

Defining the British Columbia High Technology Sector Using NAICS

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EXECUTIVE SUMMARY

The “high technology” sector is a popular subject of discussion and analyses, partly because it is viewed as an engine of growth both in the past and for the future. However, the high technology sector has no specific and universally accepted definition.

Defining and measuring the high technology sector can be done as part of basic research at the level of individual firms. A second, more “modest” approach uses pre-existing data collected on “industries” which are defined for general statistical purposes. The challenge is to determine which of these industries warrants inclusion in the measurement of the high technology sector.

In 1996 BC Stats commenced measurement of the high technology sector, based on the selection of thirty industries or part industries existing within the Statistics Canada Standard Industrial Classification (SIC). Statistics Canada has since begun conversion to a new classification system, the North American Industry Classification System (NAICS Canada, referred to in this paper as NAICS). This paper describes the methods used by BC Stats to determine which of the 925 NAICS industries warrant inclusion in the definition of the high technology sector.

Fifteen distinct methods were implemented under the banner of four principles:

1. SIC to NAICS concordance
2. Commodity lists
3. Research activities
4. Company lists

While the results of the fifteen methods are similar, they seldom completely agree on the NAICS codes to be included. In total, 188 different NAICS codes were identified by one or more methods. The disagreements were resolved by an “election” process, in which the number of methods agreeing on the selection of each NAICS code was the key factor. The election process produced a preliminary list of 23 NAICS codes.

Before the list can be finalized for use in production of statistics it must be validated. Validation could include inspection of those codes that narrowly missed inclusion, to make sure that this was not simply a statistical artifact. Similarly, some excluded codes may bear a strong resemblance or link to some included codes. Anomalies such as this also warrant inspection. Finally, the entire list will benefit from a “reality check” from industry and government experts who will eventually be the users of the resulting high technology sector statistics.

TABLE OF CONTENTS

1.0 INTRODUCTION.....	4
2.0 BACKGROUND.....	5
2.1 The " Modest Approach"	5
2.2 Previous Definition	6
2.3 The Value of NAICS	7
3.0 METHODS AND RESULTS.....	8
3.1 Concordance	9
3.2 Commodity Lists	11
3.3 Research Activities	12
3.4 Company Lists	13
3.5 High Tech Election	16
4.0 DISCUSSION.....	19
APPENDIX I.....	20

1.0 INTRODUCTION

Despite recent high profile stock market adjustments, the designation “high tech” is synonymous with growth and development. From running shoes to aerospace, everything that could conceivably be so designated gets the high tech label.

From the point of view of economic analysis, the high tech designation is in some ways not much more precise than the popular usage. Economists try to group industries or firms to make them easier to analyse and describe. To be effective, industry or firm groupings should be quite uniform internally while quite different from other groupings in the economy. Theory tells us that the “high tech” group should in the long run be distinguished by high performance, simply because “technology is the most obvious cause and effect of the cumulative wealth of rich nations”.¹ But we can not define it on that basis and then proceed with performance measurements. That would be circular reasoning. So what else is it about high tech that makes it “high tech”?

We begin with the knowledge that research and development is the basis of technological advancement. Therefore it is logical to assume that where research and development (R&D) effort is greatest, technology is likely to be “highest”. This assumes that R&D effort is uniformly successful, and that high technology firms or industries must create technology, rather than purchase it. Nevertheless, R&D effort remains a standard for assessing technology levels.

A second standard bypasses the amount of R&D effort, and looks at the nature of products and services that a firm or industry produces. Products that are recognized as high tech may be specified by panels of experts. Paradoxically, the experts may look at the R&D that went into a product in making their choices, but presumably a product could win the “high tech” label even if its creation involved fewer scientists and lesser budgets than other possible candidates. In addition, with the product standard, a firm or industry could be high tech by virtue of its product line, even if the firm or industry did not actually develop the product.²

A third way of grouping would rely on high tech sector experts to designate the firms or industries that comprise the sector. This of course is somewhat circular as well, since one would have to define the sector in order to choose the appropriate experts in it. Nevertheless, there is little debate about what constitutes the core of the sector. The expert’s contribution is to help with the more subtle distinctions.

¹ Malecki, Edward J., *Technology and Economic Development*, Longman Scientific and Technical, 1991, p.7.

² Products that are made by advanced processes, however, are not automatically high tech. For example, a mushroom from a high tech greenhouse is still just a mushroom.

Clearly, there is both art and science in deciding what “high tech” really means. What follows is an account of how BC Stats has applied some mathematics (arithmetic, really) to the challenge of re-defining the high tech sector for use in reports and economic analysis.

2.0 BACKGROUND

2.1 The “ Modest Approach ”

A natural or primary way to study any economic sector would be to identify the firms that are felt to comprise the sector, and then to conduct one or more surveys to obtain the information needed for any desired analyses. If the firms that comprise the sector are not already known, then a screening survey of either the whole population of firms would precede the main survey. The screening survey would contain questions to determine whether each firm contacted met a set of criteria predetermined for membership in the target economic sector.

This micro-level survey approach has the advantage of potentially great flexibility and precision. It does not remove the problem of “defining” the sector, but it moves the task into an arena where all the right questions can be asked and answered. The primary disadvantage of this approach is cost. It presumes that potentially all firms within a jurisdiction (province) will be contacted and that the contact information will be reviewed on a regular basis, and it presumes that a subset of the firms will fill out one or more detailed questionnaires on an ongoing basis.

A more “modest” approach takes advantage of information that is already being collected, saving on cost and on burden to respondents. If the source of information is Statistics Canada, then there is the added advantage that the information is consistent with other Statistics Canada data, and that it may well be available for comparison across provinces. The disadvantage of using pre-existing data is that it may have been collected using various definitions and procedures that do not exactly fit the needs of the desired analysis.

In the case of Statistics Canada data, none is collected “per se” for the “high technology sector”. Rather, almost all Statistics Canada industry data is collected on the basis of firm groupings defined (until recently) under the Standard Industrial Classification (SIC). The SIC contains 860 industries at its finest level. Some of these may be “high tech”, some not, and some may contain both high and low tech firms. The definition problem under the “modest approach” is to determine which industries (or potentially parts of industries) qualify as part of the high technology sector. This problem was the subject of a 1996 BC Stats paper, “Defining the High Technology/Knowledge Sector in British Columbia”³. This paper provided a SIC based definition of the high technology sector. The purpose of the present paper is to update this definition for use with the new North

³ Available at http://www.bcstats.gov.bc.ca/data/bus_stat/hi_tech.htm

American Industry Classification System (NAICS Canada, referred to in this paper as NAICS). There are 925 NAICS industries at the finest level. By 2004, almost all Statistics Canada industrial data will be reported on the NAICS basis only.

2.2 Previous Definition

The “modest approach” was implemented in 1996 for production of statistics about the high technology sector in British Columbia. These statistics are found primarily in a series of annual publications produced by BC Stats. The titles are “Profile of the British Columbia High Technology Sector” and “Input Indicators of the British Columbia High Technology Sector”.⁴ Both publication series use the following SIC based definition of the high technology sector:

SIC	Description	Weight
3211	Aircraft and Aircraft Parts Industry	100%
3351	Telecommunication Equipment Industry	100%
3352	Electronic Parts and Components Industry	100%
3359	Other Communication and Electronic Equipment Industries	100%
3361	Electronic Computing and Peripheral Equipment Industry	100%
3362	Electronic Office, Store and Business Machine Industry	100%
3369	Other Office, Store and Business Machine Industries	100%
3372	Electrical Switchgear and Protective Equipment Industry	100%
3379	Other Electrical Industrial Equipment Industries	100%
3741	Pharmaceutical and Medicine Industry	100%
3911	Indicating, Recording and Controlling Instruments Industry	100%
3912	Other Instruments and Related Products Industry	100%
7721	Computer Services	100%
7722	Computer Equipment Maintenance and Repair	100%
7752	Offices of Engineers	100%
7759	Other Scientific and Technical Services	100%
8681	Medical Laboratories	100%
8682	Radiological Laboratories	100%
8683	Combined Medical and Radiological Laboratories	100%
8684	Public Health Laboratories	100%
8685	Blood Bank Laboratories	100%
8689	Other Health Laboratories	100%
3381	Communications and Energy Wire and Cable Industry	41%
3192	Construction and Mining Machinery and Materials Handling Equipment Industry	13%
3271	Shipbuilding and Repair Industry	11%
3994	Musical Instrument and Sound Recording Industry	11%
3711	Industrial Inorganic Chemical Industries n.e.c.	10%
3194	Turbine and Mechanical Power Transmission Equipment Industry	6%
3999	Other Manufactured Products Industries n.e.c.	6%
3199	Other Machinery and Equipment Industries n.e.c.	3%

⁴ Also available at http://www.bcstats.gov.bc.ca/data/bus_stat/hi_tech.htm

2.3 The Value of NAICS

The previous definition of the BC high tech sector was based on the Standard Industrial Classification (SIC) codes. The SIC is a four-digit code developed by Statistics Canada and was last reworked in 1980. Rather than prepare a further update to SIC, Statistics Canada partnered with statistical agencies in the United States and Mexico to develop a uniform coding system to support the North American Free Trade Agreement (NAFTA). Although the three countries reached agreement about the classification of industries at a high level, there are some exceptions due to differences in the economies of the three countries.

Since 1998, Statistics Canada has been converting all business and economic statistics to NAICS. This coding system offers some advantages over the SIC in defining the high tech sector. For example, the SIC industry *Computer Services* has been broken down in NAICS to include:

- Data Processing Services
- Computer Systems Design
- Software Publishers
- Database and Directory Publishers

The finer detail in NAICS follows the recent expansion of economic activities in the computer, electronics, telecommunication, optics, and aerospace industries, which are popularly considered 'high tech'. However, for example firms involved in multi-media or electronic game design are generally considered to be part of the high tech sector, but are not captured explicitly by the NAICS coding system. Because NAICS codes may not be purely in or out of the high technology sector, statistical methods are required to determine which should or should not be included within the sector definition.

3.0 METHODS AND RESULTS

While many researchers have attempted to develop a specific definition of the high tech, there is still no definite way to identify which industries or types of firms should be included in a definition. However, the general principles described in the Introduction can guide specific calculations or methods. Fifteen detailed sets of calculations or methods were implemented under the banner of the following four principles:

5. SIC to NAICS concordance
6. Commodity lists
7. Research activities
8. Company lists

These methods use the new NAICS framework to create a definition from a composite of standard industries displaying high tech characteristics. While several methods begin at the company level, the results of each method are rolled up to the industry level. The industries identified by each method are compiled to develop a single definition of the sector.⁵

The methods differ in terms of the indicators used to identify high tech industries. Some methods examine the production of high technology commodities, while others measure research and development expenditures. We also reviewed definitions based on associations who represent BC's technology industries. Each subsection contains a brief overview followed by the details of each method.

The development of the definition was a multi-stage process. In the first stage, potential high tech NAICS were identified by the various methods. Most methods calculate a 'high tech percentage' based on establishments, employment, shipments or other measures. On many lists, the percentages ranged from 0.01% to 100%.

As these percentages are not directly comparable, it was not possible to develop an average high tech percent for each NAICS. Therefore, in the second stage, a cut-off was established to limit the number of NAICS codes included on each list. As there were many methods, a single cut-off was simpler and more effective to implement than a specific cut-off for each method. There was not sufficient information to provide justification for method-specific cut-offs.

Industries were included on the lists if the high tech percent was greater than or equal to 10 percent. This cut-off was arbitrarily established, but was supported by a sensitivity analysis. The analysis

⁵ In contrast to the method used earlier by BC Stats to establish the SIC based definition, no attempt has been made to assign portions of industries to the high technology sector. That is, at the six digit level of NAICS industries are determined to be either wholly in or wholly out of the high technology sector. This removes the requirement of

examined the number of NAICS selected by each method and the final definition list for six different cut-off levels: 1%, 5%, 10%, 15%, 20% and 50%. The 10% level seemed to be an appropriate cut-off as it provided a good balance between excluding non high-tech industries and including relevant high tech industries.

This cut-off was applied to all methods except the TechWest and BIV method 3. For these two methods, the range of percentages was considerably lower (ranging from 0.01% to 20%) and the cut-off were set to 2%.

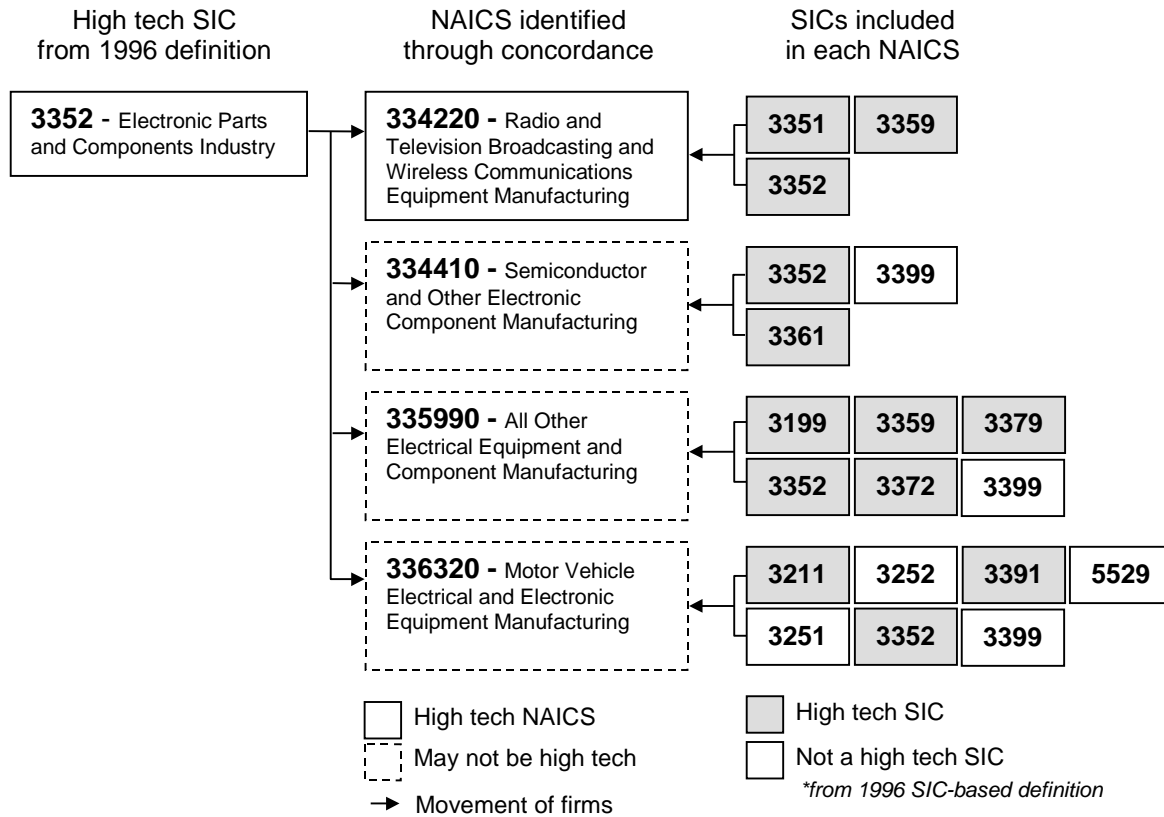
3.1 Concordance

The definition of the high technology sector in terms of the SIC had already been developed, and formed the underpinning of up to fifteen years of historical data. Since a SIC-NAICS concordance is available it would in principle be the most straightforward way of updating the high technology definition. However, the SIC-NAICS relationship is complex. In many cases there is no direct one to one match between SIC codes and the new NAICS codes. Therefore simply attempting to translate the existing SIC-based high tech definition to NAICS using concordance tables would involve assumptions that would result in considerable error.

One way to view the complexity or “splits” that are part of the SIC-NAICS concordance is to consider how the activities of individual firms might be coded under the two systems. For example, establishments within a formerly ‘high tech’ SIC may have been distributed upon recoding among several different NAICS, depending on the specifics of their activities and the definition of the NAICS codes. In turn, these NAICS codes can draw establishments from various other SICs, some of which may have been considered high tech, others may not (FIGURE 1). Without knowing the number or proportion of establishments that moved during concordance, a high tech definition based on a simple SIC-NAICS concordance would not accurately represent the high tech sector.

updating percentages on a regular basis, and permits the definition to be used more easily across provinces, however it is inherently less precise than the previous method.

FIGURE 1. Example of firm movement in the SIC-NAICS concordance.



3.1.1 Method

The concordance approach attempts to track the movement of establishments from SIC to NAICS using a count of establishments and employment estimates. The Business Register⁶ (BR) was the ideal data source for this approach as it enumerates all businesses in BC and contains employment size, SIC, and NAICS codes. With both SIC and NAICS codes, the BR contains an internal concordance.

To begin, the SIC codes from the 1996 definition were linked to the SIC codes in the BR database. For SICs with a weight of 100%, the associated BR records were marked as 'high tech'. For SICs with a weight less than 100%, it was not possible to identify which proportion of the establishments or employment within the SIC was high tech. Therefore, these records were marked 'not high tech'. All other records were also marked 'not high tech'.

The firms within each NAICS were then analysed to see whether they came from formerly high tech SICs or not. Using this distinction, the proportion of high tech firms in each NAICS was determined. A similar analysis was done to determine the proportion of high tech employment in each NAICS.

⁶ The Business Register is provided to BC Stats by Statistics Canada.

The employment estimate was obtained by using the midpoint for the BR employment size codes⁷. Industries were considered high tech when the high tech proportion (establishments or employment) was greater than or equal to 10 percent.

3.1.2 Results

Thirty-nine NAICS were identified using employment and 38 were identified using the count of establishments; 37 NAICS were common to both methods. The NAICS selected by the concordance method are listed in Appendix I.

3.2 Commodity Lists

The commodity list approach examines commodity inputs and outputs to identify high technology industries. This approach begins by identifying a list of commodities, which represent significant research and development, and stand at the leading edge of progress in their field. The industries that use or produce the commodities may be considered high tech, depending on the significance of these commodities relative to total shipments or expenditures within the industry.

3.2.1 Method

The three commodity methods use the current Advanced Technology Products (ATP) list, which was obtained from the US Department of Commerce⁸ in February 2001. This list identifies 739 commodities imported or exported by the US, which are identified as embodying special knowledge, training and technology⁹. Analysts in the Commodity Analysis Branch assigned NAICS codes to the commodities. The first commodity-based method uses this implicit NAICS-based definition of high tech industries from the ATP list.

The US uses more-detailed NAICS codes for some commodities than does Canada. For example, establishments assigned to the Canadian NAICS *334410 Semiconductor and Other Electronic Component Manufacturing* are broken out to 5 sub-codes under the US system (i.e. 334411, 334412, 334413, 334418, 334419). Therefore, the 56 US-based NAICS codes on the ATP list were reassigned to 25 Canadian NAICS. This method identifies high tech industries based on the ATP commodities that are used or produced within each industry. However, this method does not indicate proportion of high tech commodities to all commodities used or produced by a given industry.

⁷ The Business Registry documentation cautions that the employment size codes are estimates and should not be used for compiling industry employment estimates.

⁸ Contact the Commodity Analysis Branch, Foreign Trade Division of the US Census Bureau.

⁹ Abbott, T., R. McGuckin, P. Herrick, L. Norfolk. 1998. Advanced Technology Products and the U.S. Trade Balance. Discussion Paper. Center for Economic Studies, U.S. Department of Commerce, Bureau of the Census.

The second and third methods link the ATP list to the input and output commodities identified in the 1998 Annual Survey of Manufacturers¹⁰ for BC establishments. The output and input records were extracted separately from the survey microdata, obtained by BC Stats under section 11 of the federal Statistics Act. The commodities on the ATP list and in the microdata are coded using the Harmonized System (HS)¹¹. The US uses 10-digit HS, while Canada uses 8-digit HS codes. However, only the first 6 digits are common between the two countries. Therefore, the commodity codes in both data sets were truncated to 6-digits to allow matching. The 6-digit commodity codes in the Survey of Manufacturers were linked to the ATP commodities, which identified commodities as 'high tech'.

For manufacturing outputs, the net value of shipments was summarized by NAICS and the proportion of high tech shipments to total shipments was calculated. For the inputs, the cost of commodity purchases was summarized by NAICS to develop a high tech proportion for costs. In each case, industries were considered high tech when the high tech proportion was greater than or equal to 10 percent.

3.2.2 Results

Twenty-five NAICS were identified directly from using the ATP list. Fifteen NAICS were selected using the output method and 15 were selected using the input method. Ten NAICS were common to the three methods.

3.3 Research Activities

Research and development (R&D) is thought to be an indicator of high technology¹². This premise is based on the assumption that a high proportion of R&D fuels technological advancements. The approach assumes that R&D effort is uniformly successful, and that high technology firms or industries must create technology, rather than purchase it. Nevertheless, R&D effort remains a standard for assessing technology levels.

Statistics Canada collects information on R&D performed by business, government and higher education. However, NAICS based data is not yet available. In addition it is not known whether such data, when available, will be presented with sufficient detail for this analysis. Consequently, R&D analysis was performed with an alternative dataset, created by BC Stats.

¹⁰ The Annual Survey of Manufacturers is conducted by Statistics Canada (<http://www.statcan.ca/>).

¹¹ An HS (Harmonized System) code classifies each commodity that is produced by an establishment. This coding system permits the identification of all the establishments that produce a specified commodity or group of commodities (Statistics Canada, <http://www.statcan.ca/english/IPS/Data/31C0021.htm>).

¹² See *Input Indicators of the BC High Technology Sector*. 2001. BC STATS and the Ministry of Competition, Science & Enterprise.

3.3.1 Method

These methods use data collected for the 2000/2001 BC Manufacturers' Directory¹³ (BCMD). For the directory, *manufacturing* is defined as “production generally destined for the wholesale market, or for interplant transfer, rather than for direct sale to final consumers.” The directory does not include leasing, distribution or service firms, but does include software publishers. All listings in the directory are voluntary and are updated on a continuing basis by BC STATS.

In addition to collecting contact and business information, the 2001 directory questionnaire asked for information to assess a firm's high tech status, specifically:

- the proportion of scientists and engineers to total labour force (%S&E)
- the proportion of total sales spent on research and development (%R&D).

An extract was taken from the BCMD database on March 20, 2001. The extract contained information on 4,961 manufacturing firms in BC. The %S&E and %R&D reported by each firm were compiled to develop an 'average' percentage by NAICS. For each method, industries were considered high tech when the average percentages were greater than or equal to 10%.

3.3.2 Results

Thirty-seven NAICS were identified using %S&E and 24 were identified using %R&D. Sixteen NAICS were common to both methods.

3.4 Company Lists

Company lists are compiled by organizations that support or provide services to high tech firms. These methods begin at the micro-level – by identifying the firms involved in high tech activity – and have the potential to provide a clearer picture of the distinct character of BC's high tech sector.

To produce relevant results, these lists should be based on a clear operational definition of high tech. Companies included on a list should satisfy a specific set of criteria and be drawn from all regions in the province. For the company lists obtained in this analysis, information on any specific criteria was not available. The associations or companies compiling the list tended to use more subjective criteria to include companies on their list. However the lists do reflect a societal view of the composition of the high technology sector.

Three high tech company lists were obtained and used to identify high tech NAICS. The lists were linked to the Business Register to determine the NAICS to which the companies were classified. The data are summarized using number of establishments and/or estimated employment to provide a high tech percentage for each NAICS.

3.4.1 TechWest Method

The TechWest list was obtained from TREK Technologies Inc¹⁴. This organization uses a proprietary definition of high tech based on specific industry sectors, including advanced manufacturing, biotechnology, energy, engineering, health, and information technology. The sector names and definitions were established by TREK Technologies. The TechWest database was compiled from various high tech databases and each firm's information was verified through a phone interview. Firms are listed in the database if they can show that they realistically fit into the industry sectors.

The current TechWest database (purchased in March 2001) contained 1,830 companies; 86% of the companies are located in the Lower Mainland, 10% on Vancouver Island/Gulf Islands and the remaining 4% in the Interior or North of the province.

Three methods for identifying high tech NAICS were explored using the TechWest database:

1. the proportion of TechWest high tech establishments, to total establishments in the BR by NAICS
2. the proportion of TechWest high tech employment, to total employment in the BR by NAICS
3. the proportion of establishments within the TechWest database by NAICS.

The rationale of the first two methods is that the TechWest database is being used to identify which of the BR NAICS groupings has a high proportion of high tech establishments. This is similar to the rationale of many of the other methods described in this paper. The rationale of the third method recognizes that the TechWest may be an incomplete source, such that comparing it to another database (the BR) could be misleading. Instead, TechWest is treated in a standalone way to find which NAICS codes are most strongly or commonly represented.

The TechWest database was matched to the BR to identify 'high tech' companies and their associated NAICS codes. The match was conducted on the firms' legal name, resulting in 1,115 matches out of 1,830 companies in the TechWest database (61% match rate). The TechWest match rate was examined by sector to check for potential bias in matching. Match rates varied by sector from 40% to 68%. Weights were developed from the match rate to produce unbiased estimates of distribution of TechWest firms among NAICS codes. (These weights were used to calculate an average adjustment weight for each NAICS code. The average weights were applied to the count of high tech establishments, identified in the TechWest database, to produce the final estimates).

For method 2, it was not possible to calculate adjusted employment for each NAICS because there were discrepancies in employment estimates between the BR and the TechWest database. Instead, the proportion of high tech employment was calculated based on unadjusted TechWest employment

¹³ BC Manufacturers' Directory is compiled by BC Stats (<http://www.made-in-bc.ca/>)

to total employment in the BR. For both methods, industries were considered high tech when the high tech proportion was greater than or equal to 10 percent.

A third method used the proportion of establishments assigned to each NAICS in the matched database (1,115 records) to identify the 'popular' NAICS codes. These NAICS – while important within the high tech industry – may have been eliminated from the definition when compared to the overall number of establishment or total employment within the BR. NAICS codes with greater than or equal to 2% of establishments were included in the definition.

Results

Thirty-eight NAICS were identified using the adjusted proportion of high tech establishments. Twenty-three NAICS were identified using the proportion of high tech employment. Nine NAICS were identified using the relative proportion of high tech establishments in the TechWest database. There were no NAICS commonly selected by all three methods.

3.4.2 BIV Methods

The Business in Vancouver (BIV) list was obtained from BIV Publications Ltd¹⁵. This organization includes companies who are engaged in manufacturing, production, research and information services. The final list is compiled by the BIV Publication editors. The current BIV database (purchased in March 2001) contains 3,001 records; all companies on the list are located in the Lower Mainland. The database classifies firms into 31 business types.

Three methods for identifying high tech NAICS were explored using the BIV database:

1. the proportion of BIV high tech establishments, to total establishments in the BR by NAICS
2. the proportion of BIV high tech employment, to total employment in the BR by NAICS
3. the proportion of establishments within the BIV database by NAICS.

The three BIV methods used the procedures detailed for TechWest (Section 3.4.2). Matching the BIV to the BR resulted in a 28% match rate. As above, the adjustment weights were developed for business type and were used to develop the final estimates for number of establishments. Employment was not adjusted due to differences between employment estimates in the BIV and BR databases. For methods 1 and 2, industries were considered high tech when the high tech proportion was greater than or equal to 10 percent.

Method 3 used the same procedure detailed under method 3 for TechWest. NAICS codes with greater than or equal to 2% of establishments were included in the definition.

¹⁴ For more information about TechWest, visit <http://www.techwest.com>.

¹⁵ For more information about Business in Vancouver, visit <http://www.biv.com>.

Results

Sixty-seven NAICS were identified using the proportion of high tech establishments; 39 NAICS were identified using the proportion of high tech employment. Eight NAICS were identified using the relative proportion of high tech establishments in the BIV database. There were 7 NAICS in common between the three methods.

3.4.3 BCMD

On the BCMD questionnaire (introduced in section 3.3), firms were also asked two subjective questions to assess their high tech status:

1. Does their firm produce a high tech product?
2. Do they consider themselves a high tech manufacturer?

These two questions provide a list of self-identified high tech companies, which is based on the respondents' view of their firm within the 'high tech sector'. Each question became the basis for a high tech company list.

For each question, firms who left the question blank were considered 'non-respondents'. The response rate was 48% for both questions. The proportion of high tech firms to total firms responding was calculated for each NAICS. Industries were considered high tech if the high tech proportions were greater than or equal to 10%. The employment information collected for the BCMD are rough estimates, which may be influenced by seasonal variations and the mix between full and part-time workers. Therefore, employment was not used to estimate the high tech proportion from the two lists.

Results

Ninety-seven NAICS were identified by method 1 (firms producing a high tech product). Eighty-four were identified by method 2 (firms who consider themselves high tech manufacturers). Seventy-seven NAICS were common to both methods.

3.5 High Tech Election

Each of the four principles mentioned in section 3.0 is supported by at least two methods. For example, under *Company Lists*, each company list produced two or three different lists of possible NAICS codes for the high tech definition. In total, 15 separate lists were produced. While some of the lists overlap, they seldom completely agree on the same NAICS codes. In total, 188 different NAICS codes were identified by one or more methods.

The solution was to hold an “election” of NAICS codes. Each “method” nominated a set of candidate NAICS codes. Nomination by a “method” counted as one vote for that NAICS, regardless of the percentage value. Seven methods used data solely from the manufacturing sector, which meant that there were more possible votes for NAICS within this sector, compared to other NAICS. To compensate, the election was based on the number of ‘possible votes’:

- Manufacturing industries (beginning with NAICS 31 to 33) had 15 possible votes
- Other industries had 8 possible votes.

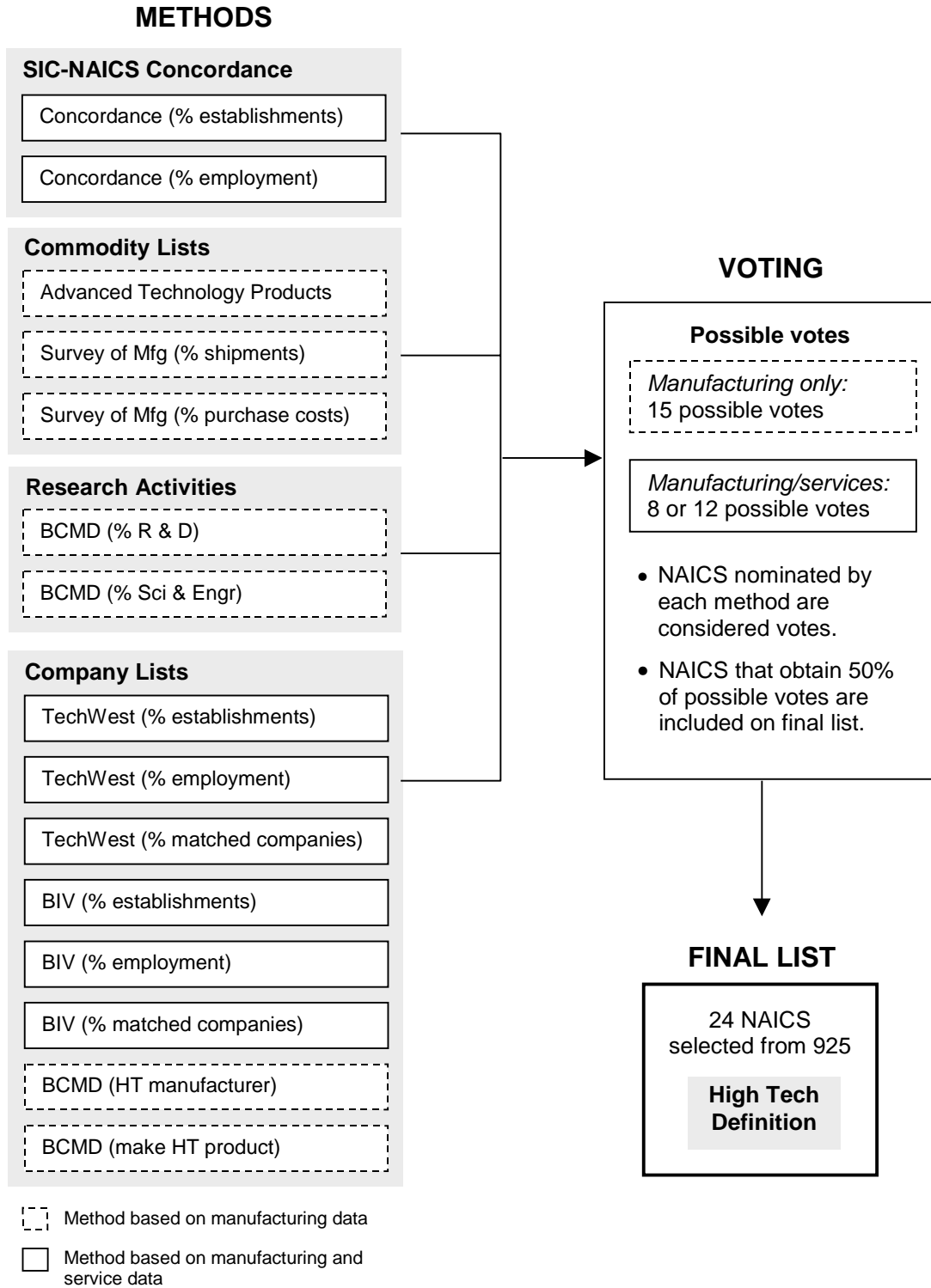
Fourteen non-manufacturing industries, including *511210 Software Publishing* and *541510 Computer Systems Design and Related Services*, were listed in the BCMD. As the BCMD was used for four methods, these NAICS codes had 12 possible votes each.

Those industries that received 50% of the possible votes were included in the high technology sector definition (FIGURE 2). The preliminary list includes 23 NAICS codes (TABLE 1).

TABLE 1: Preliminary list of industries proposed for the high technology sector definition.

NAICS	Industry Description	Possible votes	Score
511210	Software Publishers	12	92%
541710	Research and Development in the Physical, Engineering and Life Sciences	8	88%
334512	Measuring, Medical and Controlling Devices Manufacturing	15	87%
541510	Computer Systems Design and Related Services	12	83%
334210	Telephone Apparatus Manufacturing	15	80%
334220	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing	15	80%
334410	Semiconductor and Other Electronic Component Manufacturing	15	80%
334511	Navigational and Guidance Instruments Manufacturing	15	80%
335990	All Other Electrical Equipment and Component Manufacturing	15	80%
541330	Engineering Services	8	75%
325410	Pharmaceutical and Medicine Manufacturing	15	73%
334110	Computer and Peripheral Equipment Manufacturing	15	73%
336410	Aerospace Product and Parts Manufacturing	15	73%
335315	Switchgear and Switchboard, and Relay and Industrial Control Apparatus Manufacturing	15	67%
417310	Computer, Computer Peripheral and Pre-Packaged Software Wholesaler-Distributors	8	63%
443120	Computer and Software Stores	8	63%
334290	Other Communications Equipment Manufacturing	15	60%
417320	Electronic Components, Navigational and Communications Equipment and Supplies Wholesaler-Distributors	12	58%
339110	Medical Equipment and Supplies Manufacturing	15	53%
514210	Data Processing Services	8	50%
541620	Environmental Consulting Services	8	50%
541720	Research and Development in the Social Sciences and Humanities	8	50%
621510	Medical and Diagnostic Laboratories	8	50%

FIGURE 2: Election of NAICS codes for the high technology sector definition.



4.0 DISCUSSION

The election process produced a preliminary list of 23 NAICS codes. Before the list can be finalized for use in production of statistics it must be validated.

The first step is to examine those codes that narrowly missed being included, to be sure that the demarcation line is valid. For example Medical and Diagnostic Laboratories was included, with a vote of 50%, while Commercial and Service Industry Machinery Manufacturing was excluded, with a vote of 47%. Is this a valid distinction?

The second step is to consider excluded codes that may be similar or linked to included codes. For example, while Medical and Diagnostic Laboratories was included, Testing Laboratories was excluded. The reasons for this warrant examination.

Finally, the entire list will benefit from a “reality check” from industry and government experts who will eventually be the users of the resulting high technology sector statistics.

These topics will be the subject of a workshop to be convened early in 2002. Workshop results will be reported in a later version of this paper.

APPENDIX I

Detailed Table 1: NAICS selected by each method in the high tech election.

NAICS	Industry Description	Possible votes	Score	SIC-NAICS Concordance		Commodity Lists			Research Activities		Company Lists							
				Est	Emp	ATP	Mfg (in)	Mfg (out)	%S&E	%R&D	TechWest			BIV			BCMD	
											Est	Emp	Match	Est	Emp	Match	Est	Est
511210	Software Publishers	12	92%	100%	100%				33%	36%	35%		4%	39%	67%	3%	96%	93%
541710	Research and Development in the Physical, Engineering and Life Sciences	8	88%	70%	80%						17%		3%	30%	47%	2%		
334512	Measuring, Medical and Controlling Devices Manufacturing	15	87%	94%	99%	1	26%	12%	36%	16%	29%		3%	21%	32%		81%	78%
541510	Computer Systems Design and Related Services	12	83%	100%	100%				53%	35%			16%	17%	54%	21%	100%	100%
334210	Telephone Apparatus Manufacturing	15	80%	100%	100%	1	90%	97%	51%	55%	23%			79%	31%		75%	75%
334220	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing	15	80%	100%	100%	1	98%	79%	30%	20%	66%			71%	73%		100%	100%
334410	Semiconductor and Other Electronic Component Manufacturing	15	80%	97%	98%	1	77%	76%	22%	15%	31%			33%	48%		82%	82%
334511	Navigational and Guidance Instruments Manufacturing	15	80%	100%	100%	1	95%	61%	12%	15%	25%			44%	32%		100%	100%
335990	All Other Electrical Equipment and Component Manufacturing	15	80%	92%	98%	1	40%	49%	15%		23%	18%		27%	58%		71%	57%
541330	Engineering Services	8	75%	100%	100%								14%	13%	34%	18%		
325410	Pharmaceutical and Medicine Manufacturing	15	73%	100%	100%	1	26%	20%	31%	11%				13%	53%		55%	45%
334110	Computer and Peripheral Equipment Manufacturing	15	73%	100%	100%	1	99%	85%	18%	12%	35%			18%	66%		67%	80%
336410	Aerospace Product and Parts Manufacturing	15	73%	100%	100%	1	97%	32%	17%		21%			14%	59%		67%	50%
335315	Switchgear and Switchboard, and Relay and Industrial Control Apparatus Manufacturing	15	67%	97%	99%	1			23%	10%	36%			26%	11%		67%	58%
417310	Computer, Computer Peripheral and Pre-Packaged Software Wholesaler-Distributors	8	63%								11%		4%	17%	46%	5%		
443120	Computer and Software Stores	8	63%								10%		4%	19%	26%	5%		
334290	Other Communications Equipment Manufacturing	15	60%	59%	54%		16%		22%	24%	49%			23%			90%	80%
417320	Electronic Components, Navigational and Communications Equipment and Supplies Wholesaler-Distributors	12	58%								11%		3%	28%	20%	3%	100%	100%
339110	Medical Equipment and Supplies Manufacturing	15	53%	35%	57%	1	14%	12%							11%		41%	37%
514210	Data Processing Services	8	50%	88%	89%									29%	64%			
541620	Environmental Consulting Services	8	50%	100%	100%						12%				12%			
541720	Research and Development in the Social Sciences and Humanities	8	50%	18%	20%									16%	19%			
621510	Medical and Diagnostic Laboratories	8	50%	100%	100%									89%	3%			
333310	Commercial and Service Industry Machinery Manufacturing	15	47%	96%	95%	1			14%					12%			33%	25%
333611	Turbine and Turbine Generator Set Unit Manufacturing	15	47%	75%	85%						35%	12%		21%			29%	17%
334310	Audio and Video Equipment Manufacturing	15	47%	13%		1			20%	13%				82%			50%	50%
334610	Manufacturing and Reproducing Magnetic and Optical Media	15	47%				100%	100%	33%	22%			24%				90%	70%
335920	Communication and Energy Wire and Cable Manufacturing	15	47%			1	100%			13%	15%	79%					50%	50%
325189	All Other Basic Inorganic Chemical Manufacturing	15	40%			1		23%	15%	13%	15%				16%			
333910	Pump and Compressor Manufacturing	15	40%						15%		12%	10%		11%	15%		13%	
333990	All Other General-Purpose Machinery Manufacturing	15	40%	29%	76%	1									11%		32%	27%
532420	Office Machinery and Equipment Rental and Leasing	8	38%	28%	22%										28%			
541380	Testing Laboratories	8	38%	98%	97%										18%			
621990	All Other Ambulatory Health Care Services	8	38%	17%	74%									46%				
811210	Electronic and Precision Equipment Repair and Maintenance	8	38%	41%	39%										16%			
232510	Electrical Work	12	33%						15%	12%							100%	100%
325210	Resin and Synthetic Rubber Manufacturing	15	33%						15%			26%			18%		17%	17%
333511	Industrial Mould Manufacturing	15	33%						20%	11%	11%						50%	50%
335311	Power, Distribution and Specialty Transformers Manufacturing	15	33%								19%	79%		38%	88%		100%	33%
335930	Wiring Device Manufacturing	15	33%	11%	16%								15%				67%	25%
339940	Office Supplies (except Paper) Manufacturing	15	33%	30%	55%		16%	11%										33%
325999	All Other Miscellaneous Chemical Product Manufacturing	15	27%	19%	24%						10%						25%	
326122	Plastic Pipe and Pipe Fitting Manufacturing	15	27%								13%	19%					20%	20%
333120	Construction Machinery Manufacturing	15	27%				47%		10%								29%	14%

NAICS	Industry Description	Possible votes	Score	SIC-NAICS Concordance		Commodity Lists			Research Activities		Company Lists									
				Est	Emp	ATP	Mfg (in)	Mfg (out)	%S&E	%R&D	TechWest			BIV			BCMD			
											Est	Emp	Match	Est	Emp	Match	Est	Est		
333291	Paper Industry Machinery Manufacturing	15	27%																	
333519	Other Metalworking Machinery Manufacturing	15	27%			1						37%	24%		42%					50%
335312	Motor and Generator Manufacturing	15	27%	27%	39%								13%		20%				13%	20%
339990	All Other Miscellaneous Manufacturing	15	27%			1		47%											20%	20%
418410	Chemical (except Agricultural) and Allied Product Wholesaler-Distributors	8	25%												14%	30%			15%	15%
488390	Other Support Activities for Water Transportation	12	25%						100%										100%	100%
511130	Book Publishers	12	25%							11%									11%	10%
511140	Database and Directory Publishers	8	25%	30%	73%															
511190	Other Publishers	12	25%							11%									25%	25%
514191	On-Line Information Services	8	25%												28%	16%				
522329	Other Financial Transactions Processing and Clearing House Activities	8	25%											37%	56%					
541320	Landscape Architectural Services	8	25%	100%	100%															
541340	Drafting Services	8	25%	100%	100%															
541360	Geophysical Surveying and Mapping Services	8	25%	100%	100%															
541370	Surveying and Mapping (except Geophysical) Services	8	25%	97%	97%															
541690	Other Scientific and Technical Consulting Services	8	25%	55%	57%															
541990	All Other Professional, Scientific and Technical Services	8	25%	49%	55%															
611420	Computer Training	8	25%												10%	12%				
323115	Digital Printing	15	20%																33%	33%
325190	Other Basic Organic Chemical Manufacturing	15	20%			1						13%								
325510	Paint and Coating Manufacturing	15	20%									12%	42%							
325520	Adhesive Manufacturing	15	20%						17%							11%			30%	30%
325610	Soap and Cleaning Compound Manufacturing	15	20%																50%	50%
325620	Toilet Preparation Manufacturing	15	20%																	
326111	Unsupported Plastic Bag Manufacturing	15	20%																13%	
326130	Laminated Plastic Plate, Sheet and Shape Manufacturing	15	20%																14%	17%
327215	Glass Product Manufacturing from Purchased Glass	15	20%									16%	17%							
331317	Aluminum Rolling, Drawing, Extruding and Alloying	15	20%			1							42%						22%	17%
332311	Prefabricated Metal Building and Component Manufacturing	15	20%																17%	17%
332410	Power Boiler and Heat Exchanger Manufacturing	15	20%			1													14%	14%
332420	Metal Tank (Heavy Gauge) Manufacturing	15	20%									65%	10%							
332910	Metal Valve Manufacturing	15	20%									14%							29%	14%
332999	All Other Miscellaneous Fabricated Metal Product Manufacturing	15	20%			1													20%	40%
333299	All Other Industrial Machinery Manufacturing	15	20%																27%	25%
333413	Industrial and Commercial Fan and Blower and Air Purification Equipment Manufacturing	15	20%																31%	38%
333416	Heating Equipment and Commercial Refrigeration Equipment Manufacturing	15	20%																22%	11%
333619	Other Engine and Power Transmission Equipment Manufacturing	15	20%																25%	21%
335120	Lighting Fixture Manufacturing	15	20%																11%	11%
335210	Small Electrical Appliance Manufacturing	15	20%									10%			20%	30%				
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing	15	20%			1						15%	10%							
336330	Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing	15	20%									12%							25%	25%
336611	Ship Building and Repairing	15	20%									35%	10%						100%	
336990	Other Transportation Equipment Manufacturing	15	20%																13%	13%
111411	Mushroom Production	12	17%																43%	43%
232590	Other Building Equipment Installation	12	17%																100%	100%
512110	Motion Picture and Video Production	12	17%																60%	40%
312110	Soft Drink and Ice Manufacturing	15	13%																17%	17%
316990	Other Leather and Allied Product Manufacturing	15	13%																29%	29%
321215	Structural Wood Product Manufacturing	15	13%																19%	13%
322112	Chemical Pulp Mills	15	13%																33%	33%
322220	Paper Bag and Coated and Treated Paper Manufacturing	15	13%																25%	25%
323119	Other Printing	15	13%																14%	21%
324190	Other Petroleum and Coal Products Manufacturing	15	13%												16%					
326140	Polystyrene Foam Product Manufacturing	15	13%									14%	12%							
326220	Rubber and Plastic Hose and Belting Manufacturing	15	13%									30%	56%							
326290	Other Rubber Product Manufacturing	15	13%																20%	20%

APPENDIX I

NAICS	Industry Description	Possible votes	Score	SIC-NAICS Concordance		Commodity Lists			Research Activities		Company Lists							
				Est	Emp	ATP	Mfg (in)	Mfg (out)	%S&E	%R&D	TechWest			BIV			BCMD	
											Est	Emp	Match	Est	Emp	Match	Est	Est
327320	Ready-Mix Concrete Manufacturing	15	13%														17%	11%
327330	Concrete Pipe, Brick and Block Manufacturing	15	13%														18%	25%
327410	Lime Manufacturing	15	13%														50%	33%
327910	Abrasive Product Manufacturing	15	13%														33%	33%
331221	Cold-Rolled Steel Shape Manufacturing	15	13%														50%	50%
331514	Steel Foundries	15	13%														50%	50%
332118	Stamping	15	13%						10%				10%					
332210	Cutlery and Hand Tool Manufacturing	15	13%			1											20%	
332319	Other Plate Work and Fabricated Structural Product Manufacturing	15	13%														18%	22%
332439	Other Metal Container Manufacturing	15	13%								15%	52%						
332510	Hardware Manufacturing	15	13%														13%	13%
332710	Machine Shops	15	13%														20%	25%
332991	Ball and Roller Bearing Manufacturing	15	13%								30%	19%						
333130	Mining and Oil and Gas Field Machinery Manufacturing	15	13%														17%	18%
333210	Sawmill and Woodworking Machinery Manufacturing	15	13%														37%	30%
333920	Material Handling Equipment Manufacturing	15	13%			1											16%	
335910	Battery Manufacturing	15	13%														60%	60%
336110	Automobile and Light-Duty Motor Vehicle Manufacturing	15	13%						33%	26%								
336212	Truck Trailer Manufacturing	15	13%														29%	29%
336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	15	13%														11%	22%
336370	Motor Vehicle Metal Stamping	15	13%								30%	75%						
336612	Boat Building	15	13%														18%	14%
337213	Wood Office Furniture, including Custom Architectural Woodwork, Manufacturing	15	13%														22%	11%
337215	Showcase, Partition, Shelving and Locker Manufacturing	15	13%														17%	17%
339950	Sign Manufacturing	15	13%														25%	25%
212326	Shale, Clay and Refractory Mineral Mining and Quarrying	8	13%						10%									
221111	Hydro-Electric Power Generation	8	13%														95%	
231390	Other Engineering Construction	8	13%														43%	
413310	Cigarette and Tobacco Product Wholesaler-Distributors	8	13%														14%	
414210	Home Entertainment Equipment Wholesaler-Distributors	8	13%														23%	
414510	Pharmaceuticals and Pharmacy Supplies Wholesaler-Distributors	8	13%		14%													
416110	Electrical Wiring and Construction Supplies Wholesaler-Distributors	8	13%														18%	
416210	Metal Service Centres	8	13%														12%	
417210	Construction and Forestry Machinery, Equipment and Supplies Wholesaler-Distributors	8	13%														37%	
417220	Mining and Oil and Gas Well Machinery, Equipment and Supplies Wholesaler-Distributors	8	13%														22%	
417990	All Other Machinery, Equipment and Supplies Wholesaler-Distributors	8	13%														11%	
418120	Recyclable Paper and Paperboard Wholesaler-Distributors	8	13%									11%						
419170	Machinery, Equipment and Supplies Agents and Brokers	8	13%														16%	
446110	Pharmacies and Drug Stores	8	13%														67%	
493190	Other Warehousing and Storage	8	13%														16%	
513310	Wired Telecommunications Carriers	8	13%														99%	
513320	Wireless Telecommunications Carriers (except Satellite)	8	13%														92%	
514110	News Syndicates	8	13%														57%	
522210	Credit Card Issuing	8	13%														95%	
523990	All Other Financial Investment Activities	8	13%														22%	
541420	Industrial Design Services	8	13%														11%	
541611	Administrative Management and General Management Consulting Services	8	13%															
541840	Media Representatives	8	13%															
541860	Direct Mail Advertising	8	13%								14%							
541930	Translation and Interpretation Services	8	13%															
551114	Head Offices	8	13%														13%	
811122	Automotive Glass Replacement Shops	8	13%															
811310	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	8	13%															24%
911910	Other Federal Government Public Administration	8	13%														26%	
232990	All Other Special Trade Contracting	12	8%															

NAICS	Industry Description	Possible votes	Score	SIC-NAICS Concordance		Commodity Lists			Research Activities		Company Lists							
				Est	Emp	ATP	Mfg (in)	Mfg (out)	%S&E	%R&D	TechWest			BIV			BCMD	
											Est	Emp	Match	Est	Emp	Match	Est	Est
511110	Newspaper Publishers	12	8%															27%
511120	Periodical Publishers	12	8%															23%
811119	Other Automotive Mechanical and Electrical Repair and Maintenance	12	8%							15%								
311119	Other Animal Food Manufacturing	15	7%														25%	
311211	Flour Milling	15	7%															33%
311930	Flavouring Syrup and Concentrate Manufacturing	15	7%						10%									
312120	Breweries	15	7%						30%									
315226	Men's and Boys' Cut and Sew Shirt Manufacturing	15	7%															100%
315231	Women's and Girls' Cut and Sew Lingerie, Loungewear and Nightwear Manufacturing	15	7%							10%								
321992	Prefabricated Wood Building Manufacturing	15	7%															10%
322130	Paperboard Mills	15	7%						20%									
324110	Petroleum Refineries	15	7%						10%									
325920	Explosives Manufacturing	15	7%							11%								
326191	Plastic Plumbing Fixture Manufacturing	15	7%						15%									
327110	Pottery, Ceramics and Plumbing Fixture Manufacturing	15	7%															10%
327120	Clay Building Material and Refractory Manufacturing	15	7%															20%
327310	Cement Manufacturing	15	7%															33%
327420	Gypsum Product Manufacturing	15	7%															25%
331210	Iron and Steel Pipes and Tubes Manufacturing from Purchased Steel	15	7%						13%									
331222	Steel Wire Drawing	15	7%															50%
331420	Copper Rolling, Drawing, Extruding and Alloying	15	7%											19%				
331490	Non-Ferrous Metal (except Copper and Aluminum) Rolling, Drawing, Extruding and Alloying	15	7%							10%								
331511	Iron Foundries	15	7%															20%
332113	Forging	15	7%									33%						
332321	Metal Window and Door Manufacturing	15	7%															15%
332720	Turned Product and Screw, Nut and Bolt Manufacturing	15	7%						17%									
333220	Rubber and Plastics Industry Machinery Manufacturing	15	7%															100%
335229	Other Major Appliance Manufacturing	15	7%															
336211	Motor Vehicle Body Manufacturing	15	7%						17%									13%
336350	Motor Vehicle Transmission and Power Train Parts Manufacturing	15	7%															
336510	Railroad Rolling Stock Manufacturing	15	7%															66%
337110	Wood Kitchen Cabinet and Counter Top Manufacturing	15	7%							10%								
337127	Institutional Furniture Manufacturing	15	7%															10%
																		13%