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# Methodological Framework: Decisions Taken and Lessons Learned


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# Survey of Innovation 1999

# Methodological Framework: Decisions Taken and Lessons Learned

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## Working Papers

The Working Papers publish research related to science and technology issues. All papers are subject to internal review. The views expressed in the articles are those of the authors and do not necessarily reflect the views of Statistics Canada nor, in this case, the views of Industry Canada, Natural Resources Canada or the National Research Council of Canada.

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## Preface

The Information System for Science and Technology Project was created to develop useful indicators of science and technology activity in Canada based on a framework that ties them together into a coherent picture. To achieve the purpose, statistical indicators are being developed for five key entities:

- **Actors**: persons and institutions engaged in S&T activities. Measures include distinguishing R&D performers, identifying universities that license their technologies, and determining the field of study of graduates.
- **Activities**: the creation, transmission or use of S&T knowledge including research and development, innovation, and use of technologies.
- **Linkages**: the means by which S&T knowledge is transferred among actors. Measures include the flow of graduates to industries, the licensing of a university's technology to a company, co-authorship of scientific papers, and the source of ideas for innovation in industry.
- **Outcomes**: the medium-term consequences of activities. Outcomes of an innovation in a firm may be improved productivity, improved product quality and/or more highly skilled jobs. An outcome of a firm adopting a new technology may be a greater market share for that firm.
- **Impacts**: the longer-term consequences of activities, linkages and outcomes. Wireless telephony is the result of many activities, linkages and outcomes. It has wide-ranging economic and social impacts such as increased connectedness.

The development of these indicators and their further elaboration is being done at Statistics Canada, in collaboration with other government departments and agencies, and a network of contractors.

Prior to the start of this work, the ongoing measurements of S&T activities were limited to information and data on the investment of money and human resources in research and development (R&D). For governments, there were also measures of related scientific activity (RSA) such as surveys and routine testing. These measures presented a narrow picture of science and technology in Canada. More measures were needed to improve the picture.

It is in this context that the Survey of Innovation, 1999 was developed. It is hypothesized that innovation makes firms competitive. Thus one of the goals of this survey was to determine if there were significant differences between innovative and non-innovative firms in the manufacturing and selected natural resources sectors. The capacity to innovate resides in people and measures are being developed of the characteristics of people in those industries that lead science and technology activity. In these same industries, measures are being made of the creation and the loss of jobs as part of understanding the impact of technological change.

This working paper is part of a series that examines the results from the Survey of Innovation 1999. Previous working papers include an examination of national estimates of innovation in manufacturing and a second working paper, which included statistical tables of provincial estimates of innovation in manufacturing. Research papers examining innovation in selected natural resource industries are also part of this series.

The framework briefly described above that guides the future elaboration of indicators was published in December, 1998 (**Science and Technology Activities and Impacts: A Framework for a Statistical Information System,** Cat. No. 88-522). The framework has given rise to **A Five-Year Strategic Plan for the Development of an Information System for Science and Technology** (Cat. No. 88-523).

Working papers and research papers are available at no cost on the Statistics Canada Internet site at **http://www.statcan.ca/cgi-bin/downpub/research.cgi?subject=193**

## Introduction

*Why survey innovation?*

Innovation may be thought of as transforming knowledge into economic activity. From this perspective, innovation therefore forms a vital part of economic activity by contributing to economic growth and development. It is through innovation that new products are introduced into the marketplace, new production processes are developed and organizational changes are made.

The information compiled from innovation surveys can be analyzed to determine the characteristics of innovative and non-innovative businesses. It can also be used to provide indicators on how policies are regarded by the business sector. Market analysis and competitiveness can be analysed by studying impact, studies can be performed as studies on impacts, collaboration, problems and obstacles. Finally, governments can utilize this information to develop national and regional policies.

The Survey of Innovation, 1999 was designed to address these and other questions. This paper describes the methods used to develop, conduct and analyze the various elements of the survey process.

*Oslo definition of innovation*

The Oslo Manual (OECD/Eurostat, 1997) outlines proposed guidelines for collecting and interpreting innovation data at the firm level. The manual identifies two types of innovation – product and process. In the case of product innovation, the product must have been introduced to the market. The term "product" includes both goods and services as innovation outputs. A process innovation must have been used within the production process. An innovative firm is one that has offered a new or significantly improved product or introduced a new or significantly improved production/manufacturing process during the last three years. Changes to a firm's existing products which are purely aesthetic or which only involve minor modifications are not considered to be innovations. At the time the Oslo Manual was prepared, organizational innovation (or other creative improvements) that may result in significant improvements in firm performance was not supported by practical experience. Therefore, organizational innovation is included only as an Annex in the Oslo Manual.

New production/manufacturing processes are those which are new to the firm. They involve the introduction of new production/manufacturing methods, procedures, systems, machinery or equipment into the firm. These must differ significantly from the firm's previous processes. Significantly improved production/manufacturing processes involve significant changes to existing processes which may be intended to produce new or significantly improved products or processes. Minor or routine changes to processes are not considered to be innovations.

The first edition (1992) of the Oslo Manual was based on experiences with manufacturing. The second edition in 1997 was updated to incorporate survey experience, improved understanding of innovation process, and to take in wider range of industries, particularly in manufacturing, construction, utilities and marketed services. The purpose of manual is to "…provide a framework

within which existing surveys can evolve towards comparability; and to assist newcomers to this important field." It allows for the production of internationally comparable, meaningful indicators of innovation.

*Short history of innovation surveys in Canada*

Statistics Canada has conducted several surveys of innovation since 1993 to better understand innovation in Canada:

- The 1993 Survey of Innovation and Advanced Technology surveyed manufacturing firms.
- The Survey of Innovation, 1996 surveyed the communications, financial services and technical business services industries.
- The 1999 Survey of Innovation, Advanced Technologies and Practices in the Construction and Related Industries was the first survey of advanced technologies and practices in the construction sector.
- The Survey of Innovation 1999 surveyed manufacturing and was the first innovation survey of selected natural resource industries.

*Structure of questionnaire*

The questionnaire designed for the Survey of Innovation 1999 consisted of thirteen sections covering the following topics:

- competitive environment;
- firm success factors;
- new and significantly improved products and processes;
- sources of information;
- objectives;
- problems and obstacles;
- impact;
- cooperative and collaborative arrangements;
- most important new or significantly improved product or process;
- building and construction products;
- natural resource products;
- research and development, intellectual property and human resources; and
- government support programs.

**Sample Unit and Stratification**

*Target population*

The target population for the Survey of Innovation 1999 was all firms in the manufacturing sector (NAICS 31-33) (North American Industry Classification System, Statistics Canada, 1998) and all firms in selected natural resource industries (NAICS 1133, 212, 2211) that had responded to existing production surveys.

Statistics Canada conducts a broad range of annual surveys that are designed to collect production data in support of the System of National Accounts. To reduce response burden for the Survey of Innovation, it was decided to limit questions to those exploring the nature of innovation. These types of questions make them best suited to response by someone at a corporate level. For this reason it was decided to target the CEO or person designated by the CEO as the respondent. Production data would be obtained after the collection, editing and imputation phases of the survey were completed by linkage of the relevant data files

*Production data*

In order to provide production data to accompany innovation data, the sample was chosen as a sub-sample of existing responses to surveys conducted by Statistics Canada's Manufacturing, Construction and Energy Division (MCED) and Natural Resources Canada. These included MCED's Annual Survey of Manufactures, Coal Mines Annual Survey, Annual Survey of Electric Power Generation, and Natural Resources Canada's Annual Census of Mines, Quarries and Sand Pits. By using a sub-sample of respondents to these existing surveys, new businesses (births since 1997) were not part of the target population. At the time of sample selection, the most current data for a common year was chosen. Only businesses that responded to the production surveys were considered for the population for the Survey of Innovation.

The data drawn from these responses are the principal statistics. Principal statistics include shipments, materials purchased, inventories, labour data (including number of production and related workers, and salaries and wages of employees), census value added, and commodity information.

*Provincial enterprises*

The requirement to produce provincial statistics was a major criterion in defining the sampling unit. Following the recommendations of Eurostat, the enterprise was chosen. A complicating factor that whenever possible, provincial data are to be an output of surveys at Statistics Canada was also considered desirable. Accordingly, within each province, for each enterprise, all establishments coded to the same 4-digit NAICS industry groups were grouped to form one sample unit or "provincial enterprise". To reduce response burden on small businesses, only provincial enterprises with at least 20 employees and a gross business income of at least $250,000 were considered in sample selection[1].

*Stratification*

Thirty-six industry strata were identified based on groupings of 4-digit NAICS codes. The sample was randomly drawn from the population of provincial enterprises stratified by province and the thirty-six industrial strata (thirty-one industry strata for manufacturing and five industry strata for the selected natural resource industries). Details of the industry codes used are found in Annex 1.

As part of a Federal-Provincial Agreement, the sample in Quebec was augmented. The resulting sample, at the national level, was 5,944 provincial enterprises in manufacturing and 674 provincial enterprises in selected natural resource industries.

[1] Gross business income and the number of employees were derived from Statistics Canada's Business Register.

## Questionnaire Design

The questionnaire was designed by staff of the Science, Innovation and Electronic Information Division of Statistics Canada in collaboration with staff of Industry Canada, the Institute for Research in Construction of the National Research Council of Canada and Natural Resources Canada. Statistics Canada carried out cognitive interviews with a small sample of firms, in both official languages, to ensure that the questions were well understood. Feedback from these interviews was incorporated into the questionnaire design.

*Relationship between questions and respondent*

Questions that explore the nature of innovation include those on new or significantly improved products or processes and organizational practices. The best person to respond to these types of questions is the CEO or person designated by the CEO. It was assumed that different business characteristics exist between provinces and industries thus the CEO was mailed one questionnaire for each provincial enterprise.

*Why Questions 1 and 2 first?*

Given that the CEO was the target respondent, it was decided to place the competitive environment and firm success factor questions first. These types of questions would capture the interest of the CEO who would go on and complete the remainder of the questionnaire.

*Questions 3, 4, 5 and 6 define the innovator population*

To be identified as an innovator the firm must have produced a new product or a new production/manufacturing process in the past three years. Question 3 probed the firm's new or significantly improved products and Question 4, probed the firm's new or significantly improved processes.

Some firms may be in the process of or had attempted to develop a new product that was not yet on the market or were in the process of but had not yet completed or had unsuccessfully attempted to implement a new production/manufacturing process. This activity is of interest as a measure of defining potential innovators. It was captured in Question 5. In addition, information was collected on the types of activities that could be linked to innovation even if these activities were carried out in non-innovative firms. These activities were captured in Question 6.

*Skip patterns*

Respondents who responded yes to any of Questions 3, 4, 5 or 6 were asked for more details on their innovative activities by responding to a series of questions on: sources of information, objectives, problems and obstacles, impact, cooperative and collaborative arrangements, and their most important innovation. Respondents who answered no to all parts of Questions 3, 4, 5 and 6 were asked to complete Question 7, describing why the firm did not develop or introduce any innovations. These firms were then directed to skip to Question 21. A chart showing the skip patterns is presented in Annex 2.

The first skip separated the innovator sub-population from the non-innovator sub-population[2]. In so doing, it reduced the burden on the non-innovators.

Within the sub-population of innovators, smaller skip patterns allowed the respondent to move efficiently through the questionnaire. One smaller skip patterns gave respondents, who self identified as product innovators, the opportunity to report on impact of innovation (Question 12). A second skip pattern required that only respondents with cooperative or collaborative arrangements with other firms or organizations to develop innovations to indicate the reasons they considered important in determining their involvement in these collaborations (Question 14). In addition, only the respondents with cooperative or collaborative arrangements were asked to indicate the location of their collaborators (Question 15 or 16). Firms with more than one location in Canada were asked to complete Question 16 and firms with only one location in Canada completed Question 15.

Beginning with Question 21, all respondents were asked to provide information on the destination of their products into the Building and Construction Trades Sector (Questions 21 and 22) or the Natural Resource Industries (Question 23). Finally, Questions 24 and 26 allowed the respondents to skip these questions if they did not apply to them.

**Data Collection**

*Data capture*

Computer Assisted Telephone Interviewing (CATI) was used to collect the survey data. All sample units were "pre-contacted" to determine the name and correct mailing address for the respondent, the Chief Executive Officer (CEO) of the business or the person designated by the CEO. Questionnaires were mailed out with mail, telephone and fax follow ups to elicit a response from non-respondents.

Validity and flow edits were built into the data capture system and were applied during data collection and data entry. Validity edits ensured that responses to particular questions fell within a limited range of possible values. Flow edits ensured that skip patterns were followed.

The population of innovative firms was estimated by summing the weighted count of firms with successful innovation activities during the 3-year period from 1997 to 1999.

*Response rate*

The response rate for the Survey of Innovation 1999 was calculated as the total number of completed questionnaires as a percentage of the total active, in-scope survey sample. The overall response rate for manufacturing industries was 95%, for a total of 5,455 completed questionnaires. The overall response rate for selected natural resource industries was 94% for a total of 582 completed questionnaires.

Given the low rate of non-response (5%) to the survey, it was decided that it would be reasonable to assume that the characteristics of the non-response population were the same as the respondent

[2] Note that non-innovators with innovative activities were also required to complete Questions 8-20.

population. Accordingly, it was decided that the contribution of non-response to the estimates was to be accounted for by adjusting the sample weights of the respondent population.

Estimates based upon the responses to the survey questions are population estimates; that is, they represent the percentage of businesses in the population that exhibit a particular characteristic. The population estimates are generated through the accumulation of the product of the response variable and the sample weight.

*Sampling error*

As the sample selected for this survey is but one of many possible samples that could have been selected, the estimates computed from the responses also have a computed sampling error. Standard errors are used to provide a guide as to the reliability of the results. The reliability of the data was reported using the following convention:

| Symbol | Meaning | Standard Error |
|---|---|---|
| A | Very reliable | $\leq$2.5% |
| B | Reliable | >2.5% and $\leq$7.5% |
| C | Use with caution | >7.5 and $\leq$15% |
| D | Too unreliable to be published | >15% |

Estimates with very poor reliability (symbol D) were suppressed.

Not all industries operate in all provinces. Consequently, it was not possible to produce estimates for all industries in all provinces. For example, small populations restricted the production of any data for Audio and Video Equipment Manufacturing. However, this small population did contribute to estimates at aggregate level for manufacturing in Canada. Similarly, where the number of records contributing to an estimate brought the quality of representation of the data into question, these estimates were suppressed.

**Edit and Imputation**

Post collection consistency edits were applied to complete questionnaires. A complete questionnaire is one that has responses to questions 3, 4, 5, 6, 12, 21, 22 and 23. Completion of these mandatory questions ensured that we would be able to define our innovator population and the population of non-innovative firms with innovative activities (see discussion of Questions 3, 4, 5, and 6 in the section on Questionnaire Design). Collaborators with SIEID were consulted and asked to identify questions that were more important to them than others. Question 12 was identified as crucial to an assessment of the impact of innovation. Questions 21, 22 and 23 were included to explore the relationship between construction and manufacturing and the linkage between manufacturing and selected natural resource industries.

*Imputation strategy*

There are several cases where the relevance of a set of questions relies on a response to a preceding question. The ability to proceed along a path of questions is reliant on the nature of the response. The subsequent responses are influenced by the firm behaviour indicated by the response to the preceding question. Block imputation (one donor) was used for these correlated questions as a means to avoid edit failures. For instance, only those who indicated that they had a new or significantly improved product in the first part of Question 12 completed the remaining two sections. Thus if any of these parts were not completed, all three parts were completed from the results of one donor. Similarly for Question 24, only firms indicating that they undertook R&D would provide information about where and on what frequency the R&D was carried out. These too were donor imputed as a block if values were missing. Finally in Question 26, respondents would provide both the number of patents they had applied after indicating that they had applied for at least one patent. If either of these values were missing both would be provided by a donor.

Questions 14, 15 and 16 are all related to cooperative and collaborative arrangements. The sub-population of collaborators self-identify in the first part of Question 14. Only this sub-population are asked to complete the subsequent series of questions on their reasons for collaborating (the remainder of Question 14), who their collaborators were and where they were located (Questions 15 or 16). When imputation was required, the donor responses were applied to all three questions. This eliminated the possibility of having one donor without collaborations for Question 14 and a second donor with collaborations for Question 15 or 16 which would result in an edit failure.

The group of Questions 17 to 20 were all in reference to the firm's most important innovation. Only firms who described their most important innovation in Question 17 were considered for imputation for Questions 18 to 20. Block imputation was used as these questions are correlated.

Some questions (Questions 8, 10, 13, 25, and 29) contained correlated choices. The components of the response choices were in effect, one question. When there was no response in any part of these questions block imputation was used.

The questions that did not contain correlated parts (Questions 1, 2, and 9) were imputed line by line.

The change in total number of employees, Question 28, is a firm-specific phenomenon. During the edit process, any non-response to this question was coded as unknown.

There was no imputation for any of the questions requiring a written response (Questions 7, 11, and 17).

*Donor use*

Imputation was used for question or item non-response to non-mandatory questions on complete questionnaires. Donors were always chosen from the same stratum (industry/province) as defined in Annex 1. No individual record was used as a donor more than four times for any given question. There were 13 cases where a donor could not be found with the same innovator status as the recipient. Seven of these cases are non-innovators imputed with an innovator as donor. The

remaining six cases used non-innovators with innovative activities to impute for non-innovators with no innovative activities.

*Imputation rate*

The imputation rate was calculated by domain for non-mandatory questions. Imputation was carried out on completed questionnaires only. Overall, for Manufacturing and Selected Natural Resource Industries combined, the maximum imputation rate, 11.5%, was for Question 15. For each industry stratum in manufacturing, the highest rate of imputation (30.4%) was for Question 16 the Semiconductor and other Electronic Equipment Manufacturing. Finally, for Selected Natural Resource Industries, the highest rate of imputation (22.4%) was for Question 25 for Non-Metallic Mineral Mining.

**Linkages**

The Survey of Innovation 1999 covered the logging, mining (coal mines, metal ore mining and non-metallic mineral mining), electric power generation, transmission and distribution, and manufacturing sectors, requiring a number of separate linkage operations, one set at a time.

Linkage of each survey data set followed the same logic as that utilized to create the provincial enterprises. Establishment data from existing production surveys for respondents in the same province/territory and industry were accumulated to form the provincial enterprise created for the collection phase of the survey. The production data was accumulated to create the value of each principal statistic for each provincial enterprise. Records on the production data file were then matched to records on the Survey of Innovation database. Values for matched records became characteristics of the firm on the Survey of Innovation database for analytical purposes.

*Manufacturing and logging*

Production data for logging and manufacturing were both derived from the Annual Survey of Manufactures. There were 5,944 manufacturing and 168 logging provincial enterprises sampled with 5,455 manufacturing and 142 logging completed questionnaires for the Survey of Innovation. There were three records on the Survey of Innovation file that were not matched with any production data from the Annual Survey of Manufactures (ASM). The donor imputation strategy employed during the main edit/imputation phase of the Survey of Innovation 1999 was adopted to create a “complete” record.

In the population that was sampled, all threshold criteria were met, provincial enterprises with more than 19 employees and a minimum $250,000 in gross business income based on information from Statistics Canada’s Business Register. Analysis of the linked data identified cases where production data did not meet the survey sample thresholds. For example, there were 226 cases of manufacturing firms that had less than 20 employees and 12 cases of manufacturing firms with less than 250,000 in total shipments, 6 of which also fail the employment threshold. Processing of data from the Annual Survey of Manufactures resulted in new values, some of which did not meet the sample threshold criteria.

*Mining*

The Annual Survey of Mines, Quarries and Sand Pits is carried out by NRCan. The Coal Mines Annual Survey is conducted by the Energy Section of MCED, STC. There were 427 mining provincial enterprises sampled and 369 completed questionnaires for the Survey of Innovation 1999.

*Electric Power Generation, Transmission and Distribution*

There were 71 electric power provincial enterprises (NAICS 2211) in the Survey of Innovation. These data will be linked to production data from the 1998 Annual Survey of Electric Power Generation (NAICS 22111)[3].

**Lessons Learned**

*Choice of provincial enterprise*

The nature of the sample unit, the provincial enterprise, means that one enterprise can potentially receive more than one questionnaire. The characteristics of the provincial enterprise are assumed to be different for the same enterprise. In the case of a multi location and/or multi industry businesses do the responses received from the CEO in one location apply equally to all locations? Can we assume that the opinions of a CEO located in Toronto represent the business equally in Northern Ontario or southwestern Manitoba?

If a CEO received more than one questionnaire he could potentially report only once, indicating this during data collection. Statistics Canada's requirement for provincial estimates requires that the CEO report for each industry in each province for his business. The appropriateness of adding these responses at the national level raises the issue of multiplicity due to the number of questionnaires sent to one respondent.

Pierre Therrien and Pierre Mohnen (2001) undertook an analysis titled "How innovative are Canadian firms compared to some European firms? A comparative look at innovation surveys". In this paper they address the issue of multiplicity brought on by the use of a provincial enterprise. They compared innovation rates calculated using single-location firms (defined using the variable Q15) and innovation rates calculated using the entire sample. The innovation rate for the population was estimated at 80.3% whereas the innovation rate for single location firms was 79.4%. The conclusion was that the multi-location firms were not resulting in an upward bias to the innovation rate. Tests were carried out on other variables of interest and only minor and non-significant differences were observed.

The absence of upward bias in innovation rates supports the assumption that responses provided by the CEO for one location apply equally to all locations in cases where the CEO completed only one questionnaire.

It is believed that, post survey data validation is a necessary step to understanding how respondents viewed the questions. An examination of the how well a respondent understood concepts and how

[3] The Electric Utilities Financial Report summarizes data from this survey. This report file will be used for linkage.

they may have reacted to completing more than one questionnaire for their enterprise can aid in data interpretation. This would allow for hands-on evaluation of potential multiplicity and insight into the characteristics of each provincial enterprise, to test if characteristics are indeed the same or different.

*Breakdown of conceptual model when one navigates outside the well defined world of the Manufacturing Sector*

When defining an enterprise, the identification of the statistical components of that enterprise is critical. Manufacturing provides the classic example of the building block of the enterprise where characteristics of the establishment can be described fairly easily: a plant processes inputs and outputs are created.

Analysis of innovation in the forest sector (Schaan and Anderson, 2002) have found evidence that the concept of a production system is not as clear in harvesting industries where there is no factory per se. There is an issue with production concepts and the notion of a production process within these harvesting industries. In addition, industries such as electric utilities are granted a license to operate. They purchase or generate power and distribute their output to an area of service such as a municipality.

*Patents (Question 26)*

During questionnaire design, it was the opinion of subject matter experts that the number of patents in Canada or the Unites States would not exceed 99. The data capture system was designed with this specification. During data collection, some respondents indicated to the collection agent the actual amount was above this number and it was noted with the record. Two respondents indicated that they had patents in countries other than Canada and the United States. The question would have been complete if we had included a category for "other". We only have information on the location of the other patent when it was provided to a data collection agent. There were two records representing 3 firms indicating patent applications outside Canada and the United States. There were 55 records representing 87 firms indicating they had applied for patents but did not indicate a number of patents in Canada or the United States. These may have been in other countries.

*Impact of innovation (Question 12)*

Respondents were asked to indicate their percent of sales from new products and their percent of sales from significantly improved products within a series of sales percent ranges. During data analysis it was noted that the combination of these two sub-questions would be above 100%. This affects 1.5% of the manufacturing population and 1.5% of the population for selected natural resource industries. Other cases with potential to aggregate to greater than 100% (depending on value within range) affect 2.1% of the manufacturing population. Changes to the questionnaire design will eliminate this problem.

*Non-innovators with innovative activities*

Questions 5 and 6 were included to allow an assessment of those firms that were not innovative yet had undertaken innovative activities and thus, had the potential to be innovative. If the results of the

survey had shown a lower innovation rate we would have been able to use this to assess the "innovative potential" of firms however with such high innovation rates this is no longer an issue.

*Most important innovation (Question 17)*

There were 4,099 manufacturing firms and 266 firms in selected natural resource industries who described their most important innovation. Some non-innovators i.e. those who responded no to questions 3 and 4 and yes to at least one part of questions 5 or 6 had the opportunity to respond to Questions 17-20. There were 220 non-innovators in manufacturing and 219 non-innovators in selected natural resource industries who described a most important innovation. The series of questions on the most important innovation was included with the intention of producing comparable data to the European Community Innovation Surveys (CIS). The position of the series of questions within the questionnaire may have affected the responses. The focus of the set of questions preceding the set of questions on the most important innovation was on all innovators not just on the most important innovation. If the respondent was forced to think about their most important innovation immediately following the questions on product or process innovation (Questions 3 and 4) perhaps fewer non-innovators would have responded.

*Novelty of innovation (Question 18)*

Given a 95% response rate and an 80% rate of innovation, is the definition of innovation too broad? Does "novelty" refine the definition to a more manageable concept? Can the addition of "New and Unique" to the definition of novelty add value to the definition? Respondents were asked about the novelty of their most important innovation (Question 18). This type of question was considered to fall just inside the boundary of the CEO's ability to respond and was added to permit compliance with the OECD manual detailing the concepts that defined Innovation. The results of the survey showed however that there are inconsistencies in the responses thereby suggesting that there were instances where the question should have been directed to someone else in the firm. No information has been obtained to suggest where in a firm the question ought to be directed in order to obtain consistent results.

From the point of view of measurability, the three elements of novelty are themselves not well defined or well understood. If the respondent (at no matter what level in the organization) identifies a new or significantly improved product or process, by definition, it must be "new" to the firm. Thus asking the "firm first" question should be redundant. Thus in the example of the Survey of Innovation, 1999, any valid response to Question 17 should not only quantify the new or significantly improved product or process but also automatically indicate that this was a "firm first", by definition. However, this was not observed in the responses. For all manufacturing industries, 83.2% indicated that their most important innovation was a firm first, 13.5% indicated that it was not a firm first and 3.3% did not know if it was a firm first[4]. How can a new or significantly improved product or process not be a firm first but still be considered an innovation? Cozzarin (2001) found the characteristics of firms in the group of innovators who described their most important innovation but did not indicate that it was a firm first were no different from that group who did indicate a firm first.

[4] The database was edited to ensure that all world first innovations were also first in Canada and a first for the firm and that all innovations that were a first in Canada were a first for the firm.

Holbrook (2001) asserts that the terms "world first", "country first" and "firm first" are not sufficiently robust. These terms could be made sharper by the addition of the concept of the "market" of destination of the new or significantly improved product or process. Adding precision to the concepts of country first and world first might be possible through the addition of the concept of the market as has been suggested by Holbrook. He suggests that the firm would be able to identify its markets and thus would be able to respond to a question asking for information on local markets (analogous to an innovation cluster), domestic markets (a country first) and international markets (a world first).

This has appeal because it uses the language with which we would expect the respondent to be familiar. However it suffers from the same knowledge problem that we believe exists when we pose the original question. If the evidence contained in the Survey of Innovation, 1999 does not contain any indicators pointing to domestic or international outreach, then we might conclude that the business concerns itself only with local markets and it is unlikely that it possess knowledge beyond these markets. Another way of arriving at the characteristic "local".

Using the provincial enterprise as the unit of observation to query the novelty of the innovation may not be appropriate. This is because the knowledge of whether or not the innovation was a world first, country first or firm first may reside in one or more locations within the organization. Two possible locations within a firm where such knowledge might reside are the production floor and, if one exists, the R & D unit. The problem is that there is no single location within a firm where a questionnaire could be directed to obtain consistent results.

Using data from the Survey of Innovation 1999, Cozzarin (2001) has studied the relationship between novelty of innovation and firm performance in manufacturing. He found that market share, total employment, labour productivity and price-cost margins vary directly with innovation novelty. Landry and Amara (2001) conducted a study on the data from the Survey of Innovation 1999 exploring the effects of sources of information on novelty of innovation in manufacturing. Their study found that there is no significant relationship between barriers to knowledge exchange and novelty of innovation. Furthermore, they found that the degree of novelty of innovation are higher when there is greater variety to the sources of information used by firms in the development of their new or significantly improved products or processes.

*Definition of R&D*

There are three questions in the Survey of Innovation 1999 that inquire about R&D activities. The wording of each and responses vary. The first reference to R&D activities is in Question 6 where respondents were asked to indicate if they had engaged in R&D linked to new or significantly improved products or processes. 65% of manufacturing firms indicated they had engaged in R&D. Question 24 asks if the firm undertook R&D activities. 59% of manufacturing firms indicated that they had engaged in R&D. The meaning of R&D is subject to interpretation in both of these cases. R&D was not defined in the questionnaire. The third reference is in Question 29 and the use R&D tax credit programs sponsored by the federal or provincial government. Future survey questionnaires should provide a definition of R&D perhaps using the Frascati Manual (1993) as the model.

## Conclusion

Innovation surveys are new and evolutionary in nature. This iteration of a survey, designed to gain insights into the innovation process has been judged to be an important contribution to understanding innovation systems in manufacturing and selected natural resource industries. It tested out many of the concepts outlined in the Oslo Manual (1997) and found them to be workable. It also determined that some of the solutions chosen to measure innovation did not work as well as had been expected. On balance however the successful characteristics of this survey dominated the unsuccessful. The lessons learned will find their way into the next round of innovation surveys.

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## Annex 1: Manufacturing Industry Stratification

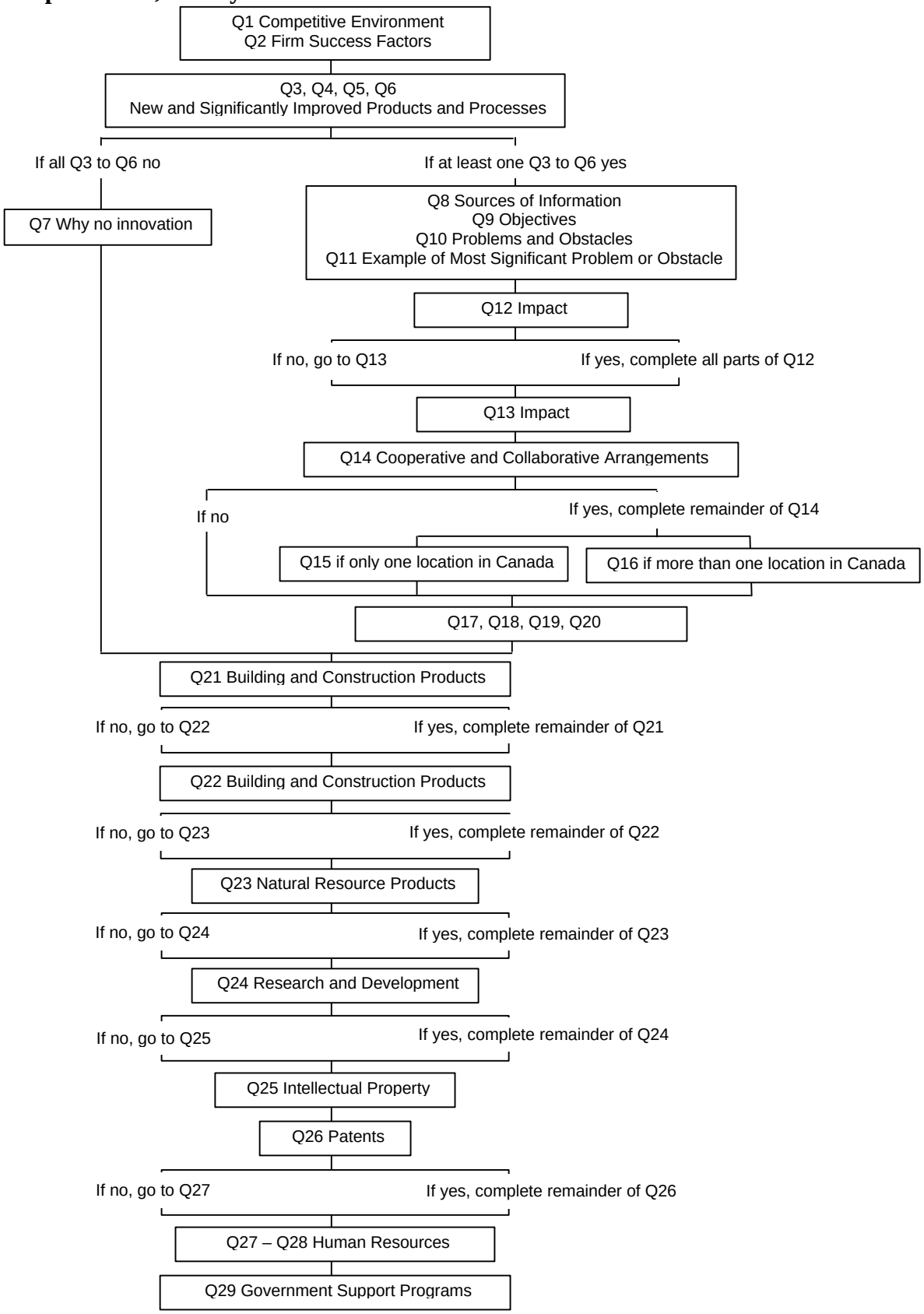
Population, Survey of Innovation 1999

| Stratum Number | NAICS | | Description | NF | PE | NS | NB | QC | ON | MB | SK | AB | BC | YT | NT | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 1133 | Logging | 8 | 1 | 5 | 16 | 80 | 37 | 3 | 6 | 25 | 160 | 0 | 0 | 341 |
| | 212 | | Mining | | | | | | | | | | | | | |
| 3 | | 2121 | Coal Mining | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 1 | 4 | 4 | 0 | 0 | 14 |
| 4 | | 2122 | Metal Ore Mining | 3 | 0 | 0 | 3 | 21 | 21 | 5 | 4 | 1 | 14 | 5 | 6 | 83 |
| 5 | | 2123 | Non-Metallic Mineral Mining | 20 | 4 | 31 | 40 | 242 | 296 | 35 | 46 | 115 | 91 | 2 | 0 | 922 |
| | 221 | | Utilities | | | | | | | | | | | | | |
| 6 | | 2211 | Electric Power Generation, Transmission and Distribution | 4 | 2 | 1 | 2 | 6 | 298 | 2 | 2 | 8 | 5 | 2 | 1 | 333 |
| | **Total Selected Natural Resources Industries** | | | **35** | **7** | **41** | **62** | **349** | **652** | **45** | **59** | **153** | **274** | **9** | **7** | **1693** |
| 7 | 311 | | Food Manufacturing | 29 | 18 | 50 | 46 | 294 | 203 | 34 | 22 | 70 | 90 | 0 | 0 | 856 |
| 8 | 312 | | Beverage and Tobacco Product Manufacturing | 3 | 2 | 5 | 6 | 32 | 22 | 3 | 3 | 10 | 13 | 0 | 0 | 99 |
| 9 | 313 | | Textile Mills | 0 | 0 | 4 | 4 | 115 | 44 | 5 | 0 | 0 | 2 | 0 | 0 | 174 |
| 10 | 314 | | Textile Product Mills | 0 | 1 | 5 | 2 | 55 | 46 | 7 | 2 | 9 | 12 | 0 | 0 | 139 |
| 11 | 315 | | Clothing Manufacturing | 0 | 0 | 4 | 8 | 380 | 104 | 21 | 5 | 13 | 36 | 0 | 0 | 571 |
| 12 | 316 | | Leather and Allied Product Manufacturing | 1 | 0 | 1 | 2 | 45 | 17 | 4 | 1 | 4 | 5 | 0 | 0 | 80 |
| | 321 | | Wood Product Manufacturing | | | | | | | | | | | | | |
| 13 | | 3211 | Sawmills and Wood Preservation | 6 | 2 | 16 | 15 | 133 | 25 | 5 | 6 | 14 | 67 | 0 | 1 | 290 |
| 14 | | 3212 | Veneer, Plywood and Engineered Wood Product Manufacturing | 0 | 0 | 3 | 7 | 37 | 24 | 3 | 3 | 14 | 26 | 0 | 0 | 117 |
| 15 | | 3219 | Other Wood Product Manufacturing | 0 | 1 | 5 | 8 | 125 | 81 | 7 | 3 | 22 | 53 | 0 | 0 | 305 |
| 16 | 322 | | Paper Manufacturing | 4 | 1 | 8 | 14 | 106 | 100 | 11 | 4 | 16 | 35 | 0 | 0 | 299 |
| 17 | 323 | | Printing and Related Support Activities | 1 | 1 | 12 | 7 | 189 | 233 | 27 | 9 | 46 | 73 | 0 | 0 | 598 |
| 18 | 324 | | Petroleum and Coal Products Manufacturing | 1 | 0 | 3 | 3 | 13 | 16 | 3 | 3 | 8 | 7 | 0 | 0 | 57 |
| | 325 | | Chemical Manufacturing | | | | | | | | | | | | | |
| 19 | | 3251 + 3252 + 3253 + 3255 + 3256 + 3259 | Basic Chemical Manufacturing + Resin, Synthetic Rubber, and Artificial and Synthetic Fibres and Filaments Manufacturing + Pesticide, Fertilizer and Other Agricultural Chemical Manufacturing + Paint, Coating and Adhesive Manufacturing + Soap, Cleaning Compound and Toilet Preparation Manufacturing + Other Chemical Product Manufacturing | 1 | 3 | 3 | 8 | 153 | 162 | 13 | 7 | 39 | 29 | 0 | 0 | 418 |
| 20 | | 3254 | Pharmaceutical and Medicine Manufacturing | 0 | 1 | 1 | 0 | 33 | 20 | 2 | 1 | 1 | 3 | 0 | 0 | 62 |
| 21 | 326 | | Plastics and Rubber Products Manufacturing | 3 | 0 | 9 | 10 | 218 | 213 | 20 | 5 | 33 | 55 | 0 | 0 | 566 |
| 22 | 327 | | Non-Metallic Mineral Products Manufacturing | 7 | 2 | 15 | 15 | 116 | 114 | 13 | 9 | 30 | 57 | 0 | 0 | 378 |
| 23 | 331 | | Primary Metal Manufacturing | 0 | 1 | 2 | 3 | 73 | 92 | 15 | 4 | 16 | 21 | 0 | 0 | 227 |
| 24 | 332 | | Fabricated Metal Product Manufacturing | 5 | 3 | 13 | 17 | 389 | 521 | 41 | 23 | 127 | 122 | 0 | 0 | 1261 |
| | 333 | | Machinery Manufacturing | | | | | | | | | | | | | |
| 25 | | 3331 + 3332 | Agricultural, Construction and Mining Machinery Manufacturing + Industrial Machinery Manufacturing | 0 | 1 | 2 | 4 | 87 | 62 | 9 | 17 | 40 | 22 | 0 | 0 | 244 |
| 26 | | 3333 + 3334 + 3335 + 3336 + 3339 | Commercial and Service Industry Machinery Manufacturing + Ventilation, Heating, Air-Conditioning and Commercial Refrigeration Equipment Manufacturing + Metalworking Machinery Manufacturing + Engine, Turbine, and Power Transmission Equipment Manufacturing + Other General Purpose Machinery Manufacturing | 0 | 1 | 6 | 3 | 190 | 322 | 17 | 10 | 39 | 43 | 0 | 0 | 631 |
| | 334 | | Computer and Electronic Product Manufacturing | | | | | | | | | | | | | |
| 27 | | 3341 | Computer and Peripheral Equipment Manufacturing | 0 | 0 | 0 | 0 | 19 | 16 | 3 | 1 | 0 | 7 | 0 | 0 | 46 |
| 28 | | 3342 | Communications Equipment Manufacturing | 1 | 0 | 0 | 1 | 27 | 21 | 2 | 0 | 7 | 9 | 0 | 0 | 68 |
| 29 | | 3343 | Audio and Video Equipment Manufacturing | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| 30 | | 3344 | Semiconductor and other Electronic Equipment Manufacturing | 0 | 0 | 1 | 1 | 24 | 19 | 0 | 0 | 3 | 4 | 0 | 0 | 52 |
| 31 | | 3345 + 3346 | Navigational, Measuring, Medical and Control Instruments Manufacturing + Manufacturing and Reproducing Magnetic and Optical Equipment | 1 | 0 | 4 | 1 | 49 | 51 | 4 | 2 | 10 | 13 | 0 | 0 | 135 |
| 32 | 335 | | Electrical Equipment, Appliance and Component Manufacturing | 0 | 0 | 4 | 1 | 84 | 95 | 4 | 3 | 12 | 19 | 0 | 0 | 222 |
| | 336 | | Transportation Equipment Manufacturing | | | | | | | | | | | | | |
| 33 | | 3361+3362 +3363 | Motor Vehicle Manufacturing + Motor Vehicle Body and Trailer Manufacturing + Motor Vehicle Parts Manufacturing | 0 | 0 | 6 | 3 | 68 | 168 | 14 | 6 | 25 | 34 | 0 | 0 | 324 |
| 34 | | 3364 | Aerospace Product and Parts Manufacturing | 0 | 3 | 3 | 0 | 30 | 22 | 4 | 0 | 3 | 7 | 0 | 0 | 72 |
| 35 | | 3365 + 3366 + 3369 | Railroad Rolling Stock Manufacturing + Ship and Boat Building + Other Transportation Equipment Manufacturing | 2 | 1 | 9 | 1 | 22 | 19 | 2 | 1 | 0 | 23 | 0 | 0 | 80 |
| 36 | 337 | | Furniture and Related Product Manufacturing | 1 | 1 | 3 | 8 | 219 | 153 | 18 | 6 | 44 | 47 | 0 | 0 | 500 |
| 37 | 339 | | Miscellaneous Manufacturing | 3 | 0 | 9 | 8 | 140 | 160 | 14 | 4 | 35 | 52 | 0 | 1 | 426 |
| | **Total Manufacturing Industries** | | | **69** | **43** | **206** | **206** | **3465** | **3,151** | **325** | **160** | **690** | **986** | **0** | **2** | **9,303** |
| | **Total Manufacturing and Selected Natural Resources Industries** | | | **104** | **50** | **247** | **268** | **3814** | **3,803** | **370** | **219** | **843** | **1,260** | **9** | **9** | **10,996** |

## Sample, Survey of Innovation 1999

| Stratum Number | NAICS | | Description | NF | PE | NS | NB | QC | ON | MB | SK | AB | BC | YT | NT | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 1133 | Logging | 8 | 1 | 5 | 16 | 78 | 16 | 3 | 6 | 13 | 22 | 0 | 0 | 168 |
| | 212 | | Mining | | | | | | | | | | | | | |
| 3 | | 2121 | Coal Mining | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 1 | 4 | 4 | 0 | 0 | 13 |
| 4 | | 2122 | Metal Ore Mining | 3 | 0 | 0 | 3 | 21 | 15 | 4 | 4 | 1 | 10 | 3 | 5 | 69 |
| 5 | | 2123 | Non-Metallic Mineral Mining | 4 | 2 | 5 | 6 | 234 | 40 | 3 | 7 | 21 | 21 | 2 | 0 | 345 |
| | 221 | | Utilities | | | | | | | | | | | | | |
| 6 | | 2211 | Electric Power Generation, Transmission and Distribution | 4 | 2 | 1 | 2 | 6 | 44 | 2 | 2 | 8 | 5 | 2 | 1 | 79 |
| | **Total Selected Natural Resources Industries** | | | **19** | **5** | **14** | **28** | **339** | **115** | **12** | **20** | **47** | **62** | **7** | **6** | **674** |
| 7 | 311 | | Food Manufacturing | 17 | 18 | 17 | 17 | 246 | 94 | 17 | 22 | 52 | 62 | 0 | 0 | 562 |
| 8 | 312 | | Beverage and Tobacco Product Manufacturing | 3 | 2 | 5 | 6 | 28 | 20 | 3 | 3 | 9 | 13 | 0 | 0 | 92 |
| 9 | 313 | | Textile Mills | 0 | 0 | 3 | 4 | 94 | 33 | 4 | 0 | 0 | 1 | 0 | 0 | 139 |
| 10 | 314 | | Textile Product Mills | 0 | 1 | 2 | 2 | 38 | 28 | 5 | 2 | 2 | 10 | 0 | 0 | 90 |
| 11 | 315 | | Clothing Manufacturing | 0 | 0 | 3 | 6 | 232 | 66 | 14 | 5 | 7 | 31 | 0 | 0 | 364 |
| 12 | 316 | | Leather and Allied Product Manufacturing | 1 | 0 | 1 | 1 | 35 | 12 | 2 | 1 | 2 | 3 | 0 | 0 | 58 |
| | 321 | | Wood Product Manufacturing | | | | | | | | | | | | | |
| 13 | | 3211 | Sawmills and Wood Preservation | 4 | 2 | 15 | 15 | 103 | 24 | 5 | 6 | 14 | 51 | 0 | 1 | 240 |
| 14 | | 3212 | Veneer, Plywood and Engineered Wood Product Manufacturing | 0 | 0 | 2 | 6 | 27 | 19 | 3 | 3 | 14 | 26 | 0 | 0 | 100 |
| 15 | | 3219 | Other Wood Product Manufacturing | 0 | 1 | 4 | 5 | 84 | 43 | 6 | 3 | 17 | 41 | 0 | 0 | 204 |
| 16 | 322 | | Paper Manufacturing | 4 | 1 | 8 | 14 | 96 | 65 | 10 | 4 | 16 | 35 | 0 | 0 | 253 |
| 17 | 323 | | Printing and Related Support Activities | 1 | 1 | 7 | 6 | 82 | 75 | 24 | 8 | 24 | 47 | 0 | 0 | 275 |
| 18 | 324 | | Petroleum and Coal Products Manufacturing | 1 | 0 | 3 | 3 | 13 | 16 | 2 | 3 | 8 | 7 | 0 | 0 | 56 |
| | 325 | | Chemical Manufacturing | | | | | | | | | | | | | |
| 19 | | 3251 + 3252 + 3253 + 3255 + 3256 + 3259 | Basic Chemical Manufacturing + Resin, Synthetic Rubber, and Artificial and Synthetic Fibres and Filaments Manufacturing + Pesticide, Fertilizer and Other Agricultural Chemical Manufacturing + Paint, Coating and Adhesive Manufacturing + Soap, Cleaning Compound and Toilet Preparation Manufacturing + Other Chemical Product Manufacturing | 1 | 3 | 3 | 8 | 133 | 90 | 11 | 7 | 39 | 29 | 0 | 0 | 324 |
| 20 | | 3254 | Pharmaceutical and Medicine Manufacturing | 0 | 1 | 1 | 0 | 28 | 20 | 2 | 1 | 1 | 3 | 0 | 0 | 57 |
| 21 | 326 | | Plastics and Rubber Products Manufacturing | 3 | 0 | 9 | 10 | 148 | 100 | 20 | 5 | 33 | 43 | 0 | 0 | 371 |
| 22 | 327 | | Non-Metallic Mineral Products Manufacturing | 7 | 2 | 13 | 15 | 90 | 60 | 11 | 8 | 26 | 44 | 0 | 0 | 276 |
| 23 | 331 | | Primary Metal Manufacturing | 0 | 1 | 2 | 3 | 69 | 60 | 14 | 4 | 16 | 21 | 0 | 0 | 190 |
| 24 | 332 | | Fabricated Metal Product Manufacturing | 4 | 3 | 8 | 15 | 224 | 120 | 15 | 15 | 67 | 71 | 0 | 0 | 542 |
| | 333 | | Machinery Manufacturing | | | | | | | | | | | | | |
| 25 | | 3331 + 3332 | Agricultural, Construction and Mining Machinery Manufacturing + Industrial Machinery Manufacturing | 0 | 1 | 1 | 4 | 59 | 50 | 8 | 17 | 35 | 21 | 0 | 0 | 196 |
| 26 | | 3333 + 3334 + 3335 + 3336 + 3339 | Commercial and Service Industry Machinery Manufacturing + Ventilation, Heating, Air-Conditioning and Commercial Refrigeration Equipment Manufacturing + Metalworking Machinery Manufacturing + Engine, Turbine, and Power Transmission Equipment Manufacturing + Other General Purpose Machinery Manufacturing | 0 | 1 | 4 | 3 | 121 | 100 | 12 | 9 | 35 | 34 | 0 | 0 | 319 |
| | 334 | | Computer and Electronic Product Manufacturing | | | | | | | | | | | | | |
| 27 | | 3341 | Computer and Peripheral Equipment Manufacturing | 0 | 0 | 0 | 0 | 12 | 16 | 3 | 1 | 0 | 7 | 0 | 0 | 39 |
| 28 | | 3342 | Communications Equipment Manufacturing | 1 | 0 | 0 | 1 | 21 | 21 | 2 | 0 | 5 | 9 | 0 | 0 | 60 |
| 29 | | 3343 | Audio and Video Equipment Manufacturing | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| 30 | | 3344 | Semiconductor and other Electronic Equipment Manufacturing | 0 | 0 | 1 | 1 | 18 | 19 | 0 | 0 | 3 | 4 | 0 | 0 | 46 |
| 31 | | 3345 + 3346 | Navigational, Measuring, Medical and Control Instruments Manufacturing + Manufacturing and Reproducing Magnetic and Optical Equipment | 1 | 0 | 4 | 1 | 26 | 48 | 3 | 2 | 9 | 13 | 0 | 0 | 107 |
| 32 | 335 | | Electrical Equipment, Appliance and Component Manufacturing | 0 | 0 | 4 | 1 | 68 | 57 | 4 | 3 | 11 | 19 | 0 | 0 | 167 |
| | 336 | | Transportation Equipment Manufacturing | | | | | | | | | | | | | |
| 33 | | 3361+3362 +3363 | Motor Vehicle Manufacturing + Motor Vehicle Body and Trailer Manufacturing + Motor Vehicle Parts Manufacturing | 0 | 0 | 4 | 3 | 47 | 87 | 12 | 6 | 17 | 33 | 0 | 0 | 209 |
| 34 | | 3364 | Aerospace Product and Parts Manufacturing | 0 | 3 | 3 | 0 | 21 | 16 | 4 | 0 | 3 | 7 | 0 | 0 | 57 |
| 35 | | 3365 + 3366 + 3369 | Railroad Rolling Stock Manufacturing + Ship and Boat Building + Other Transportation Equipment Manufacturing | 2 | 1 | 4 | 1 | 19 | 10 | 1 | 1 | 0 | 19 | 0 | 0 | 58 |
| 36 | 337 | | Furniture and Related Product Manufacturing | 1 | 1 | 3 | 7 | 116 | 70 | 9 | 4 | 31 | 33 | 0 | 0 | 275 |
| 37 | 339 | | Miscellaneous Manufacturing | 1 | 0 | 6 | 5 | 84 | 60 | 5 | 3 | 13 | 34 | 0 | 1 | 212 |
| | **Total Manufacturing Industries** | | | **52** | **43** | **140** | **163** | **2,382** | **1,505** | **231** | **146** | **509** | **771** | **0** | **2** | **5,944** |
| | **Total Manufacturing and Selected Natural Resources Industries** | | | **71** | **48** | **154** | **191** | **2,721** | **1,620** | **243** | **166** | **556** | **833** | **7** | **8** | **6,618** |

## Annex 2: Skip Patterns, Survey of Innovation 1999



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