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The Canadian Bioproducts Industry
Analysis of the Bioproduct Development Survey – 2004

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Abstract: Bioproducts are often presented as one of the potential saviours of Canadian agriculture, offering non-food applications for agricultural products. However, relatively little is known about the sector or the characteristics of the firms. This paper presents an analysis of the Canadian bioproducts sector based on the first survey of bioproduct firms in Canada. The survey was performed by Statistics Canada in 2004 using 2003 firm results.

The paper analyzes the responses to the bioproducts survey on two important dimensions, by region and firm size. The results indicate that for most of Canada's 232 bioproducts firms, bioproducts are just one part of the business activities, accounting for less than one third of employees and slightly more than one quarter of total firm revenue. Bioproduct activities provide both market and environmental benefits. The major challenges to the industry are financing and regulation. However, the relative importance of bioproducts, benefits and strategies and the focus and success of firms vary dramatically by region and by firm size.

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INTRODUCTION

Canada, like many other countries, has been actively developing bioproducts and promoting the companies behind them. Although bioproducts in some forms have been around for years, recently the production of bioproducts from agricultural biomass has gained considerable attention. There is a perception that using agricultural biomass as an input will increase demand for agricultural commodities with positive impacts on commodity prices. In the case of sugar cane there is evidence that this perception may be justified.

This paper examines the state of the Canadian bioproducts industry through an analysis of the responses to a 2004 Statistics Canada survey on the industry. For the purposes of the survey bioproducts were defined as those products which were derived from biomass, specifically biomass from agricultural crops, forestry, marine & aquaculture, food processing, animal manure, industrial and municipal organic waste. The analysis is presented on two dimensions, industry characteristics by province or region and by firm size. In 2003, the bioproducts sector in Canada exhibited striking regional differences on some dimensions but similarities on others. The results will serve as a valuable input to managers and policy makers.

Methods

To better understand the Canadian bioproducts sector, Agriculture and Agri-Food Canada (AAFC) commissioned Statistics Canada to undertake the first national bioproducts survey in the world. The survey was based partially on the Biotechnology Use and Development Surveys administered by Statistics Canada every two years. The Bioproducts Development Survey was administered in 2004 with firms required to answer questions and report results based on their 2003 data.

The data analyzed in this report was organized and reported on two dimensions. The first is regional, with data provided for the Atlantic Provinces as a single region and for each of the remaining six provinces individually. The second categorization is by firm size, measured by the number of employees. Firms are classified as small (less than 50 employees), medium (50-149 employees) and large (more than 149 employees). For this initial analysis, data was not provided on other dimensions or on the two dimensions simultaneously, and so the analysis necessarily is performed on these two dimensions.

Results: Canadian Bioproducts Businesses

Two hundred and thirty-two firms across Canada participated in the production or development of bioproducts during 2003. Some of the most important characteristics of Canadian bioproduct firms are identified by region in Appendix 1 and by firm size in Appendix 2. Seventy percent of Canada's bioproduct companies were located in Quebec, Ontario, or British Columbia.

Approximately 66 percent of firms were small in size, with less than 50 employees. Of the remaining firms 17.2 percent were medium sized with 50 – 149 employees, and 16.4 percent were large firms with more than 149 employees.

Entry into the Bioproducts Sector

Most of the firms surveyed had been in the business of bioproducts for a relatively short period of time. Sixty-five percent had been involved in bioproduct-related activities for 10 years or less, and for small firms the percentage 10 years or less increased to 75 percent. Quebec appeared to have created an environment conducive to entry into the bioproduct sector; forty-three percent of Quebec firms were five years old or less. About thirty-nine percent of firms in Alberta and Saskatchewan were five years old or less compared to less than thirty-five percent of firms in all other regions. The proportion of firms under five years of age was markedly higher for small firms (42.6 percent) compared to 17.4 percent and 17.8 percent for medium and large firms respectively.

Approximately 19 percent of Canadian bioproducts firms originated as spin-offs. Not surprisingly, most were small (86 percent) and none were large. The vast majority originated from either universities (64 percent) or other firms (32 percent). Quebec was home to nearly half of all spin-off companies, and 57 percent of all spin-offs from companies. Alberta and Ontario spin-offs were almost exclusively from universities. Government agencies did not figure prominently in bioproduct company spin-offs. Although some firms began their involvement in bioproducts through collaborations with other firms/organizations (15 percent), most companies

(66 percent) entered the bioproducts field as the result of internal company research and development Figure 1. The remaining firms entered through M&A activity, purchasing another firm's activities, or other means.

Table 1: Number of firms by origin of spin-off, 2003

| | Total Number of Spin-offs | Percentage of all Canadian Spin-offs | University | Another firm | Government agency/ laboratories | Other |
|------------------|---------------------------|--------------------------------------|------------|--------------|---------------------------------|-------|
| Region | # | % | # | # | # | # |
| Canada | 44 | | 28 | 14 | F | F |
| Atlantic | F | | 0 | 0 | 0 | F |
| Quebec | 20 | 45.5 % | 11 | 8 | F | 0 |
| Ontario | 10 | 22.7% | 9 | 1 | 0 | 0 |
| Manitoba | 0 | | 0 | 0 | 0 | 0 |
| Saskatchewan | 3 | 6.8% | 0 | 3 | 0 | 0 |
| Alberta | 7 | 15.9% | 7 | 0 | 0 | 0 |
| British Columbia | F | | 0 | F | 0 | 0 |

Note: F indicates unreliable data not released by Statistics Canada

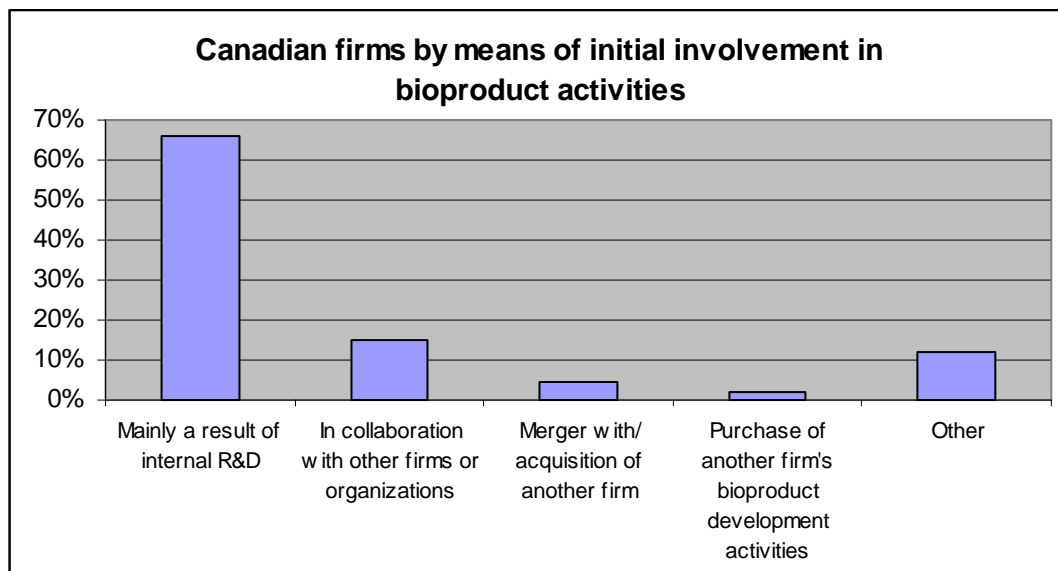


Figure 1: Initial entry the bioproducts sector, 2003

Ownership

More than 40 percent of bioproducts firms in Manitoba, Alberta and B.C. were public companies compared to less than 30 percent of those in other provinces (Appendix 1). At least 80 percent of firms in all regions are Canadian-owned, with the exception of Manitoba and Alberta where 67 and 70 percent of firms were owned by Canadians.

Large firms are far more likely to be public companies, and more likely to be foreign owned than smaller companies. Only 18 percent of firms were subsidiaries of multi-national corporations (MNC's); 44 percent of medium sized firms were in this category. Predictably, larger firms were more likely to be public and foreign-owned.

Table 2: Ownership of Canadian bioproduct firms, by firm size, 2003

| Firm size (# of employees) | Total Number of Firms | % of firms which are public | % of firms which are subsidiaries of MNC's | % of firms with majority Canadian stock ownership |
|---|--------------------------------------|--|---|--|
| Small (< 50) | 154 | 19.8% | 8.0 | 91.9 |
| Medium (50 – 149) | 40 | 37.1% | 44.0 | 74.1 |
| Large (>149) | 38 | 60.1% | 31.5 | 60.3 |

Bioproduct Development

Canadian firms were actively developing and producing a variety of bioproducts. In 2003, the 232 firms had a total of 1,048 products under development or in production, an average of 4.5 products/firm. Of these, 60 percent were already on the market, 18 percent were mid-development, and 22 percent were in early stages. The largest category of products by far was bio-chemicals, which made up 41 percent of all bioproducts under development or on the market

We can see that the distribution of products also varies by firm size (Figure 2)

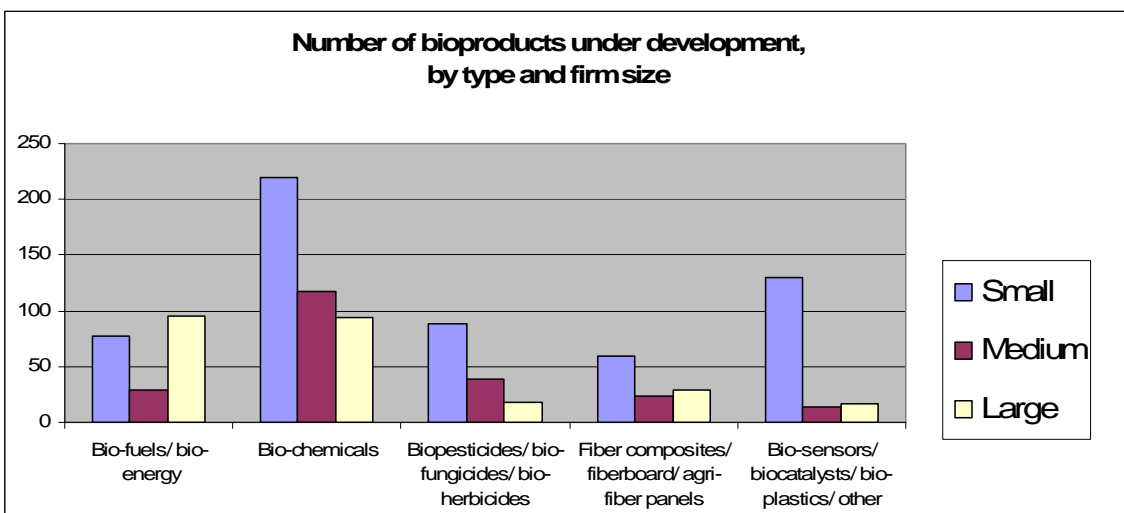


Figure 2: Bioproduct development by product type, 2003

Product development patterns were fairly consistent across all product types with small firms having the largest number of products under development. The exception is in bio-fuels/bio-energy products where large companies dominate. Large firms were also very involved in bio-chemicals. This result reflects the nature of the chemical and energy businesses, which are dominated by large companies with significant resources.

It is interesting to note that the bioproducts sector saw more products on the market than in development, especially from medium and large firms (Figure 3). Small companies were more focused on the early stages of research and development than larger firms but still had many products on the market. This is typical, as much of the research and development and proof of concept work for the development process is done in small firms. Medium sized and large companies have the resources to produce and market a limited number of commercial products so they tend to dominate the last stage of development.

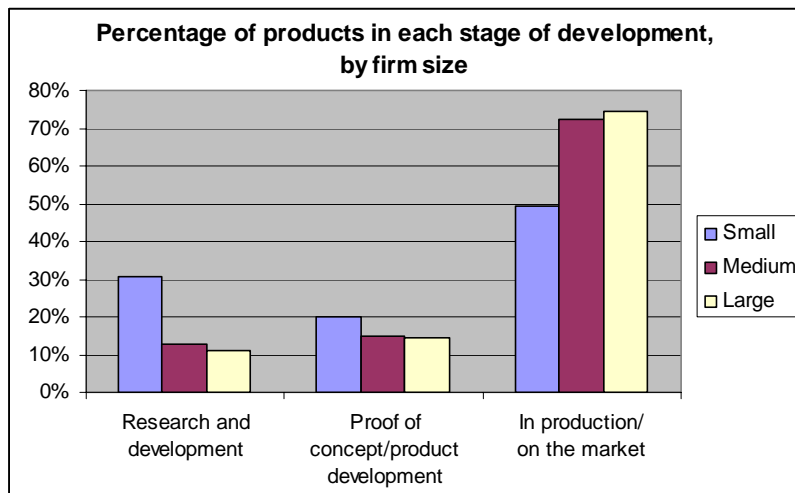


Figure 3: Product development by stage shown as a percentage of total products under development, 2003

Biomass Use

Agricultural crop and forestry biomass were the most common forms of biomass used in 2003 (Appendices 1 and 2). These sources were used by 93 and 77 firms, respectively, more than twice the number of firms using any other single type of biomass. (Note that responses are not mutually exclusive.) Agricultural crop biomass was the dominant form used in both small and medium sized firms, while large firms most often used forestry biomass in their production. Infrequent use was made of marine products, food processing products, animal manure, or municipal organic waste.

Only 18 percent of all Canadian firms had their biomass on site, and nearly 60 percent of firms were farther than 50 km from their primary source. This suggests that an active market with substantial search and transport costs exists in the sourcing of biomass inputs. Off-site sourcing was especially important for small and medium sized firms (Figure 4); as firm size increases, the share of biomass input sourced on-site increases, a finding consistent with the increasing level of by-product used with increasing firm size. This would suggest that smaller firms were focused more on processing biomass not produced by the firm, while large firms used biomass processing as a means to develop a revenue generating output based on some other production process. Alternatively, larger firms may be adjacent to sources of their biomass inputs, thus taking advantage of agglomeration economies.

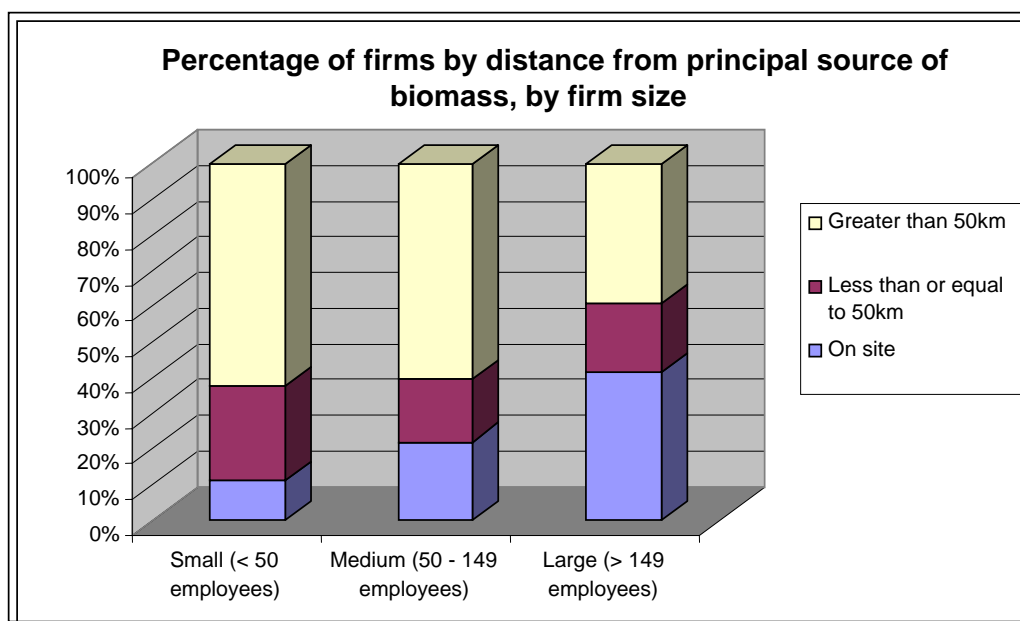


Figure 4: Percent of firms by distance from location of principal biomass input, by firm size, 2003

Within Canada as a whole, most firms (65 percent) indicated they sold their bioproducts directly to consumers or distributors, followed by 47 percent who reported sale to another firm for use as an intermediate input and 33 percent who use their bioproduct internally. Note that the responses to this question were not mutually exclusive and that the responses varied by firm size (Table 3)

Table 3: Percent of firms by end user of bioproducts, by firm size, 2003

| Firm Size | Sold directly to consumers or distributors | Sold to other firms to be used as input(s) | Produced for internal use |
|---------------------------------|--|--|---------------------------|
| Small (less than 50 employees) | 63.9% | 43.0% | 26.9% |
| Medium (50 - 149 employees) | 78.2% | 70.9% | 22.0% |
| Large (more than 149 employees) | 52.8% | 40.4% | 67.2% |

Bioproduct Revenue

For most firms bioproducts was only part of their business. Of nearly \$12 billion in revenue generated by Canadian bioproducts firms in 2003, only 26 percent was derived from bioproduct activities (Appendix 1). With the exception of Saskatchewan and Alberta, firms in most provinces obtained more than 30 percent of their revenues from bioproduct activities. Ontario had the highest total provincial revenue from bioproducts at \$871 million, but firms in Quebec, Alberta and British Columbia generated provincial totals in excess of \$600 million from bioproduct

activities. Bioproduct revenues were highly dependent on exporting, with Alberta and Saskatchewan firms generating 81 and 78 percent respectively of their total bioproduct revenues from exports (Appendix 1).

Bioproduct revenues as a percentage of total revenue also varied widely depending on firm size (Appendix 2). Medium sized firms derived the largest portion of total revenue and exports from bioproducts. Large firms appear to incorporate bioproducts as just one line of business; only 18 percent of total revenue was derived from bioproducts.

Bioproduct Research and Development Expenditures

Canadian firms each spent an average of just over \$1 million on R&D in 2003, with 39 percent (approximately \$400,000) devoted to their bioproduct programs (Appendix 1). Firms in Alberta, Manitoba, and Quebec spent more than the average on both total R&D and bioproduct R&D. Quebec firms spent \$1.3 million and \$571,543 on average total and bioproduct R&D respectively, nearly twice as much as Ontario firms. Although their total spending was lower, Ontario firms did utilize 46 percent of their R&D spending to fund bioproduct development, which was the highest of any region. Quebec firms were a close second with 43 percent.

As a percentage of total R&D, small firms were the most intensely focused on bioproduct development, with seventy-two percent of R&D expenditures aimed at bioproducts (Table 4). Large firms focused roughly a fifth of their R&D budgets on bioproducts R&D, spending only marginally more in total than medium sized firms and almost double what small firms spent.

Table 4: Average research and development expenditures, by firm size, 2003

| Firm Size | Average Total R&D | Average Bioproduct R&D | Average Bioproduct/ Average Total R&D |
|------------------|------------------------------|-----------------------------------|--|
| Small | \$444,369 | \$321,395 | 72% |
| Medium | \$1,516,962 | \$512,147 | 34% |
| Large | \$2,906,076 | \$618,863 | 21% |

Intellectual Property

Thirty percent of all Canadian firms either possessed or had applied for some form of Intellectual Property (IP) rights during 2003. Most obtained their IP through either a patent assignment or a licensing agreement. Quebec firms were the most likely to have acquired or pursued IP protection for their technology (43 percent of firms), compared with 30 percent of B.C. firms and just 23 percent of Ontario firms (Appendix 1). Quebec was the only province where firms viewed IP audits as one of their most important knowledge management strategies. With the exceptions of Ontario and Quebec, the percentage of firms which possessed/pursued IP rights during the year was fairly stable across the country, ranging from 28 percent to 32 percent of firms.

Ontario firms were the most likely to have obtained foreign IP as a percentage of all IP (Figure 5) while firms in Alberta and Quebec were least likely. All of Manitoba's IP came from foreign sources but the data on both Manitoba and Saskatchewan data are insufficient to make significant conclusions.

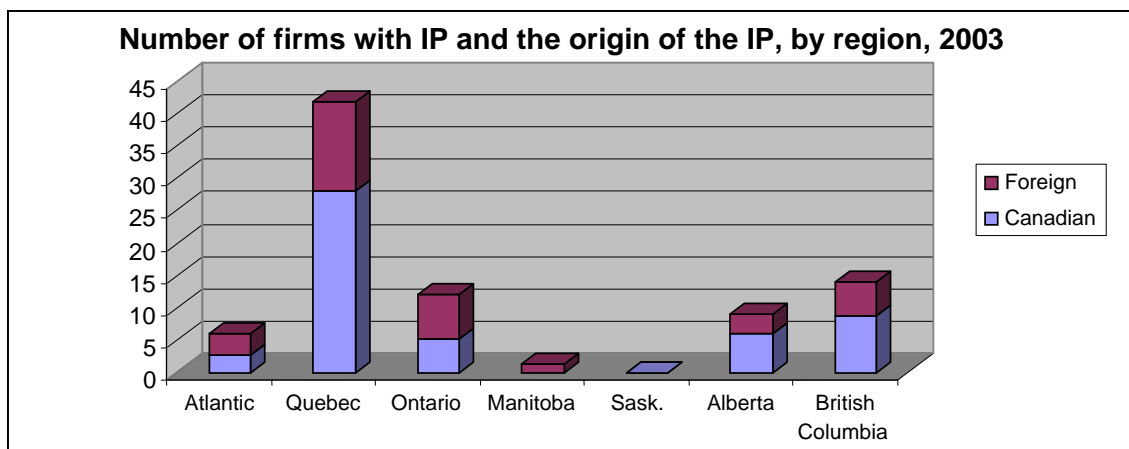


Figure 5: Number of firms which acquired by source of IP, by region, 2003

Small firms were also most likely to have acquired/pursued IP protection, with 36 percent having done so (Appendix 2). This is also consistent with other areas of the survey, which indicate that the small firms may be more involved in the early development of new technologies. Medium and large sized firms had relatively lower rates, at 15 percent and 25 percent respectively. The proportion of firms which obtained IP from domestic sources varied from 50 percent for medium sized firms to 59 percent for small firms and 73 percent for large firms.

Contracts and Collaborations

Canadian firms relied heavily on outside organizations for research and development activities, to reduce costs and risk exposure and to access new markets. These relationships were important knowledge management strategies for bioproducts firms who accessed skills and capabilities in other organizations either through contracts or collaborations.

Contracts

Canadian companies spent nearly \$117 million on bioproduct-related contracts in 2003. On average, 36 percent of firms contracted out some part of their bioproduct activity during the year, a percentage that was fairly stable across firm sizes, but varied by province (Table 5). Forty eight percent of Manitoba firms were involved in contracting, while Ontario firms were the least involved in this type of arrangement. A total of \$76.4 million of contracts were provided by Alberta companies, while another \$16.4 million came from Quebec firms, together representing 80 percent of the total value of contract expenditures by Canadian bioproducts firms. Most bioproduct-related contracts were with private research labs and universities. Contracts with these institutions comprised 40 percent and 37 percent, respectively, of all contracts (Figure 6).

Table 5: Total number of contracts, by partner type and region, 2003

| Region | Percentage of Firms Involved in Contracts | Type of Partner | | | | |
|------------------|---|-----------------|------------|----------------|--------------|-------|
| | | Private lab | University | Government lab | Foreign firm | Other |
| Canada | 35.5% | 114 | 108 | 21 | 23 | 23 |
| Atlantic | 29% | 0 | F | 0 | F | 4 |
| Quebec | 38.6% | 50 | 39 | 12 | 7 | 9 |
| Ontario | 24.2% | 10 | 17 | 3 | F | 0 |
| Manitoba | 48.3% | 15 | 5 | 0 | 7 | 0 |
| Saskatchewan | 45% | 9 | 4 | 3 | 0 | 8 |
| Alberta | 37.6% | 14 | 16 | 0 | 0 | 3 |
| British Columbia | 38.6% | 16 | 25 | 3 | 3 | 0 |

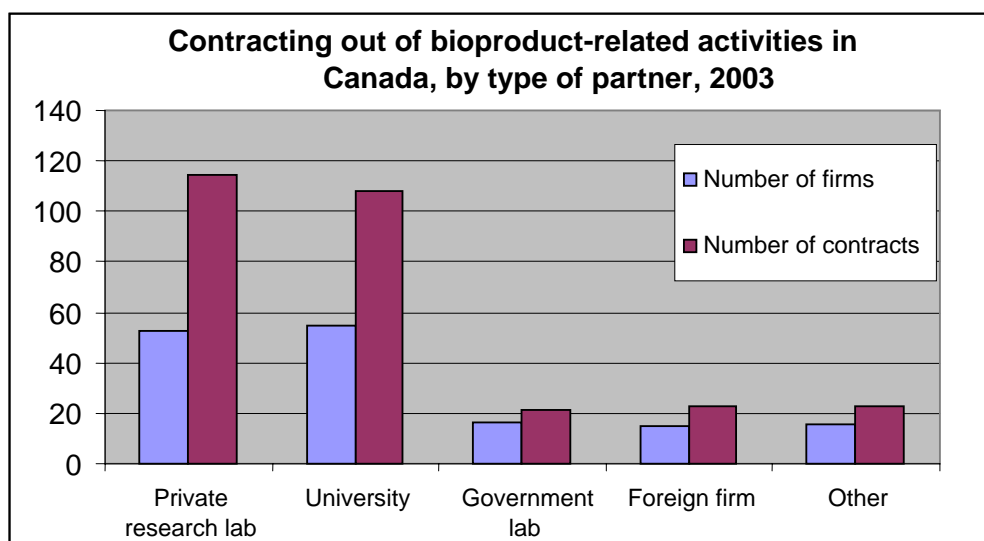


Figure 6: Contracting arrangements by partner type, 2003

Analysis of contracts by partner by firm size reveals the extent to which small firms rely on contracts. While only 36% of small firms were involved in contracts they contributed 70% of total contract value. Small firms tended to have more contracts with private labs than with universities, and large firms had more contracts with universities than with private research labs.

Collaborations

Collaborations were an important source of knowledge and expertise for Canadian bioproducts firms. Thirty-five percent were involved in collaborations with other organizations in 2003. Fifty-one percent of firms reporting collaborations cited the access to external scientific expertise as their primary motivation. This appeared relatively common across all sizes and regions. Cost reduction related to R&D activities was the second motivating factor. As with contracts, firms in Ontario were least likely to be involved in collaborations (Appendix 1). Saskatchewan firms were most likely (at 58 percent) followed by Quebec firms (at 41 percent).

Small firms were more likely than larger firms to be involved in collaborative arrangements (Appendix 2). Their motivations were primarily to access external skills not available inside the organization. Small firms were more likely to work with private sector organizations, while larger firms collaborated more closely with academic institutions, for both access to expertise and reducing the cost of R&D.

Foreign Collaborations

Foreign collaborations were relatively rare. Only 22 percent of bioproducts firms in Canada had entered into foreign collaborations. Due to confidentiality reasons the only available data is for Quebec, Ontario, Saskatchewan and B.C. who have 18, 9, 7, and 7 collaborations with foreign partners, respectively. Saskatchewan had the most firms involved, at 38 percent, and Ontario the fewest (of the numbers given) at 16 percent. Data is reported for small and large firms only. Only 23 percent of small firms had foreign collaborations, compared to 25 percent of large firms. The overwhelming reason for entering into foreign collaborations was access to foreign markets.

Financing

Of the 232 respondents from across Canada, 54 percent attempted to raise capital in 2003 to assist in the development or production of bioproducts (Table 6). Most firms were at least partially successful. A total of over \$275 million was raised by the 96 successful companies. However, funding success varied widely from province to province. Alberta firms raised nearly \$93 million with an average of \$7 million per firm seeking capital, ten times the Ontario average. Quebec had a high number of firms seeking capital, a success rate of 86 percent and Quebec firms secured over half of the capital raised in Canada. Firms in Atlantic Canada, Ontario and Saskatchewan appeared to have difficulty securing funding.

Table 6: Financing success, by region, 2003

| | Number of firms | Sought funding | Percent seeking funding | Raised funds | Percent successful | Total Raised (\$'000) | Average/ firm seeking funding (\$'000) |
|------------------|------------------------|-----------------------|--------------------------------|---------------------|---------------------------|------------------------------|---|
| Canada | 232 | 124 | 53.6% | 96 | 77.4% | 275,072 | 2,218 |
| Atlantic | 15 | 6 | 39.2% | 4 | 66.7% | F | 407 |
| Quebec | 72 | 44 | 61.4% | 38 | 86.4% | 126,022 | 2,864 |
| Ontario | 53 | 28 | 53.2% | 16 | 57.1% | 19,601 | 700 |
| Manitoba | 9 | 3 | 34.8% | 3 | 100.0% | F | 2,351 |
| Sask. | 18 | 9 | 49.9% | 8 | 88.9% | 1,586 | 176 |
| Alberta | 27 | 13 | 47.9% | 11 | 84.6% | 92,732 | 7,133 |
| British Columbia | 38 | 21 | 55.0% | 15 | 71.4% | 25,636 | 1,221 |

Examining financing by firm size reveals some interesting anomalies. Small firms were most likely to seek financing, least likely to succeed but those that were successful raised the most on

average (Table 7). Interestingly, funding for large firms was typically much lower than for small or medium sized firms and they achieved far less of their target funding (Figure 7).

Table 7: Financing Success, by firm size, 2003

| Firm Size | Attempted to raise capital | | Successfully raised capital | | Total amount raised | Average amount raised |
|-----------|----------------------------|---------|-----------------------------|---------|---------------------|-----------------------|
| | Number | Percent | Number | Percent | (\$000) | (\$000) |
| Small | 93 | 60.4% | 70 | 75.3% | \$211,817 | \$1,362 |
| Medium | 18 | 45.0% | 15 | 83.3% | \$45,717 | \$1,149 |
| Large | 12 | 31.6% | 11 | 91.7% | \$17,537 | \$485 |

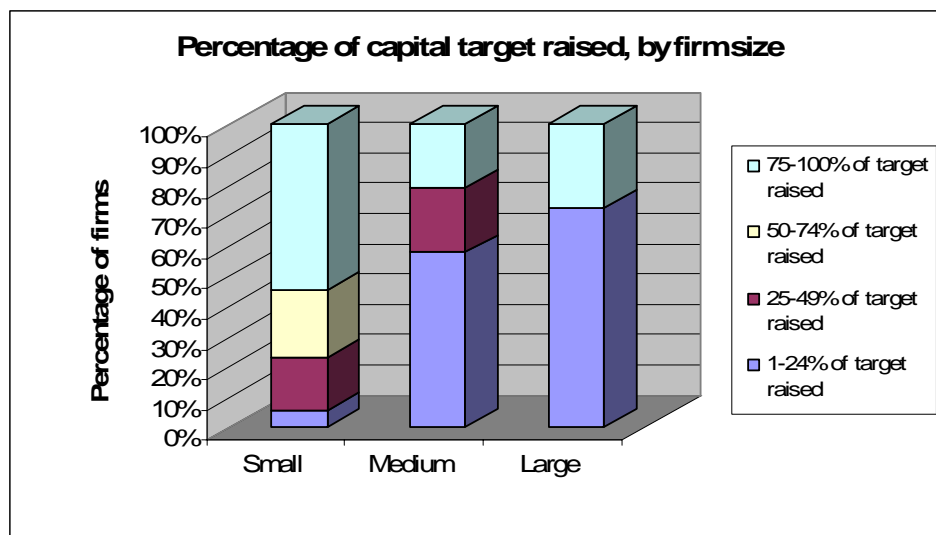


Figure 7: Firm financing success, by firm size, 2003

The number one reason cited by firms of all sizes for pursuing financing was to fund R&D. Raising funds to repay investors and fund regulatory expenses was only important to small firms (likely due to firm structure and relative “newness” to the sector). Medium and large firms required more funding for production and manufacturing since they were more focused on products on the market. Just over half of firms, regardless of size, cited the need for operating capital as a financing objective.

The funding received by these firms came from numerous sources. Government programs comprised 43 percent of all sources of funding for Canadian firms. Other common sources included Canadian based venture capitalists (13 percent) and angel investors/ family (15 percent). Less frequently used were financial institutions, public offerings, private placements, and alliances/ collaborations. Quebec companies captured most of the funding and led in obtaining

funding from most public and private sources (Figure 8). Loan programs were often administered provincially. Alberta firms had a disproportionately high number of the private placements, which might account for their very high levels of funding per firm relative to companies in other provinces.

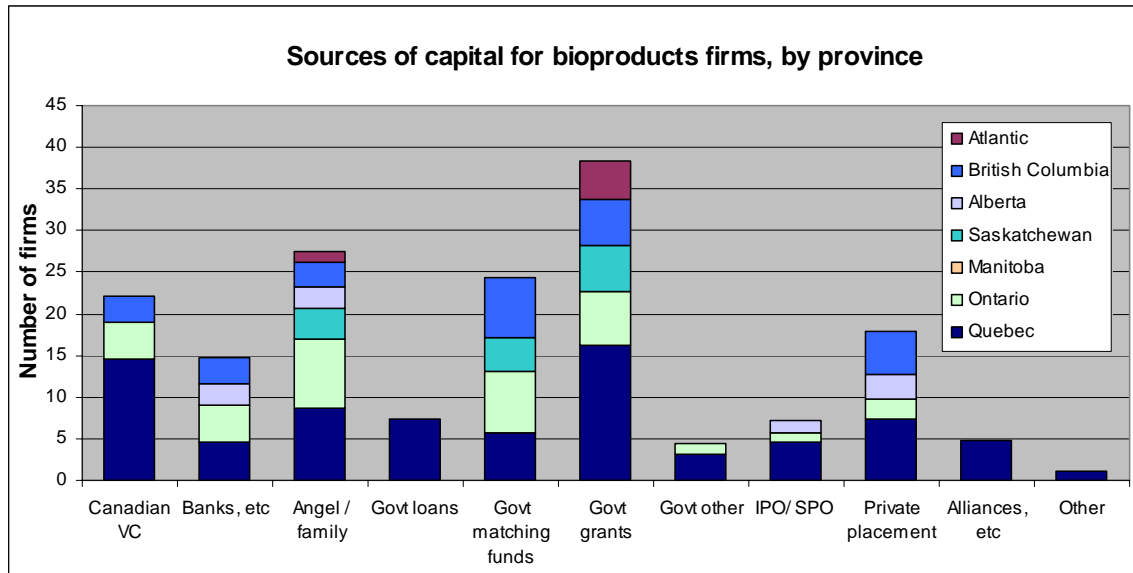


Figure 8: Number of firms using different financing methods, by region, 2003

Various reasons were cited for the firms’ inability to access capital funding more successfully, the most common being the lack of availability of capital. The other major reasons cited pertained to the development stage of the product/technology (too early) or a lack of proven market demand, however, these applied mostly to small-sized firms who tended to have early-stage products. There was little regional variation in the reasons.

Use of Government Support Program

Participation in government support programs was only moderate with approximately one third of firms applying to federal programs and one third applying to provincial programs (Table 33). With the exception of Quebec, applications to federal programs were above those of provincial programs. In Quebec, participation in provincial programs was 70 percent, more than double the national average (Table 8).

Table 8: Firm use of Government Support Programs in the past five years, by region, 2003

| By Region | Percentage using Federal Programs | Percentage using Provincial Programs |
|------------------|-----------------------------------|--------------------------------------|
| | % | % |
| Canada | 33.1 | 34.8 |
| Atlantic | 41.9 | 29.1 |
| Quebec | 38.9 | 70.4 |
| Ontario | 15.6 | 8.1 |
| Manitoba | 59.3 | F |
| Saskatchewan | 50.5 | 46.0 |
| Alberta | 38.0 | 16.5 |
| British Columbia | 25.2 | 18.6 |

Small firms made more use of both federal and provincial support programs (at approximately 42 percent for each category) than larger firms (24 percent each). Medium firms presented an interesting anomaly, making relatively little use of either category of support programs but using provincial programs (18 percent) more frequently than federal programs (11 percent). Technology development programs were most likely to be accessed but small firms also made extensive use of loan guarantees, information and training programs. Medium and large firms accessed technology development and training primarily. Both small and medium sized firms used provincial training programs more than federal programs.

Use of funding under the Scientific Research and Experimental Development (SR&ED) tax program varied widely among the provinces and firm sizes (Table 9). Firms in Manitoba and Quebec were much more likely to use the program but Manitoba and B.C. firms were far ahead in terms of the amount requested by participating firms. Alberta was third, with all other regions trailing.

Table 9: Firm use of SR&ED tax program in the past five years, by region, 2003

| By Region | Number using SR&ED | Percentage using SR&ED | Total benefits applied for under program | Average benefits applied for/firms using program | Average cumulative credits/firm in region |
|--------------|--------------------|------------------------|--|--|---|
| | # | % | \$'000 | \$'000 | \$'000 |
| Canada | 90 | 47.4% | 87,198 | 792 | 1,299 |
| Atlantic | 4 | 26.7% | F | F | 3,761 |
| Quebec | 38 | 65.3% | 28,813 | 613 | 1,173 |
| Ontario | 15 | 37.7% | 5,500 | 275 | 840 |
| Manitoba | 6 | 55.6% | 15,873 | 3,175 | 1,071 |
| Saskatchewan | 5 | 38.9% | X | x | 315 |

| | | | | | |
|------------------|----|-------|--------|-------|-------|
| Alberta | 7 | 25.9% | 11,481 | 1,640 | 3,891 |
| British Columbia | 14 | 52.6% | 21,970 | 3,139 | 882 |

Small firms were more likely to use of the SR&ED tax credit program but they applied for and received less than larger firms (Table 10). Large size firms have been the most successful in securing tax credits over the last five years.

Table 10: Firm use of SR&ED tax program in the past five years, by firm size, 2003

| Firm Size | Number using SR&ED | Percentage using SR&ED | Total benefits applied for under program | Average benefits applied for/firms using program | Average cumulative credits/firm in region |
|-----------|--------------------|------------------------|--|--|---|
| | # | % | \$'000 | \$'000 | \$'000 |
| Small | 77 | 50.0% | 21,792 | 283 | 795 |
| Medium | 19 | 47.5% | 26,079 | 1,373 | 2,321 |
| Large | 15 | 39.5% | 39,328 | 2,622 | 2,505 |

Human Resources

It is estimated that 24,195 people were employed by firms engaged in the development and/or production of bioproducts in Canada in 2003. Of these, the greatest proportion was in Quebec, followed by Ontario, the Atlantic Provinces and British Columbia. Around 75 percent were employed in large firms, with only 9 percent employed in small firms, indicating that, even though two thirds of the firms are small, large firms dominate the sector in terms of number of employees.

Within the firms, an estimated 7,864 of employees had responsibilities related to bioproducts. Around 32 percent of employees were involved in bioproduct activities including scientific research and development (1,022), technicians (1,007) and management, marketing, finance and production (5,606), with the remainder (229) engaged in a variety of other related tasks. Over 58 percent of employees with responsibilities related to the development and/or production of bioproducts in Canada were employed by companies in Quebec or Ontario. More than 38 percent of all scientific research and development personnel were employed in Quebec, with a further 22 percent in Ontario and 15 percent in British Columbia. The Atlantic Provinces account for almost 8 percent of scientific research and development personnel but only 3 percent of total employment in the sector.

The focus of small firms on early stage R&D was evident in employment patterns. Small firms accounted for 43 percent of all employees engaged in scientific research and development across the bioproducts sector, but only 15 percent of those involved in management, marketing, finance

and/or production. On an individual firm basis small firms committed half of their personnel to development (Table 11). By contrast, large firms accounted for 51 percent of management, marketing, finance and/or production personnel but only 29 percent of employees engaged in scientific research and development.

Table 11: Average employees/firm with bioproduct responsibilities, by firm size, 2003

| Company Size | Responsibility | | | | |
|--------------|----------------|-------------|---|-------|-------|
| | Scientific R&D | Technicians | Management/marketing/finance/production | Other | Total |
| Small | 2.85 | 2.56 | 5.43 | 0.31 | 11.14 |
| Medium | 7.33 | 9.2 | 47.7 | 4.58 | 68.78 |
| Large | 7.63 | 6.42 | 75.32 | 0 | 89.4 |

Benefits from Bioproduct Development and Production

Respondents were asked to rate the importance of various benefits obtained by their firms as a result of bioproduct development or production. The importance of each benefit was rated using a five point likert scale, where a low importance rating was scored as one and a high importance score was rated as a five. A weighted average of the scaled responses was calculated, with the proportion of respondents selecting the various rating serving as weight. This weighted average provided the importance score used to rank the various benefits.

For all firms in Canada, increased sales/market share were ranked as the most important, followed by development of new market niches/new products, reduced damage to the environment, improved product value/performance, increased product range, reduced production cost and finally reduced energy consumption. Across regions, either increased sales/market share, development of new market niches/new products or reduced damages to the environment was the top ranked benefit (based on the importance score). Moreover, these benefits are generally in the top three ranked benefits within each region. Exceptions do exist to this general conclusion. For instance, in all but Atlantic Canada, and Saskatchewan, improved product value/performance ranked higher than either increased sales/market share, reduced demand to the environment or development of new market niches/new products. Reduced production cost and reduced energy consumption were viewed as less important. On a regional basis, however, firms in the Atlantic region, Manitoba,

and B.C. ranked reduced production cost and reduced energy consumption higher than other benefits.

Responses based firm size (Table 12) indicate that small firms viewed developing sales, new markets and improving the value or performance of their products as the most important bioproduct benefits. This was very similar for medium size firms except that reduced environmental impact replaced new market development. Improved product value or performance had the highest importance score for medium firms. The importance of environmental impact appears to increase with firm size since large firms ranked reduced damage to the environment as the most important.

The benefit rankings are not entirely unexpected. One might expect smaller firms to be seeking market expansion opportunities as a means to facilitate growth and sustainability. Medium size firms, who might already have well developed product lines and markets, might well focus on generating additional value (or performance) with existing products. Larger firms may view reduced environmental damage as very important as this lessens the negative publicity they receive and mitigates any liability they may face arising from environmental damage. They are also actively involved in using by-products. Reduced production cost and energy consumption had higher importance scores for larger firms than for small and medium firms suggesting that they are more focused on cost control than market growth. Such differences in business strategy, based on firm size, are not unexpected.

Table 12: Importance scores for benefits, by firm size, 2003

| Firm Size | Reduced production cost | Reduced energy consumption | Reduced damages to the environment | Developed new market niche or new products | Increased product range | Improved product value or performance | Increased sales or market share |
|-----------|-------------------------|----------------------------|------------------------------------|--|-------------------------|---------------------------------------|---------------------------------|
| Small | 3.12 | 2.58 | 3.76 | 4.22 | 3.78 | 3.87 | 4.12 |
| Medium | 3.27 | 2.52 | 3.55 | 3.07 | 3.13 | 3.63 | 3.59 |
| Large | 3.91 | 3.71 | 4.36 | 3.23 | 2.79 | 2.93 | 3.48 |

Note: The three highest ranked benefits for each firm size are identified by bold text.

Barriers to Bioproduct Development and Production

Respondents were asked to rate the importance of various barriers their firm experienced in the development or production of bioproducts. As with the benefits question, the rating of each

benefit was scaled using a five point likert scale and the responses were used to develop importance scores for each barrier by region and firm size. The two major barriers by region and firm size are shown in (Appendices 1 and 2). For bioproduct firms in Canada, lack of financial capital, high cost and timeliness of regulatory approval and higher price of raw materials or feedstock were the top three barriers, based on the importance scores. In Quebec, Manitoba and B.C. unreliable supply of raw material or feedstock also rated in the top three importance scores. In Manitoba, the most important barrier was higher transport cost of main feedstock or raw material.

The higher cost and timeliness of regulatory approval was perceived as one of the top three barriers to bioproduct development by bioproduct firms in Canada, regardless of their size. For small firms the other two most important barriers were lack of financial capital and lack of adequate product standard or certification. The importance of these barriers is not unexpected. Small firms often encounter difficulties sourcing capital from various sources. The importance of lack of adequate product standard or certificate may reflect the fact that smaller firms may have truly novel innovations for which appropriate standards do not exist. In conjunction with the regulatory approval process issues, it would seem that smaller firms not only need additional capital, but also a clear, more flexible regulatory/standards approval process.

For medium sized firms, the other important barriers were the high cost of raw material or feedstock and lack of technology or technical information. The latter barrier is somewhat surprising as one would expect this group of firms to be more mature than smaller firms and have adequate access to technology and information. Besides regulatory approval costs, important barriers for large firms were higher transportation cost of main feedstock or raw material and higher price of raw materials or feedstock.

It would thus seem important to develop human capital that enables firms to navigate their way through the regulatory system. Alternatively, the regulatory system needs to be modified to make it easier for firms to take a concept from R&D to the market.

Business Strategies

Respondents to the survey were presented with a series of strategies related to knowledge development and their overall business and asked to indicate how important each had been for

their firm in 2003 on a five-point scale from “low” (1) to “high” (5). Across the sample as a whole, the most important strategies related to acquisition of knowledge from other industry sources (including industry associations, competitors, clients and suppliers) and the commencement of new research and development projects (Table 13). Entering product trials and/or adapting products for increased market penetration were also important to companies within the sector. Changes in firm size through downsizing or acquisitions, mergers or joint-ventures were relatively unimportant strategies.

Table 13: Mean importance of strategies for firm, 2003

| Strategy | Mean Importance Score |
|--|------------------------------|
| Acquired and used knowledge obtained from other industry sources such as industry associations, competitors, clients and suppliers | 3.3 |
| Began new research and development project | 3.2 |
| Entered product trials/adapted products or processes for increased market penetration | 3.2 |
| Developed/encouraged staff education/upgrading | 3.1 |
| Acquired and used knowledge obtained from public research institutions including universities and government laboratories | 3.0 |
| Developed firm policies and practices for knowledge/intellectual property protection | 2.8 |
| Expanded into foreign markets | 2.7 |
| Used and updated databases of scientific information | 2.6 |
| Conducted an intellectual property audit to ensure protection of products and processes at all stages of development | 2.4 |
| Downsized operations of the firm | 1.9 |
| Increased firm size through acquisition, merger or joint venture | 1.8 |

Broadly, across the provinces these same knowledge development and business strategies remained important for bioproduct firms. However, there were some notable differences. In Quebec, the Atlantic Provinces and Saskatchewan knowledge acquisition through public institutions, including universities and government laboratories, were relatively more important strategies for knowledge development. As discussed earlier, Quebec is the only province which considers IP audits a fairly important business strategy.

Across respondents by company size, new R&D projects and product trials emerged as most important business strategies. Knowledge development strategies overall, and acquisition and use of knowledge from public research institutions in particular, were of much less importance for medium-sized firms than either smaller or larger companies.

Common Themes in the Canadian Bioproducts Sector, 2003

Bioproducts are just one part of firm business activities and the proportion decreases with firm size - In general, bioproducts were a small part of the business activities for most of the 232 Canadian firms involved in bioproducts in 2003. Firms had less than one third of their employees involved in bioproducts and derived just over one quarter of their revenue from bioproducts activities. Almost half of firms secured inputs from by-products. This provides the industry with greater stability and certainly of income than if they were focused entirely on bioproducts development.

Bioproduct firms generally entered the business as a result of internal R&D - Nearly two thirds of firms entered the bioproducts business primarily as a result of internal research and development. The most common benefits from bioproduct involvement pertained to new product/market opportunities, but firms also secured benefits relating to environmental impact and product performance. While reducing energy usage was a low-rated benefit, rising energy costs should increase interest in the development of bio-energy products. Thus, there are many reasons for firms to enter the bioproducts business and no obvious single motivation which can be used to promote the industry in general.

Barriers to expansion include capital, particularly for small firms, and regulation –

The factors limiting the expansion of bioproduct activities are relatively consistent, with capital as the most commonly cited barrier and difficulties related to regulatory approval second. Access to capital is the major barrier for small firms, but is less important for large ones. Interestingly, less than half of survey respondents made use of the SR&ED Tax Credit program. Cost and timeliness of regulatory approval was also among the top three barriers for all firm sizes and most provinces. The related issue of lack of product standards or certification was relatively important across Canada and for small and large firms. Also of interest are the factors not cited as barriers -

problems related to intellectual property, human resources and negative public perception were not often rated as major problems.

Knowledge Acquisition was and Important Strategy

The final area of similarity across firms and provinces related to firm strategies. Acquiring industry knowledge was rated as the top knowledge management strategy across all firm sizes and six of the seven regions. Firms used a combination of internal and external knowledge management strategies, accessing external knowledge from industry and research institutions while at the same time promoting employee development. Both contracts and collaborations were employed to facilitate access to external expertise and capabilities.

Policy Implications:

The different strategies and challenges of firms from different size and regions necessitates distinct policies to promote bioproduct development among Canadian companies.

However, the common themes point out some reasonable starting points at the national level.

The regulatory approval process was a challenge to firms across regional and size categories. It is worthwhile investigating why this issue was raised so regularly and what can be done to improve the situation. Further analysis is required to determine whether the issue is the same across all product categories.

Addressing challenges related to lack of capital is a different matter since is particularly an issue for small firms operating in an area of relatively new technology. While individual programs may be targeted at the bioproducts sector, programs aimed at promoting new technologies in general may help to create an environment conducive to the creation of new companies in a variety of technology sectors. The relatively limited use of the Scientific Research and Experimental Development, particularly in some provinces, represents an opportunity to improve the flow of capital to support research. Just under half of firms used the SR&ED tax credit program and only one third accessed federal and provincial support programs. Identifying the reasons why firms do not apply or are not successful can improve program use and value to the industry.

One obvious conclusion is that different approaches are required depending on whether the target is promotion of bioproducts development in large firms or increasing the number and success of small bioproducts firms focused on developing new bioproducts. Large firms incorporate bioproducts into their existing businesses for environmental, cost and market reasons and would respond to incentives to further activities aligned with current business activities. Small firms build a major portion of their business on bioproducts and commit a significant percentage of their scientific development resources to those products. They tend to require assistance in every area from technology development to loan guarantees and training since a lack of both financial and personnel resources are significant factors limiting their development. All categories have made use of training and those programs could be expanded in the future.

Recommendations for Further Analysis

This first analysis of the Canadian bioproducts sector provides a reasonable overview of the sector but was not intended to delve more deeply into the workings of the sector and the factors contributing to success in bioproduct development and commercialization. The analysis contained here was conducted based on regional or firm size differences. In this regard, scope exists to develop cross-tabulations that interact, not only the regional and firm size variables, but also other variables such as firm age, nature of business arrangements, the impact of collaborations, etc. At the same time, use of multivariate or other statistical methods can be used to test and measure the relationship between bioproduct development or business success and various firm specific factors.

The bioproducts survey also presents an opportunity to create a baseline assessment of the sector and the firms. Future studies will facilitate analysis of the evolution of the sector but also of individual firms common to this and future surveys. Firm level longitudinal analysis will provide extremely useful information about the nature of firm bioproduct development and the role of different strategies and policy in shaping that development. Given that this sector is predicted to grow at a significant rate over the next few decades, building an understanding of the sector and critical success factors as early as possible is essential.

Appendix 1: Key Bioproduct Firm Indicators by Region (2003) *Note: F indicates unreliable data.*

| Category | Canada | Atlantic | Quebec | Ontario | Manitoba | Sask. | Alberta | B.C. |
|--|------------------------------|------------------------------|---------------------------|--------------------------|---------------------------------------|---------------------------------|----------------------------------|-------------------------------------|
| Number of Firms | 232 | 15 | 72 | 53 | 9 | 18 | 27 | 38 |
| Firm Characteristics | | | | | | | | |
| % < 5 years in BP | 34.6% | 21.2% | 42.7% | 30.0% | 29.0% | 39.4% | 39.6% | 24.5% |
| % Public companies | 29.3% | 18.9% | 20.9% | 24.5% | 65.1% | F | 43.9% | 45.0% |
| Avg. # of emp./BP emp. | 105 / 34 | 262 / 15 | 83 / 35 | 77 / 39 | 108 / 32 | 157 / 12 | 96 / 40 | 100 / 39 |
| Avg. % BP employees | 32.5% | 5.8% | 41.7% | 50.7% | 29.5% | 7.7% | 41.6% | 39.4% |
| Entry into bioproducts | | | | | | | | |
| % from internal R&D | 65.9% | 49.6% | 73.2% | 65.9% | 34.4% | 84.8% | 42.8% | 72.5% |
| Biomass Use: | | | | | | | | |
| Top 3 Biomass Sources :% primary/ % by-prod. | Ag/F/Other 46 / 47 | F/Ag/Food 61 / 22 | Ag/F/Marine 46 / 47 | Ag/F/Other 43 / 52 | Ag mainly 50 / 45 | Ag/Manure/F 47 / 53 | Ag/F/Other 58 / 43 | F/Ag/Food 37 / 51 |
| Revenue (\$ 000): | | | | | | | | |
| Average total/firm | \$ 51,560 | \$ 26,966 | \$ 32,504 | \$ 52,666 | \$ 43,385 | \$ 85,775 | \$ 105,492 | \$ 43,243 |
| Average % from BP | 26.4% | F | 33.5% | 31.2% | 32.5% | 6.5% | 21.9% | 38.6% |
| % BP rev. from export | 47.5% | F | 30.8% | 48.5% | 59.0% | 78.4% | 80.6% | 27.1% |
| R & D (\$ 000): | | | | | | | | |
| Average R&D/firm | \$ 1,033 | \$ 288 | \$ 1,327 | \$ 674 | \$ 1,589 | \$ 562 | \$ 1,922 | \$ 736 |
| Average BP R&D/firm | \$ 403 | \$ 33 | \$ 572 | \$ 309 | \$ 640 | \$ 206 | \$ 526 | \$ 310 |
| Avg. # of BPs under development/firm | 4.5 | 3.0 | 5.1 | 3.2 | F | 4.9 | 5.4 | 4.5 |
| % on market | 60.3% | 71.8% | 54.1% | 70.4% | F | 54.2% | 65.6% | 59.1% |
| Financing | | | | | | | | |
| - % seeking financing | 53.6% | 39.2% | 61.4% | 53.2% | 34.8% | 49.9% | 47.9% | 55.0% |
| - Avg. raised/firm seeking (\$000) | \$ 2,218 | \$ 407 | \$ 2,864 | \$ 700 | \$ 2,351 | \$ 176 | \$ 7,133 | \$ 1,221 |
| IP - % firms with IP | 30.5% | 28.5% | 43.0% | 23.0% | 32.9% | F | 27.9% | 30.2% |
| Collaborations | | | | | | | | |
| - % with collaborations | 35.7% | 39.1% | 41.4% | 24.1% | 34.4% | 57.9% | 37.1% | 28.8% |
| - Main collaborations | Non-bioP | Non-bioP | Academic | Non-bioP | F | BioP/Academic | Non-bioP | Academic |
| Strategies | | | | | | | | |
| - Top knowledge dev. | Acquire Ind. Know. | Acquire Ind. Know. | Pub. Know /IP Audit | Acquire Ind. Know. | Staff Educ. Trials | Acquire Ind. Know. Trials | Acquire Ind. Know. New R&D | Acquire Ind. Know. Trials/R&D |
| - Top business strategy | New R&D | New R&D | New R&D | Trials/New R&D | Trials | Trials | New R&D | Trials/R&D |
| Benefits – Top two identified (PM = Product/Market) | ↑ Sales/ New PM | Env. Impact/ New PM | New PM/ ↑ Sales | New PM/ Env. Impact | ↑ Sales/ New PM | New PM/ Env. Impact | New PM/ ↑ Sales | Env. Impact/ ↓ Prod'n cost |
| Barriers – Top two identified | Capital/ Reg. approval | Reg. approval/ Capital | Reg. approval/ Capital | Capital/Reg. approval | Transportati on/ Price of Mat'l | Capital/Price of Mat'l | Capital/Price of Mat'l | Capital/Reg. approval |

Appendix 2: Key Bioproduct Firm Indicators by Firm Size (2003)

| Category | Firm Size | | |
|--|---------------------------------|---------------------------------------|--------------------------------------|
| | Small | Medium | Large |
| Number of Firms | 154 | 40 | 38 |
| Firm Characteristics | | | |
| % less than 5 years in bioproducts | 42.6% | 17.4% | 17.8% |
| % Public companies | 19.8% | 37.1% | 60.1% |
| # of employees/ # BP employees | 14 / 11 | 98 / 69 | 476 / 89 |
| % Scientific R&D or Technicians | 77.7% | 70.4% | 18.8% |
| Entry into bioproducts | | | |
| % as a result of internal R&D | 72.0% | 47.1% | 60.4% |
| Biomass Use: | | | |
| Top Three Biomass Sources ² | Ag/F/Other | Ag/F/Marine | F/Ind/Ag |
| Source:% primary/ % by-product | 48% / 46% | 44% / 48% | 40% / 53% |
| Revenue (\$ 000) : | | | |
| Average total/firm | \$ 6,026 | \$ 43,429 | \$ 244,654 |
| Average % revenue from BP | 45% | 63% | 18% |
| % BP revenue from exports | 62% | 53% | 41% |
| Research and Development (\$000): | | | |
| Average R&D/firm | \$ 444 | \$ 1,517 | \$ 2,906 |
| Average bioproduct R&D/firm | \$ 321 | \$ 512 | \$ 618 |
| Average # of BP under development/firm (% on market) | 3.7 49.5% | 5.5 72.3% | 6.6 74.5% |
| Financing | | | |
| - % seeking financing | 60.4% | 45.0% | 31.6% |
| - Avg. raised/firm seeking (\$ 000) | \$ 1,362 | \$ 1,149 | \$ 485 |
| Intellectual Property | | | |
| - % of firms with IP rights | 35.8% | 15.0% | 24.9% |
| Collaborations | | | |
| - % with collaborations | 42.8% | 15.0% | 28.9% |
| - Main collaborations | Non-BP | BP | Academic |
| Strategies | Acquire Ind. Know. New R&D | Acquire Ind. Know. Trials | Acquire Ind. Know. New R&D |
| - Top knowledge development | | | |
| - Top business strategy | | | |
| Benefits – Top two identified | New PM/ ↑ Sales | Improve Value performance/↑ Sales | Env. Impact/ ↓ Prod'n costs |
| Barriers – Top two identified | Capital/ Regulatory approval | Price of Material/Regulatory approval | Price of Material/ Transportation |

² Ag: Agriculture, F: Forestry, Ind – Industrial Organic Waste