly half the plants create them. This is done in-house and/or with other firms. More plants (41%) develop new process technologies within the firm than do so in conjunction with other firms (29%). Development activities are mostly located in Canada, although within-firm development (e.g. in own facilities or subsidiaries located abroad) and joint development with others are done outside Canada by some 10-13% of plants (Table 9). Thus, in addition to technology acquisition, technology creation is an important mechanism for technology transfer both within Canada and from other countries.

The adoption of new technologies often is associated with the introduction of new products. In the food-processing industry, 53% of plants report having made at least one product innovation requiring a process innovation in the previous three years. Analogous to the adoption of new processes, new products can be purchased, purchased and modified, or developed. Only 15% of plants simply purchase (from related or unrelated firms) the right to produce a product while 35% purchase the rights to an existing product and modify it. By far the most common approach, an approach followed by 63% of all plants, is to develop new products, either alone or with other firms. The relative importance of new product development is in contrast to process innovation where acquisition is more common. This difference in method could reflect the need to differentiate one's products from those of competitors and the need for confidentiality.

3.1.3 Technology development

The ability to create new technologies, alone or with others, would be expected to give a firm a competitive edge. It implies that the technology will meet a specific need and, in particular, it will not be available to other firms, at least not immediately.

This part focuses on the development of new technologies. It first describes the sources of technology development capability and their use in the food-processing industry. It then examines in more detail the R&D activities of firms in the industry, including who performs them and where.

Sources of technology development capability

Whether new technologies are developed within the firm or with others, is determined by the resources and strategies of the firm and the nature of the development. In both cases, options are available. For example, within the firm it could carry out development activities in its own research unit, development unit or production group. The choice would partly depend on where the work to be done falls on the basic-to-applied continuum; each of these units has its unique perspectives on problems and opportunities and expertise for dealing with them.

If done outside the firm, technology development could be done by suppliers, consultants, customers, public institutions or other producers in the industry. These sources would have different interests and associated competencies. For example, suppliers might be more process-oriented and customers more product-oriented.

Using outside sources gives rise to concerns about control over the technology produced, concerns that would differ by source. For example, government, public institutes and universities would be more suitable for relatively generic R&D as opposed to proprietary R&D. This suitability is based on their expertise and mandate to make results widely available at little or no cost to users compared to their cost or value. In some cases, control can be increased for a period of time by confidentiality agreements.

The development of new products and processes is not limited to the work of an R&D unit. Internal contributors to new processes and technologies are the research unit, development unit, and production group and include head office and related firms. In the food-processing industry, the most important internal contributor to technology development is the production group (58%). Only 5-10% of plants report that the internal development activities of these groups take place outside Canada (Table 10).

External contributors to technology development can be classified in the same way as information sources. Sector market firms, especially suppliers, are the most commonly used by food processors to develop new technologies. Suppliers are used by 56% of plants while customers are not far behind at 48%. Non-market collaborators (governments, institutes, universities) are used by 30% of plants. Collaborators located outside Canada are used, but much less so than domestic ones (Table 10).

Table 10. Internal and external contributors to technology development, domestic and foreign

Contributor	Location		
	All locations	Canada only	Foreign
		percentage of plants	
Internal			
Research Unit	44	35	9
Development Unit	43	36	7
Production group	58	53	5
Head Office or Related Firms	38	28	10
External			
Sector market			
Suppliers	56	40	16
Customers	48	36	13
Other Processors	30	21	9
Other Firms' R&D or Production Units	19	13	6
Technology Services Market			
Consultants	44	33	11
Non-market			
Government/Institutes/ Universities	30	25	5
Other	1	-	-

Research and development

Although firms in the food-processing industry (and other industries) clearly use a variety of ways to develop new technologies, a strong R&D program is often considered to be a key requirement for a firm wanting to have a technological advantage over its competitors. In addition, government policies often focus on R&D as a key area for improving the performance of the economy. R&D is a mechanism for technology transfer domestically and internationally.

There are three options to perform R&D:

- in-house
- jointly with another firm
- on contract

These options clearly differ with respect to the ability to control the knowledge generated, cost and access to the expertise and resources of others. Of course, any one firm could use more than one method. Sixty-seven percent of all plants belong to a firm that has an R&D program, that is, the firm follows at least one of these options.

More specifically, 60% of plants belong to a firm that does R&D in-house, 29% jointly with another firm and 22% on contract. By far, most R&D is located in Canada. At the same time, of those plants with an R&D program, 14% do development work outside the country jointly with another firm and 12% outside the country in their own firm, (Table 11). R&D programs are thus one way that technology is not only generated but also transferred within and outside Canada.

Table 11. Internal and external R&D programs, Canadian and foreign location

R & D Program	Location		
	All locations	Canada only	Foreign
		percentage of plants	
All plants			
In-house	60	50	9
Jointly with another firm	29	21	8
Contract out	22	18	3
Plants with an R&D program			
In-house	89	76	14
Jointly with another firm	44	31	12
On contract	33	28	5

The scope of R&D programs is indicated by their objectives. This study identified five objectives:

- the creation of original equipment or process technology
- substantial adaptation of technology
- minor adaptation of technology
- the creation of original products
- the adaptation of existing products

Objectives reflect broader strategies such as improving productivity and expanding markets. For example, productivity could be improved by creating new technologies or adapting existing ones. The degree of adaptation could be substantial or minor. In addition, an R&D program could have the objectives of creating original products or adapting existing products. In each case, the activity could be done in the firm, with a related firm, with an unrelated firm or with a public R&D institution/university. Again, the means used has implications for technology transfer within and across industries in Canada and internationally.

R&D is substantially more likely to be directed at product innovation and minor adaptations of process innovations than it is to be directed at major adaptations or the creation of new technologies. For about 90% of those plants that have an R&D program, the objectives are to modify existing products and to create new ones. Nearly as many (84%), have the objective of making minor adaptations of technology. About 70% of R&D programs have the objectives of substantial adaptations of technologies and the creation of original technology, respectively. Of course, any one program could have more than one objective and many clearly do (Table 12).

Table 12. R&D objectives during the last five years, in own firm and/or with collaborators

Objectives	Own Firm	Collaborator: Related firm	Collaborator: Unrelated firm	Collaborator: Public R & D institution[a]	At Least One Way
	percentage of plants[b]				
Creation of original equipment or process technology	65	22	19	22	73
Substantial adaptation of technology	61	18	16	15	67
Minor adaptation of technology	80	26	18	16	84
Creation of original products	85	30	22	18	88
Adaptation of existing products	88	32	18	16	90

[a] Including universities
[b] Percentage of plants whose firm has an R&D program

An in-house program is by far the most common method used for all objectives, about three times more common. Where a collaborator is used, there is little difference in the choice of collaborator for any one objective or among objectives; in most cases each collaborator is used by 15-20% of plants. The main exceptions are greater reliance on a related firm than an unrelated firm or a public institution for R&D on products and for R&D on minor changes to technology (Table 12). Preference for a related firm for product development and minor modifications of technology would be based partly on concerns for confidentiality and control. Awareness of the need for change and convenience also might favour use of a related firm for doing R&D on minor changes to technology.

3.1.4 Technology acquisition

While the ability to develop original technology can provide a competitive advantage, R&D is an expensive and risky activity. In most cases, the only practical alternative is acquisition and it is the most common method for improving technology in the food-processing industry.

New technologies can be acquired internally from other parts of the overall firm or externally through market and non-market sources. Acquisitions can be made directly by methods such as purchasing and leasing, and less directly through mechanisms such as mergers and staffing. This part examines the sources of technology acquisitions and the methods used.

Sources of acquisition

From the point of view of an establishment or subsidiary firm, internal sources of technology acquisition are head office and related firms. These sources are used by 37% of plants. Eleven percent of all plants obtain them from a head office or related firm located outside Canada (Table 13).

Table 13. Internal and external sources of new technology acquisitions, Canadian and foreign

Sources	Location		
	All locations	Canada only	Foreign
		percentage of plants	
Internal			
Head Office or Related Firms	37	26	11
External			
Sector market			
Suppliers	69	42	27
Customers	41	27	14
Other Processors	41	27	14
Non-market			
Government/Institutes/ Universities	27	22	4
Other	1	1	-

Not surprisingly, suppliers are the most important source of new technology acquisitions. Approximately 70% of plants acquire new technologies from them. The other sector market sources - customers and other processors - are each used by about 40% of all plants, about equal to the use of internal sources of acquisitions.

While few plants rely exclusively on foreign-based sector market sources, such sources are important. In particular, while 42% of all plants use only Canadian-based suppliers, 27% obtain new technologies from suppliers located outside Canada, again emphasizing the importance of international technology transfer.

Although public organizations are a significant source of new technology acquisitions (27%), they are the least commonly used.

Methods of acquisition

There are six methods for acquiring new technologies:

- leasing or purchasing equipment
- transfer agreements such as licenses and patents
- joint ventures or alliances
- mergers and acquisitions with firms owning the technology
- transfer of skilled personnel
- reverse engineering

These options differ with respect to cost, financial risk and control. The choice of method also depends on the opportunities available at any point in time.

In the food-processing industry the most common method for both internal and external transactions is leasing or purchasing (45%). Very few use reverse engineering, while the others are each used by 15-20% of plants. The transfer of personnel is the second most commonly used method of technology acquisition internally but one of the least used externally (Table 14).

Table 14. Methods used to acquire technologies, by source

Method	All firms	Source: Related firms only	Source: Other firms only	Source: Related & other firms
	percentage of plants			
Leasing or purchasing equipment	45	16	23	6
Transfer agreements (e.g. licenses, patents)	16	8	6	2
Joint venture/Alliances	19	8	8	3
Mergers/Acquisitions	15	7	5	2
Transfer of skilled personnel	20	14	4	2
Reverse engineering	5	3	2	1
Other	-	-	-	-

3.1.5 Relationships among innovative activities

Each of the three innovative activities (obtaining ideas and information on new products and production processes, acquiring and developing them) utilizes a diverse set of sources. At the same time, we have seen that the sources used are often the same, no doubt reflecting the interdependence among the activities themselves. For example, discussions with suppliers on a particular acquisition could lead to ideas for other technologies and joint development work.

For the industry as a whole, production engineers and staff share the lead with head office and related firms as internal sources of information and they also are the leading internal contributors in the development process. Head office and related firms are more important as information sources than as sources of technology development and acquisition.

Suppliers are the leading external source of all three activities with customers and other processors playing an important role in all three. Except for suppliers as a source of acquisitions, these sources also are less commonly used for technology development and acquisition than for information. Public institutions (infrastructure) are a lesser but significant participant with about 30% of plants using them in all three activities. While internal research and development units are important, they clearly are not the only or primary participants in the innovative activities of most food processing firms (Table 15).

Table 15. Relationships among sources of information, technology development and technology acquisition

Source	Information[a]	Technology Development	Technology Acquisition
		percentage of plants	
Internal			
Research Unit	46	44	
Development Unit	46	43	
Production Group	65+	58	
Head Office or Related Firms	64+	38	37
External			
Suppliers	65	56	69
Customers	61	48	41
Other Processors	47	30	41
Consultants	43	44	
Government/Institutes/Universities	28+	30	27

[a] Trade fairs and conferences, publications and industry associations are omitted from this table. Plus signs indicate the percentage is at least this high; see greater detail in earlier tables.

In the great majority of cases, innovative activities have sources or take place in Canada. However, as indicated in earlier sections, foreign sources are not insignificant and provide an indication of the contribution of international transfers of technology to the Canadian industry. The role of multinational firms in this process is examined in Chapter 5.

3.2 Differences in activities between innovators and non-innovators

A key question is how differences in the innovative activities of firms influence their rate of innovation. One way to investigate this is to compare the behavior of innovators with non-innovators. Innovators are those who have made an innovation within the three-year period preceding the survey, that is, over the 1995-1997 period. Although many if not all plants would be innovators over a longer period, the premise is that plants that have made innovations relatively recently would be more likely than others to participate in the innovative activities included in this study. The study thus looks at how innovators differ from non-innovators in the relative degree to which they utilize the various sources of information, technology development and technology acquisition. Again, the focus is on process innovation, although some attention is also given to product innovation.

This section has four parts:

- Information sources
- Methods of introducing new technologies
- Technology development
- Technology acquisition

3.2.1 Information sources

Process innovators make appreciably more use of all the information sources, internal and external, than do process non-innovators.[14] The largest difference is in the use of trade fairs and conferences: 72% of innovators use them compared to 41% of non-innovators. The next largest differences are in the use of internal research, development and production engineering units and the external use of suppliers, although several others are close behind. The smallest (absolute) difference is in the use of universities, government research organizations and industrial research firms. These sources are the least used by both innovators and non-innovators and in relative terms these differences between innovators and non-innovators are similar to those for many of the other sources (Tables 16 and 17).

In addition, innovators are more likely to use foreign-based information sources in all cases except public organizations. In the latter case, foreign sources are little used by both innovators and non-innovators (Tables 16 and 17).[15]

Table 16. Internal sources of ideas for new technologies, by process innovators and non-innovators

Sources	All locations		Foreign	
	Innovators	Non-innovators	Innovators	Non-innovators
	percentage of plants			
Head office	71	52	11	5
Related plants	39	26	13	6
Functional unit:				
Research	57	30	15	10
Development	57	30	13	9
Design	41	22	14	7
Production engineering	52	27	11	7
Production staff	74	52	6	3
Technology watch group	23	11	6	3
Sales/Marketing	70	50	14	6
Other	3	3	1	1

Table 17. External sources of ideas for new technologies, by process innovators and non-innovators

Sources	All Locations		Foreign	
	Innovators	Non-innovators	Innovators	Non-innovators
	percentage of plants			
Sector market				
Suppliers	75	51	32	18
Customers	69	48	26	14
Other processors	54	35	23	12
Technology services market				
Industrial research firms	27	17	9	4
Consultants and service firms	50	34	15	7
Non-market services				
Publications	61	41	34	16
Trade fairs, conferences	72	41	43	21
Industry associations	46	30	19	11
Universities	31	23	7	7
Federal or provincial research organizations	32	22	3	3
Other	2	2	1	1

3.2.2 Methods of introducing new technologies

For both process innovators and non-innovators the most important method of introducing new technologies is to buy ready to use, next buy and adapt to own needs, and finally develop the new technology. Almost 70% of process innovators buy ready to use, 60% adapt purchases and 58% develop new technologies, compared to 43%, 34% and 28% of non-innovators, respectively. In addition, innovators are more likely than non-innovators to use foreign sources (Table 18).

Table 18. Methods of introducing new process technologies, by source, process innovators and non-innovators

Method	All Locations		Foreign Locations	
	Innovator	Non-innovator	Innovator	Non-innovator
	percentage of plants			
Buy ready to use	69	43	39	21
Adapt purchases:				
From all firms	60	34	31	12
From unrelated firms	41	20	25	11
Develop new technology				
By own or other firms	58	28	22	9
By own firm	52	25	13	5
With other firms	36	18	17	7

With respect to product innovation, recent product innovators are about twice as likely as non-innovators[16] to use the respective methods of introducing new products:

- purchasing production rights
- adopting purchased products
- developing new products

However, unlike the case of process innovation, both product innovators and product non-innovators place the greatest emphasis on the development of new products and the least emphasis on acquisition (Table 19). This factor could reflect the need to differentiate one's products from those of competitors.

Table 19. Methods of introducing new products, product innovators and non-innovators

Method	All Plants	Product Innovators	Product Non-Innovators
		percentage of plants	
Purchasing production rights	15	17	10
Adopting purchased products	35	41	22
Developing new products	63	74	37

3.2.3 Technology development

In technology development, the largest difference between innovators and non-innovators is in the greater use by innovators of the production group, followed by their greater use of research and development units (Table 20).

Table 20. Internal and external contributor to technology development, domestic and foreign, by process innovators and non-innovators

Contributor	All Locations		Foreign	
	Innovators	Non-innovators	Innovators	Non-innovators
	percentage of plants			
Internal				
Research unit	53	30	12	5
Development unit	53	27	9	4
Production group	70	40	7	3
Head office or related firms	44	28	12	7
External				
Sector market				
Suppliers	64	44	21	8
Customers	53	41	16	7
Other Processors	32	26	10	7
Other firms' R&D production units	24	13	8	4
Technology services market				
Consultants	52	32	15	5
Non-market				
Government/Institutes/ Universities	35	23	5	4
Other	1	1	-	-

With respect to R&D, 82% of process innovators have an R&D program of some type compared to only 44% of process non-innovators. The largest difference is for an internal R&D program; 74% of process innovators have an in-house R&D program while only 37% of non-innovators do so. For external R&D programs, the difference is substantial but smaller. The corresponding picture for product innovators and non-innovators is quite similar (Table 21). Eighty-one percent of product innovators and 35% of non-innovators have an R&D program of some type. These results confirm the importance of R&D in the innovation process.

Table 21. Internal and external R&D programs, domestic and foreign, process and product innovators and non-innovators

R & D Programs	All Locations		Foreign	
	Innovator	Non-innovator[a]	Innovator	Non-innovator[a]
	percentage of plants			
Process innovators:				
In-house	74	37	13	4
Jointly with another firm	37	17	12	3
On contract	28	12	5	1
Product innovators:				
In-house	73	30	11	5
Jointly with another firm	35	16	10	4
On contract	27	9	4	1

[a] Process and product non-innovator, respectively

3.2.4 Technology acquisition

The major difference between innovators and non-innovators in technology acquisition is in their use of suppliers. Suppliers are the most common source for the acquisition of technologies and suppliers are used by 77% of innovators and 57% of non-innovators (Table 22).

Table 22. Internal and external sources of new technology acquisitions, domestic and foreign, by process innovators and non-innovators

Sources	All Locations		Foreign	
	Innovator	Non-innovator	Innovator	Non-innovator
	percentage of plants			
Internal				
Head office or related firms	41	30	13	7
External				
Sector Related				
Suppliers	77	57	34	16
Customers	45	35	17	8
Other processors	44	36	17	10
Public organizations				
Government/Institutes/ Universities	30	21	5	4
Other	1	1	0	1

Innovators and non-innovators also differ in their methods used to acquire technologies. The main differences are in the percentages of plants leasing or buying equipment and using joint ventures or alliances to acquire new technologies. Innovators also are more likely to use foreign sources, especially when leasing or purchasing equipment (Table 23).

Table 23. Methods used to acquire technologies, by source, by process innovators and non-innovators

Methods	All Locations		Foreign	
	Innovator	Non-innovator	Innovator	Non-innovator
	percentage of plants			
Leasing or Purchasing Equipment	55	30	35	18
Transfer agreements (e.g. licenses, patents)	20	9	11	5
Joint ventures/Alliances	27	7	15	4
Mergers/Acquisitions	19	9	10	4
Transfer of skilled personnel	23	14	7	4
Reverse engineering	8	2	4	1

3.2.5 Relationships among innovative activities

Like the food-processing industry as whole, individual plants use the same sources for obtaining ideas and information, technology development and technology acquisition. The relative importance (ranking) of the sources is the same across the uses, while the importance (absolute frequency of use) of a source differs by activity. These general results also apply to both process innovators and non-innovators, with both groups giving the same ranking (Table 24).

Table 24. Sources of information, technology development and technology acquisition, recent process innovators and non-innovators

Sources	Innovators			Non-Innovators		
	Information[a]	Technology develop.	Technology acquisition	Information[a]	Technology develop.	Technology acquisition
	percentage of plants					
Internal						
Research unit	57	53		30	30	
Development unit	57	53		30	27	
Production group	74+	70		52+	40	
Head office or related firms	71+	44	41	52+	28	30
External						
Sector related market						
Suppliers	75	64	77	51	44	57
Customers	69	53	45	48	41	35
Other processors	54	32	44	35	26	36
Technology services market						
Consultants	50	52		34	32	
Non-market						
Government/Institutes /Universities	32+	35	30	22	23	21

[a] Trade fairs and conferences, publications and industry associations are omitted here. Plus signs indicate the percentage is at least this high; see greater detail in earlier tables.

3.3 Summary

Innovation is a complex and risky process. The steps in this process range from basic and applied research through design and engineering, pilot plant production and full implementation, with feedback loops throughout. This chapter focused on the methods used by process innovators to obtain information on innovative opportunities, to acquire new technologies and to develop them. The ways in which these activities are carried out define the ways that technology is developed and transferred domestically and internationally. Innovation is related to technological competitiveness. The findings of this study thus should be of interest to firms in the industry wishing to assess their own approaches and to public policy makers.

Sources of information, acquisitions and developmental capability can be internal or external to the firm. While R&D units are important internal sources used for information and development, the most important source is the production group (engineers and staff). Head office is an important internal source for all three activities, especially information. The involvement of all of these groups illustrates the range of information and capabilities that needs to be coordinated in the innovative process.

External sources used in some or all these activities are the sector market (suppliers, customers, other processors), the technology services market (industrial research firms, consultants and service firms) and the non-market (publications, trade fairs and conferences, industry associations, universities and government organizations). Technology is basically knowledge. Therefore, it is difficult for creators of technology to control fully its use and markets for it are imperfect; 'spillovers' are common, especially for the more generic forms of knowledge. Spillovers occur for all three categories of external sources but especially the non-market sources. They are thus an important mechanism of technology transfer, although they also reduce the incentive for private technology creation.

Food processors tend to emphasize applied knowledge. By far the most important external source for information, technology development and technology acquisition is suppliers. While significant, the least used is the public or quasi-public sector (governments, institutes and universities). This low ranking may reflect the basic or generic nature of many of their results which feed into the work of the other sources.

The ranking of the several external sources in terms of usage rates, at least where applicable, is the same for the three innovative activities, suggesting that the activities are broadly complementary. The use of external sources presupposes a certain level of in-house expertise to identify and use such sources appropriately.

The Canadian food-processing industry benefits from international transfers of technology. Sources located outside Canada are especially important for generic information and technology acquisition, reflecting the global nature of the food industry and its suppliers.

R&D programs are important to the innovation process. Two-thirds of plants report an R&D program, mostly in-house. Objectives include both the creation and modification of products and processes, especially products, and minor adaptations of technology. The latter would reflect the emphasis of firms on incremental technological change and the need to adapt purchased technology to plant requirements.

As would be expected, process innovators are much more likely than process non-innovators to undertake all of these activities. The use of innovative activities by non-process innovators is not an anomaly. Probably all firms would have at least investigated the possibilities and made some type of innovation in the not too distant past. Also, some process non-innovators are product-only innovators. The more interesting results are that process innovators are especially more likely to be innovative in four ways:

- obtaining information from trade fairs and conferences
- making use of the production group for technology development
- having an in-house R&D program
- acquiring new technologies from suppliers

Innovators also are more likely to use foreign-based sources than are non-innovators.

The differences between innovators and non-innovators emphasize that the innovative activities examined in this chapter influence the rate of innovation in the food-processing industry. At the same time, they raise the question of why an appreciable portion of the industry lags others in efforts to be innovative. In part, this lag would be related to differences in strategies and practices discussed earlier. It also may be related to differences as related to firm and industry structure and to impediments to technological change.

Chapter 3 Endnotes:

[11] For detailed discussions of the stages of innovation and the innovative process see Baldwin and Hanel 1999, Mahdjoubi 1996, Mowery and Rosenberg 1989, Stoneman 1996 and Tassey 1994.
[12] In this and other cases, any one plant could use more than one source, method, etc.
[13] For most methods of technology acquisition, few plants only use foreign sources. Ready-to-use technology is an exception in that about a quarter of plants use foreign sources only.
[14] When speaking of process innovators versus non-innovators, the latter category includes firms that made a product innovation not requiring a process innovation. They could also have made process innovations prior to the designated three-year period and could do so in the future.
[15] Differences between all innovators (product and process) and all non-innovators in the use of internal and external information sources are present in much the same way as the differences between process innovators and process non-innovators (Appendix Tables A2 and A3).
[16] In this case, non-innovators include those firms that introduced a process innovation not involving a new product.

4.0 Innovative Activities and Industry Structure

Indicators of technological competence and rates of innovation tend to be higher for foreign-controlled plants and larger plants. They also differ by individual food-processing industries, being relatively high in the dairy, fruit and vegetable, and the other industries (see Chapter 2). This chapter examines the differences in technology development and technology acquisition and has four main sections:

- Innovative activities by country of control
- Innovative activities by plant size
- Innovative activities by industry
- Summary

4.1 Innovative activities by country of control

Multinational firms are widely recognized as major creators of advanced technologies and important conduits by which technologies are transferred internationally (Blomstrom and Kokko 1997, Caves 1982, Dunning 1993). Such firms tend to be large and have the expertise and financial resources to be leaders in the development of new technologies. One motivation for foreign direct investment is to exploit more fully the advantages of new technologies by using them in other countries while maintaining control over them. This also applies to the food-processing industry (Vaughan 1995, Vaughan et al. 1994).

Foreign multinational firms play an important role in the Canadian food-processing industry. Although foreign-controlled plants are only 11% of all plants, they account for some 40% of the value of industry shipments. They are relatively large plants and are found in all of the individual food-processing industries, especially the cereal, fruit and vegetable and the other industries. In addition, they are leaders in the industry in the use of many advanced technologies and business practices (Baldwin, Sabourin and West 1999).

This section on the role of multinational firms has five parts:

- Information sources
- Methods of introducing new technologies
- Technology development
- Technology acquisition
- Relationships among innovative activities

4.1.1 Information sources

Foreign-controlled plants use information sources more than Canadian-controlled plants. The largest difference is the use of internal sources, where foreign-controlled plants are twice as likely to obtain information from related plants. Among functional units, the largest difference is in the use of the firm's production engineering unit (37 percentage points) followed by research and development units (27 and 23 percentage points respectively). Not surprisingly, foreign-controlled plants are several times more likely to use internal information sources located outside Canada than are Canadian-controlled plants (Table 25).

Table 25. Internal sources of ideas for new technologies, domestic and foreign, by country of control

Sources	All Locations		Outside Canada	
	Canada	Foreign	Canada	Foreign
	percentage of plants			
Head office	63	71	4	51
Related plants	29	72	5	56
Functional units:				
Research	43	70	9	45
Development	44	67	8	40
Design	31	54	8	35
Production engineering	38	75	5	45
Production staff	63	81	3	21
Technology watch group	17	31	2	22
Sales/Marketing	61	72	9	29
Other	3	3	1	1

Among sources external to the firm, foreign-controlled plants are much more likely to use suppliers and non-market services. On the other hand, Canadian-controlled plants are more likely to use government research organizations. There is little or no difference in the other areas. Although Canadian-controlled plants make significant use of foreign-based sources, foreign-controlled plants are more likely to use them. They are especially more likely to use foreign-based suppliers and publications (Table 26). This greater use of foreign-based sources by foreign-controlled plants would partly reflect the fact that many suppliers to the Canadian food-processing industry are multinational firms based in the United States and Europe, the two regions where most multinational food firms are based.

Table 26. External sources of ideas for new technologies, domestic and foreign, by country of control

Sources	All Locations		Outside Canada	
	Canada	Foreign	Canada	Foreign
	percentage of plants			
Sector market				
Suppliers	64	78	23	52
Customers	61	60	20	34
Other processors	47	47	16	33
Technology services market				
Industrial research firms	24	21	7	10
Consultants and service firms	42	52	10	23
Non-market				
Publications	51	66	23	53
Trade fairs, conferences	59	67	32	55
Industry associations	38	51	13	36
Universities	27	31	6	14
Federal or provincial research organizations	29	21	3	5
Other	2	2	-	2

4.1.2 Methods of introducing new technologies

Foreign-controlled plants are more likely to use each of the three basic ways of introducing new technologies - buy ready to use, adapt purchases, and develop new technology. In particular, they are much more likely buy ready to use technologies and to develop new technologies in-house (Table 27). The ability to develop new technologies, especially in-house, would be a competitive advantage in terms of meeting specific plant needs on a timely basis with unique solutions.

While Canadian-controlled plants are somewhat more likely than foreign-controlled plants to use Canadian-based sources, foreign-controlled plants have a very substantial lead in the use of foreign-based sources. One reason for the greater use by foreign-controlled plants of all methods of introducing new processes is their much greater use of foreign-based sources. In particular, 47% of foreign-controlled plants use foreign-based sources for new process development - mostly their own firm - while only 13% of Canadian-controlled plants do so (Table 27).

Table 27. Methods of introducing new process technologies, by source, by country of control

Methods	Country of Control and Source					
	Canadian control			Foreign control		
	Any location	Canada only	Foreign	Any location	Canada only	Foreign
			percentage of plants			
Buy ready to use	56	28	28	78	16	62
Adapt purchases						
from all firms	48	28	20	63	17	46
from unrelated firms	31	13	18	43	11	31
Develop new technology						
by own or other firm	44	31	13	65	17	47
by own firm	39	33	6	60	20	40
with other firms	28	17	11	34	8	26

With respect to product innovations, Canadian and foreign-controlled plants are about equally likely to purchase the right to produce a product, the least common way (15-17% of plants) to introduce a product innovation. Foreign-controlled plants are a little more likely to develop new products (72% versus 62%) and much more likely to adapt existing products (56% versus 32%). At least in part, the latter difference could be related to the need of foreign-controlled firms to adapt products sold in foreign markets to Canadian consumer tastes and preferences.

4.1.3 Technology development

Foreign-controlled plants are more likely to perform technology development activities. As was the case with information sources, the largest differences between Canadian-controlled plants and foreign-controlled plants in sources of technology development are internal. In particular, 71% of foreign-controlled plants use an internal research unit and 63% a development unit while only about 40% of Canadian-controlled plants do so. Among external sources, the largest difference is in the use of suppliers and consultants. However, there is only a small difference in the use of non-market services and no difference in the use of customers, other processors and other firms' R&D units (Table 28).

While foreign-controlled plants carry out a significant part of their development work in Canada, especially by production staff, they are much more likely to use foreign-based sources than are Canadian-controlled plants (Table 28).

Table 28. Internal and external contributor to technology development, Canadian and foreign, by country of control

Contributor	Control and Location					
	Canadian control			Foreign control		
	Any	Canada only	Foreign	Any	Canada only	Foreign
	percentage of plants					
Internal						
Research unit	41	36	4	71	22	49
Development unit	40	37	3	63	24	39
Production group	56	54	2	74	42	32
Head office or related firms	34	30	4	65	12	53
External						
Sector market						
Suppliers	54	42	12	70	28	43
Customers	48	37	11	50	24	25
Other processors	30	22	8	30	12	19
Other firms' R&D or production units	19	14	5	20	5	15
Technology services market						
Consultants	42	33	9	60	36	24
Non-market						
Government/Institutes/ Universities	29	26	3	35	20	15
Other	1	1	-	-	-	-

Foreign-controlled plants are more likely than Canadian-controlled plants to have an R&D program (87% versus 64%). With respect to type of program, 79% of foreign-controlled plants report an in-house program compared to 57% of Canadian-controlled plants. Foreign-controlled firms are also much more likely to do R&D jointly with another firm. In both cases, the foreign-controlled plant is appreciably more likely to use foreign sources. There is little relationship between country of control and doing R&D on contract (Table 29).

Table 29. Internal and external R&D programs, domestic and foreign, by country of control

Sources	Control and Location					
	Canadian control			Foreign control		
	Any	Canada only	Foreign	Any	Canada only	Foreign
	percentage of plants					
In-house	57	53	4	79	28	51
Jointly with another firm	27	21	5	49	16	33
On contract	21	18	3	24	17	7

The greater use of R&D by foreign-controlled plants is almost all connected to a much greater use of related firms in R&D programs. This is the case for each of the five R&D objectives examined - creation of original equipment or process technology, substantial adaptation of technology, minor adaptation of technology, creation of original products, and adaptation of existing products - especially the last two. This greater use of R&D in turn would be related to the greater use of foreign-based sources by foreign-controlled plants, that is, they rely heavily on the use of R&D performed by their foreign-based related firms (Table 30).

Table 30. R&D collaborators by objectives of R&D program, by country of control

R & D Collaborators	Country of Control		
	Canada	Foreign	All
		percentage of plants	
Creation of Original Equipment or process technology			73
in own firm	66	59	65
with related firms	20	38	22
with unrelated firms	19	19	19
with public institutions[a]	22	16	21
Substantial adaptation of technology			67
in own firm	62	57	61
with related firms	15	37	18
with unrelated firms	16	14	16
with public institutions[a]	15	12	15
Minor adaptation of technology			84
in own firm	80	78	80
with related firms	21	55	26
with unrelated firms	18	17	18
with public institutions[a]	17	13	16
Creation of original products			88
in own firm	85	83	85
with related firms	25	61	30
with unrelated firms	21	25	22
with public institutions[a]	18	13	17
Adaptation of existing products			90
in own firm	88	90	88
with related firms	27	64	32
with unrelated firms	18	16	18
with public institutions[a]	17	10	16

[a] Public R&D institutions or universities.

4.1.4 Technology acquisition

Technology acquisition is a key method of technology transfer by both Canadian and foreign-controlled firms. Sixty-five percent of foreign-controlled plants acquire new technologies from head office or related firms compared to 34% of Canadian-controlled plants. In addition, foreign-controlled plants are a little more likely to obtain them from suppliers and from public organizations, while Canadian-controlled plants are relatively more likely to acquire new technologies from customers and other processors. In all cases, a high proportion of foreign-controlled plants use foreign-based sources for their acquisitions

(Table 31). Technology acquisition is thus an important way in which multinational firms contribute to the international flow of technology.

Table 31. Internal and external sources of new technology acquisitions, by country of control and by location

Sources	Canadian control: Any	Canadian control: Canada only	Canadian control: Foreign	Foreign control: Any	Foreign control: Canada only	Foreign control: Foreign
	percentage of plants					
Internal						
Head office or related firms	34	28	5	65	8	56
External						
Sector related						
Suppliers	68	44	24	78	25	53
Customers	41	29	12	35	13	22
Other processors	43	29	13	29	6	22
Non-market						
Government/Institutes/ Universities	26	23	3	32	19	14
Other	1	1	-	-	-	-

Foreign-controlled firms are appreciably more likely to use each of the methods of acquiring new technologies, including joint ventures and alliances, mergers and acquisitions, transfer of skilled personnel and reverse engineering. There is little difference between the two groups in the order of use of these methods. Foreign-controlled plants are more likely to use both related and unrelated plants as sources of technology acquisitions, which is consistent with their greater use of foreign-based sources discussed above (Table 32).

Table 32. Methods used to acquire technologies, by country of control and by source

Methods	Canadian control: All firms	Canadian control: Related firms only	Canadian control: Other firms only	Canadian control: Related & other firms	Foreign control: All firms	Foreign control: Related firms only	Foreign control: Other firms only	Foreign control: Related & other firms
	percentage of plants							
Leasing or purchasing equipment	43	16	22	4	63	17	29	17
Transfer of agreements (e.g. licences, patents)	14	6	6	1	33	17	8	7
Joint ventures/Alliances	17	8	6	3	36	12	16	8
Mergers/Acquisitions	13	7	4	2	28	10	14	5
Transfer of skilled personnel	17	12	4	1	39	25	4	9
Reverse engineering	5	3	2	-	11	3	3	6
Other	-	-	-	-	-	-	-	-

4.1.5 Relationships among innovative activities

The consistency between incidence of use of the several sources across the activities of gathering information, technology development and technology acquisition that was found for the industry as a whole, also largely applies to both Canadian-controlled and foreign-controlled plants. For all three activities, foreign-controlled plants are more likely to use all the internal sources and suppliers. Internally, the main difference across activities is that foreign-controlled plants are relatively more likely to use head office and related plants for technology development and technology acquisition compared to their use as a source of ideas and information.

Externally, there is little difference between the two groups in the use of customers and other processors either as information sources or technology development, while foreign-controlled plants are less likely to use these two sources for technology acquisition. In addition, while Canadian-controlled plants are more likely to use government, institutes and universities for information on new technologies, foreign-controlled plants are more likely to use them for technology development and technology acquisition (Table 33).

Table 33. Sources of information, technology development and technology acquisition, Canadian-controlled and foreign-controlled plants

Sources	Canadian Control			Foreign Control		
	Information[a]	Technology development	Technology acquisition	Information[a]	Technology development	Technology acquisition
	percentage of plants					
Internal						
Research unit	43	41		70	71	
Development unit	44	40		67	63	
Production group[b]	63+	56		81+	74	
Head office or related firms[c]	63+	34	34	71+	65	65
External						
Sector market						
Suppliers	64	54	68	78	70	78
Customers	61	48	41	60	50	35
Other processors	47	30	43	47	30	29
Other firms' R&D or production units						
Technology services market						
Consultants	42	42		52	60	
Non-market						
Government/ Institutes/ Universities	29+	29	26	21+	35	32

[a] Trade fairs and conferences, publications and industry associations are omitted here Plus signs indicate the percentage is at least this high; see greater detail in earlier tables.

[b] Production engineering is an information source for 38% of Canadian controlled plants and 75% of foreign controlled plants, respectively.

[c] Related plants is an information source for 29% of Canadian controlled plants and 72% of foreign controlled plants, respectively.

4.2 Innovative activities by plant size

Larger firms/plants might be expected to be more innovative than smaller ones. Five hypotheses support this view:

- large firms can more easily cover the costs of innovation by larger sales
- large firms benefit from economies of scale and scope in innovation
- large diverse firms can more easily exploit unforeseen innovations
- large firms can spread the risks of R&D over more projects
- large firms have better sources of financing

On the other hand, innovation may be more difficult to manage in large firms (Symeonidis 1996).[17]

For the manufacturing industry as a whole, Baldwin (1997a) found that large and small plants in Canada have different skills and approaches to innovation, and that these differences are related to differences in rates of innovation and technology use. In addition, larger plants in the Canadian food-processing industry are more likely than smaller plants to use advanced technologies and to be product and process innovators (Baldwin, Sabourin and West 1999). The question is how the differences in the use of new technologies and innovative activities are related to differences in innovative activities. Such differences can have implications for public innovation policies, such as whether to target them to smaller and medium size plants. In addition, differences in innovation by country of control and industry could be partly related to plant and firm size effects.

This section examines the relationship of innovative activities in food processing to size of plant or firm.[18] Five plant size groups are used based on the number of employees (during seasonal peak production periods) reported in the survey: 10-29, 20-49, 50-99, 100-249, and 250 or more. The section has four parts:

- Information sources
- Methods of introducing new technologies
- Technology development
- Technology acquisition

4.2.1 Information sources

The percentages of plants in the two smallest size groups using the internal sources of information are consistently below the respective industry average and those for the two largest groups are above it. In nearly all cases, the smallest size group is far below average and the largest size group well above average. The largest differences are in the use of related plants and the use of the more specialized development units, that is, the research, development, design and production engineering units. This greater use would reflect economies of size and scope and the greater ability of larger firms to carry the financial risks of having such units (Table 34).

The use of information sources external to the firm also is related to plant size. The largest size group again leads by a wide margin in all cases and the smallest size group trails. However, for cases such as customers, industrial research firms and universities the differentials among the smaller to mid-size groups are quite small (Table 35).

Table 34. Internal sources of ideas for new technologies, by employee size group

Source	Plant Size - Employee Size Group					
	10 - 19	20 - 49	50 - 99	100-249	250 or more	All
	percentage of plants					
Head Office	52	62	68	66	82	64
Related Plants	17	27	36	44	67	34
Functional unit:						
Research	32	44	48	51	73	46
Development	30	44	48	53	74	46
Design	22	30	32	41	57	33
Production engineering	26	36	45	49	76	42
Production staff	52	62	64	76	83	65
Technology watch group	13	15	19	22	32	18
Sales/Marketing	52	61	64	65	79	62
Other	4	3	3	2	2	3

Table 35. External sources of ideas for new technologies, by employee size group

Sources	Plant Size - Employee Size roup					
	10-19	20-49	50-99	100-249	250 or more	All
	percentage of plants					
Sector market						
Suppliers	56	60	65	74	88	65
Customers	59	61	56	60	75	61
Other processors	36	46	45	54	63	47
Technology services market						
Industrial research firms	15	27	13	27	44	23
Consultants and service firms	33	39	41	50	73	43
Non-market						
Publications	39	51	49	63	79	53
Trade fairs, conferences	45	57	60	69	85	60
Industry associations	30	32	41	47	64	39
Universities	22	26	27	26	48	28
Federal or provincial research organizations	16	28	30	30	43	28
Other	3	1	2	2	-	2

4.2.2 Methods of introducing new technologies

The three methods of introducing new technologies are to buy ready to use, to adapt purchases and to develop new technologies. The lead of the largest size group in using information sources also applies to these methods to introduce new technologies. In all three cases, there is relatively little difference among the other size groups, except that plants with 10-19 employees are much less likely to develop new technologies (Table 36).

Table 36. Methods of introducing new process technologies, by employee size group

Methods	Plant Size - Employee Size Group					
	10 - 19	20 - 49	50 - 99	100-249	250 or more	All
	percentage of plants					
Buy ready to use	50	51	66	60	85	59
Adapt purchases						
from all firms	42	43	53	47	81	50
from unrelated firms	33	31	36	31	55	33
Develop new technology						
by own or other firm	32	47	48	47	74	46
by own firm	30	39	41	42	72	41
with other firms	21	29	28	27	50	29

Among the reasons that large plants might be more likely to engage in the three methods of introducing new technologies is their use of foreign-based sources (Table 37). To some extent, this greater use of foreign-based sources would be related to the fact that they have greater resources for accessing such sources. In addition, a relatively high proportion of the largest size plants is foreign-controlled.

Table 37. Methods of introducing new process technologies, foreign-based sources, by employee size group

Methods	Plant Size - Employee Size Group					
	10 - 19	20 - 49	50 - 99	100-249	250 or more	All
	percentage of plants					
Buy ready to use	20	22	39	34	69	32
Adapt purchases						
from all firms	16	15	27	21	57	23
from unrelated firms	10	14	25	18	48	19
Develop new technology						
by own or other firm	13	11	17	16	42	17
by own firm	9	3	11	12	29	10
with other firms	9	9	14	11	33	13

With respect to the introduction of new products, there is no difference among plant size in purchasing production rights. On the other hand, adapting purchased products and developing new products are both positively related to plant size (Table 38).

Table 38. Methods of introducing new products, by employee size group

Methods	Plant Size - Employee Size Group					
	10–19	20–49	50–99	100–249	250 or more	All
	percentage of plants					
Purchasing production rights	15	12	18	15	18	15
Adapting purchased products	29	33	35	36	50	35
Developing new products	56	59	66	67	77	63

4.2.3 Technology development

The same pattern applies to specific technology development activities - in many cases plants with 10-19 employees are well below average, plants with 250 or more employees are well above average and there is relatively little difference among the three middle plant sizes. The exceptions are mainly the use of sector markets. In particular, for customers there is no size relationship, and for suppliers, customers and other processors, there is little difference between plants with 10-19 employees and the middle plant sizes in frequency of use (Table 39).

Table 39. Internal and external contributors to technology development, by employee size group

Contributors	Plant Size - Employee Size Group					
	10 - 19	20 - 49	50 - 99	100-249	250 or more	All
	percentage of plants					
Internal						
Research unit	33	44	45	43	67	44
Development unit	31	37	45	47	69	43
Production group	44	58	58	66	79	58
Head office or related firms	25	34	37	43	70	38
External						
Sector market						
Suppliers	51	49	57	61	77	56
Customers	52	50	39	48	53	48
Other processors	31	27	26	27	43	30
Other firms' R&D production units	13	18	22	19	34	19
Technology services market						
Consultants	36	38	39	50	78	44
Non-market						
Government / Institutes / Universities	23	28	33	32	44	30
Other	-	1	2	-	-	1

While the use of R&D programs also is related to plant size, the difference between the largest and smallest size groups is much larger for in-house R&D than for R&D done jointly with another firm or on contract. Working with others would be one way for smaller firms to spread the cost and risk of R&D work (Table 40).

Table 40. Internal and external R&D programs, by employee size group

R & D Programs	Plant Size - Employee Size Group					
	10 - 19	20 - 49	50 - 99	100-249	250 or more	All
	percentage of plants					
In-house	41	57	68	67	82	60
Jointly with another firm	20	26	33	33	45	29
On contract	17	14	25	25	41	22
Any of the above	49	65	71	76	86	67

4.2.4 Technology acquisition

The several sources of technology acquisitions follows the same relationship to plant size as that for technology development (Table 41). This similarity is not unexpected given the close relationships among sources used for information, technology development and technology acquisition discussed earlier for the industry as a whole.

Table 41. Internal and external sources of new technology acquisition, by employee size group

	percentage of plants					
Internal						
Head office or related firms	30	33	35	44	60	37
External						
Sector related						
Suppliers	65	66	64	77	82	69
Customers	39	43	33	44	47	41
Other processors	43	42	34	45	44	41
Non-market						
Government/Institutes/ Universities	18	27	31	22	43	27
Other	4	-	-	-	-	1

The plants with 250 or more employees are substantially more likely to use each of the several methods of technology acquisition included in this study (Table 42).

Table 42. Methods used to acquire technologies, by employee size group

Methods	Plant Size - Employee Size Group					
	10 - 19	20 - 49	50 - 99	100-249	250 or more	All
	percentage of plants					
Leasing or purchasing equipment	31	39	50	53	70	45
Transfer agreements	10	10	22	17	33	16
Joint Venture/Alliances	14	11	23	20	43	19
Mergers/Acquisitions	6	8	19	16	40	15
Transfer of skilled personnel	12	15	22	25	39	20
Reverse engineering	3	2	6	7	14	5
Other	-	-	-	-	-	-

4.3 Innovative activities by industry

Rates of innovation and the use of advanced technologies differ among the individual food industries (Chapter 2).[19] For example, the dairy, fruit and vegetable and other industries introduced more product and process innovations in the three years prior to the survey (1995-1997) and tended to have a higher incidence of use of advanced technologies, especially as compared to the bakery and fish industries. The question is whether such differences are related to differences in innovative activities.

Differences among industries in innovative activities would be expected because the industries differ in the proportions of plants that are large and foreign-controlled. In addition, innovative activities could differ because of differences in the need for change (e.g. to respond to changes in consumer demand or government regulations) and the opportunities for change (e.g. new processes developed by others).

This section provides a very brief overview of how innovative activities differ by industry and has four parts:

- Information sources
- Methods of introducing new technologies
- Technology development
- Technology acquisition

4.3.1 Information sources

The most commonly used information sources are the same across industries. Head office, production staff and sales/marketing are the three leading internal sources for all industries, but not necessarily in that order (Table 43). Also, suppliers, customers, and either publications or trade fairs and conferences are the three leading external sources (Table 44).

Table 43. Internal sources of ideas for new technologies, by industry

Source	Bakery	Cereal	Dairy	Fish	F&V	Meat	Other	All
				percentage of plants				
Head office	58	70	61	53	76	60	71	64
Related plants	30	47	43	23	32	29	36	34
Functional units:								
Research	31	55	53	37	60	36	60	46
Development	36	48	50	39	59	40	57	46
Design	25	40	32	28	39	28	43	33
Production engineering	37	51	53	29	51	30	51	42
Production staff	55	76	61	60	67	61	74	65
Technology watch group	14	27	10	10	27	21	20	18
Sales/Marketing	52	77	63	54	61	59	67	62
Other	1	4	6	1	2	4	3	3

Table 44. External sources of ideas for new technologies, by industry

Source	Bakery	Cereal	Dairy	Fish	F&V	Meat	Other	All
				percentage of plants				
Sector market								
Suppliers	52	72	76	53	78	66	70	65
Customers	51	64	59	57	66	65	63	61
Other processors	38	47	54	47	59	50	41	47
Technology services market								
Industrial research firms	13	26	20	27	27	26	23	23
Consultants and service firms	34	51	53	41	51	44	38	43
Non-market								
Publications	39	64	58	49	66	51	51	53
Trade fairs, conferences	44	70	59	57	60	61	66	60
Industry associations	25	45	45	44	46	43	34	39
Universities	10	44	38	27	30	28	23	28
Federal or provincial research organizations	10	25	28	44	33	34	23	28
Other	-	2	3	1	3	2	3	2

While the rankings of information sources are the same across industries, their level of use differs. The bakery and fish industries are below average and the cereal and other industries are above average in the use of all the internal information sources. The bakery industry is below average and the fruit and vegetable industry is above average for all external sources of information.

4.3.2 Methods of introducing new technologies

While there are relatively small differences among industries in the frequency of buying ready to use technologies, there are some significant differences among industries in the frequency of use of adapting purchases and developing new technologies. Adapting purchases is by far the most common in the dairy industry and least common in the fish industry. The fruit and vegetable, meat and the other industries are the most likely to develop new technologies. The bakery and fish industries are below average for all three methods of acquisition (Table 45).

Table 45. Methods of introducing new process technologies, by industry

Methods	Bakery	Cereal	Dairy	Fish	F&V	Meat	Other	All
				percentage of plants				
Buy ready to use	55	60	64	43	62	65	62	59
Adapt purchases								
from all firms	40	51	65	35	59	52	53	50
from unrelated firms	28	28	41	21	39	38	37	33
Develop new technology								
by own or other firm	36	43	44	40	58	51	54	46
by own firm	32	41	35	33	53	47	49	41
with other firms	21	27	34	21	29	35	32	29

The other, dairy and fruit and vegetable industries are most likely to use foreign sources for technology acquisitions while the other industry is the most likely to use foreign sources for process development (Table 46).

Table 46. Methods of introducing new process technologies, foreign-based sources, by industry

Methods	Bakery	Cereal	Dairy	Fish	F&V	Meat	Other	All
				percentage of plants				
Buy ready to use	30	31	38	26	32	32	35	32
Adapt purchases								
from all firms	20	20	39	15	28	22	26	23
from unrelated firms	16	12	23	15	25	22	25	19
Develop new technology								
by own or other firm	15	17	17	9	18	15	26	17
by own firm	8	11	10	6	10	5	18	10
with other firms	11	12	16	6	12	14	17	13

The dairy industry leads in all three categories of methods of introducing new products. The fish industry is well below average in developing new products. Otherwise, differences among industries are relatively small (Table 47).

Table 47. Methods of introducing new products, by industry

Methods	Bakery	Cereal	Dairy	Fish	F&V	Meat	Other	All
				percentage of plants				
Purchasing Production Rights	13	14	28	8	12	14	18	15
Adapting Purchased Products	32	42	43	28	39	25	41	35
Developing New Products	63	66	71	47	69	62	68	63

4.3.3 Technology development

There are significant differences among industries in sources of technology development. The cereal, dairy, fruit and vegetable and other industries lead in the use of internal sources. The most common internal source of technology development for all industries is the production group. It is used by about three-quarters of plants in the dairy and fruit and vegetable industries compared to the industry average of 58% (Table 48).

The cereal and dairy industries are also above average in the use of all external sources of technology development. The fruit and vegetable industry is above average for half the external sources and average for the other three, whereas the other industry is below average for all external sources. At least at the industry level, there would appear to be some substitution between internal and external sources (Table 48).

Table 48. Internal and external contributors to technology development, by industry

Contributors	Bakery	Cereal	Dairy	Fish	F&V	Meat	Other	All
				percentage of plants				
Internal								
Research unit	34	52	57	30	53	37	53	44
Development unit	30	47	51	30	56	35	57	43
Production group	46	63	72	46	75	56	62	58
Head office or related firms	25	49	38	33	45	41	36	38
External								
Sector market								
Suppliers	52	64	66	42	61	60	53	56
Customers	44	54	52	39	51	54	45	48
Other processors	24	34	32	31	31	34	25	30
Other firms' R&D or production units	12	25	24	18	17	22	18	19
Technology services market								
Consultants	33	56	51	40	42	47	41	44
Non-market								
Government/Institutes/ Universities	14	42	34	36	34	30	25	30
Other	-	-	-	1	1	2	-	1

Plants in the other, fruit and vegetable and dairy industries are much more likely than average to have an R&D program, especially to have it in-house. The cereal industry is most likely of all industries to do R&D jointly with another firm, and the fruit and vegetable industry to contract R&D (Table 49).

Table 49. Internal and external R&D programs, by industry

R&D Programs	Bakery	Cereal	Dairy	Fish	F&V	Meat	Other	All
				percentage of plants				
In-house	53	54	68	49	71	54	74	60
Jointly with another firm	22	45	33	26	34	20	30	29
On contract	10	23	28	24	34	17	26	22
Any of the above	56	69	74	54	78	60	81	67

4.3.4 Technology acquisition

There also are some differences among industries in where they acquire new technologies. In particular, the cereal industry is well above average in the use of head office and the bakery industry is well below average. With respect to external sources, the dairy and fruit and vegetable industries lead in the use of suppliers and the latter leads in the use of other processors. The fish industry is by far the most likely and the bakery industry is the least likely to use public organizations as sources of new technology acquisitions (Table 50).

Table 50. Internal and external sources of new technology acquisitions, by industry

Sources	Bakery	Cereal	Dairy	Fish	F&V	Meat	Other	All
				percentage of plants				
Internal								
Head office or related firms	27	47	38	32	41	36	40	37
External								
Sector market								
Suppliers	62	76	79	53	82	70	71	69
Customers	39	33	39	42	52	49	35	41
Other processors	37	39	36	42	50	47	38	41
Non-market								
Government/Institutes/ Universities	11	30	30	43	30	27	20	27
Other	-	1	-	-	1	3	2	1

The main differences among industries in their method of acquiring new technologies are in the use of transfer agreements, joint ventures and alliances, and mergers and acquisitions. The dairy and cereal industries have substantial leads in all three of these methods while the bakery industry is well bellow average in their use (Table 51).

Table 51. Methods used to acquire new technologies, by industry

Methods	Bakery	Cereal	Dairy	Fish	F&V	Meat	Other	All
				percentage of plants				
Leasing or purchasing	41	49	47	42	45	47	44	45
Transfer agreements	8	27	26	10	18	12	17	16
Joint ventures/Alliances	12	25	36	13	18	16	20	19
Mergers/Acquisitions	8	19	24	9	17	14	16	15
Transfer of skilled personnel	20	22	21	16	16	22	20	20
Reverse engineering	5	6	7	4	6	4	7	5
Other	-	-	-	-	-	1	-	-

4.4 Summary

Foreign-controlled plants are more likely than Canadian-controlled plants to participate in innovative activities. The major reason is their much greater use of foreign-based sources, especially internal ones. In particular, they are much more likely to develop new technologies and to do so internally through related plants located outside Canada. These results confirm the important role that multinational firms play in technology development and international technology transfer.

In almost all cases, plants with 250 or more employees are by far the most likely to undertake innovative activities and plants with 10-19 employees are the least likely. There is relatively little difference among plants with 20-249 employees. It appears that only the relatively largest plants/firms are likely to have the necessary resources and see sufficient benefits to undertake many innovative activities. This finding is particularly true for creating new technologies internally. In addition, a higher percentage of larger then smaller plants are foreign-controlled, a fact that would at least partly explain the greater levels of innovative activity by both multinational and large firms.

There also are differences among the individual food-processing industries in participation rates in innovative activities. The industries that lead in use of advanced technologies tend to be the leaders in carrying out several activities. In particular, the fruit and vegetable and other industries are the most likely to use each of the three methods of introducing new technologies (buy ready to use, adapt purchases, develop new technology). Along with the dairy industry, they are the most likely to have an R&D program. Given the relationship between process innovation and technology use, this broad result is not surprising.

These differences in innovative behaviour by plants with differing structural characteristics help to explain the behaviour found in the food-processing industry as a whole.

Chapter 4 Endnotes:

[17] This paper is a survey of the literature on the relationship of innovation to firm size (and market structure).

[18] Since the unit of observation in the survey was plants, the results are presented on this basis.

[19] Seven industries are identified—bakery, cereal, dairy, fish, fruit and vegetable, meat and other. The first six correspond to their respective SIC three-digit definitions while the other industry is the oilseed, sugar and other food products SIC industries (see Chapter 1).

5.0 Innovation and Human Resources

As a knowledge-based activity, innovation has a number of human resource implications. If a firm is to be innovative, it has to have the professional, technical and managerial skills required to carry out the innovative activities of identifying, researching, developing, adapting and acquiring new products and processes. In addition, new products and processes must be implemented into the production process. This implementation can affect both the number of employees required and the levels of skills demanded. What a company knows, how it implements what it knows, and how it learns, are increasingly seen as essential elements of sustainable competitive advantage (Marti 1999). One feature of a 'world class' organization is its ability to create a learning climate that helps it not only to react to change but also to anticipate change and to stay ahead of it (Hodgetts, Luthans and Lee 1994).

Product innovations have the potential to increase the demand for labour (of all types) by increasing sales. The effect of process innovations is less clear. They often reduce the labour used per unit of output and could decrease or increase plant, firm or industry employment depending on whether cost or quality improvements result in more than proportionate increases in sales. For all manufacturing, a study of the employment effects of the adoption of advanced computer-based technologies found that more firms report an increase than a decrease in numbers of production and non-production workers (Baldwin and Da Pont 1996).

The effect of innovation on skill requirements also could be positive or negative. On the one hand, automation can lead to the ability of machines to replace human skills leading to relatively low-skilled mundane tasks. On the other hand, automation can eliminate repetitive, mechanical tasks leaving more time for workers to focus on more complex tasks requiring judgement, conceptual skill and dexterity. Studies of innovation in all manufacturing found that in most cases innovation increases skill requirements and in very few cases decreases them (Baldwin and Da Pont 1996). The increased demand for greater skills is one reason for widening differentials in employee compensation (Baldwin and Rafiquzzaman 1998).

Firms up-grade the skills of employees through employment and training. In all manufacturing, the introduction of computer-based technologies has led to more training to increase both firm-specific and more generic types of skills. This correlation means that investments in new technology and human capital are complementary (Baldwin and Johnson 1995).[20]

This chapter investigates the implications of process innovation for human resources in the food-processing industry. The emphasis is on skill requirements and how they are met. It first looks at the skill set of plant employees and the personnel used to incorporate new technologies into plant operations. It has six sections:

- Educational levels
- Professionals and technicians used to implement new technologies
- Advanced technologies, skill requirements and labour use
- Strategies for training employees
- Kinds of training provided when advanced technologies are implemented
- Summary

5.1 Educational levels

Skill levels are a function of education, training and experience. While experience would be difficult to measure, survey results provide information on educational levels. Plant managers were asked about the educational levels of plant employees by occupational group. There were five occupational groups: production; supervisor; scientists, engineers, technical; support; and management.

The four educational levels were elementary, high school, college or technical, and university. Using university education as an indicator, the educational level of production, supervisory and support personnel differs little between process innovators and non-innovators. However, process innovators and all innovators are more likely than non-innovators to have university-trained scientists, engineers and technical staff (Table 52). This fact is at least weak evidence that innovation requires advanced technical skills.

Table 52. Plants having a majority of employees with a university education, by occupational group, process innovators, all innovators and non-innovators

Occupational group	Process[a]		All Types[b]		All Plants
	Innovators	Non-innovators	Innovators	Non-innovators	
	percentage of plants				
Production	-	-	-	-	-
Supervisory	7	13	9	12	10
Scientists, engineers, technical	52	33	49	31	44
Support	13	7	12	8	11
Management	51	40	49	40	46

[a] Process only or product requiring process innovation.

[b] Process only, product only or product requiring process innovation.

5.2 Professionals and technicians used to implement new technologies

The process of implementing new technologies requires a range of professionals and technicians. The professionals include science, engineering, and computer professionals. The technicians include science technicians, engineering science technicians, computer assistants, computer equipment operators, electronic equipment operators, and plant and machine operators. The firm could hire these personnel or acquire their services from other firms, or do both.

For the food-processing industry as a whole, engineers are the most common professionals followed by computer professionals and scientists. Among the technicians, the leaders are plant and machine operators (which at 57% of plants leads all categories by a wide margin), computer assistants and computer equipment operators. In all cases, the plant's own firm is the leading source of personnel. Engineering and computer professionals are much more likely than scientists to come from other firms, in both absolute and relative terms (Table 53).

Table 53. Personnel used to incorporate new technologies into the plant, by source

Occupation	Source			
	Own firm only	Other firms only	Both	All
	percentage of plants			
Professionals				
Science professionals	22	7	7	36
Engineering professionals	23	14	12	49
Computing professionals	22	13	9	44
Other	6	-	-	7
Technicians				
Science technicians	21	7	5	33
Engineering science technicians	12	10	6	28
Computer assistants	26	11	7	44
Computer equipment operators	29	7	6	42
Electronic equipment operators	20	8	5	34
Plant and machine operators	45	5	8	57
Other	-	-	-	1

Process innovators are much more likely than non-innovators to use all types of professionals and technicians. The differences are largest for science and engineering professionals and plant and machine operators. In relative terms, there is little difference between the two groups in the use of external versus internal sources (Table 54). This finding is additional, stronger evidence that innovation requires relatively highly skilled personnel. Also while outside help can be useful, the main requirement is for in-house capability.

Table 54. Personnel used to incorporate new technologies into the plant, by source and by process innovators and non-innovators

Occupation	Process Innovators				Non-Innovators			
	All	Own firm	Other firm	Both	All	Own firm only	Other firm only	Both
	percentage of plants							
Professionals								
Science professionals	46	28	9	10	19	12	5	2
Engineering professionals	62	27	19	16	29	16	8	6
Computing professionals	54	27	15	12	29	15	10	3
Other	6	6	-	-	7	7	-	-
Technicians								
Science technicians	42	27	9	7	20	13	5	2
Engineering science tech.	37	15	13	8	15	8	4	2
Computer assistants	53	31	13	9	30	18	8	3
Computer equip. operators	51	35	8	9	28	21	5	2
Electronic equip. operators	43	26	9	8	20	12	6	2
Plant & machine operators	69	52	5	11	40	33	4	3
Other	1	-	-	-	-	-		-

As would be expected given their greater involvement in innovative activities, foreign-controlled plants are appreciably more likely than Canadian-controlled plants to employ all of these types of professionals and technicians (Table 55), and larger firms more so than smaller firms (Table 56).

Table 55. Personnel used to incorporate new technologies into the plant, by country of control

Occupation	Country of control		
	Canada	Foreign	All
	percentage of plants		
Professionals			
Science professionals	33	58	36
Engineering professionals	45	80	49
Computing professionals	42	66	44
Other	7	2	7
Technicians			
Science technicians	31	56	33
Engineering science technicians	24	56	28
Computer assistants	41	66	44
Computer equipment operators	40	59	42
Electronic equipment operators	31	55	34
Plant and machine operators	54	81	57
Other	1	-	1

Table 56. Personnel used to incorporate new technologies into the plant, by plant size

Occupation	Plant size - employee size group					
	10-19	20-49	50-99	100-249	250 or more	All
	percentage of plants					
Professionals						
Science professionals	22	27	39	43	70	36
Engineering professionals	27	39	54	65	84	49
Computing professionals	28	35	47	56	80	44
Other	6	8	8	6	3	7
Technicians						
Science technicians	20	26	35	44	63	33
Engineering science technicians	16	20	29	37	58	28
Computer assistants	34	37	43	49	74	44
Computer equipment operators	29	38	41	48	76	42
Electronic equipment operators	21	25	35	45	64	34
Plant and machine operators	40	52	68	63	81	57
Other	-	2	1	-	-	1

With some exceptions, industry differences in the use of professionals and technicians to incorporate new technologies into plant operations also are related to innovative activity. The cereal, dairy, other, and fruit and vegetable industries are the leading users in most categories of both professionals and technicians. The dairy, other and fruit and vegetable industries are the leaders in the use of advanced technologies and process innovation. The dairy and other industries lead in the use of science professionals, followed by the meat industry. In all three industries, the frequency of use of science professionals is almost the same for computer professionals (Table 57).

Table 57. Personnel used to incorporate new technologies into the plant, by industry

Occupation	Bakery	Cereal	Dairy	Fish	F&V	Meat	Other	All
				percentage of plants				
Professional								
Science professionals	18	36	52	25	37	34	51	36
Engineering professionals	33	60	59	42	53	43	56	49
Computing professionals	34	65	50	34	40	38	49	44
Other	11	3	4	5	11	9	5	7
Technicians								
Science technicians	20	33	49	20	43	31	45	33
Engineering science tech.	15	35	41	15	37	21	38	28
Computer assistants	31	61	53	37	44	36	51	44
Computer equip. operators	31	52	43	33	44	44	46	42
Electronic equip. operators	26	43	35	26	46	32	35	34
Plant & machine operators	46	69	61	49	63	52	64	57
Other	1	-	1	1	2	1	-	1

5.3 Advanced technologies, skill requirements and labour use

The adoption of advanced technologies could increase or decrease employee skill requirements. In the food-processing industry, 40% of plant managers believe that increased skill requirements are a very important result of the adoption of advanced technologies and 14% believe that it is of low importance. While about 37% of the plant managers report that advanced technology requires them to substitute more skilled personnel for less skilled personnel, 54% believe that it has no such effect. Only 16% report an increased ability to substitute less skilled for more skilled workers and 59% report no effect. In other words, on balance, new technologies in the food-processing industry increase the skills needed by many employees (Baldwin, Sabourin and West 1999).

Over half (58%) the managers consider that reduced labour requirements per unit of output is a very important result of adopting new technology, but the overall effect on employment is not known.[21]

5.4 Strategies for training employees

Having skilled personnel is a key element of the technology strategies of firms, and process innovators put somewhat more emphasis on this than non-innovators. In Chapter 3 it was noted that 37% of managers stress the importance of the systematic collection and monitoring of information on the supply of skilled personnel, putting it behind information on new products and processes but ahead of information on scientific developments.

There are three ways to improve the skill level of employees: hire highly skilled people, train current employees, and introduce innovative compensation packages. The choice would depend on factors such as whether the innovation required a modest or drastic change in skills and the supply of such skills in the labour market.

As part of their overall business strategy, 62% of the managers stress continuous training, 46% stress recruitment of skilled personnel and 24% stress the use of innovative compensation schemes (Table 58). The heavy emphasis on continuous training would be partly related to the preference for incremental improvements in technology as opposed to radical change.

Innovators put more stress on the importance of having skilled personnel and on all three methods of having them than do non-innovators. This emphasis is also the case for process innovators and process non-innovators. The similarity of responses for all innovators and process innovators indicates that product innovators put the same emphasis on these strategies as do process innovators (Table 58).

Foreign-controlled plants are more likely than Canadian-controlled plants to stress the need for a skilled workforce. They also put more emphasis on training and recruitment. The two groups put equal and much less emphasis on the use of innovative compensation packages (Table 58).

Larger plants are more likely than smaller plants to rate highly the need for skilled personnel. They are also somewhat more likely to emphasize each of the strategies for improving skill levels (Table 58).

All of the individual food-processing industries put the greatest emphasis on training, followed by recruitment and compensation as strategies for increasing skill levels. The dairy industry is unique in placing almost equal stress on training and recruitment as methods of increasing skill levels. However, industries differ in the importance that they attach to the individual strategies. For example, plants in the cereal, dairy, meat and other industries are more likely to stress the need for skilled employees. They also lead in the emphasis placed on continuous training, recruitment and, except for cereal, in the use of innovative compensation practices (Table 58). These differences in human resource strategies are not closely related to industry differences in the use of advanced technologies and the reasons for this would require further analysis.

Table 58. Importance of human resource strategies

	Strategy			
	Skilled personnel	Continuous training	Innovative compensation	Recruiting skilled people
	percentage of plants[a]			
All	58	62	24	46
Industry				
Bakery	46	56	18	44
Cereal	66	70	21	49
Dairy	65	65	28	62
Fish	51	58	22	37
Fruit and vegetable	55	54	25	41
Meat	61	64	29	49
Other	62	64	25	45
Plant size				
10-19	52	55	19	41
20-49	55	61	25	42
50-99	54	62	23	43
100-249	62	65	25	54
250 or more	78	76	34	62
Country of control				
Canada	57	60	24	45
Foreign	67	77	23	58
Innovators and non-innovators				
All innovators[b]	62	67	27	51
All non-innovators	48	50	18	33
Process innovators[c]	62	67	28	51
Process non-innovators	51	54	19	39

[a] Percentage of establishments giving a rating of 4 or 5 on a 5-point scale with 5 being extremely important.
[b] Process only, product only or product requiring process innovation
[c] Process only or product requiring process innovation

5.5 Kinds of training provided when advanced technologies are implemented

We have seen that new technology requires new skills and that firms emphasize training as the way to improve skills. There were 10 skills included in the survey as possible areas for training: basic language/literacy, basic numeracy, computer literacy, problem solving, technical, leadership, quality, safety, interpersonal communication, and other skills (Table 59).

The most common training program when advanced technology is implemented is safety; it is provided by 84% of all plants (Table 59). Worker safety is always a key concern in any manufacturing industry and is one of the effects of new technology use. As an important outcome of using advanced technologies is improved worker safety (Baldwin, Sabourin and West 1999), 64% of all plants reported improved worker safety.

In keeping with the industry's focus on quality, the next most common training area is quality skills. As would be expected, new technology requires new technical skills and this area is third in frequency of use. It is followed by computer literacy skills.

Basic language/literacy skills and basic numeracy skills are the least frequently provided by plants. Although clearly important, these skills are not plant-specific and would be expected to be provided publicly.

The greater stress placed on the strategies of improving skills and using training by process innovators compared to process non-innovators carries over into a greater use of all of these training programs by innovators (Table 59). While the rankings of the programs are much the same, the largest difference is in technical and leadership skills. The greater use of technical skills would be related to the introduction of more innovations. Training in leadership skills would be associated with problems of adjusting to new processes, including how to deal with unexpected complications and employee concerns arising from innovations.[22] Leadership skills also would be essential as part of organizing and driving the innovative activity itself.

Table 59. Skills provided by training, by process innovators and non-innovators

Skills	Process[a]		All Types[b]		All Plants
	Innovators	Non-innovators	Innovators	Non-innovators	
	percentage of plants[c]				
Basic language/literacy	23	14	21	16	20
Basic numeracy	22	17	21	16	20
Computer literacy	64	47	61	47	58
Problem solving	48	38	46	37	44
Technical	75	56	72	56	69
Leadership	57	38	53	40	50
Quality	80	66	78	69	76
Safety	87	77	86	78	84
Interpersonal communication	49	30	45	33	43
Other	4	2	3	2	3

[a] Process only or product requiring process innovation
[b] Process only, product only or product requiring process innovation
[c] Percentage of plants using at least one advanced technology that provide the training

While differences in the use of training programs by country of control and plant size reflect differences in strategies and innovation rates, these relationships are less clear at the industry level.

Usage rates of the training programs by Canadian-controlled and foreign-controlled plants using advanced technologies have the same ranking (and the same for the industry as a whole), but the latter are substantially more likely to provide them. The largest differences are in literacy, problem solving and leadership skills (Table 60).

Table 60. Training provided when advanced technology is implemented, by country of control

Skills	Country of Control		
	Canada	Foreign	All
	percentage of plants [a]		
Basic language/literacy	19	25	20
Basic numeracy	20	22	20
Computer literacy	55	78	58
Problem solving	42	61	44
Technical	67	82	69
Leadership	48	66	50
Quality	75	82	76
Safety	82	94	84
Interpersonal communication	41	53	43
Other	3	4	3

[a] Percentage of plants using at least one advanced technology that provide the training.

Except for basic language/literacy and basic numeracy skills, the incidence of use of training is positively related to plant size. The relationship is especially strong for leadership, computer and technical skills. However, the ranking of programs in terms of use is much the same across plant sizes (Table 61).

Table 61. Training provided when advanced technology is implemented, by plant size

Skills	Plant Size - Employee Size Group					
	10–19	20–49	50–99	100–249	250 or more	All
	percentage of plants[a]					
Basic language/literacy	16	17	17	23	33	20
Basic numeracy	18	22	18	17	30	20
Computer literacy	44	52	56	70	81	58
Problem solving	35	44	43	46	61	44
Technical	56	64	71	75	89	69
Leadership	41	40	50	59	78	50
Quality	64	76	72	83	93	76
Safety	73	81	85	93	95	84
Interpersonal communication	33	33	41	52	69	43
Other	1	3	2	3	10	3

[a] Percentage of plants using at least one advanced technology that provide the training.

Safety, quality, technical and computer skills are the four most commonly taught skills by each of the individual food industries. The dairy and fruit and vegetable industries lead in the use of training and the fish industry uses training the least (Table 62).

Table 62. Training provided when advanced technology is implemented, by industry

Skills	Bakery	Cereal	Dairy	Fish	F&V	Meat	Other	All
				percentage of plants[a]				
Basic language/literacy	27	18	21	16	26	21	14	20
Basic numeracy	26	21	22	16	23	17	18	20
Computer literacy	53	77	64	46	57	47	63	58
Problem solving	50	46	44	39	51	44	40	44
Technical	70	72	80	53	71	68	70	69
Leadership	56	50	57	38	50	48	52	50
Quality	72	78	83	73	83	75	72	76
Safety	80	87	87	81	86	90	78	84
Interpersonal communication	44	44	47	36	52	42	39	43
Other	3	4	4	4	4	3	1	3

[a] Percentage of plants using at least one advanced technology that provide the training

5.6 Summary

Innovation and the adoption of advanced technologies increase employee skill requirements. Human resource strategies and practices associated with this need differ by plant and industry characteristics and, in particular, between innovators and non-innovators.

The educational level of employees indicates that technological change requires greater skills. Except for production and supervisory staff, process innovators have more university-educated staff than non-innovators. Innovators also are more likely to use science and engineering professionals in implementing new technologies. There is no difference between innovators and non-innovators in using external sources of expertise as opposed to their own professionals and technicians.

Innovators put more emphasis on strategies to increase skill levels than do non-innovators, including training, recruitment and innovative compensation packages. Training is the favoured and most common way to increase skill levels. The key training areas are safety and quality, followed by technical and computer training skills. Basic language/literacy and basic numeracy skills are the least commonly offered training; they are the least firm-specific.

There are differences in behaviour between plants by country of control, plant size and industry in several of these human resource areas. Foreign-controlled plants and larger plants put more emphasis on increasing skill levels, a result consistent with their higher levels of innovative activity. The dairy and fruit and vegetable industries are the leading users of training and among the leading users of advanced technologies, but there is not a consistent pattern to this relationship across industries.

While managers report that productivity improvement, including greater output per worker, is an important result of adopting advanced technologies, total employment would not necessarily fall. The effect of innovation on total employment at the plant, firm and industry levels also depends on possible increases in output resulting from lower costs and improved quality and service. Of course, improvements in productivity, quality and service are also a function of employee skills.

Chapter 5 Endnotes:

[20] For a comprehensive review of human resources as related to innovation and use of advanced technologies, see Baldwin 1999.
[21] This question was not asked
[22] For examples, see Chapter 6, Impediments to the adoption of new technologies.

6.0 Impediments to the Adoption of New Technologies

Plants will adopt new technologies and undertake associated innovative activities only if the anticipated benefits outweigh the anticipated costs and risks. As discussed in the first study (Baldwin, Sabourin and West 1999) and reviewed briefly in Chapter 2, firms adopting advanced technologies in the food-processing industry report significant economic benefits. Three specific benefits are:

- increased productivity in terms of reduced labour, capital and materials inputs per unit of output
- improved products in terms of characteristics such as nutritional content, taste, shelf-life and consumer convenience
- improved ability to meet a range of regulatory requirements.

Other effects reported include changes in plant organization, which represent both advantages and challenges. These organizational changes include more product lines, increased production flexibility and the need for more skills.

Despite these benefits, not all plants adopt advanced technologies and some adopt fewer than others. While 12% of plants in the food-processing industry use no advanced technologies, 33% use one to five and 7% use more than 20 of the 61 advanced technologies identified in this study. In addition, adoption rates differ appreciably among industries, plant size and country of control. One reason for a plant not to adopt some advanced technologies would be a lack of their applicability to the plant's operations. A more general reason would be that some impediment prevents the adoption of new technologies.

As indicated in Chapter 2, innovation rates also differ appreciably across these same structural characteristics. Given the central role of technology to major process innovation, impediments to technology adoption would also be expected to apply to innovation.

Studies of the manufacturing sector have identified a number of impediments to innovation and the adoption of new technologies. They include expected rate of return and financial resources. In addition, there is a range of specific factors with cost or revenue implications. The latter include a lack of employee and management skills, a lack of information and support services and inadequate or intrusive government programs and regulations (Baldwin, Sabourin and Rafiquzzaman 1996, Baldwin and Da Pont 1996). Such impediments were expected also to be important in the food-processing industry.

This study examines six factors that might be expected to limit the adoption of new technologies in the food-processing industry:

- financial justification
- financial resources
- management
- human resources
- external support services
- government policies/standards/regulations

Financial justification

The 'bottom line' is whether or not the expected rate of return on the required investment meets the company's investment criteria.[23] On the revenue side, benefits could be limited by small market size and could be quite uncertain. On the investment/cost side, costs are not limited to buying, leasing or developing the technology. Costs also are incurred in developing appropriate software, integrating the new technologies into existing systems, and could include additional operating costs.

Financial resources

Firms must raise the funds necessary for adoption. They must either have the necessary cash reserves or cash flow or look to outside financial sources. A lack of cash flow or a lack of outside financial sources (at acceptable cost) are included in this study as possible impediments.

Management

Successful process innovation requires that the firm have the capacity to decide on priorities, to obtain effectively the required technical information, to make an accurate assessment of benefits and costs, and to carry out development, acquisition and implementation activities as appropriate. This capacity means a significant commitment of resources and a willingness to accept risk. Thus the plant requires a high strategic priority on being innovative. A lack of such commitment, a lack of appropriate procedures to acquire scientific and technological information and a lack of ability to evaluate new technology would be impediments to the adoption of advanced technologies.

The problem of properly evaluating new technologies is an example of the extra stress put on management by innovation. Conventional capital budgeting techniques may be inadequate when it comes to evaluating new technologies (Dean 1987). Many of the costs, as well as the benefits, are difficult to quantify. Costs associated with labour-related issues, management attitudes, information flow problems, and compliance with government regulations are hard to quantify and may not be directly part of narrow 'rate of return' calculations, but they are still an important part of the decision-making process.

Human resources

As discussed in Chapter 5, the adoption of advanced technologies increases the skill levels required of all affected employees. These skills are associated with the implementation, operation and maintenance of the technology. Such skills may not be available from the labour or service markets. Training programs, which are costly in terms of both direct expenses and time away from the job, may be needed. In any case, training may be more effective than hiring if technological change is incremental (as it tends to be) since it builds on current skills and rewards employees willing to adjust. On the other hand, if labour mobility is high, investment in training is risky.

Aside from a shortage of skills and training difficulties, worker resistance to change has a long history as an impediment to the adoption of new technology.

External support services

As discussed in Chapters 3 and 4, firms make extensive use of external sources of expertise in the innovative process. Hence, a lack of technical support from suppliers or a lack of access to consultants and professional services offering technical advice, testing and standards would be impediments to many firms.

Government policies / standards / regulations

Governments require plants to meet specific standards in a diverse set of areas. The objective and, in most cases, the effect is to improve industry performance with respect to society's needs. Regulation generally has the effect of increasing costs, including capital, operating and compliance costs. While the use of advanced technologies helps many plants in the food-processing industry to meet regulatory requirements better (Baldwin, Sabourin and West 1999), its use could impede other plants. In addition to labour and environmental regulations, plants must meet regulations pertaining to food composition, food safety and plant hygiene.

This chapter on the impediments to the adoption of new technologies has six sections:

- Importance of the impediments
- Differences between innovators and non-innovators
- Differences by country of control
- Differences by plant size
- Differences by industry
- Summary

6.1 Importance of the impediments

Plant managers consider some of the factors identified above to be much more important impediments to the adoption of advanced technologies than others. A lack of financial justification, not a technical or organizational problem, is the most important impediment. The key factor is the cost of buying, leasing or developing new technology/equipment; it is highly rated in importance by 65% of managers (Table 63). It also is the key cost factor in other manufacturing industries (Baldwin, Sabourin and Rafiquzzaman 1996).

The other cost factors, especially the cost of integrating new technology with current technology (45%)and additional operating cost also are relatively important (47%) (Table 63). Although the emphasis given to additional operating cost may be surprising (given the positive effects of advanced technologies on productivity), many technologies are related more to improving quality and service than to reducing unit costs.

Small market size and the degree of uncertainty associated with the evaluation of benefits are rated as highly important by nearly 40% of managers. This rating makes them second to costs in establishing financial justification (Table 63). The relatively small Canadian market size affects both revenues and those costs that vary with scale of operations and it is a reason for seeking export markets. Uncertain benefits are inherent in innovation.

While financial justification is a key impediment to the adoption of new technology, access to financial resources is of less importance. More managers consider it to be of low importance (about 40%) than high importance (Table 63).

The other factors investigated as possible impediments to the adoption of advanced technologies - management, human resources, external support services, government policies/standards/regulations - provide insight into the underlying characteristics of the broad cost categories and the role of management. In all cases except external support services, 25 - 30% of managers consider them highly important. However, in all cases more managers (about 40%) consider them to be of low than high importance (Table 63). Because they are more specific than the general cost categories, perhaps this result is not surprising.

Table 63. Importance of impediments to the adoption of new technologies

Impediments	Low	Medium	High
		percentage of plants[a]	
Financial justification			
Small market size	27	34	39
Degree of uncertainty associated with the evaluation of benefits	22	39	38
Cost of buying, leasing or developing new technology/equipment	13	22	65
Cost to develop software	30	30	41
Cost of integrating new technology with current technology	22	33	45
Additional operating cost	18	34	47
Financial resources			
Lack of outside financing	42	30	28
Lack of cash flow	39	31	30
Management			
Lack of procedures to acquire scientific and technological information	41	36	23
Low strategic priority	36	38	26
Lack of capabilities to evaluate the new technology	42	36	23
Human resources			
Shortage of skills	41	32	27
Training difficulties	40	35	25
Worker resistance	46	32	22
External support services			
Lack of technical support from vendors	50	34	16
Lack of technological services (e.g. technical and scientific consulting, tests, standards)	50	35	16
Government policies/standards/ regulations			
Labour	38	35	27
Food composition	41	37	21
Food safety	41	28	30
Plant hygiene	41	27	32
Environment	40	32	28

[a] Percentage of plants giving a rating of 1 or 2 (low), 3 (medium) and 4 or 5 (high), using a five point scale, where 5 is extremely important.

Differences in the relative importance of specific factors within the categories also help our understanding of the nature of impediments to technology adoption and innovation. In the management category, the problem of low strategic priority appears to be a little more important (26%) than lack of procedures to acquire scientific and technological information and lack of capabilities to evaluate the new technology (23% each). In the human resources category, skill shortages (27%) and training difficulties (25%) are somewhat more important than worker resistance to change (22%). Few managers have serious problems with lack of technical support from vendors or lack of technical services (16% each) (Table 63).

In the government policies / standards / regulations category, there are few differences in the importance attached to the five areas - labour, food composition, food safety, plant hygiene, and environment. About 40% of managers give each a low rating. At 21%, food composition is the least likely to be considered to be a highly important impediment to technology adoption while the others range from 27% to 32% (Table 63).

6.2 Differences between innovators and non-innovators

Given the benefits of adopting advanced technologies, one would expect that non-innovators face greater impediments to technology adoption than innovators. On the other hand, studies of technology use and innovation find that in many cases it is the innovators who put greater stress on the importance of impediments (Baldwin, Sabourin and Raffiquzzaman 1996). The suggested reason for this emphasis is that their first-hand experience with the problems that can arise allows them to appreciate better which factors represent major impediments. This phenomenon is called 'learning by doing.'

Both of these results are found in the food-processing industry. In the first instance, non-innovators are much more likely to find a lack of financial resources to be a major impediment to the adoption of advanced technologies, especially a lack of outside financing. A lack of outside financing is highly important for 36% of all types of non-innovator plants and 25% of all types of innovators. The corresponding figures for lack of cash flow are 34% and 29% respectively. In the case of process innovation, the difference for lack of outside financing is smaller but still significant whereas there is essentially no difference for cash flow (Table 64).

However, innovators are more likely than non-innovators to give a high importance rating to five impediments and the 'learning by doing' model appears to fit well for at least four of them. In the area of financial justification, innovators are the ones most concerned with small market size and the cost to develop software. They are also more concerned with the degree of uncertainty associated with the evaluation of benefits and training difficulties. In addition, innovators put more emphasis on food safety regulations as an impediment. With the possible exception of small market size, which should be evident at an early stage in the innovation or adoption process, these are areas where experience is important.

In three of these five cases - small market size, training difficulties and food safety - process innovators are more concerned than non-innovators. In addition, process innovators are more concerned than non-innovators with regulations in the areas of food composition and the environment, areas where processes would be especially important.

However, for most impediments, there is little difference between innovators and non-innovators in their evaluations. In addition, with the exception of financial resources, overall ranking of impediments is essentially similar for both groups, that is, the same as discussed above for the industry as a whole.

The conclusion is that, although financial justification is the most important impediment to innovation by innovators and non-innovators alike, the impediment that critically distinguishes non-innovators from innovators is a lack of financial resources, including both a lack of outside financing and a lack of cash flow. Innovators and non-innovators either agree on the importance of other impediments or innovators consider them to be even more significant than do non-innovators.

Table 64. Importance of impediments by type of innovator and non-innovator

Number of Technologies	Process[a]		All Types[b]		All Plants
	Innovator	Non-innovator	Innovator	Non-innovator	
	percentage of plants[c]				
Financial justification					
Small market size	41	36	41	34	40
Degree of uncertainty associated with the evaluation of benefits	38	38	38	39	38
Cost of buying, leasing or developing new technology/ equipment	66	64	65	65	65
Cost to develop software	41	40	42	38	41
Cost of integrating new with current technology	46	44	45	43	45
Additional operating cost	47	48	47	49	47
Financial resources					
Lack of outside financing	25	31	25	36	28
Lack of cash flow	30	31	29	34	30
Management					
Lack of procedures to acquire scientific and technological information	23	22	23	22	23
Low strategic priority	25	27	27	24	26
Lack of capabilities to evaluate new technology	23	22	24	19	23
Human resources					
Shortage of skills	27	27	28	26	27
Training difficulties	27	22	27	19	25
Worker resistance	22	23	22	23	22
External support services					
Lack of technical support from vendors	18	13	17	14	16
Lack of technological services (e.g. technical and scientific consulting, tests, standards)	17	14	16	15	16
Government Policies/ Standards/Regulations					
Labour	28	25	28	26	27
Food composition	24	18	22	20	21
Food safety	33	27	32	26	30
Plant hygiene	32	32	32	32	32
Environment	30	26	28	29	28

[a] Process only or product requiring process innovation
[b] Process only, product only or product requiring process innovation
[c] Percentage of establishments reporting a score of 4 or 5 on a 5 point scale, where 5 is extremely important

6.3 Differences by country of control

Foreign-controlled plants are more likely than Canadian-controlled plants to adopt advanced technologies (Baldwin, Sabourin and West 1999). Therefore, one might anticipate that Canadian-controlled plants would rate the importance of impediments more highly than foreign-controlled plants. This high rating is the case for two elements of financial justification - cost of buying, leasing or developing new technology/equipment and cost to develop software - and to all elements of financial resources and management (Table

65). These results are consistent with generally accepted views of the competitive advantages of multinational firms.

In addition, Canadian-controlled plants give higher impediment ratings to each of the five areas of government activity identified.

However, the greater concern of Canadian-controlled plants with impediments to technology adoption does not apply to three elements of financial justification - small market size, degree of uncertainty associated with the evaluation of benefits, and cost of integrating new with current technology. Foreign-controlled plants are more likely to rate each of these as a highly important impediment. In addition, foreign-controlled plants are more concerned with a lack of external support services (Table 65). In other words, foreign-controlled plants appear to be relatively more concerned with impediments related to the benefits and implementation of innovation whereas Canadian-controlled plants are relatively more concerned with the cost and management of the innovative process as such.

Table 65. Importance of impediments to technology adoption, by country of control

Impediments	Country of Control		
	Canada	Foreign	All
		percentage of plants[a]	
Financial justification			
Small market size	38	45	39
Degree of uncertainty associated with the evaluation of benefits	38	42	38
Cost of buying, leasing or developing new technology/equipment	66	62	65
Cost to develop software	42	32	41
Cost of integrating new with current technology	44	50	45
Additional operating cost	48	47	47
Financial resources			
Lack of outside financing	29	18	28
Lack of cash flow	31	23	30
Management			
Lack of procedures to acquire scientific and technological information	24	12	23
Low strategic priority	27	21	26
Lack of capabilities to evaluate new technology	23	17	23
Human resources			
Shortage of skills	27	24	27
Training difficulties	25	24	25
Worker resistance	22	21	22
External support services			
Lack of technical support from vendors	16	21	16
Lack of technological services (e.g. technical and scientific consulting, tests, standards)	15	21	16
Government policies/ standards/regulations			
Labour	29	15	27
Food composition	22	16	21
Food safety	31	23	30
Plant hygiene	34	20	32
Environment	29	19	28

[a] Percentage of establishments reporting a score of 4 or 5 on a 5 point scale, where 5 is extremely important.

6.4 Differences by plant size

Although the use of advanced technologies is strongly positively related to plant size (Baldwin, Sabourin and West 1999), this relationship is less true for impediments.[24] As might be expected, plants with 250 or more employees tend to be less concerned than the others with financing (at least outside financing) and a lack of technological services, and the two largest size groups with training difficulties. In addition, the two smallest size groups are more concerned than the others with additional operating cost and skill shortages. Surprising results are the lack of emphasis on small market size by the largest size group, and some of the ratings by the mid-size groups. In particular, there is no relationship between plant size and the importance attached to government policies/standards/regulations as impediments to technology adoption (Table 66).

6.5 Differences by industry

Industries differ in their use of the advanced technologies identified in this study. Overall, plants in the dairy, other and fruit and vegetable industries are more likely to use them while those in the bakery and fish industries are less likely to do so. These differences are related to factors such as plant size, country of control, nature of markets, plant operations and business strategies (Baldwin, Sabourin and West 1999). The question here is whether differences in impediments to technology adoption help to explain these industry differences in adoption rates.

Although for the most part industry differences in impediment ratings are not large, they are appreciable in some areas (Table 67). In terms of financial justification, plants in the fruit and vegetable industry are much more likely to stress the cost of buying, leasing or developing new technology/equipment, the cost of integrating new with current technology, and additional operating cost than plants in the other industries. Plants in the cereal industry are least likely to be concerned about the cost of buying, leasing or developing new technology/equipment and the cost to develop software. The fish industry is least concerned about small market size, perhaps because it is a leading exporter.

The fruit and vegetable and fish industries face the greatest problems in financing new technology; in the former case this could be related to its cost concerns.

The cereal industry is the least concerned with skill shortages. The fish industry is the most concerned with worker resistance to new technology. The dairy industry puts much more emphasis on a lack of technical support from vendors than do any of the other industries.

Table 66. Importance of impediments to technology adoption, by plant size

Impediments	Plant Size - Employee Size Group					
	10–19	20–49	50–99	100–249	250 or more	All
	percentage of plants[a]					
Financial justification						
Small market size	45	38	36	42	26	39
Degree of uncertainty associated with the evaluation of benefits	36	41	36	44	31	38
Cost of buying, leasing or developing new technology/equipment	61	64	73	64	64	65
Cost to develop software	41	43	43	36	36	41
Cost of integrating new with current technology	47	44	45	42	46	45
Additional operating cost	54	50	45	41	41	47
Financial resources						
Lack of outside financing	29	33	22	30	17	28
Lack of cash flow	32	31	29	31	27	30
Management						
Lack of procedures to acquire scientific and technological information	26	21	20	27	18	23
Low strategic priority	26	28	19	33	23	26
Lack of capabilities to evaluate new technology	22	24	23	24	16	23
Human resources						
Shortage of skills	33	28	25	22	23	27
Training difficulties	30	27	25	20	16	25
Worker resistance	24	19	29	21	16	22
External support services						
Lack of technical support from vendors	14	17	19	15	20	1
Lack of technological services (e.g. technical and scientific consulting, tests, standards)	15	15	20	16	9	16
Government policies/ standards/regulations						
Labour	31	29	24	27	20	27
Food composition	23	24	19	19	21	21
Food safety	29	34	31	27	30	30
Plant hygiene	27	36	36	28	34	32
Environment	26	31	28	26	31	28

[a] Percentage of establishments reporting a score of 4 or 5 on a 5 point scale, where 5 is extremely important.

Table 67. Importance of impediments to technology adoption, by industry

Impediments	Bakery	Cereal	Dairy	Fish	F & V	Meat	Other	All
				percentage of plants[a]				
Financial justification								
Small market size	42	35	50	24	43	35	46	39
Degree of uncertainty associated with the evaluation of benefits	38	31	39	47	38	44	32	38
Cost of buying, leasing or developing new technology/equipment	66	48	74	65	80	71	62	65
Cost to develop software	39	31	50	40	48	46	37	41
Cost of integrating new with current technology	44	44	54	36	57	51	37	45
Additional operating cost	51	43	42	39	61	57	43	47
Financial resources								
Lack of outside financing	35	27	12	38	37	24	23	28
Lack of cash flow	28	24	20	45	34	30	31	30
Management								
Lack of procedures to acquire scientific and technological information	25	17	24	24	24	26	20	23
Low strategic priority	29	21	26	29	33	25	22	26
Lack of capabilities to evaluate new technology	28	15	26	23	35	20	20	23
Human resources								
Shortage of skills	34	18	34	24	32	30	23	27
Training difficulties	26	20	31	28	25	23	24	25
Worker resistance	20	22	18	33	21	21	19	22
External support services								
Lack of technical support from vendors	16	17	30	14	15	17	11	16
Lack of technological services (e.g. technical and scientific consulting, tests, standards)	17	18	17	12	13	18	13	16
Government policies/ standards/regulations								
Labour	26	16	28	39	26	23	32	27
Food composition	15	12	27	21	27	26	25	21
Food safety	28	9	26	38	33	41	33	30
Plant hygiene	30	13	27	44	31	47	28	32
Environment	25	13	27	37	32	36	27	28

[a] Percentage of establishments reporting a score of 4 or 5 on a 5 point scale, where 5 is extremely important.

There also are industry differences in the degree to which government policies / standards / regulations are an impediment to technology adoption. In particular, the fish industry is the most concerned with the government's role in the area of labour, and the meat and fish industries in food safety, plant hygiene and the environment. On the other hand, plants in the cereal industry are by far the least likely to see the government as an impediment in any of these areas, presumably reflecting in large part the nature of its product lines (e.g. food safety and environmental concerns would be less complex for grain-based operations than for most other food industries).

The importance placed on impediments by an industry is not consistently related to the use of advanced technologies. For example, while the fish industry is among the most concerned with impediments and among the least likely to use advanced technologies, the fruit and vegetable industry is also among the most concerned with impediments and is among the most likely to use advanced technologies.

6.6 Summary

In the food-processing industry, financial justification is the most important impediment to the adoption of new technology. In this regard, the key impediment is the cost of buying, leasing or developing new technology/equipment but other costs and revenue factors also are important. A lack of access to financial resources is the second most important impediment. A lack of external support services is the least important impediment to technology adoption.

Innovators and non-innovators give the same rankings of the importance of these factors as impediments. However, for some impediments, there are significant differences between innovators and non-innovators in the absolute percentages of plants rating them as highly important. In particular, non-innovators put much more emphasis on a lack of financial resources than do innovators. Perhaps surprisingly however, it is the innovators who put more stress on five of the impediments than do non-innovators - small market size, cost to develop software, lack of capabilities to evaluate new technology, training difficulties and food safety. These results may be partly explained by the 'learning by doing' model of innovation and adoption of new technologies.

Unlike the rates for the adoption of advanced technologies and innovation that differ in fairly consistent patterns by country of control and plant size, impediment ratings of plant managers do not. As might be expected, given the generally greater resources of multinational firms, Canadian-controlled plants are more concerned than foreign-controlled plants about financial resources, the cost of buying, leasing or developing new technology/equipment and the cost to develop software, and some management aspects of innovation. On the other hand, foreign-controlled plants are more concerned with elements of financial justification related to benefits and operational costs, namely small market size, degree of uncertainty associated with the evaluation of benefits and cost of integrating new with current technologies.

The importance of several impediments is associated with plant size, but most are not. Differences among industries in the importance attached to these impediments do not appear to be related to differences in technology use and innovation. The characteristics of these groups associated with technology use and innovation apparently do not apply as strongly to impediments, perhaps again reflecting the 'learning by doing' phenomenon.

Chapter 6 Endnotes:

[23] In some cases (e.g. meeting regulatory requirements) the 'bottom line' criteria may not be strictly financial.
[24] Ratings of benefits of the adoption of advanced technologies are positively related to plant size for some functional areas and not for others.

7.0 Role of Government

Governments in most if not all countries directly or indirectly support the development and transfer of new technology. Government participation reflects the belief that new technologies benefit the economy but firms face obstacles in trying to create or acquire them. More fundamentally, government intervention also reflects the inability of market forces to determine optimal levels of innovative activities. For example, the development of new technology involves uninsurable risks and the creators of new technology have difficulty in capturing the benefits of their work. Therefore less new technology will be produced than would be economically desirable unless governments offset these market limitations with financial assistance, legislative measures or institutional arrangements.

Federal and provincial governments thus offer a wide range of programs to facilitate technological change or, more specifically, the creation, development, transfer and implementation of new technology. To evaluate their usefulness, managers were asked whether or not they had used several generic kinds of programs over the previous three years and to rate the importance of the benefits experienced. Thirteen programs were identified and placed in four areas—research and development, investment, human resources and markets. While not exhaustive with respect to the overall set of economic and industrial policies and programs, this set is indicative of government activities directly related to innovation.[25]

Research and development

Governments encourage R&D by reducing costs and by providing intellectual property protection. Reducing costs includes direct financial assistance in the form of grants and tax credits. Reducing costs also includes the direct provision of research facilities as well as services such as information on new technologies and technical assistance. Examples of government R&D programs are the Industrial Research Assistance Program (IRAP), which includes a technology advisory service as well as financial support for R&D, and the strategic technologies (projects) program.

Intellectual property protection applies to the identification of products and technologies, expressions and information, and function. Identification is protected by trademarks and appellations of origin; expressions and information by copyrights, industrial designs and trade secrets; and function by patents, copyright on computer software and trade secrets. Plant breeders' rights provide protection to seeds and other propagation material (Baldwin 1997b).

Investment

Many new technologies are embodied in machinery and equipment, as well as in buildings and related facilities. Tax incentives for machinery and equipment and more general investment incentives help to offset the costs of the acquisition of new technologies.

Human resources

Government training programs and employment programs address the need to upgrade skills. An example of the latter is the hiring program for recent science graduates which facilitates their employment by industry.

Markets

Considering that the financial justification for investments in technology includes prospective revenue, programs that expand markets or reduce market risk facilitate technological change. Three examples are market information programs, export incentives and services, and government procurement of goods and services.

The contribution that governments make to innovation in the food-processing industry is indicated by the degree to which the programs are used and the views of users on the importance of the benefits they provide. The following sections discuss these two measures for the food-processing industry as a whole, differences between innovators and non-innovators, and the differences by country of control, plant size and industry.

This chapter on the role of government has six sections:

- Use and importance of programs and services
- Use and importance by process innovators and non-innovators
- Differences by country of control
- Differences by plant size
- Differences by industry
- Summary

7.1 Use and importance of programs and services

Government programs are widely used by plants in the food-processing industry. About 80% use at least one program. Industry participation in the 13 types of programs identified in this study ranges between 51% and 64% of all plants.

There is little difference in the incidence of use between financial and service programs.[26] Nor is there much difference in incidence between the four categories of research and development, investment, human resources and markets. Both of these points are illustrated by the top four programs in incidence of use: tax incentives for machinery and equipment (64%), market information programs (64%), training programs (63%) and R&D tax credit (62%) (Table 68).

With every individual program being used by at least 50% of all plants, government programs would appear to have a key role in the innovative process. This conclusion, however, is tempered by the program evaluations of plant managers. In all cases, substantially more managers using a program give a low rating to its importance than a high rating.

In terms of both little use and low importance, the four least significant government programs are: strategic technologies program, intellectual property protection, hiring program for recent science graduates, and procurement of goods and services.

On the more positive side, R&D tax credit and tax incentives for investment in machinery and equipment are the highest rated in importance and among the most used. R&D grants and training programs rank next for high importance and are widely used. While some programs in all areas are widely used, the programs with the highest ratings are more likely to be financial in nature (Table 68).

Table 68. Use and importance of government programs

Government Programs	Use	Importance[a]		
		Low	Medium	High
		percentage of plants		
Research and development				
Information and technical assistance programs	60	57	22	21
R&D grants	59	55	20	25
Strategic technologies programs	52	68	22	10
Research facilities	58	59	22	18
Intellectual property protection	51	71	18	11
R&D tax credit	62	44	22	34
Investment				
Investment grants	56	64	17	18
Tax incentives for machinery and equipment	64	44	25	31
Human resources				
Training programs	63	52	23	25
Hiring program for recent science graduates	52	66	19	15
Markets				
Market information services	64	54	31	15
Export incentives and services	59	55	25	20
Procurement of goods and services	53	70	18	12
Other	6	70	21	9

[a] Ratings of those plants using the program. Ratings are based on a 5 point scale. Scores given by managers have been aggregated into low (1 or 2), medium (3) and high (4 or 5).

7.2 Use and importance by process innovators and non-innovators

As would be expected given their greater involvement in innovative activities, process innovators are substantially more likely than non-innovators to use government programs to facilitate the process. This use applies to all programs. The difference is quite consistent - the smallest difference between the two groups using any one program is 14 percentage points and the largest difference is 21 percentage points. The largest differences are in the use of export incentives and services and four of the six programs in the research and development area: information and technical assistance programs, R&D grants, R&D tax credit and research facilities (Table 69).[27]

In addition, process innovators are more likely than non-innovators to consider government programs to be highly important. However, at least in an absolute sense, differences between innovators and non-innovators in their evaluations of the importance of these programs are less than the differences in the rates at which they use them (Table 69).

More significant is the question of whether use and ratings are correlated; if a high proportion of users rate a program highly, use would be expected to be relatively high unless there is some impediment to using the program. In fact, there is at best a weak positive correlation between usage and importance. The positive correlation appears to be relatively strong for R&D programs and weak for all other categories. For example, by far the largest difference in ratings between innovators and non-innovators is for R&D tax credit (22 percentage points) and it also has one of the largest differences in use (19 percentage points). At the same time, the two groups give the same rating of importance to export incentives and services, which also has one of the largest differences in use (20 percentage points) (Table 69).

Table 69. Use and importance of government programs, process innovator and process non-innovator

Government Programs	Use		Importance[a]		
	Process innovators	Process non-innovators	Process innovators	Process non-innovators	All users
	percentage of plants				
Research and development					
Information and technical assistance programs	68	48	23	17	21
R&D grants	67	48	28	20	25
Strategic technologies programs	57	43	10	8	10
Research facilities	65	47	21	13	18
Intellectual property protection	56	42	11	10	11
R&D tax credit	69	50	41	19	34
Investment					
Investment grants	62	46	20	16	18
Tax incentives for machinery and equipment	70	55	34	25	31
Human resources					
Training programs	69	54	28	20	25
Hiring program for recent science graduates	58	42	17	12	15
Markets					
Market information services	70	54	15	13	15
Export incentives and services	67	47	20	20	20
Procurement of goods and services	59	44	12	11	12
Other	5	9	13	7	9

[a] Percentage of those plants using the program that gave a score of 4 or 5 on a 5 point scale where 5 is extremely important.

7.3 Differences by country of control

Canadian-controlled plants are more likely to be concerned about some impediments to technology adoption than are foreign-controlled plants and less concerned about others. Given the generally greater resources of multinational firms, it might be expected that Canadian-controlled plants would be more likely to use government programs. On the other hand, government programs are generally equally available to both and foreign-controlled plants tend to be more involved in innovative activities.

Survey results indicate that foreign-controlled plants are more likely than Canadian controlled plants to use all government programs. The differences range between four and 11 percentage points. While the smallest difference is for training programs and the largest for R&D tax credit, there is no pattern to differences in use among types of program (Table 70).

While foreign-controlled plants are more likely to use government programs, Canadian-controlled plants are as likely or more likely to place a high level of importance on them. The biggest difference is in the importance attached to investment grants (12 percentage points), followed by market information services (nine percentage points). In nearly half the cases the difference is within plus or minus two percentage points (Table 70).

Table 70. Use and importance of government programs, by country of control

Government Programs	Use		Importance[a]		
	Canada	Foreign	Canada	Foreign	All users
	percentage of plants				
Research and development					
Information and technical assistance programs	59	64	21	16	21
R&D grants	58	64	26	22	25
Strategic technologies programs	51	59	10	5	10
Research facilities	57	63	19	17	18
Intellectual property protection	50	58	11	12	11
R&D tax credit	60	71	34	32	34
Investment					
Investment grants	55	62	20	8	18
Tax incentives for machinery and equipment	63	70	31	29	31
Human resources					
Training programs	63	67	25	27	25
Hiring program for recent science graduates	50	59	16	11	15
Markets					
Market information services	63	69	16	7	15
Export incentives and services	58	68	20	22	20
Procurement of goods and services	52	60	12	7	12
Other	7	4	10	-	9

[a] Percentage of those plants using the program that gave a score of 4 or 5 on a 5 point scale where 5 is extremely important.

In those cases where the differences between Canadian-controlled and foreign-controlled plants in ratings of the importance of government programs are significant, the differences do not appear to be closely related to differences in level of use or to type of program. The relatively greater emphasis placed on some financial programs by Canadian-controlled plants is consistent with their greater concern about financial resources as an impediment to innovation but for the most part the differences in program ratings do not seem to be related to differences in impediment ratings.

7.4 Differences by plant size

There is little a priori basis for predicting the relationship between plant size and the use or importance of government programs. Although rates of the adoption of advanced technologies and participation in innovative activities are positively related to plant size, we have seen that the importance of impediments is, for the most part, not related to plant size. Most programs are available to all firms, although some are focused more on smaller and medium size firms.

In the food-processing industry, plants with 250 or more employees are most likely to use all the government programs and plants with 10-19 employees are the least likely. Use increases with size up to plants with 50-99 employees, levels off, then increases sharply for plants with 250 or more employees (Table 71).

Table 71. Use of government programs, by plant size

Government Programs	Plant Size - Employee Size Group					
	10-19	20-49	50-99	100-249	250 or more	All
	percentage of plants					
Research and development						
Information and technical assistance programs	45	56	68	67	75	60
R&D grants	44	56	69	62	77	59
Strategic technologies programs	41	47	55	53	79	52
Research facilities	47	54	60	59	87	58
Intellectual property protection	41	47	55	52	75	51
R&D tax credit	48	55	70	69	82	62
Investment						
Investment grants	43	51	61	61	79	56
Tax incentives for machinery and equipment	52	57	70	69	87	64
Human resources						
Training programs	51	62	66	66	85	63
Hiring program for recent science graduates	40	47	55	56	74	52
Markets						
Market information services	53	62	65	69	82	64
Export incentives and services	44	56	63	65	84	59
Procurement of goods and services	45	49	54	58	70	53
Other	9	6	4	6	3	6

The importance attached to government programs shows no consistent relationship to plant size. Of the 13 programs identified, only the importance of R&D tax credit is monotonically positively related to plant size. In two other cases-R&D grants and training programs-plants with less than 50 employees are clearly less likely than larger plants to consider a program to be highly important. In the remaining 10 cases, there is a variety of patterns; in several cases plants in the mid-size groups are most likely to give a high rating (Table 72).

Table 72. Importance of government programs, by plant size

Government Programs	Plant Size - Employee Size Group					
	10-19	20-49	50-99	100-249	250 or more	All
	percentage of plants[a]					
Research and development						
Information and technical assistance programs	21	19	24	22	17	21
R&D grants	19	19	31	31	31	25
Strategic technologies programs	7	8	11	12	9	10
Research facilities	20	14	21	17	22	18
Intellectual property protection	11	13	13	9	6	11
R&D tax credit	25	29	34	39	44	34
Investment						
Investment grants	19	13	22	23	15	19
Tax incentives for machinery and equipment	32	27	29	34	35	31
Human resources						
Training programs	16	21	29	30	29	25
Hiring program for recent science graduates	12	14	13	22	14	15
Markets						
Market information services	11	12	16	22	10	15
Export incentives and services	15	19	20	26	19	20
Procurement of goods and services	18	9	13	12	4	12
Other	17	-	10	11	-	9

[a] Percentage of those plants using the program that gave a score of 4 or 5 on a 5 point scale where 5 is extremely important.

7.5 Differences by industry

We have seen that there is not a consistent pattern to differences among industries in the importance that they attach to impediments. We have also seen that industry differences in evaluations of importance of impediments are not related to differences in the use of advanced technologies nor to the undertaking of innovative activities. Therefore, it might be expected that any industry patterns in the use of government programs and evaluations of the importance of programs would not be closely related to industry differences in the importance of impediments. The question is whether program use and importance are related to technology use and innovation.

Although industries differ in the absolute rates at which they participate in government programs, relative participation rates tend to be much the same. In particular, tax incentives for machinery and equipment, market information services, training programs, and R&D tax credit are the four most used programs by almost all industries. While there is less agreement, the least used programs tend to be procurement of goods and services, strategic technologies program, intellectual property protection, and the hiring program for recent science graduates (Table 73).

In particular, the dairy industry, one of the leaders in the use of advanced technologies, is by far the main user of government programs; it has a clear lead in the use of seven of the 13 programs and is among the leaders in others. The other industry, which is also a leader in the use of advanced technologies, is by far the most likely to use the R&D tax credit. The bakery industry, one of the least likely to use advanced technologies, is the least likely to use all of the government programs (Table 73). While these examples may suggest that government programs are positively related to the use of advanced technologies, this relationship does not apply across all industries or programs. A related characteristic is that industries differ much less in program use than technology use.

Table 73. Use of government programs, by industry

Government Programs	Bakery	Cereal	Dairy	Fish	F&V	Meat	Other	All
				percentage of plants				
Research and development								
Information and technical assistance programs	46	63	72	63	64	60	59	60
R&D grants	48	61	68	60	64	55	62	59
Strategic technologies programs	43	57	56	54	56	50	49	52
Research facilities	45	63	65	59	65	58	56	58
Intellectual property protection	44	56	59	45	53	50	53	51
R&D tax credit	52	64	67	56	67	57	72	62
Investment								
Investment grants	47	59	65	57	62	54	54	56
Tax incentives for machinery and equipment	52	67	70	67	70	63	63	64
Human resources								
Training programs	52	66	76	64	62	67	61	63
Hiring program for recent science graduates	41	58	61	48	50	49	55	52
Markets								
Market information services	54	67	72	66	65	63	63	64
Export incentives and services	46	61	66	64	62	62	58	59
Procurement of goods and services	43	58	63	50	59	54	52	53
Other	10	8	4	3	8	3	8	6

Although the importance attached to government programs also differs by industry, most agree that R&D tax credit and tax incentives for machinery and equipment are among the most important. Industries also mostly agree that the least important are the strategic technologies program, intellectual property protection and procurement of goods and services.

The importance attached to government programs at the industry level is not related to program use nor to technology adoption and innovation rates. For example, the fish industry along with the bakery industry have relatively low rates of technology use and innovation. The fish industry either leads or shares the lead in the importance attached to all programs, while the bakery industry is the least likely or second least likely to give a high rating for eight of the 13 programs (Table 74).

Table 74. Importance of government programs, by industry

Government Programs	Bakery	Cereal	Dairy	Fish	F&V	Meat	Other	All
	percentage of plants[a]							
Research and development								
Information and technical assistance programs	8	10	17	45	27	14	25	21
R&D grants	12	21	23	42	26	19	31	25
Strategic technologies programs	3	2	9	21	13	11	8	10
Research facilities	5	16	26	28	23	18	15	18
Intellectual property protection	10	6	11	19	17	4	13	11
R&D tax credit	23	27	37	43	32	27	43	34
Investment								
Investment grants	11	8	19	33	22	18	18	18
Tax incentives for machinery and equipment	28	20	36	50	31	22	31	31
Human resources								
Training programs	25	16	24	32	29	25	25	25
Hiring program for recent science graduates	12	6	24	20	18	10	20	15
Markets								
Market information services	11	7	11	30	20	12	13	15
Export incentives and services	7	16	19	33	26	14	26	20
Procurement of goods and services	7	2	10	20	16	15	13	12
Other	9	11	-	33	16	-	6	9

[a] Percentage of those plants using the program that gave a score of 4 or 5 on a 5 point scale where 5 is extremely important.

In general, there is more variation among industries in their evaluations of the importance of government programs than in their use of them. Evaluations are thus not strongly related to use, although as indicated, the bakery industry trails in program use as well as giving low evaluations for a number of programs.

7.6 Summary

In view of the benefits of technological change to the economy and the impediments to it, governments offer a range of programs and services to industry. Thirteen programs in four areas - research and development, investment, human resources and markets - were identified. Some programs provide financial support and some provide facilities or services.

Government programs are widely used by food processors. Eighty percent of plants make use of at least one program. The top four programs in terms of use are market information, tax incentives for machinery and equipment, training programs and R&D tax credit. They are used by 62-64% of plants and cover the four program areas.

However, every program is considered by substantially more managers to be of low importance than high importance. Programs that are both widely used and relatively highly rated are tax incentives for machinery and equipment, R&D tax credit, R&D grants and training programs. The programs considered to be most important tend to be financial in nature. The importance of financial programs is consistent with the relative importance of costs and financial resources as impediments to innovation. However, the small proportion of users of government programs that considers them to be of great importance may indicate that program improvements are needed.

The implications of results for levels of innovation are reinforced by the finding that process innovators are more likely than non-innovators to use government programs and to rate their importance highly. Also, there appears to be only a weak positive correlation to the differences between the two groups in use of government programs and the differences in the importance they attach to them. If the programs were equally accessible to the two groups, one would expect that those with the greatest difference in use would be the ones with the greatest difference in ratings of importance. This relationship is the case for some such as R&D tax credit but not others such as export incentives and services.

Foreign-controlled plants are more likely than Canadian-controlled plants to use government programs. This may reflect the greater level of innovative activity of the former. But foreign-controlled plants are a little less likely to rate the importance of government programs highly, perhaps reflecting their stronger resource base. There is no pattern to these differences with respect to type of program, level of use or impediments, except for the greater importance that Canadian-controlled plants place on financial impediments and programs.

Larger plants are more likely to use government programs than smaller plants, although there is little difference in the mid-size ranges. There is no consistent relationship between plant size and importance attached to programs; a few are positively related, a few negatively related and in some cases the mid-size groups give the highest ratings. These results are consistent with the weak relationship between impediments and plant size but somewhat surprising given the strong positive relationship of innovation and use of advanced technologies to plant size.

Industries differ in the rate at which they participate in government programs and in the importance they attach to them. Whereas relative usage rates are much the same across industries, this is not the case for the importance attached to them. No consistent relationships between importance and use of programs, impediments or technology use are evident across industries.

Chapter 7 Endnotes:

[25] See West 1999 for a more complete listing of current government programs.
[26] Some programs have both features.
[27] Program use and ratings by all innovators and non-innovators are reported in the Appendix, Table A4.

8.0 Conclusions

This study provides a broad overview of the process of technological change in the food-processing industry. Innovation is a complex process. Both the process and the success achieved are influenced by factors such as firm and industry structure, business strategies and practices, and technology infrastructure, including government programs and services. The conclusions follow.

Innovation contributes to firm performance. Technological competence involves innovation and a range of general and specific strategies and practices, not just the use of advanced technologies. Process innovators are more likely than non-innovators to be users of advanced technology and to be technologically competitive internationally.

An R&D unit plays a key role in the innovative process but innovation does not necessarily begin or end with it. Innovative ideas, basic and applied research, pilot plant testing and full scale implementation are steps in the process. Ideas can originate anywhere and one stage can feedback to the others; the process is far from a simple sequential one. Non-research groups, most notably the production group, are important contributors to all phases of the process. Plants tend to emphasize incremental improvements in technology suggesting that relatively small R&D efforts (or at least successes) can be valuable.

Sources of information, technology development and technology acquisition external to the firm are the sector market, the technology services market and the non-market. Because knowledge is difficult to control it is not always fully compensated; spillovers occur in all three cases. Spillovers are an important mechanism of technology transfer domestically and internationally. They are especially important for non-market sources of relatively generic information.

Suppliers are the most common source of information, new technology acquisition and technology development. This result is an example of the complementarity among these elements of the innovation process. It also reflects in part the costs and uncertainties of creating new technologies in-house. At the same time, it indicates the dependence of the food-processing industry on others for its technological prowess.

Universities and governments are significant but less important sources in all phases of the process. However, this result reflects direct use by the industry; these groups also contribute through suppliers, conferences, publications and consultations. Much of their work is generic in nature and spillovers are purposefully high.

The Canadian food-processing industry benefits greatly from international transfers of technology. Other countries are important sources of ideas and R&D capability as well as technology itself.

Process innovators are more likely than non-innovators to engage in innovative activities. In particular, they are more likely to have an R&D program and to use the production group in the innovation process. Innovators also are more likely to use foreign-based sources for all activities.

The innovative process requires personnel with the requisite skills and new processes tend to increase operational skill requirements. Processors rely primarily on training to meet these needs.

Although innovation has benefits, plants face several impediments. The principal impediment to innovation for all plants is the effect of costs on financial justification. A lack of financial resources is relatively more important for non-innovators than it is for innovators and appears to be the key impediment to innovation.

Perhaps surprisingly, innovators are more concerned than non-innovators with impediments such as small market size, lack of capability to evaluate new technology and training difficulties. They also are more concerned about food safety regulations (but not other areas of government regulation). The fact that these impediments are of more concern to innovators than non-innovators supports the notion that innovation is at least partly a matter of 'learning by doing' and emphasizes the importance of the financial resource limitation to innovation.

Innovators are more likely than non-innovators to use government programs and to consider that they are very important. However, most users, whether innovators or not, believe that government programs are of low importance. This suggests the need to improve the performance of these programs.

Foreign multinational firms play an important role in technology development and transfer in the food-processing industry. Foreign-controlled plants are more likely than Canadian-controlled plants to be innovators and to engage in innovative activities. A key advantage is their ability to use foreign-based sources for information and the development and acquisition of new technologies. Foreign-controlled plants are less concerned about financial resources, management and government regulation as impediments to innovation than Canadian-controlled plants, but more concerned about some elements of financial justification, including small market size, the degree of uncertainty associated with the evaluation of benefits, and external support services. They are more likely to use government programs but not more likely, and in several cases less likely, to consider them to be highly important. These results are broadly consistent with the theory that a firm engages in foreign direct investment to exploit more fully its technology while maintaining as much control as possible.

Large plants are more likely than small plants to be innovators, and to undertake the various innovative activities. This size relationship is clearest for process innovation and is consistent with the greater use of advanced technologies by larger plants. With a few exceptions, there is no consistent relationship between plant size and importance of impediments nor the use of government programs.

Industries differ in levels of innovation and innovative activity. In most cases, the other, dairy, and fruit and vegetable industries lead the way, just as they do in the use of advanced technologies. Industries also differ in the importance they place on impediments to innovation, the use of government programs and the importance attached to programs. While some relationships among these three characteristics are evident, in most cases there is not a consistent pattern across industries.

An important qualification to the conclusions about relationships between innovative activities and characteristics such as country of control, plant size and industry is that the effects of these characteristics are not independent. For example, foreign-controlled plants tend to be larger than Canadian-controlled plants and some industries have proportionately more and larger or foreign-controlled plants. Multivariate statistical analysis is required to determine and to explain more fully these separate effects.

Although largely descriptive, the results of this study, along with those on technology use reported in Baldwin, Sabourin and West (1999), may be helpful to plants and firms in the industry wishing to evaluate their technological competence and to develop suitable approaches for improving it. The results also may be of use to government policy makers and program administrators in their efforts to identify and meet the needs of firms and the industry, a topic addressed in a separate report.

Appendix

Table A1. Type of innovator, by number of advanced technologies used

Type of Innovator	Number of Technologies Used				
	None	1 - 5	6 - 10	11 or more	At least one
			percentage of plants		
Process Innovators[a]	25	47	66	85	65
Process Non-Innovators	75	53	34	15	35
Total	100	100	100	100	100
All Innovators[b]	37	62	82	91	77
All Non-Innovators	63	38	18	9	23
Total	100	100	100	100	100

[a] Process only or product requiring process innovation.
[b] Process only, product only or product requiring process innovation.

Table A2. Internal sources of ideas for new technologies, by all innovators and non-innovators

Sources	All Locations		Foreign	
	Innovators	Non-innovators	Innovators	Non-innovators
		percentage of plants		
Head office	69	50	10	7
Related plants	38	24	12	5
Functional unit:				
Research	53	28	14	10
Development	54	27	13	8
Design	38	22	13	7
Production engineering	49	24	11	6
Production staff	72	45	5	4
Technology watch group	22	9	5	2
Sales/Marketing	68	46	13	7
Other	3	3	1	1

Table A3. External sources of ideas for new technologies, by all innovators and non-innovators

Sources	All Locations		Foreign	
	Innovators	Non-innovators	Innovators	Non-innovators
	percentage of plants			
Sector market				
Suppliers	73	46	29	17
Customers	67	44	24	15
Other processors	52	33	22	9
Technology services market				
Industrial research firms	27	14	8	3
Consultants and service firms	48	31	14	5
Non-market				
Publications	59	36	31	16
Trade fairs, conferences	69	35	41	16
Industry associations	44	28	18	11
Universities	31	20	7	6
Federal or provincial research organizations	31	19	4	2
Other	2	2	1	-

Table A4. Use and importance of government programs, by all innovators and non-innovators

Government Programs	Use		Importance[a]		
	Innovators	Non-innovators	Innovators	Non-innovators	All users
	percentage of plants				
Research and development					
Information and technical assistance programs	65	46	21	18	21
R&D grants	64	45	27	20	25
Strategic technologies programs	55	42	9	12	10
Research facilities	63	44	20	12	18
Intellectual property protection	55	40	11	11	11
R&D tax credit	67	47	37	21	34
Investment					
Investment grants	61	43	20	13	18
Tax incentives for machinery and equipment	69	50	33	25	31
Human resources					
Training programs	69	50	26	22	25
Hiring program for recent science graduates	56	39	17	9	15
Markets					
Market information services	69	51	15	15	15
Government export incentives and services	64	46	20	21	20
Procurement of goods and services	57	42	11	12	12
Other	5	9	13	4	9

[a] Percentage of those plants using the program that gave a score of 4 or 5 on a 5 point scale where 5 is extremely important.

References

Äkerblom, M., M. Virtaharju, and A. Leppäahti. 1996. "A Comparison of R&D Surveys, Innovation Surveys, and Patent Statistics Based on Finnish Data", *Innovation, Patents and Technological Strategies*. Paris: OECD.

Baldwin, J. R. 1997a. "The Importance of Research and Development for Innovation in Small and Large Canadian Manufacturing Firms." Research Paper No. 107. Ottawa: Statistics Canada.

Baldwin, J.R. 1997b. "Innovation and Intellectual Property." Catalogue No. 88-515-XPE. Ottawa: Statistics Canada.

Baldwin, J. R. and J. Johnson. 1995. "Business Strategies in Innovative and Non-innovative Firms in Canada," *Research Policy*, 25: 785–804.

Baldwin, J. R. and D. Sabourin. 1998. "Technology Adoption: A Comparison Between Canada and the United States." Research Paper Series No. 119. Ottawa: Statistics Canada.

Baldwin, John. 1999. "Innovation, Training, and Success." Manuscript. Ottawa: Statistics Canada.

Baldwin, John and Petr Hanel. 1999. "Innovation in the Manufacturing Sector." Manuscript. Ottawa: Statistics Canada.

Baldwin, John and Zhengxi Lin. 1999. "Impediments to Advanced Technology Adoption for Canadian Manufacturers." Manuscript. Ottawa: Statistics Canada.

Baldwin, John, David Sabourin and Mohammed Rafiquzzaman. 1996. "Benefits and Problems Associated with Technology Adoption in Canadian Manufacturing." Catalogue No. 88-514-E. Ottawa: Statistics Canada.

Baldwin, John, David Sabourin and Donald West. 1999. "Advanced Technology in the Canadian Food-Processing Industry." Catalogue 88-518. Ottawa: Statistics Canada. (Forthcoming)

Baldwin, John R. and Moreno Da Pont. 1996. "Innovation in Canadian Manufacturing Enterprises." Catalogue No. 88-513 XPB. Ottawa: Statistics Canada.

Baldwin, John R. and Guy Gellatly. 1998. "Are There High-Tech Industries or Only High-Tech Firms? Evidence from New Technology-Based Firms." Research Paper Series No. 120. Ottawa: Statistics Canada.

Baldwin, John R. and Mohammed Rafiquzzaman. 1998. "The Effect of Technology and Trade on Wage Differentials Between Non-Production and Production Workers in Canadian Manufacturing." Research Paper 98, Analytical Studies Branch. Ottawa: Statistics Canada.

Blomstrom, Magnus and Ari Kokko. 1997. "How Foreign Investment Affects Host Countries." Policy Research Working Paper 1745. Washington: International Economics Department, The World Bank.

Caves, Richard E. 1982. *Multinational Enterprise and Economic Analysis*. Cambridge: Cambridge University Press.

Cohen, W. and S. Klepper. 1996. "Firm Size and the Nature of Innovation within Industries: The Case of Process and Product R&D." *Review of Economics and Statistics* 78: 232–243.

Dunning, J. H. 1993. *Multinational Enterprises in the Global Economy*. Toronto: Addison-Wesley.

Dean, James W. Jr. 1987. *Deciding to Innovate: How Firms Justify Advanced Technology*. Cambridge, Massachusetts: Ballinger Publishing Company.

Hodgetts, Richard M., Fred Luthans and Sang M. Lee. 1994. "New Paradigm Organizations: From Total Quality to Learning to World-Class." *Organizational Dynamics*, Winter: 5–19.

Marti, Josep Marin Viedma. "ICBS Intellectual Capital Benchmarking System." Paper presented at the Third World Congress on Intellectual Capital and Innovation, January 20–22, 1999, Hamilton, Ontario.

Mahdjoubi, Darius. 1996. "An Innovation Model for the Real World." *Engineering Dimensions* 17:22–25.

McFetridge, Donald G. 1995. "Science and Technology: Perspectives for Public Policy." Occasional Paper No 9. Ottawa: Industry Canada.

Mowery, D. C. and N. Rosenberg. 1989. *Technology and the Pursuit of Economic Growth*. Cambridge: Cambridge University Press.

Stoneman, Paul 1996 . "Introduction." In Stoneman, Paul (Editor). *Handbook of the Economics of Innovation and Technological Change*. Cambridge, Massachusetts: Blackwell Handbooks in Economics.

Symeonidis, George. 1996. "Innovation, Firm Size and Market Structure: Schumpeterian Hypotheses and Some New Themes." Economics Department Working Paper No. 161. Paris: Organization for Economic Co-operation and Development.

Tassey, Gregory. 1994. *Technology Infrastructure and Competitive Position*. Norwell, Massachusetts: Kluwer Academic Publishers.

Teece, David J. 1994. "Firm Organization, Industrial Structure, and Technological Innovation." *Journal of Economic Behaviour and Organization* 31: 193–224.

Vaughan, Odette S. 1995. "Implications of Foreign Direct Investment for the Canadian Food and Beverage Manufacturing Industry." Working Paper No. 2/95. Ottawa: Policy Branch, Agriculture and Agri-Food Canada.

Vaughan, Odette S., Margaret Malanoski, Don West and Charles Handy. 1994. "Firm Strategies for Assessing Foreign Markets and the Role of Government Policy." Working Paper No. 5/94. Ottawa: Policy Branch, Agriculture and Agri-Food Canada.

West, Donald A. 1999. "Technology Use and Innovations in the Food-Processing Industry: Implications for Technology Policy." Ottawa: Policy Branch, Agriculture and Agri-Food Canada.