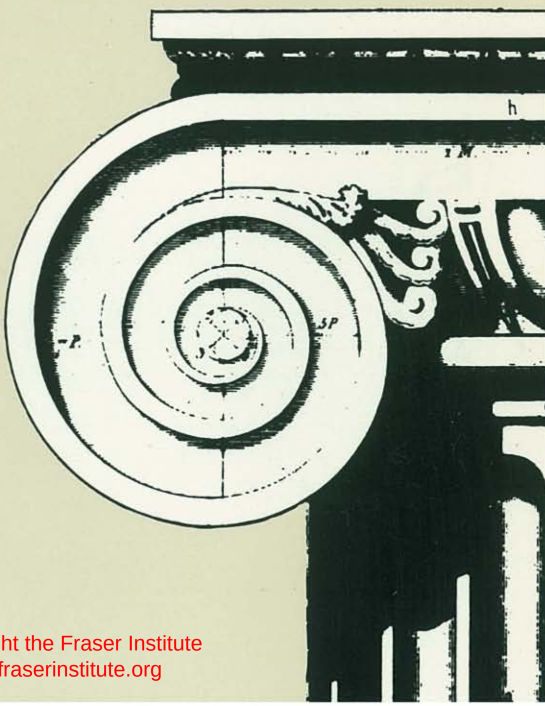
THE ECONOMICS
OF THE SERVICE SECTOR
IN CANADA

Shaping Our Nation

An Economic Analysis of Canada's Consulting Engineers

David L. Hammes



THE FRASER INSTITUTE

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Series Editors:
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To my parents,

Constant M. and Helen J. Hammes

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PREFACE

Any time an economist writes aiming at a widespread audience he or she usually has in mind the following words from John Maynard Keynes in *The General Theory of Employment, Interest and Money:*

> Practical men, who believe themselves to be quite exempt from any intellectual influences, are usually the slaves of some defunct economist. Madmen in authority, who hear voices in the air, are distilling their frenzy from some academic scribbler of a few years back (Macmillan & Co., London, 1936:383).

First, as authors, economists hope their ideas will indeed infuse the airs of public policy debate, if only to be distilled at a much later date. Secondly, not wishing to become "defunct," economists write and predict (with some license) future trends that may be derived from past observation in order to give their work continued legitimacy and interest. Finally, the style of writing often appears to be "scribbling" in order to impress the general reader with the author's scholarly abilities.

It is, however, also wise for authors and readers to keep in mind a comment made by the physicist Neils Bohr. After hearing a presentation by Wolfgang Pauli, he said, "Herr Professor, we are all agreed that your theory is crazy. However, we are not convinced that it is crazy enough to be right" (*NBER Macroeconomics Annual 1987*, The MIT Press, p.164).

In this work I tread the fine line between scribbling and craziness. In some senses it is highly presumptuous for a non-engineer to write about the engineering industry. In another sense, it may be most appropriate. Not being enmeshed in the profession itself, a somewhat distant observer may provide insights not likely to come from within the profession. On the other hand, an observer from outside misses much of the daily rough-and-tumble of the industry and the life within, and it is often this intimate knowledge of subject which propels readers along without seeming effort.

Consequently, I ask more of the reader than most authors. This book presents a picture of consulting engineering in Canada derived from official and other statistical sources. The statistical picture is built up from the complex interactions of the consulting engineering industry and domestic and foreign clients, competitors, and the various levels of Canadian government. These interactions are probably of most interest to the general reader. In those instances where I've strayed, seemingly bogged down in detail, I apologize to the reader beforehand. However, without the primary colours provided by statistical detail, the picture would be faint indeed.

Public policy considerations appear on almost every page of the text. Governments are major buyers and suppliers of engineering services. On that basis alone, government policy is important to the industry. Procurement practices, education policy and provincial self-licensure legislation provide the sizing upon which the detailed picture must be painted. At the foundation, it is government legislation which has and continues to define the industry.

Some issues, for example education policy, are too general for consideration in this text. (The reader is encouraged to see the books in this series on education by E. West and S. Easton.) However, other aspects of government-industry interactions that have and will continue to have a major impact on the industry are considered.

Predicting future changes is risky business. New developments occur daily while evidence on magnitudes is scant. Directions seem more obvious than rates of change and, where possible, those directions are discussed. I hope the reader finishes this study with a better feel for the size, composition and complexities of the engineering market in Canada.

As stated above, I started this project with a background blissfully ignorant of engineers and engineering in Canada. Consequently, I am indebted to those who made efforts to help me see the patterns and richness of texture sometimes not evident in the statistical sources. My greatest debt in this regard is owed to Mr. John Dauvergne, Department of Regional Industrial Expansion, Ottawa. His patient suggestions, encouragement, generous sharing of information and its sources provided me invaluable assistance.

I am also very thankful to the following people and their organizations who, along with John Dauvergne of DRIE, Professor Herbert Grubel and Dr. Michael Walker, Director of the Fraser Institute, participated in an Industry Forum held at the Fraser Institute in August 1987: Mr. Brian Bentz, B.Sc., C.A., Vice President, Project and Corporate Finance, H.A. Simons (International) Ltd.; Mr. Vince Borch, P. Eng., Associated Engineering (BC) Ltd.; Mr. R.A. Brocklebank, P. Eng., President, McElhanney Engineering Services Ltd.; Mr. Ross Clayton, P. Eng., Sandwell Swan Wooster Inc.; Mr. Dennis Cote, P. Eng., Chairman, The UMA Group; Mr. S.J. Cunliffe, P. Eng., President, Willis, Cunliffe Tait and Company; Ms. Darlene Facchin, Statistics Canada; Mr. William Magee, President, William Magee Consulting Services; and Mr. Barry Needham, Vice President, Finance, Wright Engineers Ltd.

I have also benefited from conversations with Mr. Bert Shore, P. Eng., and Mr. James N. Keen, P. Eng., R.P.A., immediate past and current Executive Director respectively, of the Consulting Engineers of British Columbia; Dr. Miles Parsons of Klohn Leonoff Ltd., Mr. John Austin, P. Eng., of Austin and Associates and Dr. Mario Polese, Director of the *Institut national de la*

recherche scientifique, Universite du Quebec, a Montreal. Many provincial associations of professional engineers and consulting engineers were most helpful in sending along data where and when available. Space considerations unfortunately make naming them all impractical.

This book would not have been written without the resources, atmosphere, stimulation and help provided by the staff of the Fraser Institute. Their interest, encouragement and accessibility made my work much easier. Special thanks are due to Professor Herbert G. Grubel, Project Director of the Service Industries Project at the Fraser Institute, for instilling enthusiasm and discipline in equal measure. Writing a book takes both.

Finally, my wife Kathy and two sons, Mark and Steven, were an unfailing source of support when enthusiasm and discipline failed to carry the load. Most of all, writing a book requires understanding and this they provided generously.

Having thanked all these people, it should be stressed that neither they nor their firms are in any way responsible for the views, opinions or any remaining errors found in this book.

SUMMARY

Consulting engineering provides services to almost every sector of the Canadian economy. There are roughly 4,000 firms in the industry, with about 200 of those supplying services abroad as well as domestically. In terms of fee revenue, value added and employment, the industry accounts for less than one percent of the national totals. However, as a service to business management, growth in engineering services has outpaced growth in the economy as a whole during the 1970s and part of the 1980s.

The main consumers of engineering services are governments and the private sector in almost equal measure. The major portion of fee revenues come from design work on infrastructure. This infrastructure is most often associated with forest products, highways and railways, plant process design and municipal services.

Production of engineering services in Canada is provided almost entirely by Canadian engineers, most of whom have at least one university degree. The industry has a significant presence in foreign markets, having approximately 10 percent of the international design market.

The demand for engineering services is highly dependent on the level of real construction activity. As a consequence, the industry was hit very hard by the recession of the early 1980s. Additionally, foreign work became harder to get over this period as the Canadian dollar appreciated relative to the currencies of many major engineering competitors, especially the British, French and Koreans.

Estimates of engineering provided in-house by both private firms and governments are hard to make. Preliminary evidence shows the proportion of the total number of engineers decreasing in every two-digit SIC division except mining, quarries and oil, and community, business and personal services over the decade 1971 to 1981. On the other hand, five divisions in addition to the community, business and personal services division experienced an increase in the number of engineers per 1,000 employees over that same time period.

The structure of the industry is changing. Growth is occurring most rapidly in areas that are not traditional strengths in consulting engineering. These areas include services not usually tied to or bundled with capital construction activity. This is not a problem for the economy as the firms providing these services are robust and competitive world-wide. However, for purposes of measurement, their activity is not reflected in the statistical category of consulting engineering. Consequently, to the degree that capital projects spend-

ing slows, growth in consulting engineering will lag growth in these other more high tech sectors.

Regional employment and production of engineering services shows a distribution of engineering manpower and skills congruent with the economic landscapes of the various regions. As a result, we find mining and petroleum engineers concentrated in the western provinces and chemical, electrical, mechanical, metal, industrial and aerospace engineers concentrated in Ontario. This implies that the impact of different economic events impinges differentially across the country within this industry. For example, the drop in oil exploration activity consequent upon the drop in world oil prices hit petroleum engineers harder than engineers in other subgroups. Evidence shows that profits per dollar of fee revenue fell over the 1974 to 1982 period in the industry. As one would expect, wages, salaries and benefits, amounting to approximately 65 percent of total costs, are the major cost component in the operation of consulting engineering firms.

Productivity levels and growth rates outpace those of many other services to business but are generally lower than rates in the rest of the economy. Growth in productivity appears to have been in the range of 0.5 to 2.0 percent per year over the 1974 to 1982 period. As computer-aided drafting and design stations replace technicians and draftspersons, the level of productivity per employee will rise.

The international market for engineering services is changing in areas that traditionally do not favour engineers. Requirements to form joint ventures, provide financing or take equity positions in projects have become commonplace in developing Third World nations. Consequently, the "physical" engineer is required to become a "financial" engineer as well. The increased costs and uncertainties of this business also encourage engineers to stick to the more stable markets of Europe and North America.

Successful exporting requires a network providing timely information and on-site representation. These networks have been put in place by the major Canadian engineering firms successfully operating in world markets. It is not clear that governments can provide market intelligence with the same immediacy and intimate relevance for any particular industry, including engineering. Further, it is certainly not clear that such a subsidy is warranted. The added costs of export activity should be borne by the firms involved. These costs may be shared through joint ventures or other forms of agreements with other Canadian firms or foreign firms if need be.

The 1987 free trade agreement with the United States represents a chance for growth in this industry. Eased access to the U.S. market is important, but of far more importance in all regions will be the increased levels of investment in Canadian capital projects likely to follow ratification. More specifi-

cally, increased interest in Canadian energy sources promises to translate into increased activity in those regions not enjoying the boom currently being experienced in the centre of the country.

ABOUT THE AUTHOR

David L. Hammes is a Research Economist with the Fraser Institute, Vancouver, British Columbia. Born in 1951 in Minneapolis, Minnesota, he received his B.A. (Magna Cum Laude) from Humboldt State University in 1973. He received both his M.A. and Ph.D. in Economics (1985) from Simon Fraser University.

Dr. Hammes taught economics at the University of Western Australia in Perth from 1976 to 1978, and also taught economics at Simon Fraser University as a Sessional Instructor and Assistant Professor (limited term) through 1981 to 1986. As of August 1, 1988, Dr. Hammes will take up a permanent position at the University of Hawaii at Hilo.

Dr. Hammes' research interests are reflected in his authored and co-authored articles in *Economic Inquiry*, *The Review of Income and Wealth*, *The Review of Economics and Statistics* (forthcoming), *The Service Industries Journal* (forthcoming), *Kyklos* (forthcoming), and *The Philosophy of the Social Sciences*. He has also contributed to symposia volumes on the service sector in Canada.

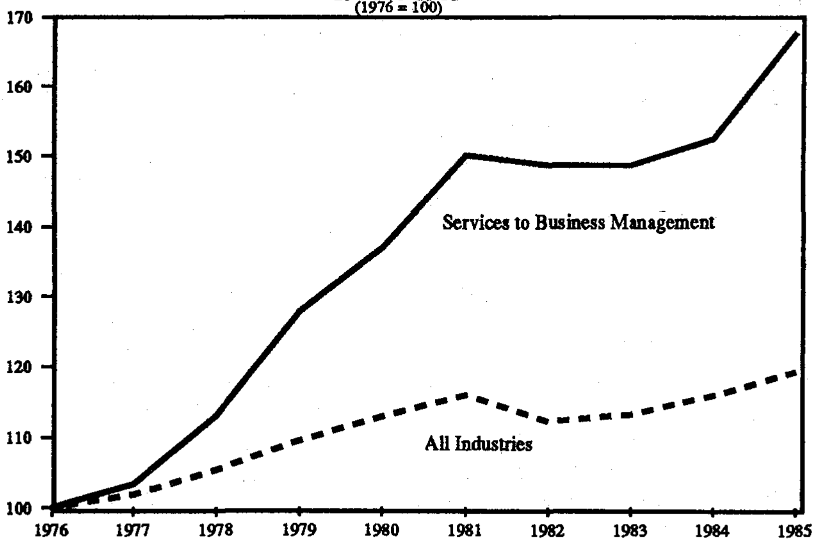
CHAPTER 1

INTRODUCTION AND OVERVIEW

INTRODUCTION

The increasing use of services in the manufacturing process is one trend apparent across the industrialized, western nations. In Canada over the past decade, employment in services to business management (SBM) has risen dramatically relative to employment in the rest of the economy. This is shown in figure 1 using the relevant values in 1976 as a base.[1]

Figure 1
Indices of Employment, Canada
1976 to 1985
(1976 = 100)



Source: Statistics Canada, catalogue 71-001, February 1986, p. 102.

There are several possible explanations for the growing proportion employment services has come to represent in the production process. Lowered costs, increased demand, increasing quality and statistical measurement techniques may all contribute to the phenomenon.[2]

In this study, the interest will be more narrowly focused on the economic characteristics of an important industry within the services to business management category, the consulting engineering industry in Canada. Along with the other industry studies in this series, this study may explain some of the behaviour in the broader services to business management aggregate. In addition, issues of industrial organization, labour force composition, remuneration, changing markets and sources of demand and contemporary policy issues will be addressed.

OVERVIEW

Through the post-World War II years, Canadian consulting engineers have enjoyed a strong market for their services both domestically and in the international market. The export success of Canadian consulting engineers has highlighted engineering as one of the Canadian service industries—along with banking, life insurance, real estate development and remote sensing—that is competing successfully with producers in the rest of the world. Given the potential changes in trade laws, Canadian producers will need to be competitive internationally to survive domestically.

Consulting engineers are perceived to have successfully entered the world market. Thus, government policy-makers see the industry as providing interest on several fronts. First, it is hoped that a study of the engineering market and prospects will lead to a better understanding of what lies ahead in the domestic and international markets for other Canadian service industries. Secondly, there is the hope that a successful Canadian engineering presence will lead to the follow-on export of capital goods from Canada. Thirdly, domestic regional development goals may be attained more easily by encouraging services like consulting engineering. There is also interest in the role consulting engineers play in the diffusion of technological know-how throughout the economy and in manufacturing industries in particular. Finally, the "pure" service aspect of consulting engineering and its independence from manufacturing or construction is interesting. I hope to provide insights into the consulting engineering industry that will explain these and other issues of interest.

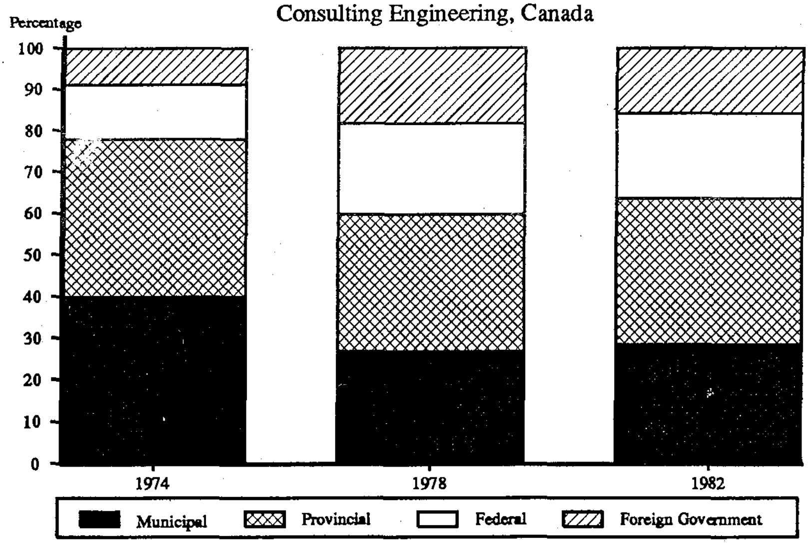
THE ENGINEERING MARKET

Private and Public Sources of Demand

In terms of fee income, survey data and estimates for the years 1974 through 1982 show that fee incomes, or revenues, in consulting engineering run between seven-tenths and nine-tenths of one percent of gross domestic product. Government purchases of services from the engineering industry are important. Roughly half the fee income derived by consulting engineers is from the private sector and half from the public sector.[3] This result is significantly different only in 1982 when approximately 67 percent of fee income was generated from private sector clients and the remainder from public sector clients.

Figure 2 provides information on the split of consulting engineers' fee income generated from the public sector for the years 1974, 1978 and 1982. Provincial governments have accounted for about 40 percent of all public sector fee income in each of those years, with the federal government share ranging between 15 percent and 20 percent. An increase in the proportion of fee income from foreign governments and a decrease from municipal governments characterizes the other public sector clients.

Figure 2
Fee Income from the Public Sector
Consulting Engineering, Canada



Source: Statistics Canada surveys, catalogue 62-528 (1977), 63-537 (1980) and 63-537 (1985).

Foreign Clients

The share of total fee income generated by foreign clients, private and public, has fluctuated over the period 1974 to 1982. From 9.45 percent of total fee income in 1974, foreign clients' business rose to 15.8 percent of consulting engineers' fee income in 1978 and dropped to 11.2 percent in 1982. In the U.S., the share of fee income derived from foreign sources has fallen through the 1982 to 1985 period, from 16.2 percent of total billings in 1982 to 11.8 percent in 1985.[4]

Of the foreign business done by Canadian firms, roughly half was generated from private sector clients and half from governments—foreign and Canadian—in both 1974 and 1982. In 1978, the government sector accounted for 60 percent of foreign fees generated with private sources generating the remainder.

Treatment in Government Statistics

In the following chapters most of the statistical material presented is from the surveys cited in note 3 or from government documents outlined below. There are some private sources of information, and they will be discussed when used.

Consulting engineering is covered in the Standard Industrial Classification (SIC) 864 (1970) along with "other scientific and technical services" establishments. Consequently, in standard Statistics Canada sources such as *The Labour Force Survey*, catalogue 71-001 monthly, and *Employment, Earnings and Hours*, catalogue 72-002 monthly, employment estimates may be made if one has a notion of the size of consulting engineering relative to other scientific and technical services.

This proportion may be inferred from the results in the two quadrennial surveys taken in 1978 and 1982. These surveys covered both consulting engineering and other scientific and technical services establishments and show that consulting engineering accounts for about two-thirds of the total revenue in SIC 864. Since 1980 the SIC classification has been more finely divided so that consulting engineering services are SIC 7752 and other scientific and technical services are SIC 7759, however, data are still being reported at the three-digit SIC 775 level.

In the System of National Accounts, Statistics Canada (*Gross Domestic Product by Industry*, catalogue 15-001) provides estimates for gross domestic product at factor cost on a monthly basis. Unfortunately, consulting engineering is aggregated with the other professional business services. There

is not a straightforward method of disentangling the contributions to the total of the various industries.

One final source for establishment data on a SIC basis is the Longitudinal Employment Analysis Program (LEAP) of Statistics Canada, which is derived from establishment tax data. One of the best sources for a breakdown of industry employment data on a provincial basis is LEAP data.

For occupational data, Statistics Canada census figures on Standard Occupational Classifications (SOC) are used. In the 1970 classification, engineers and architects form the three-digit grouping 214/215.

PLAN OF BOOK

Chapter 2 provides a detailed look at consulting engineering employment and output at both national and regional levels. Chapter 3 presents an analysis of the factors influencing the demand for engineering services and innovation within the industry. Chapter 4 discusses the industrial organization of the industry, outlines some evidence on the amount of engineering work done within other industries and presents some qualitative evidence on growth potential through public and private reorganization. Chapter 5 details the size and demographic characteristics of the labour force, areas of specialization, and geographic location. Chapter 5 also includes information on rates of remuneration and a comparison of employment earnings in the industry with levels for other professionals and the labour force as a whole. Chapter 6 outlines the cost structure in consulting engineering and estimates productivity measures of employees. Chapter 7 shows the importance of the Canadian consulting engineering industry in the world market and discusses changes in the way foreign business is being done. Chapter 8 outlines the inter-relationships between current domestic government practice and the industry. Finally, chapter 9 draws together policy implications implicit, sometimes explicit, in the analyses of the earlier chapters.

NOTES

1. SBM is the Statistics Canada aggregate which is made up of advertising, accounting, architectural, business consulting, computing, engineering, legal, management consulting and other miscellaneous services to business.

2. These and other considerations are examined thoroughly in Grubel and Walker (1988), *The Canadian Service Industries*, The Fraser Institute, Vancouver, B.C.

2. These and other considerations are examined thoroughly in Grubel and Walker (1988).

3. Statistics Canada catalogues *Consulting Engineering Services 1974*, 62-528, occasional, 1977; *Engineering and Scientific Services*, 63-537, 1980; and *Architectural, Engineering and Scientific Services 1982*, 63-537, occasional, 1985.

   Lack of funds halted further surveys, though Statistics Canada is preparing new survey instruments for future use in this industry.

   The existing surveys have varying response rates, for example, in 1982 refusals, others and non-responses amounted to 23.7 percent of the survey mail-outs and no imputations were made to the reported data. In 1978 the non-response rate was 39.3 percent and in 1974, 6.3 percent. Consequently, one is loath to report absolute numbers and levels from these sources as they will likely understate the industry's importance. However, proportions, rates of change, direction and other qualitative inferences are probably more safely supported through these surveys.

4. Sources for the U.S. data are annual surveys on the Top 200 Design Firms carried out by *Engineering News Record*, a trade weekly published by McGraw-Hill Publishing Company. The design of the surveys captures only those firms earning more than (US) $5 million. Consequently, many smaller firms, which in total may do substantial work abroad, are not included in the U.S. revenues in this section.

   The Canadian figures are from the quadrennial surveys and are likely understated due to the non-responses reported in note 3.

   The non-coverage and non-response limitations make inter-country comparisons difficult. However, given that both biases are in the same direction, the relative similarity of proportions of total fee income derived from foreign work is probably not biased. Care should be taken in comparisons nonetheless.

CHAPTER 2

CONSULTING ENGINEERING AS PART OF THE DOMESTIC ECONOMY

THE INDUSTRY

The consulting engineering industry provides a wide variety of services in the planning, design, procurement, construction and management of structures and processes. It is safe to say that "from the time one rises and turns the tap for a morning shower until the light is snapped off before going to bed at night, every person who is a part of our industrialized economy benefits in some way from the services of consulting engineers."[1]

Engineering services include reporting, advising, valuing, measuring, laying out, designing, directing, constructing, and inspecting works or processes. These services are provided by over 4,000 firms, ranging in size from a single practitioner to firms of over 4,000 employees with a tremendous variety in clientele, fields of engineering and scope. This list is necessarily brief and imprecise as the types of structures and processes are many. A more detailed breakdown of the fields in which consulting engineers provide services includes municipal, buildings, petroleum and natural gas, power, mining and metallurgy, plant process design, transportation, forestry, agriculture and fisheries, dams and irrigation, air and seaports, telecommunications, and miscellaneous services ranging from air and noise pollution control to soil mechanics.[2] Within these fields, more than 100 specializations are identifiable. For example, services provided in the municipal sector may include the design and management of water supplies, sewage and waste disposal, roads and streets, traffic engineering and urban and regional planning.

In this chapter, the absolute and relative size of consulting engineering relative to the national and regional economies is shown, with comparisons on two levels. First, the absolute and relative size of the industry is shown using measures of output and sales. Secondly, the national and regional shares are given using employment data. This information is useful in estimating the size of the industry and where engineers are employed. Finally,

there is a discussion of regional representation of engineers. From the data presented in this chapter, it will become clear that the Atlantic region, adjusted for size, has lower engineering value added and lower levels of engineers employed than the other regions. Data on the regional representation of the services to business management (SBM) aggregate are presented to test whether or not engineers have a different share of employment per region than other professionals engaged in services to business. The results of this may provide another aspect for consideration for those interested in regional development issues.

Main Consumers of the Services

Fee Income

Given the wide variety and scope of engineering services, it is no surprise that both the private sector and all levels of the public sector are clients for these services. The breakdown between public and private demand was given in chapter 1. For consulting engineers, total revenues (in 1981 dollars) rose from approximately $2.2 billion in 1974 to approximately $3.26 billion in 1982.[3] Real revenues as a percentage of real gross domestic product, also in 1981 dollars, was about nine-tenths of one percent in 1982, up from seven-tenths of one percent eight years earlier.

The historical trend and recent performance of the engineering, architectural and surveying services industry in the U.S. are similar. In 1972, real receipts in the design industry—of which engineering services account for roughly 80 percent—were about one-half of one percent of U.S. real GNP. Ten years later that figure had risen to about nine-tenths of one percent and has been virtually unchanged at that level through 1985.[4] Because engineering receipts are 80 percent of the industry's total receipts, when concentrating on engineering services alone the above real receipts to real GNP percentages must be altered to four-tenths of one percent in 1972 and seven-tenths of one percent in 1982 to 1985. The level and rates of changes in engineering activity relative to the economy have been similar in both countries.

In Canada, over the period 1974 to 1982, the average annual growth rate in real revenues of consulting engineers was 5.5 percent. The growth in Canadian real gross domestic product for the eight-year period was 2.8 percent per year. In the U.S., over the 13-year period 1972 to 1985, real receipts in engineering revenues rose at 6.7 percent per year while real GNP rose at 2.4 percent per year.

Regional Differences in Production and Sales in Canada

Figures 3 and 4 show the regional shares of fee incomes derived from consulting engineering in the survey years 1974, 1978 and 1982. Figure 3 shows each region's share of domestic work. Figure 4 shows each region's share of foreign projects.[5]

While it is clear from figure 3 that Ontario and western-based firms generate a major portion of domestic fee income, this result ignores the fact that there are a different number of firms in each region. Table 1 gives the distribution of firms by region.

Given that Ontario and the western provinces have a far greater number of firms than Quebec, it is apparent that the average Quebec consulting engineering firm must have greater fee income. Figure 5 shows total fee income (both domestic and foreign) per firm in millions of 1981 dollars for the three years 1974, 1978 and 1982. The figure clearly shows that when fee income by region is adjusted for the number of firms per region Quebec engineering firms are substantially larger on average than their counterparts in other regions of the country.[6]

Importance of Imports and Exports

By its very nature, consulting engineering is high skilled and labour intensive and that labour is Canadian. Imports play almost no role in the production process of the Canadian consulting engineering firm.

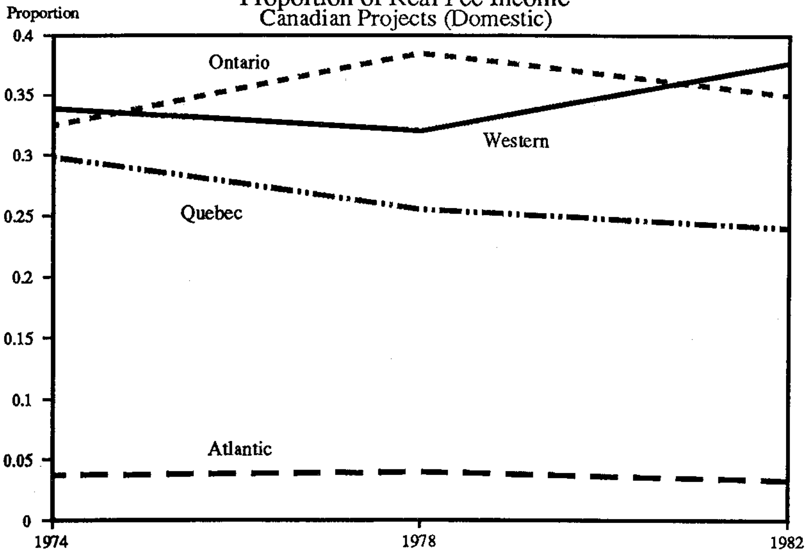
Exports are a small but important and growing segment of fee income. Indeed, for some 200 or so firms active in the export market, fee income from foreign sources may comprise upwards of 40 percent of their total fee income.[7]

INDUSTRY OUTPUT

Initial Considerations

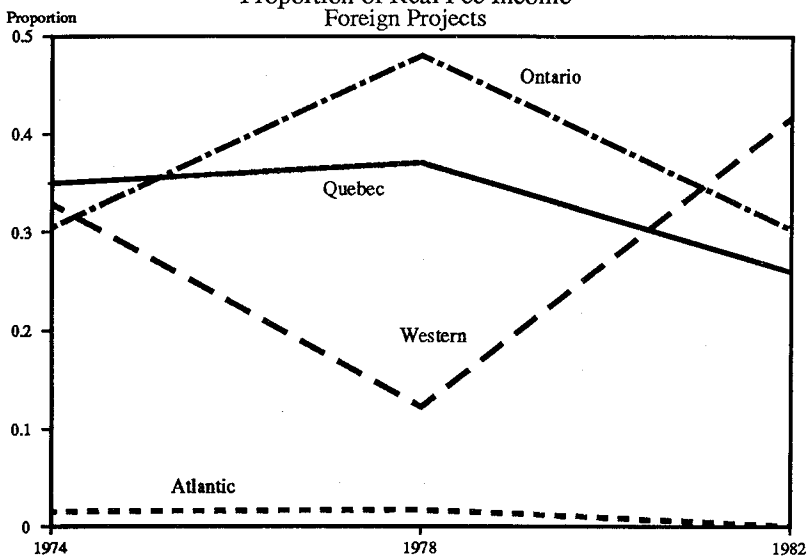
Measuring service output is notoriously difficult.[8] In medical services, for example, imperfect proxy measures for output are widely used. The number of patient visits, the number of patient-days, number of prescriptions, number of bed-days, all serve as proxies for physician and/or hospital output. These proxies, imperfect though they may be, exist primarily because of the billing system. That is, recording transactions provides the data upon which output proxies may be constructed. In consulting engineering, as in some

Figure 3
Proportion of Real Fee Income
Canadian Projects (Domestic)



Source: Statistics Canada surveys, catalogue 62-528 (1977), 63-537 (1980) and 63-537 (1985).

Figure 4
Proportion of Real Fee Income
Foreign Projects



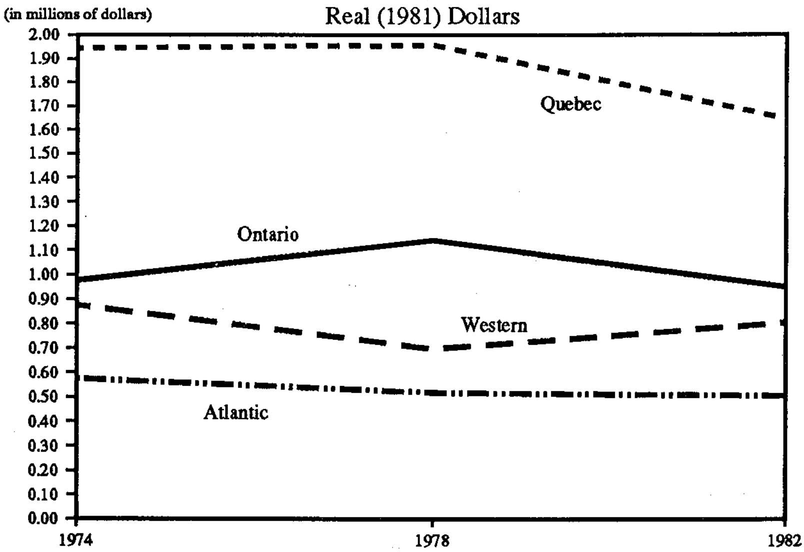
Source: Statistics Canada surveys, catalogue 62-528 (1977), 63-537 (1980) and 63-537 (1985).

Table 1
Percentage Distribution of Firms by Region

		1974	1978	1982
Region				
	Atlantic	6.5	6.8	5.7
	Quebec	16.5	14.0	14.3
	Ontario	34.8	36.2	34.6
	Western	42.1	43.0	45.4

Source: Statistics Canada industry surveys.

Figure 5
Fee Income Per Firm
Real (1981) Dollars



Source: Statistics Canada surveys, catalogue 62-528 (1977), 63-537 (1980) and 63-537 (1985).

other service industries, transactions are rarely made in such a way that measures suitable for the construction of output proxies result.

Consulting engineers bill clients in several different ways depending on the nature of the service provided. Certain of these ways can make the output indicator quantifiable, for example, billing per hour for hours spent on the job, but make the output measure dependent on the input measure. This dependence, which measures output by input, does not allow for changes in productivity in the activity. Other methods of billing, such as a percentage of the cost of the project and/or negotiated fee, make the heterogeneity of the service even more obvious and the resultant difficulty of defining a unique output measure even more apparent.

In the Statistics Canada surveys cited in chapter 1, information is available only on the number of establishments, employment, total fee income, and total billings of responding firms. Fee income and billings are an amalgam of fees earned by hourly rates, fees earned for services provided on a basis of a percentage of the total project cost, and negotiated fees.

As Jerome Mark of the U.S. Bureau of Labor Statistics states: "the principal alternative, in the absence of quantitative information on the amount of service, is to remove from the change in value of the volume of services the change in price. This approach is tantamount to price weighting quantities of services provided. In-so-far-as [*sic*] price relationships among the various component services of a service industry are similar to the unit labor requirements or unit labor costs, this is a close approximation of the desired measure. And since it is easier to measure price change for services defined with detailed specification than it is to measure directly the number of services provided, it is this approach most generally that is followed" (1983:5).

Following Mark, output indices are constructed in this chapter by deflating the dollar value of sales (fee income) by the relevant price indices of engineering services.[9] Where time value is directly or indirectly used for billing, this procedure yields a measure of hours billed, hence of output.[10] Where fees are collected on a percentage of the cost of the project basis, this method produces an imperfect measure of output change. The value of the project should not necessarily be deflated by a price index of engineering services. As used here, one or more price indices of total construction are preferred deflators. From survey sources, it is impossible to determine the proportion of fees derived from the time based versus cost of project based fee schedules. This is so because fees derived from a particular sector, for example agriculture or mining, may be billed any of the three ways discussed above. Consequently, while suggestive, the following output measures should be treated as tentative only.[11]

Levels of Production in Canada

Current Dollars

In current dollar values, figure 6 gives fee income from domestic and foreign work accruing to the consulting engineering sector in Canada for the years 1974 to 1982.[12] Nominal fee income rose at a rate of 14.1 percent per year over the eight-year period. However, as is obvious from the figure, growth rates have varied, being as high as 16.6 percent per year in the 1978 to 1982 period compared to 11.5 percent per year in the 1974 to 1978 period.

Constant Dollars

Figure 6 also presents constant 1981 dollar measures of fee income of Canadian consulting engineers. Figure 7 presents fee income relative to real GDP over the 1974 to 1982 period. Three different deflators were used on the nominal dollar amounts as discussed above. There was not a great variance in the three different deflated results, so those values using the implicit GDP deflator only are shown.

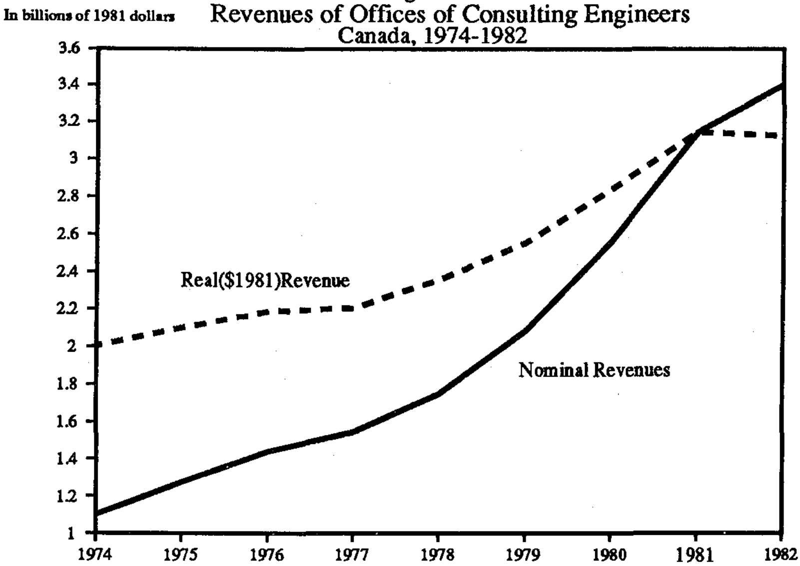
The average annual compounded growth rate for real revenues over the eight-year period was 5.6 percent and for real GDP, 2.8 percent. Again, there is variation in growth rates of engineering revenue within the period with real growth actually falling from 1981 to 1982.[13]

LEVELS OF SALES IN CANADA, VALUE AND QUANTITIES

The nominal output figures for Canadian consulting engineers given above include work done domestically and work done in foreign countries by Canadian firms. From *Engineering News Record* survey data, estimates of revenues from foreign work in 1982 and 1984 are $404 million and $410 million, respectively.[14] In those two years, fee revenues of foreigners doing work in Canada amounted to $36.7 million and $37.3 million, respectively.[15]

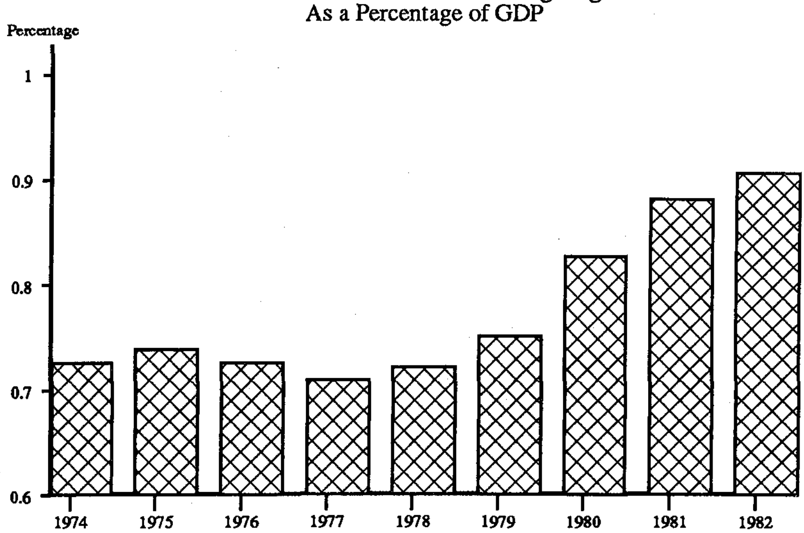
Sales in Canada are the output levels reported above minus the foreign-derived fee revenues plus the revenues accruing to foreigners providing engineering services in Canada. In nominal terms for 1982, this method yields sales in Canada of approximately $3.037 billion.

Figure 6
Revenues of Offices of Consulting Engineers
Canada, 1974-1982



Source: See text.

Figure 7
Revenues of Offices of Consulting Engineers
As a Percentage of GDP



Source: See text.

Composition of Sales

Domestic Buyers

There are 12 major sectors from which consulting engineers derive fee revenue.[16] Figure 8 presents the proportion of fee income generated by domestic sales of Canadian consulting engineers for the three survey years 1974, 1978 and 1982. Strong markets in forest-related products and processes, buildings, plant process design, municipal services and petroleum and natural gas are apparent from the figure. Miscellaneous and unspecified services have approximately doubled as a proportion of domestic fee income from 1974 to 1982.

Foreign Buyers

Figure 9 gives the composition of fee income derived from foreign sales of Canadian consulting engineering services for the same three survey years. From the figure it is clear that work on developing Canada's resource base has provided the experience, skills and comparative advantage in sales abroad. Agriculture, fisheries, forestry, and forest products; plant process design; mining and metallurgy; and power generation, transmission and distribution are the major sectors in each of the survey years generating incomes from foreign projects.

Regional Distribution

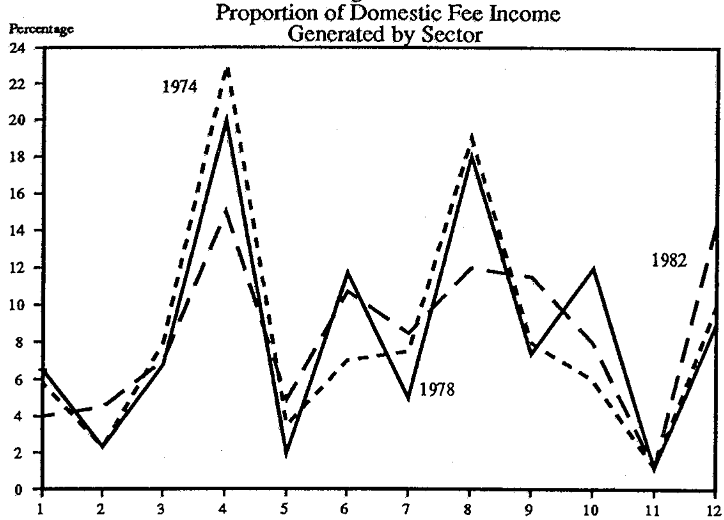
Production

Figures 3 and 4 provide detail on the proportion of consulting engineering production accruing to firms in the four regions from domestic and foreign work in the three survey years 1974, 1978 and 1982. For expositional ease, figure 10 aggregates the amounts derived by region from all sources, foreign and domestic, and presents the proportion of total real fee income earned by firms in the regions.

Sales

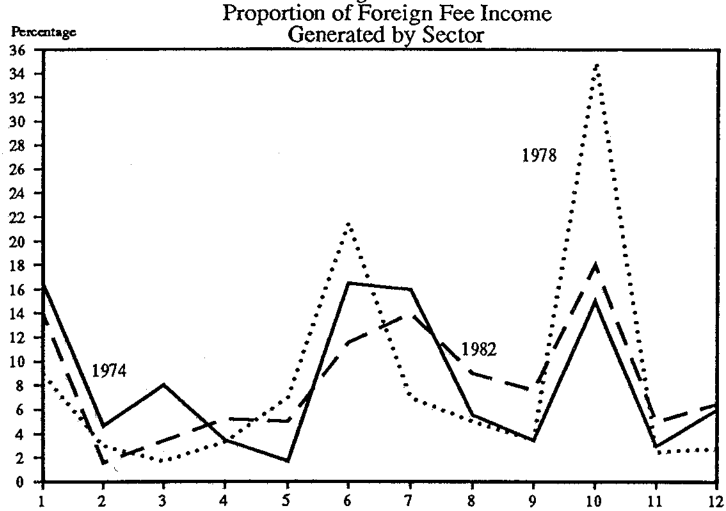
Figures 11 and 12 detail the sales of engineering services by Canadian producers to regions and by the 12 sectors discussed above for the survey year 1982. For example, of consulting engineering sales to the agricultural, fisheries, forestry and forest products sector, just over 60 percent was sold to

Figure 8
Proportion of Domestic Fee Income
Generated by Sector



Source: Statistics Canada, catalogues 62-528 (1977) and 63-537 (1980 & 1985).

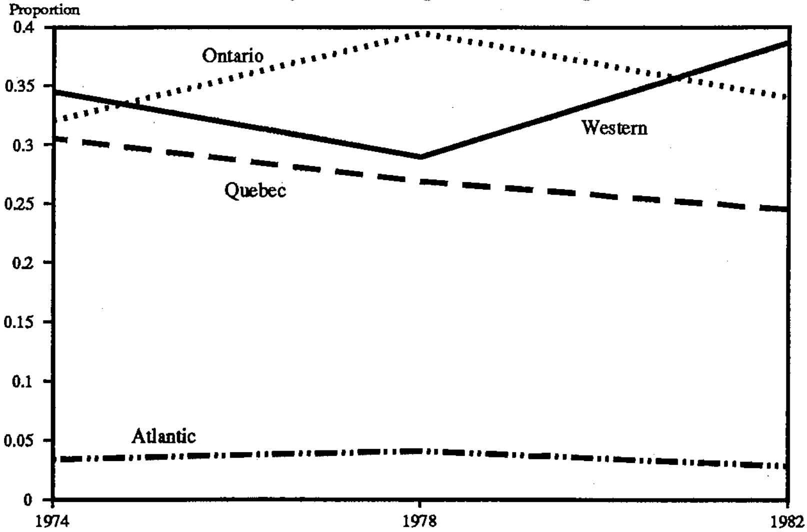
Figure 9
Proportion of Foreign Fee Income
Generated by Sector



Source: Statistics Canada, catalogues 62-528 (1977) and 63-537 (1980 & 1985).

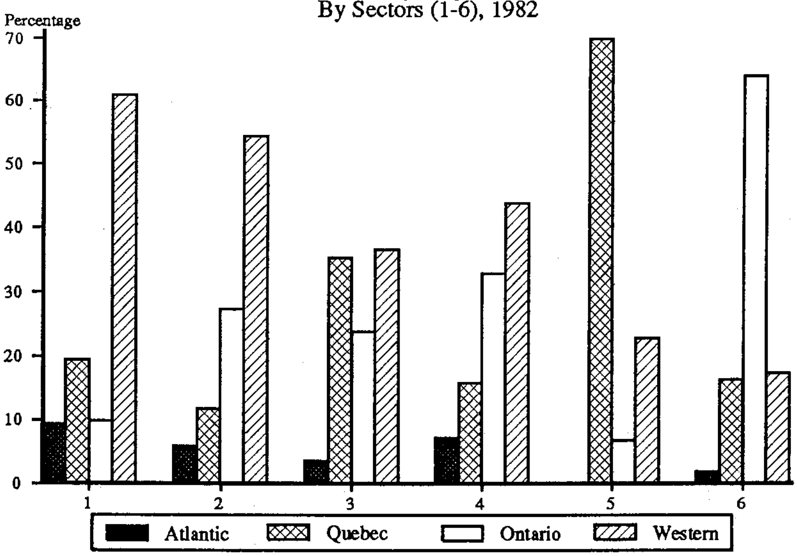
Specialty:
1--Agriculture, fisheries, forestry, forest products
2--Air and seaports, harbours and terminals, coastal works
3--Bridges, tunnels, highways and railways
4--Buildings
5--Dams, irrigation and flood control
6--Plant process design
7--Mining and metallurgy
8--Municipal services
9--Petroleum and natural gas
10--Power generation, transmission and distribution
11--Telecommunications
12--Miscellaneous and unspecified

Figure 10
Proportion of Real Fee Income from Consulting Engineering
All Projects Accruing to Firms in Region



Source: Statistics Canada, catalogues 62-528 (1977) and 63-537 (1980 & 1985).

Figure 11
Fee Income by Region of Project
By Sectors (1-6), 1982



Source: Statistics Canada, 63-537 (1985), table 7.

buyers in the Western region, just under 20 percent sold to Quebec buyers, and about 10 percent sold in each of Ontario and the Atlantic region.

In aggregate for 1982, total sales from domestic suppliers to the various regions were split roughly in the following way: 45 percent to the Western region, 30 percent to Ontario, 20 percent to Quebec, and 5 percent to the Atlantic region.[17]

Sales to Canadian buyers from producers in other countries are a very small proportion of the Canadian market.[18]

VALUE ADDED OF THE INDUSTRY

Indices of Growth

Figure 13 shows the growth in real GDP and real value added in engineering over the period 1974 to 1982.[19] As is apparent from the figure, real value added rose at the same rate of 3.7 percent per year as real GDP from 1974 to 1978. From 1978 to 1982, it is clear that value added in consulting engineering rose at a greater rate than did real GDP. Over that four-year span, the annual average rate of growth in real value added in consulting engineering was 8 percent. The corresponding rate for real national GDP was 1.9 percent per year.

Value Added Relative to Regional GDP

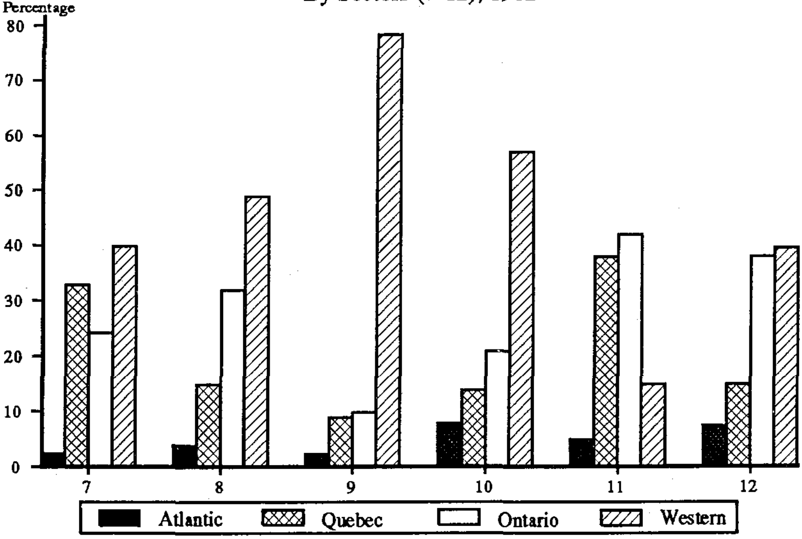
Figure 14 shows the percentage of real regional GDP attributable to the real value added of the region's consulting engineering sector for the survey years 1974, 1978 and 1982.[20] Again, as with employment and output, the percentage of regional GDP attributable to consulting engineering is less than one percent.[21] It is clear that consulting engineering plays a more significant role in the economies of Quebec, Ontario and the western provinces than it does in the Atlantic region.[22]

CONSULTING ENGINEERS IN THE CANADIAN LABOUR FORCE

Employment and Growth Rates

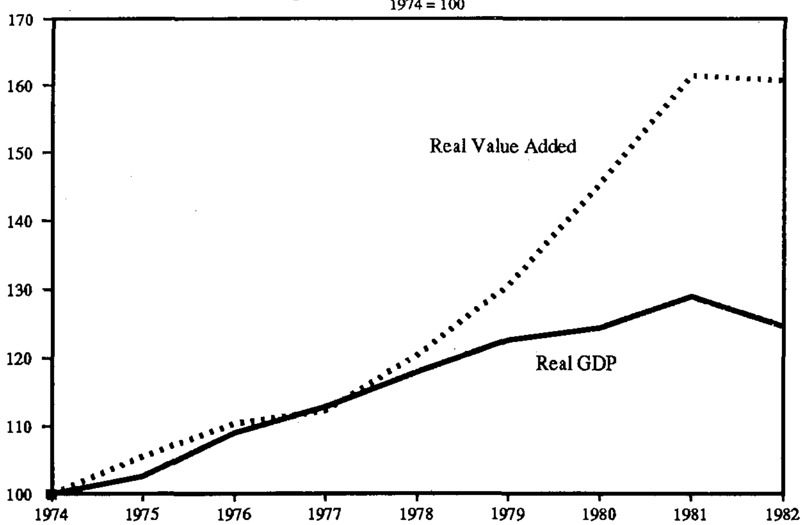
Census data provide a first look at the relative size of this industry in the labour market.[23] The absolute number of engineers in Canada rose from about 18,500 in 1941 to roughly 135,000 in 1981. In the decade 1971 to

Figure 12
Fee Income by Region of Project
By Sectors (7-12), 1982



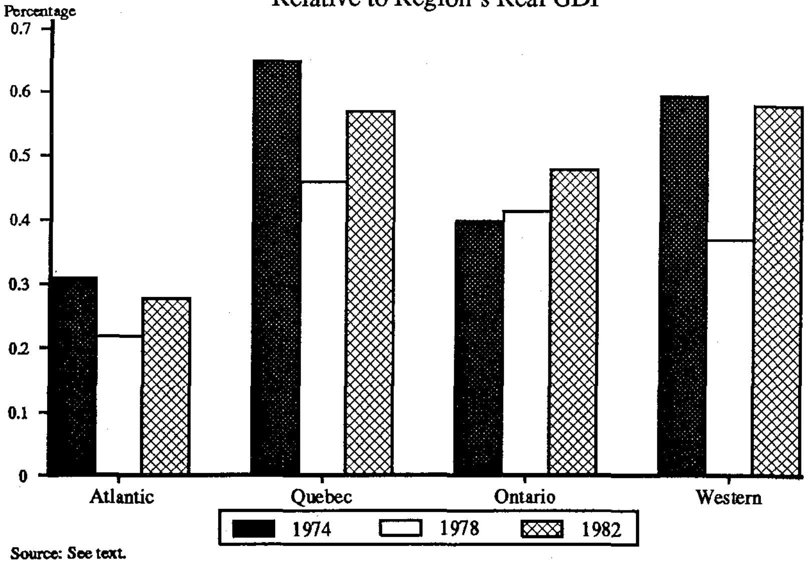
Source: Statistics Canada, 63-537 (1985), table 7.

Figure 13
Indices of Growth, 1974-1982
Engineering Value Added and GDP
1974 = 100



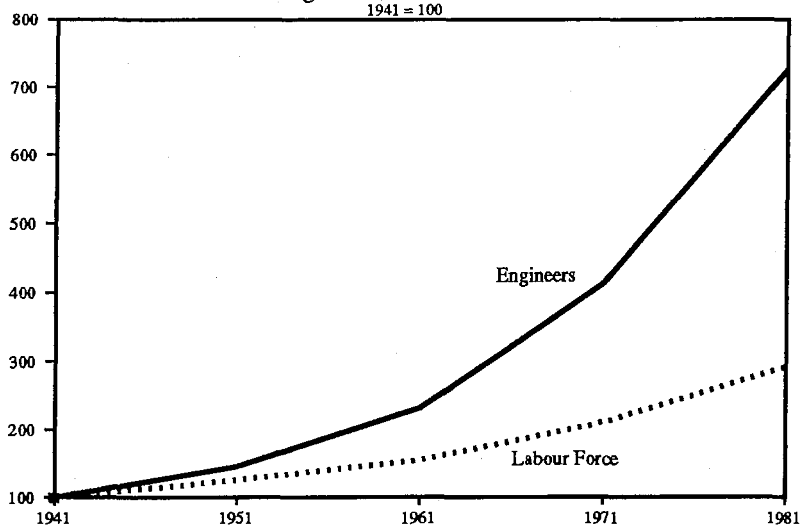
Source: See text.

Figure 14
Real Value Added of Consulting Engineering
Relative to Region's Real GDP



Source: See text.

Figure 15
Relative Rates of Growth, Labour Force
and Engineers, Canada 1941-1981
1941 = 100



Source: Census of Canada, various years

1981, the number of engineers grew from 76,000 to 135,000, yielding an average annual growth rate of 5.7 percent per year. The labour force as a whole grew at an annual rate of 3.3 percent over the same decade.[24]

Figure 15 shows the growth in the total labour force and growth in the occupational group of engineers using the values in 1941 as the base.[25] The occupational group of engineers has grown at rates greater than that of the labour force as a whole in all decades shown. During the 1960s, the number of engineers grew at an average annual rate of 5.8 percent, higher than the labour force average annual growth rate of 3.1 percent per year.

The smooth growth through the decades shown in figure 15 belies the recent performance of employment in the engineering industry. While, as shown in figure 1, employment in services to business management and in the economy as a whole turned down in the recession of the early 1980s, employment in engineering fluctuated more extremely. Figure 16 shows employment in consulting engineering and employment in SBM over the years 1976 to 1984. From the figure it is clear that engineering services lost ground relative to other services to business management.

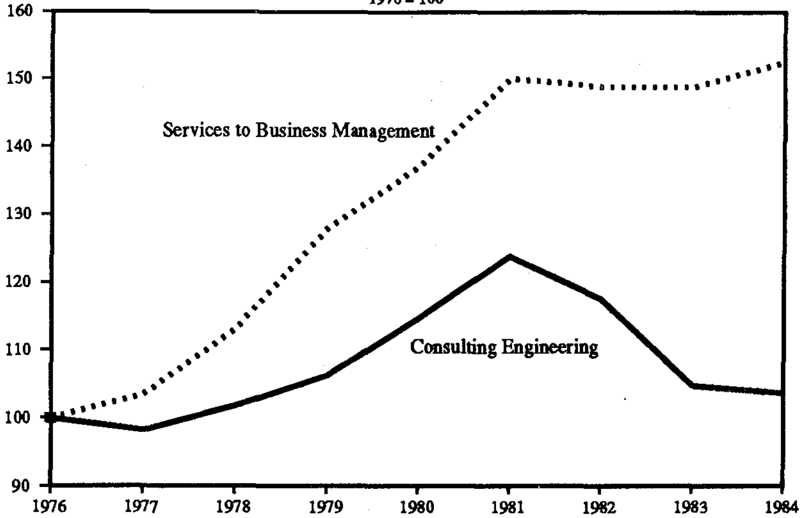
Historically, the consulting engineering industry has been a major component of SBM. However, as figure 16 implies and figure 17 shows explicitly, employment in consulting engineering as a proportion of total employment in SBM has fallen from 15.5 percent in 1976 to just under 11 percent in 1984.

The drop in construction activity due to the recession of the early 1980s has had a disproportionate impact on consulting engineering's share of employment relative to other business services. While some improvement in share is to be expected with increases in construction activity, the trend downward started in the mid- to late 1970s—earlier than the onset of the recession. It is too early to tell if the drop in consulting engineering relative to other services in SBM, evident in figure 17, presages a future trend.

Employment by Regions, Survey Data

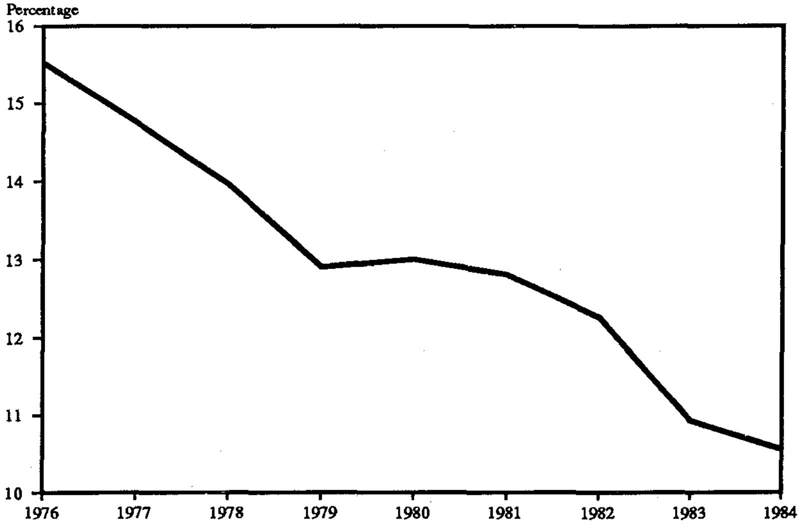
Figure 18 shows the level of employment in consulting engineering as a proportion of aggregate employment nationally and by regions for 1974, 1978 and 1982.[26] Employment in engineering as a proportion of the total employed varies widely from survey year to survey year, especially in Quebec and the Western region. The influence that relatively few large projects may have in any one year is evident here. Also readily apparent is the much lower ratio of engineers per total employed in the Atlantic provinces relative to the other regions.

Figure 16
Indices of Employment, Canada, 1976-1984
Services to Business Management and Consulting Engineering
1976 = 100



Source: Statistics Canada, catalogues 71-001 and 72-002.

Figure 17
Employment in Consulting Engineering
As a Percentage of Employment in Services to Business Management



Source: Same as figure 1 and catalogue 72-002.

REGIONAL DISTRIBUTION OF SERVICES TO BUSINESS MANAGEMENT

Regional development policies have been and are a major concern of all levels of government. The chronic disparity in incomes in the Atlantic region versus central Canada and even the West has created pressure for the government to respond. As a consequence, a plethora of departments and programmes have come and gone. As this is written, the "old" Department of Regional Industrial Expansion has been trisected into separate programmes for the Atlantic provinces, the Western provinces, and a merging with other departments in Ottawa. The thrust of most, if not all, regional development aid has been toward encouraging manufacturing activity.

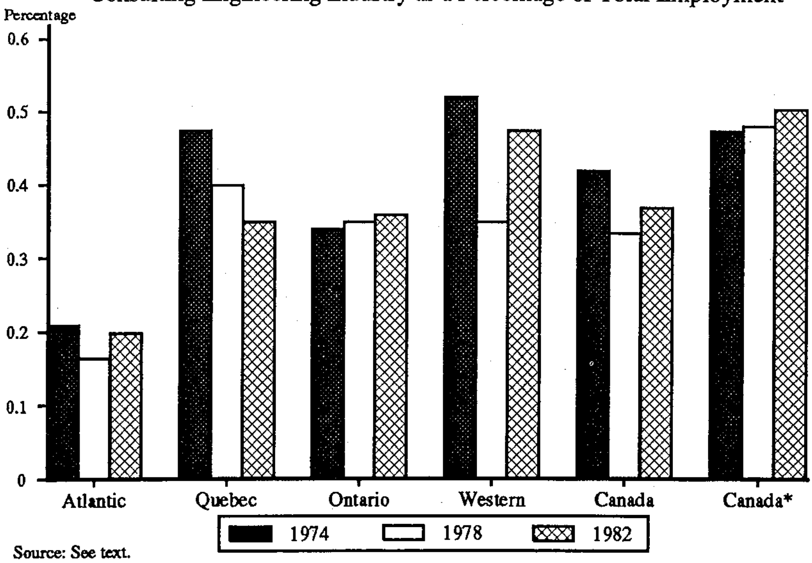
As shown in figures 14 and 18, the value added and employment of engineers in the Atlantic region is far below that in the rest of the country. This under-representation of engineers reflects the lack of a manufacturing base in the Atlantic provinces. It is not clear that a concerted effort to encourage engineers to move to Atlantic Canada will bring service and manufacturing industries along. Nor is it clear that, relative to other services to business management, engineering is the weak reed of the Atlantic region's economic performance. Consequently, a policy aimed at engineers only would probably be wasteful and misdirected.

To place the employment and manufacturing bases of the Atlantic region in the national context, several figures are presented. Figure 19 shows regional employment in all industries as a percentage of the nation's total employment for the years 1976 to 1985. It is obvious that the Atlantic region has a significantly lower proportion of the employed, roughly 8 percent, relative to other regions. This is not out of proportion to the population in the Atlantic region which was 9.5 and 9.2 percent of the national total in 1971 and 1981, respectively.[27]

Nor is the employment of engineers in the Atlantic region at variance with the employment of other service industries within the services to business management (SBM) aggregate. As figure 20 shows, the Atlantic region's share of employment of personnel in SBM has been just under 5 percent through the years 1976 to 1985. This indicates that engineers are not the only under-represented service input relative to employment in all industries in the Atlantic region. Nearly 45 percent of the nation's employment in SBM is in the more industrial province of Ontario.

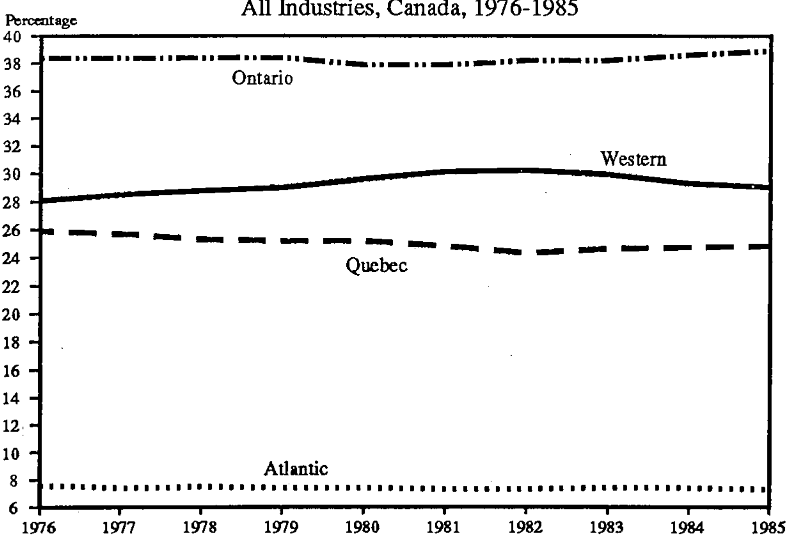
This point is better shown in figure 21 where a region's share of total employment in SBM nationwide is deflated by that region's share of total employment in all industries. For example, if a region had X percent of the nation's SBM employment and X percent of the nation's total employed in

Figure 18
Regional and National Employment
Consulting Engineering Industry as a Percentage of Total Employment



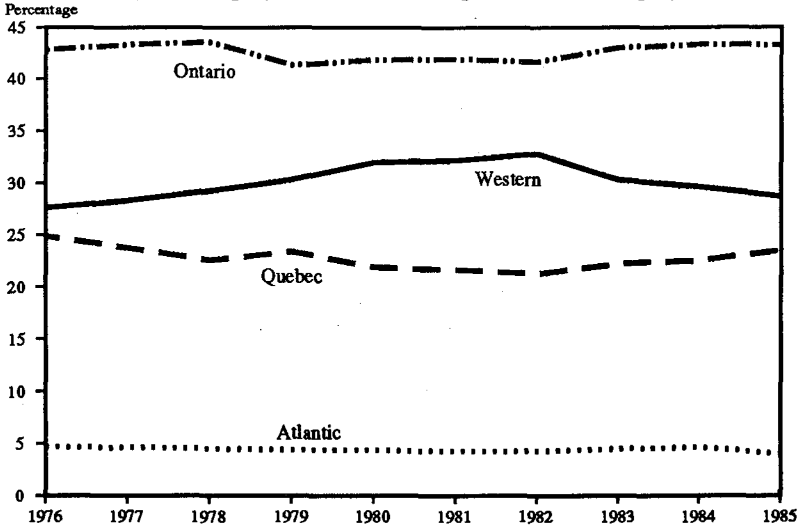
Source: See text.

Figure 19
Regional Employment as a Percentage of National Employment
All Industries, Canada, 1976-1985



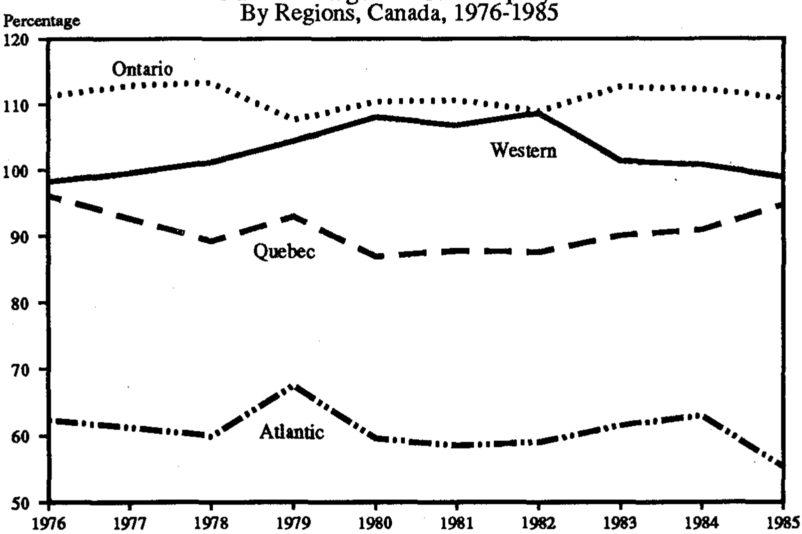
Source: Statistics Canada, catalogue 71-001 (February 1986), page 102.

Figure 20
Services to Business Management, 1976-1985
Regional Employment as a Percentage of National Employment



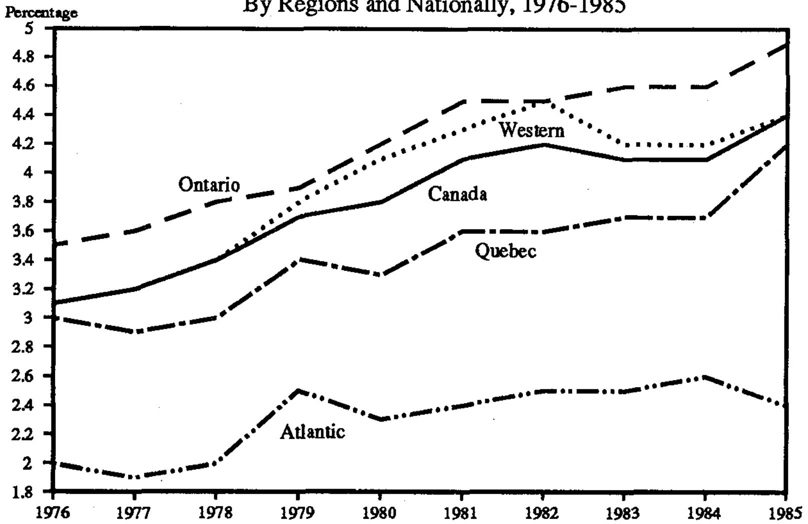
Source: Statistics Canada, catalogue 71-001 (February 1986), page 102.

Figure 21
Share of Services to Business Management
As a Percentage of Total Employment
By Regions, Canada, 1976-1985



Source: Statistics Canada, catalogue 71-001 (February 1986), page 102.

Figure 22
Employment in Services to Business Management
As a Percentage of Total Employment
By Regions and Nationally, 1976-1985



Source: Statistics Canada, catalogue 71-001 (February 1986), page 102.

all industries, the ratio would be 1.00. In the figure, this is translated to 100 percent to indicate that the SBM employment share is just equal to the "all industries" share. The Atlantic region ratio hovers at approximately 60 percent, while it rarely falls below 90 percent in the other three regions.

Finally, figure 22 shows employment in SBM regionally and nationally as a percentage of total employment in the four regions and for the nation, respectively. It is clear that less than 2.5 percent of the work-force in the Atlantic region is employed in the SBM category, which is not at great variance with the information presented in figure 18 for engineers alone. Ontario, with a steadily rising share of SBM employed relative to employment in all industries, had almost 5 percent of its work-force employed in the SBM industries in 1985.[28]

SUMMARY

From data presented in this chapter, two things are readily apparent. The first is that relative to absolute levels of output and employment consulting engineers are a small fraction of the national economy.[29] The second feature is that the employment and production of engineers is proportionately lower by all measures in the Atlantic region relative to the other three regions of the country.[30] This second feature may lead to calls for assistance to engineers in the Atlantic region. However, as was shown in the final part of this chapter, engineers are not under-represented in the Atlantic region relative to other industries providing services to business management.

NOTES

1. C. Maxwell Stanley, *The Consulting Engineer*, John Wiley and Sons, New York, 1982:3.
2. For a full listing see any of the quadrennial surveys cited in chapter 1.
3. The figures for Canada are based on the quadrennial surveys. Unfortunately, the surveys do not capture the entire industry as there were non-respondents. Consequently, revenue per employee figures were derived from survey data and then industry employment estimates from Statistics Canada (*Employment, Earnings and Hours*, catalogue 72-002) were used to estimate total industry revenues. The number of self-employed engineers missed by *Employment, Earnings and Hours* is quite small, and their addition to industry totals may be estimated by using Revenue Canada *Taxation Statistics*. For example, in 1982 there were 4,329 self-employed engineers and architects with a total income of $173,500,000. If this entire dollar total, including self-employed architects' incomes, were included in consulting engineering industry revenues, it would represent about 5 percent of total industry revenues in 1982.
4. J. Randolph, "Architectural and Engineering Services," *U.S. Industrial Outlook 1987*, pp. 65-1 to 65-4, U.S. Department of Commerce, 1986.
5. The sources for information in figures 3 and 4 are the quadrennial surveys.

   For the purposes of this volume, the regions, other than Quebec and Ontario, are defined as follows. Atlantic: Newfoundland, Prince Edward Island, Nova Scotia and New Brunswick. Western: Manitoba, Saskatchewan, Alberta, British Columbia and the territories. Firms based in British Columbia are by far the major exporters of consulting engineering services in their region, having about 75 percent of the region's total exports in 1982.

   The rate of growth of exports from the various provinces is often very different. For example, in nominal dollars, exports from firms based in Alberta grew by 439 percent over the period 1974 to 1982. For British Columbia firms over the same period, the nominal value of exports grew 272 percent. The national average was 209 percent.
6. Indeed, the three largest firms in the industry, Lavalin Inc., the SNC Group, and Monenco Ltd., are all headquartered in Quebec. These three firms account for roughly one-fourth of the industry's fee income and the smallest of the three, Monenco Ltd., is still at least twice as large as the next firm in the industry.
7. *Engineering News Record*, August 6, 1987, pp. 22-31.

8. See Jerome A. Mark, "Measuring Productivity in Service Industries—Problems and Progress," paper presented to the Federal Statistics Users' Conference on the Service Sector of the U.S. Economy, Washington D.C., June 1983.

9. Price indices of engineering services per se are not available. Implicit price indices for gross national product, construction and total components of construction were used.

   The sources are: for the implicit gross domestic product deflator, Statistics Canada, *Canadian Statistical Review*, catalogue 11-003E, monthly, January 1987; for the price indices on total construction and total components (a weighted sum of the indices for building construction, engineering construction, and machinery and equipment), Statistics Canada, *Fixed Capital Flows and Stocks*, catalogue 13-211, annual.

   For fees derived from cost of project and fixed fee (or negotiated fee) billing methods, these latter two indices are probably better to use than one of prices on engineering services in any event as it is the cost of construction which drives the fee.

10. This assumes that the price indices discussed above are good proxies for the unobservable prices of engineering services.

11. Several different price indices are used as deflators in order to assess the sensitivity of the output measure to the index used. In the final analysis, there does not seem to be much difference in outcomes when using the different price indices.

12. The sources for these estimates are the quadrennial surveys and *Employment, Earnings and Hours* as outlined in chapter 1.

13. Since both nominal series were deflated by the implicit GDP deflator, the ratio of consulting engineering revenues to national GDP will be the same for both the real and nominal series.

14. This assumes that the *ENR* surveys capture 70 percent of Canadian revenues from foreign work. Given the omission of at least one firm that does substantial foreign work, due to the firm's non-participation, and a host of firms doing smaller amounts of work abroad, perhaps 100 in total, this estimate is reasonably conservative.

15. *Engineering News Record*, various issues featuring Top 200 International Design Firms. These figures probably understate the amount of foreign work done in Canada, consequently the results of this section are suggestive only.

16. This classification scheme comes from the surveys done by Statistics Canada cited in chapter 1. There is no way to break this classification into one compatible with the Standard Industrial Classification (SIC) therefore no way to credibly detail sales to industry as normally constituted. However, in chapter 3, employment of engineers in SIC industry groupings is given for 1971 and 1981. This information comes from the censuses in those two years.

17. The obvious impact of the recession and the declines in petroleum and minerals prices world-wide since 1982 can be expected to have had a dramatic impact on sales in the Western region of Canada where such activity is concentrated.

18. These sales were primarily from U.S. suppliers to the Western region and, if anything, would skew the aggregate sales proportions for 1982 even more heavily towards the Western region. Much foreign activity ceased in the West after the declines in oil and minerals prices.

19. Definition of real value added is the value of sales minus payments to intermediate factors of production. A detailed calculation is in chapter 4.

20. Source for regional GDP: Statistics Canada, *GDP by Province*, catalogue 11-213, annual. Real regional GDP was constructed by using national GDP deflator.

21. This is true even when we recall that the survey data understates real value added by a factor of anywhere from 10 to 20 percent.

22. This estimates the value added contribution of consulting engineers only. The amount of engineering done within industry and government is another matter. This topic will be covered in chapter 3 which covers the industrial organization of the industry.

23. Census data covering a particular occupation are determined by respondents self-classifying themselves. Consequently, census information on a particular occupation should be used with caution. For example, the population of self-classified census engineers includes more individuals than licensed professional engineers. This limits the strength of the conclusions one may draw from census sources.

24. This and all rates that follow, unless otherwise specified, are compounded average annual growth rates.

25. Engineers and architects are the Standard Occupational Classification (1970) 214/215, with architects being the four digit SOC (1970) 2141. Of that classification, engineers swamp architects in absolute number. There were roughly 135,000 engineers and 6,200 architects in the SOC 214/215 in the 1981 Census.

Clearly more is captured in census data than intended for a study of the *consulting* engineering industry. Not all engineers are consulting engineers—hence in the consulting engineering industry. As a consequence, the absolute size of engineers in the labour force as discussed in the text overstates the number of consulting engineers in the national labour market. However, the rate of change of the group relative to the national labour market—as shown in figure 15—may reflect changes in the narrower consulting engineering industry of interest.

Figures from other sources will be presented below in an effort to more closely approximate the absolute number of consulting engineers in the Canadian labour market.

26. Sources: for consulting engineering, Statistics Canada surveys of industry for those years; for total employed, *Canadian Statistical Review*, various issues. "Canada" is the percentage that the total employment in the industry—from the surveys—is of the national total. "Canada*" is the percentage that the employment estimates of engineering from Statistics Canada, *Employment, Earnings and Hours*, catalogue 72-002, is of the total number employed in the nation.

The survey figures will likely understate engineering's significance by 10 to 20 percent. This would only change the results slightly. At the outside, employment in engineering is roughly six-tenths of one percent of total employment on a national level. Regionally, figure 18 gives a good idea of the relative levels.

Recall that employment figures estimated from catalogue 72-002 are not available for this industry by region so only a national figure may be derived.

27. Statistics Canada, *Canada Yearbook 1985*, catalogue 11-402E/1985, table 2.6, p. 53.

28. Some services may be "leading edges" or "growth poles," for example, insurance, major health centres, resorts and entertainment complexes. These services are not primarily services to businesses, as is engineering. See D.L. McKee, "On Services and Growth Poles in Advanced Economies," *The Service Industries Journal*, vol. 7, April 1987, no.2, pp. 165-175.

29. This statement should not be interpreted as stating that engineers are unimportant to the national or regional economies.

30. In chapter 4 more detailed information will be presented of the employment by region in the various specialties within engineering.

CHAPTER 3

DEMAND FOR ENGINEERING SERVICES AND INNOVATION

INTRODUCTION

Chapter 2 detailed the size of the consulting engineering industry relative to national and regional economies. In this chapter, some determinants of the total demand for engineering services are examined. By examining these determinants, future prospects for growth in the industry may become easier to estimate. One of the determinants of demand is the innovativeness with which engineers provide and change their service. Consequently, the process of innovation within engineering is also discussed in this chapter.

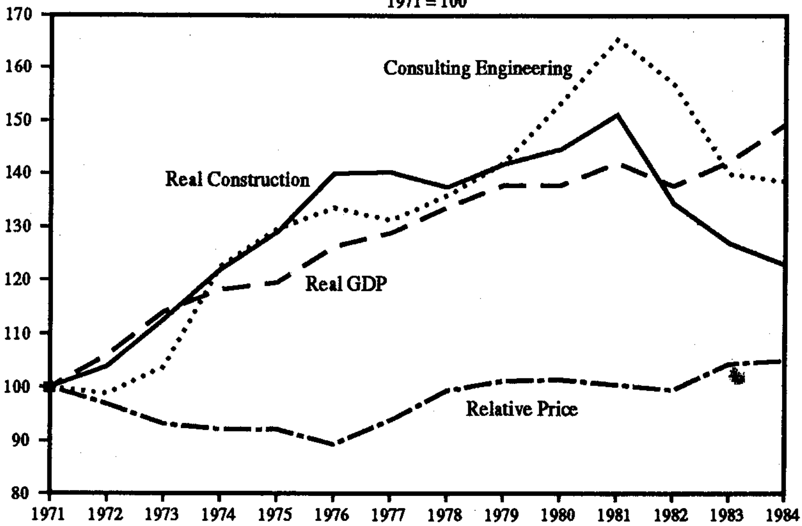
RELATIVE IMPORTANCE OF SOURCE OF DEMAND CHANGE

Relative Price Effect

Figure 23 presents indices of activity in the Canadian economy as proxied by real gross domestic product—the real value of construction and employment in consulting engineering. The relative price of construction is also shown.[1] Values in 1971 are used as the bases for each of the series.

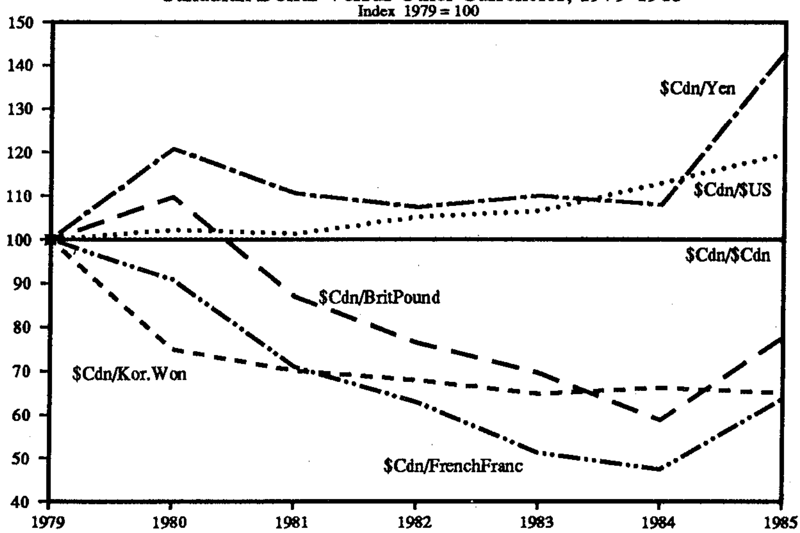
While a very crude measure, the relative price of total components of construction activity is a proxy for the relative price of engineering services.[2] A sympathetic glance at figure 23 indicates that there appears to be an inverse relationship between engineering employment and the relative price. Much more evident is the inverse relationship between the relative price of construction and real construction activity, a relationship that is theoretically expected.

Figure 23
Indices of Activity, Canada, 1971-1984
Real GDP, Construction, Employment of Engineers and Relative Prices
1971 = 100



Source: See text.

Figure 24
Exchange Rate Movements
Canadian Dollar Versus Other Currencies, 1979-1985
Index 1979 = 100



Source: IMF Financial Statistics, July 1986.

General Growth—Income Effect

Figure 23 also casts light on the relationship between engineering employment and output in the economy as measured by real gross domestic product. In general, the two series move together until 1982 when real GDP rises and employment in engineering continues its post-1981 decline. Seemingly much more important as a determinant of employment in the engineering industry is the level of real construction activity. That series also falls from 1981 to 1984 and moves much more closely with engineering employment than does real GDP, which is a broader measure of output.[3]

These considerations, as well as common sense, suggest that real construction activity is an important determinant of engineering employment and activity in the engineering industry. As an intermediate input into the construction process, demand for engineering services is expected to be positively related both to real construction activity and real GDP. The demand for engineering services is expected to be inversely related to the relative price of real construction activity. Figure 23 visually validates these observations.[4]

Exchange Rate Movements

Figure 24 presents recent movements in the Canadian dollar vis-à-vis currencies of many major competitors in engineering services. As outlined in chapter 2, there is relatively little foreign engineering activity in Canada and that is mostly from the U.S. and is confined to activity in the petroleum and natural gas sector. However, Canada is a major exporter of engineering services. Figure 24 provides some explanation for recent Canadian performance due solely to exchange rate movements.

The number of Canadian dollars per unit of the foreign currency in 1979 was used as the base for calculation. For example, the number of Canadian dollars per unit of Canadian dollars is always one, and that relationship is plotted as the straight, horizontal line at index value 100 for all years. The number of Canadian dollars per U.S. dollar has risen over time, so that relationship plots as a rising line above the horizontal at 100. This means the Canadian dollar has depreciated versus the U.S. dollar over the period.

From the figure it is evident that some of the widely noted success of the British, French and Koreans may well be due to the favourable (for exports) changes in their exchange rates over the period 1979 to 1985. Relative to the Canadian dollar, all three of these currencies have fallen dramatically in that time period. While there are many other considerations involved in successful exporting, having a currency that is cheapening relative to your competitors' *ceteris paribus* yields an advantage.

To summarize this section, from the evidence it appears that the prime determinant of the demand for engineering services is the level of real construction activity within the Canadian economy. In comparison, the level of real gross domestic product does not explain employment in the industry at all well. Exchange rate movements may go some way toward explaining foreign successes relative to Canadian engineers in the export market of the 1980s.

INNOVATION AND CHANGES IN SERVICES OFFERED

Measurement

Consulting engineers derive their income primarily from projects associated with the resource, construction and manufacturing bases of a region or country. It is the demand of final producers of raw, semi-finished and finished products, both private and governments at all levels, that drives the demand for intermediate inputs such as engineers. These traditional areas of demand have been the mainstay of the engineering profession.

When new products and processes are proposed for the market there is a new demand for engineering services. Often, these new sources of demand and revenue may be subsumed within a traditional statistical classification. In engineering, the sectors specified in Statistics Canada surveys are so broad that income derived from new services provided, for example in plant process design, will be lumped with all other income derived from that sector. This makes it very hard to quantify totally new services within a sector.

An example of this is the recent advance in biotechnology. Following from theoretical work in genetic structure, new opportunities for mechanical engineers have been created. As the quantities of man-made proteins produced become larger and reach commercial viability, engineers are needed to design and construct the facilities necessary to operate the larger scale ventures.[5] It is probable that statistics collected will roll these new services in with existing plant process design services. Innovations in services such as these in biotechnology become hard, if not impossible, to quantify given the aggregative nature of statistical collection.

Another avenue that may lead to a greater understanding of new services provided is the evidence (presented in chapter 2) that the proportion of domestic fee income generated by the catch-all "miscellaneous and unspecified" sector has risen over time. Unfortunately, one has no idea from that evidence if there are new services being provided and if so, what they might be.

Finally, there is evidence that many new services that conceivably could be provided by consulting engineers are being provided by "other scientific and technical services" establishments.[6] This is not the place to engage in a drawn out discussion of classification schemes, but it is worth noting that not only is engineering being carried out by all industries on an in-house basis but carried on in other *service* industries as well. This makes it doubly hard to quantify the extent of innovations in engineering.

Innovation

Innovation is "a process which, through technical, industrial and commercial steps, leads either to the marketing of new and improved products or to the commercial use of new and improved production processes and equipment, or both."[7] In most industries, innovating changes are the result of market-driven incentives. This attempt to gain a market advantage is achieved through applied research and development expenditures rather than basic research expenditures.[8] Consulting engineering industry members characterize the innovation process as very similar to the general description given above.[9]

Innovation in engineering takes place primarily through four channels: keeping current with state of the art developments through internal technical reports; informal communication with colleagues; redesign of existing plans based on changes made by the owner since construction; and observing developments made by competitors by observing structures and/or processes they've put in place for customers.[10]

For example, the designer of a pulp mill keeps up with developments primarily by going through a mill he built in the past and noting how the owner/operator has changed the layout, design and/or process in order to facilitate operation. He may also try to gain access to a mill developed by a competitor to see what improvements exist.[11] All of this activity is innovation as defined above and goes on in the normal course of events, but it probably would not strike anyone as anything other than sound business practice.[12]

In addition to these traditional methods of innovation, evidence exists on the rapidity with which new industrial technology, products and processes leak to rivals. On average, within 12 to 18 months of making development decisions this information is in the hands of rivals. Information on the detailed nature and operation of a new product or process generally leaks out within one year.[13] Activities which encourage this leakage—movement of personnel, informal communications between scientists and engineers,

professional meetings, scrutinizing patents and reverse engineering—might be termed intelligence gathering and lend themselves to innovation.

It is clear that much innovation of the type discussed above is carried out in the engineering industry. However, it is also clear that little of this would be explicitly charged as research and development costs. Therefore, the industry looks "non-innovative" in some respects. This is deceptive. On the other hand, there is little reason to believe that a government could design a regulatory, tax, subsidy or other structure to enhance the process as currently practised.[14]

The Client

The Canadian consulting engineering industry has had a longstanding interest in industrial innovation. In response to numerous submissions made by the industry, the National Research Council (NRC) established an Associate Committee on Consulting Engineering and Technology Transfer (ACCETT). ACCETT assists the NRC in becoming better acquainted with the mechanisms associated with the development of the nation's technology base by consulting engineers and the needs of the industry in this regard. In turn, ACCETT engaged the consulting firm of Ernst & Whinney (1985) to study the technological work of consulting engineers. Ernst & Whinney concentrated on the nature of work for which clients engaged consulting engineers and the criteria clients used in selecting one firm over another.

Ernst & Whinney found that clients look to consulting engineers to do applications engineering only and that the consulting engineer is most often selected for individual or company experience in a field, not for the ability to innovate, acquire or develop new technology nor for its proprietary technological knowledge.

This view is reinforced by survey results gathered in the *Market Perception Study*, done for the Consulting Engineers of British Columbia, which found that, "generally, consulting engineers are viewed as creative followers, rather than leaders in the areas of innovation and technology. In effect, they are 'middlemen,' transferring the ideas flowing out of universities and other research institutes through to the end user (i.e. the client)" (May 1986:52-53).

These findings do not mean that consulting engineers are not led by the market to innovate, only that clients do not specify innovation and research as a primary product from engineers.[15] However, engineers are forced to innovate and acquire innovative techniques to stay profitable, and these innovations find their way into the products engineers design and develop.

The Process

Innovation by doing the same task less expensively is accomplished quite readily without the conscious design or interference of government. Encouraging innovation by trying to pick winners and pouring funds into one project or another without reference to the market leads only to well-publicized disasters.[16] What government may do to discourage innovation is lower the returns to innovation by proscribing innovators' returns to their inventions. What government may do to encourage innovation is foster a business climate, patent and tax structure which rewards innovators by allowing them to reap the returns of their insights and investments. Licensing, royalties and other agreements for use will ensure that processes and products are diffused throughout society.[17] The more cost saving the innovation the faster it will be adopted.

Evidence shows that engineers do not use patents as a major source of information. Rather, own-source information, technical reports kept in-house and informal communications are seen as quicker, more effective sources for innovation.[18] Given this almost "oral tradition" amongst engineers, another avenue for encouraging information transfer in the industry may be regional engineering trade shows with themes keeping to the resource and industrial bases of the regions. If there are public benefits to information transfer, a case for government sponsorship or co-sponsorship of such trade fairs could be made.[19]

For consulting engineers the process of innovating goes on daily, spurred by the profit motive. Being able to do a specific task at a lower cost translates into profits. Consequently, firms have the incentive to carry out their own research and design in order to win contracts in the future. SIC 864 (of which consulting engineering constitutes about two-thirds) carried out 21 percent of R&D performed by all service industries in 1983.[20]

Computers

What is transforming the innovation issue in this as other industries is the dramatic lowering in costs associated with the micro- and mini-computer. Buildings may now be wired and climatically controlled through a central "brain" with sensors on windows and walls using natural heat and light sources to best advantage. Geographic information systems and mapping are now more easily done with digital technology processed in large volume and high speed by computer. This computer revolution is giving rise to the rapid growth in the so-called unbundled services, those not directly associated with the conception or design of capital facilities. One now has the ability to do stock assessment, planning, transportation and scheduling problems—pre-

viously feasible only on a large mainframe computer at great cost and complexity—at one's desk with user-friendly software on a micro-computer.[21]

Growth in these unbundled services has been dramatic. While operating revenues for consulting engineers roughly doubled (in nominal terms) between 1978 and 1982, operating revenues for meteorological, urban planning, geographic information systems, and facilities information management services taken together increased by a factor (again nominal) of seven times over that same period.[22]

Nor has the computer revolution left bundled services behind. Software systems have been developed that can calculate building costs from a blueprint.[23] Design and drafting software are featured in a myriad of books, personal computer and trade association magazines and trade convention sessions are devoted to it.[24]

What all of this suggests is that consulting engineers know where their interests lie and are seeking them. Perhaps their work is not flashy and immediately associated with technological breakthroughs, but it is at the applications level, as "creative followers," that consulting engineers best serve their clients.

QUALITY OF SERVICE

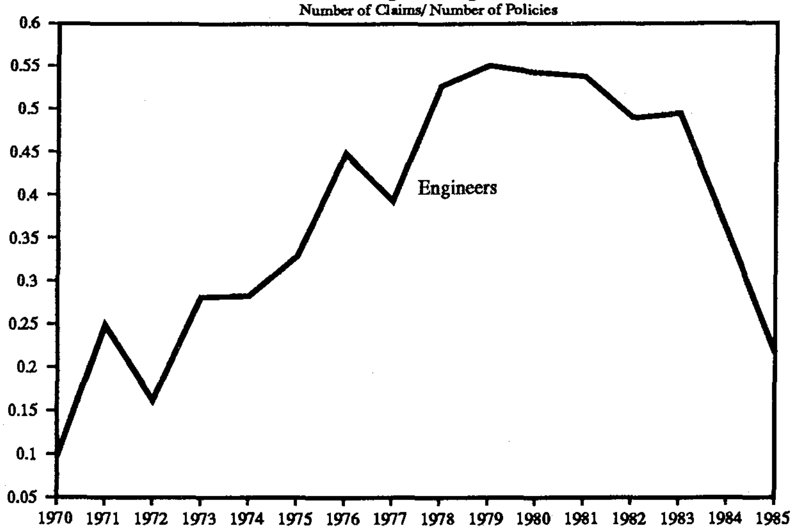
There is no direct way to measure the quality of services rendered. However, in this section I will use insurance industry data as a proxy for the quality of work done. This has two benefits. First, to the extent that insurance statistics are a valid proxy we have a measure, albeit indirect, of quality. Secondly, recent claims have been made that "crises in insurance" have soured the business climate.[25] Using insurance industry data, this assertion may be assessed.

In engineering, such a pro-litigious mood could restrain activity severely as the engineer faces no time limit on the liability claims on work performed. Figures 25 and 26 plot the behaviour of claims per policy and total costs of claims incurred in each year from 1970 to 1985, respectively.[26]

Figure 25 illustrates the upward trend in claims per policy through the 1970s, which went from 0.10 claims per policy in 1970 to a peak of approximately 0.56 claims per policy in 1979. Notice that this peak levelled off and then turned down to approximately 0.23 claims per policy in 1985.

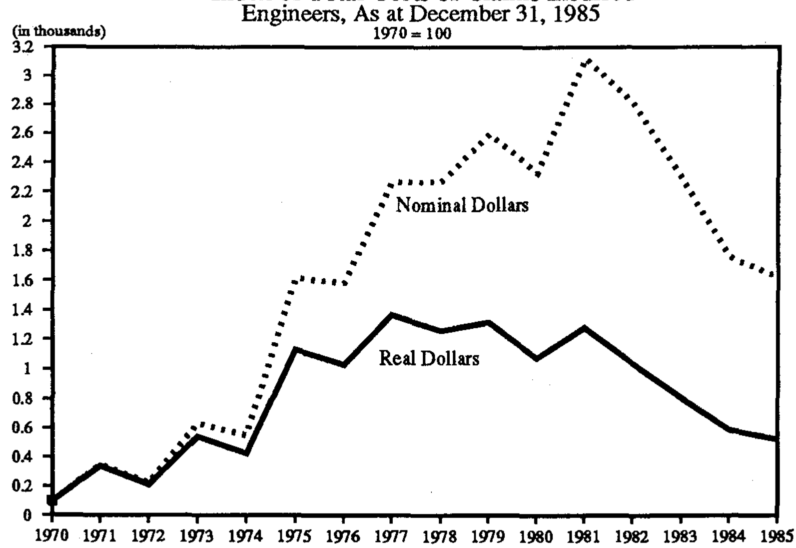
Figure 26 shows the total costs of claims incurred (in real and nominal values) using the relevant values in 1970 as the base of comparison. Both series rise from 1970, with the real series peaking in 1977 at an index value some 13 times above the 1970 level. The nominal series peaks in 1981 at an index value roughly 32 times that of 1970.

Figure 25
Claims Per Policy
Canadian Engineering, 1970-1985
Number of Claims/ Number of Policies



Source: Insurance industry data.

Figure 26
Index of Total Costs of Claims Incurred
Engineers, As at December 31, 1985
1970 = 100



Source: Insurance industry data.

The dramatic rise in the real total costs of claims incurred has two sources.[27] First, a rise in the number of policies, or a scale effect, and secondly, more claims per policy as per figure 25.[28] Claims per policy are the driving force in the real series, with claims per policy rising about four times from 1970 to 1977 while real costs incurred rise about 13 times over that period. That leaves the number of policies rising by about 3.25 times from 1970 to 1977.

The nominal series, while experiencing a much more dramatic, 32-fold increase, has the rapid inflation of the late 1970s and early 1980s driving much of its rise. The level of total real costs incurred dropped to about 500 in 1985. This reflects the drop in claims per policy. This drop in claims per policy may well indicate a rise in the quality of product being offered.

It is uncertain that recent engineering activity was seriously limited by rises in insurance premiums to reflect the claims and costs pictures shown above. However, it is certain that the decline in demand for engineers, squeezing of profit levels and fall in activity—all due to the drop in construction activity—were exacerbated by these rising insurance costs. However, if trends continue as they have through the 1980s, it would seem that insurance cost and availability considerations will not be major concerns of the engineering industry.[29]

SUMMARY

The demand for engineering services, as proxied by employment in the industry, is a direct function of the level of real construction activity in the country. Further, exchange rate appreciation of the Canadian dollar relative to many foreign competitors may explain their relative success in the tight markets of the 1980s. The level of economic activity, as proxied by real gross domestic product, is not a significant explanator of employment in the industry.

The process of innovation in the industry is one of quiet and subtle change. Often, it consists of visiting a plant designed and constructed years earlier and observing how the client/owner has altered the process and design for better use. On the other hand, innovation is not always desired. For some projects, particularly those demanded by the government client, innovation is actively discouraged. This is especially true in circumstances where the expected loss from system failure is greater than the expected savings of introducing the innovation. Private sector clients encourage innovation when the cost savings warrant.

Computers are being used more and more in the offices of engineers. However, there is no striking evidence that new services are being offered by

engineers. Rather, computers are being used to provide design and redesign as well as drafting services more quickly. Allied with this change, however, has been the change in the composition of inputs in the workplace. As will be shown in chapter 4, the structure of the workplace, not the service offered, is being changed by computers.

New services made possible by computers are being offered by new firms in allied industries, for example, "other scientific and technical services establishments." Growth in these firms has outpaced that of engineering in the 1980s.

Finally, the quality of engineering services may be rising if judged by the decline in the number of lawsuits per policy. As well, this decline is mirrored by a decline in the level of total real payments by the insurer. This indicates that rising insurance costs should not be a factor in the cost of doing business.

NOTES

1. Sources: Real GDP, Statistics Canada, *Canadian Statistical Review*, publication 11-003E, monthly, June 1987; real construction activity, Statistics Canada, *Construction In Canada*, catalogue 64-201; employment in engineering estimated from Statistics Canada, catalogue 72-002, various issues, as per chapter 2; and relative price is the implicit deflator of the total components of construction divided by the GDP deflator, as per chapter 2.

2. This assumes engineering fees are tied by a fixed percentage to projects and that this percentage remains unchanged.

3. Sector specific unemployment data is hard to come by. However, in B.C. the Professional Engineers Manpower Assessment Committee (PEMAC) was formed by the Association of Professional Engineers of B.C. (jointly funded by the Canada Employment and Immigration Commission) to assess the impact of the recession. As of July 31, 1983, 16.5 percent of the association's membership were unemployed. Fifty-five percent of consulting engineers were unemployed on this date. This compares to a provincial unemployment rate of 13.4 percent at the same date. These figures from *The B.C. Professional Engineer*, January 1984, p. 7.

   The percentage of unemployed engineers fell to 15.6 percent (13.8 percent for the provincial labour force and 32 percent for consultants) as of January 31, 1984, *The B.C. Professional Engineer*, November 1984, p. 21. Finally, in the last report published to date in the above publication of June 1987, p. 16, unemployment of members in B.C. had fallen to 12.9 percent as of December 1986, compared to 13.4 percent for the province with no separate figure for consultants.

   That the market for engineers "works"—in the sense that they follow incentives and go where the work is—is shown by the fact that the June 1987 issue attributes much of the drop in unemployment to "an exodus of 9 percent of the B.C. engineering workforce to retired status and other geographic locations."

   As recently as September 3, 1987, estimates were that unemployment of engineers in B.C. had fallen still further to 8 or 9 percent. The provincial unemployment rate was 11.4 percent. This drop in unemployment rates of engineers was reportedly due to upgrading of pulp and paper plants. See "Engineers in B.C. Going Back to Work," *Vancouver Sun*, September 3, 1987, B7.

4. A simple model of the demand for engineering employment can be specified and estimated econometrically, however, data limitations

make such efforts of limited use. For example, let the demand for engineering services (D) be a function of real GDP, real construction activity (RC) and a long-term interest rate (I). This last variable may serve as a proxy for the return to physical assets. If we assume the supply of engineers to be exogenously determined and estimate in logs, then:

(1) $Ln(D) = a + b\,Ln(GDP) + c\,Ln(RC) + d\,Ln(I) + e$

where b, c and d are all expected to be positive, and e is an error term with all the usual properties.

In a simple OLS regression using annual data from 1971 to 1984, with employment in engineering, real GDP and real construction defined and sourced as before and letting the "Government of Canada average bond yield 10 years and over," series S13/T8, from Statistics Canada, *Canadian Statistical Review*, serve as the interest rate, the following results:

(1′) $Ln(D) = -0.18 + 0.02\,Ln(GDP) + 0.65\,Ln(RC) + 0.36\,Ln(I)$, NOBS = 14

R^2(adjusted) = 0.98, Durbin-Watson = 1.96, t-statistics on Ln(RC) and Ln(I) both significant at the 1 percent level, t-statistic on Ln(GDP) insignificant.

Needless to say, this is a very simple model. It is only estimated to give a numerical "feel" for some of the relationships plotted in figure 23.

The interpretation of (1′) is that a 10 percent rise in real construction activity generates a 6.5 percent increase in the demand for engineering services as proxied by engineering employment.

It is possible that real construction activity determines not only the demand for engineering services, but also the supply of such services. A two-stage least-squares estimate of the same form as (1) was estimated for the same period using the natural log of the price of real construction, natural log of the interest rate and the natural log of real GDP as instruments in the first stage on real construction activity. There was virtually no change in the results as far as t-statistics, Durbin-Watson, or R^2(adjusted) are concerned. The coefficient on Log (I) was unchanged and on Log (RC) dropped from 0.65 to 0.59.

5. See Robert C. Dean, "Opportunities in Biotechnology for Mechanical Engineers," *Mechanical Engineering*, July 1987.

6. For example, MacDonald Dettweiler, a Vancouver area firm whose staff currently numbers about 600 and has been growing at 30 percent per year, provides computer/satellite remote sensing packages to

clients. They are classified with "other scientific and technical" services.

7. See K.S. Palda, *Industrial Innovation—Its Place in the Public Policy Agenda,* The Fraser Institute, Vancouver B.C., 1984, p. 27.

8. See D.P. DeMelto, K.E. McMullen and R.M. Wills, *Preliminary Report: Innovation and Technological Change in Five Canadian Industries,* Economic Council of Canada, October 1980, discussion paper no. 176, pp. 98 and 144.

9. Industry members represented medium- to large-sized firms handling a wide variety of engineering specialties including mining, forestry, pulp and paper, industrial processes and delivery systems, municipal works and others.

10. See H.L. Shuchman, *Information Transfer in Engineering,* The Futures Group, Washington D.C., 1981.

11. Ford Motor Company when designing the Taurus reportedly "tore down" similar mid-sized cars built by competitors and considered the design, working and placement of almost every part. This process of 'de-engineering' is used frequently, especially the smaller and less complex the item.

12. In some areas of engineering new products or processes with a promise of cost savings, but also the risk of intermittent service, are avoided and products/processes with a minimal chance (preferably zero) of failure are chosen. This is especially true in municipal works for water supply and treatment where assured supply is the main criterion. Here, innovations that cannot *guarantee* better delivery performance simply will not be purchased.

13. See E. Mansfield, "How Rapidly Does New Industrial Technology Leak Out?", *Journal of Industrial Economics,* vol. XXXIV, no. 2, December 1985.

14. Given the evidence on product/process leakage, it is conceivable that information could more easily and efficiently be shared through trade meetings or trade fairs.

15. Evidence on the patenting behaviour of engineers in U.S. industry is that patent activity varies by industry and size of firm. The electrical, machinery and metals industries are the most productive of engineering patents. Engineers in medium-sized firms are the most patent productive, although as a whole engineers in industry have a lower success rate than all those who apply for and are granted patents. See H.L. Shuchman, *Information Transfer in Engineering,* The Futures Group, Washington D.C., 1981, chapter 6.

Some clients do not want nor can they afford innovation. According to *The Market Perception Study,* "this [not wanting innovation] is particularly evident in the area of government projects, where many clients have indicated that, while they are open to ideas on how to reduce costs, they generally believe that they have a good idea of what they want and how they want it done" (p.53).

16. There is also evidence in the U.S. that private firms lower their research and development (R&D) expenditures when federal government R&D expenditures rise. Consequently, "these findings thus make heavier the burden of proof on those who would claim that federal contract R&D makes a positive contribution to aggregate technical progress." See F.R. Lichtenberg, "The Relationship Between Federal Contract R&D and Company R&D," *American Economic Review,* May 1984, vol. 74, no. 2, pp.73-78.

17. Seemingly, little can be done to preserve an advantage once gained. Mansfield (1985) reports that technological information on the detailed nature and operation of a new product or process generally leaks out within about one year no matter what measures firms take to prevent these leaks. He also finds this result tends to hold across industries. However, patent protection to innovation encourages "first movers" to innovate in order to gain an advantage. Further, "time to leak" is different from "time to producing a credible substitute," as Mansfield notes.

18. See Shuchman (1981), chapter 2.

19. That patents are not always the optimal incentive to invention has been shown by B.D. Wright in "The Economics of Invention Incentives: Patents, Prizes and Research Contracts," *American Economic Review,* September 1983, vol. 83, no. 4, pp. 691-707.

20. Statistics Canada, *Industrial Research and Development Statistics,* 1983.

21. One large firm in British Columbia hired a software "tinkerer" who, after expenses grew upwards of $200,000, was almost let go. The computer software developed by this person alone has, to date, been sold for many multiples of the development costs. From discussions with industry representatives, I got the feeling that this type of research was not common at this date.

22. Discussions with representatives from medium- to large-sized firms in the industry in Vancouver stressed them planning to stick to what they know best. There may be natural integrations possible, for example pulp and paper engineers entering the mapping and remote sensing of forests to gauge their pulp potential, but on the whole these participants

were publicly skeptical of their role in non-traditional pursuits. This professed skepticism and unwillingness may have been a strategic response to being seated with seven or eight competitors in the same room.

23. See "System Can Calculate Building Costs from a Blueprint," *Toronto Globe and Mail*, July 7, 1987.

24. For example, B.J. Korites, *Engineering Software for Micros*, Kern Publications, 1982. *Computer Design*, a Penn Well Publication, is a monthly devoted to CADD; so is *Computer Aided Design*, from Butterworth's and *Cadalyst—The Journal of CADD*. In addition, special issues of journals aimed at the general computer market, for example, *Byte* magazine of July 1986, also feature CADD developments. Finally, trade shows such as "A/E/C Systems '87, The Eighth International Computer and Management Show for Architects, Engineers, Contractors and Facility Managers," feature days of sessions on the applications of computers in the above fields.

25. For an examination of such claims in the aggregate, see D. Gill, *Liability Insurance—Crisis in Supply*, The Fraser Institute, Vancouver, B.C., 1987.

26. This information was kindly supplied by one of the two insurance companies in Canada presently insuring engineers. The firm estimates it covers more than half of the engineers in Canada. The data supplied were put into ratio and index form to protect its confidential nature.

27. This assumes that the average payment or award per claim, in real terms, remains unchanged.

28. The relationship is, abstracting from administration costs, as follows:

    Total Costs of Claims Incurred = (Number of Policies) x (Claims/Policy) x (Award/Claim).

29. Time limits on liability and other changes in the law, however, may still be of concern to engineers and other design professionals.

CHAPTER 4

INDUSTRIAL ORGANIZATION AND GROWTH

INTRODUCTION

There are several characteristics and conceptions of the organization of the Canadian consulting engineering industry which make it interesting.[1] Among these are the size structure of the industry, the extent to which engineering is done by and may continue to be done by non-engineering firms and governments and why, in Canada, the industry is populated mainly by "pure" consulting firms. In this chapter these and other issues relating to industry and firm structure are examined, starting with a brief discussion of the legal requirements for practise as a professional engineer.

PROFESSIONAL PRACTICE

The practice of professional engineering is self-regulated at the provincial and territorial level by associations of professional engineers. These bodies are empowered by provincial legislatures via engineers' acts to establish standards of membership and grant membership privileges through licences as well as govern and discipline members. In addition, any individuals or corporations engaging in the practice of professional engineering as defined in the acts, usurping the functions of a professional engineer, assuming verbally or otherwise the title of professional engineer, or acting in a manner which leads any person to believe he or it is authorized to fill the office may be fined. Further, such individuals or corporations violating those sections are not entitled to recover any fee or remuneration in any court of law in the province for any work done or service rendered which is comprised in the definition of "practice of professional engineering" in the acts.[2]

Membership and receipt of a licence to practise are usually attained through a combination of educational achievement and experience or experience and examination performance satisfactory to the association council. Clearly, any individual(s) or corporation wishing to legally practise

professional engineering on a consulting basis within a province or territory requires a licence from the relevant provincial association and as such falls under the rules and regulations of that association.

Self-regulation and licensure often entail restrictions on both advertising and fee competition. T.R. Muzondo and B. Pazderka[3] have found that in professions where these restrictions are practised, including engineering, average returns are significantly above those of professions where advertising and fee competition restrictions are not practised. There are, however, efficiency arguments supporting self-regulation[4] and licensure.[5] Evidence is presented in chapter 5 that these powers have been substantially weakened during the recession of the early 1980s. Relative to the self-employed in other professions and relative to the average of all occupations, the earnings of self-employed engineers has fallen from 1959 to 1984.

INDUSTRIAL ORGANIZATION CHARACTERISTICS

Importance of Corporations and Other Legal Forms of Ownership

Table 2 compares the rates of incorporation between the two survey years of 1974 and 1982. Obvious from the table is the high and rising level of incorporation rates and the dramatic increase in incorporation, especially in Quebec-based firms, over the eight-year period.

Table 2

Percentage of Consulting Engineering Firms Incorporated

		1974	1982
Region			
	Atlantic	76.0	95.3
	Quebec	28.1	67.8
	Ontario	74.0	91.5
	Western	84.9	93.5

Source: Statistics Canada industry surveys.

Size Distribution of Firms

Figure 27 presents information from LEAP data for SIC 864, engineering and other scientific and technical services establishments. The figure shows the size distribution by number of employees per firm for the two years 1978 and 1984. Over that six-year period, the distribution of firms has become

even more skewed towards firms of less than five employees relative to every other size.[6]

In terms of employment, the picture is vastly different. Figure 28, again based on the LEAP data, shows that the smallest firms (less than five employees) employed only 7 percent of the industry's total employees in 1978. In the same year, the largest firms of 500 or more employees accounted for over 30 percent of total industry employment. In 1984, the smallest firms had more than doubled their portion of industry employment at the expense of the firms of 100 to 500 and 500-plus employees.

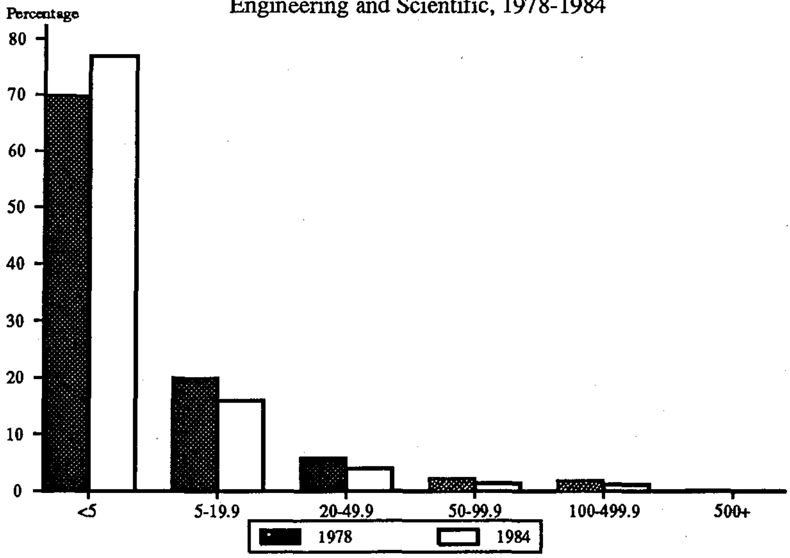
Figure 29 gives information from survey data for the year 1982 on size distribution of firms by fee income.[7] From the figure it is obvious that the majority of the firms—about 77 percent of the 2,236 firms responding—are generating fee incomes of $500,000 (in 1982 dollars) or less.

However, just as was shown in figures 27 and 28, the number of firms alone in a size class does not tell all. Total fee income generated per fee income class, shown in figure 30, is a function of both the number of firms and the dollar value of fee income per firm in that class.[8] Figure 30 shows that, among survey respondents, the small number (34) of firms in the largest fee income range generate over 50 percent of fee income in the industry. While the next largest fee income range, $5 million to $10 million, has a mid-point two and one-half times greater than the income range $1 million to $5 million, the lower income range generates more than twice the fee income of the next higher class. This result is due to the greater number of firms, 232 to 34, in the lower of the two classes. From this and earlier material it is possible to construct an approximate concentration ratio for the industry.[9] Measured by revenues, in 1982 the four largest firms in the industry accounted for about 30 percent of the domestic industry's total. The largest 34 firms earned approximately 50 percent of the industry's total revenue. The largest 68 firms had 60 percent of the market, and the largest 300 firms had slightly more than 80 percent of the market.

Industrial Associations

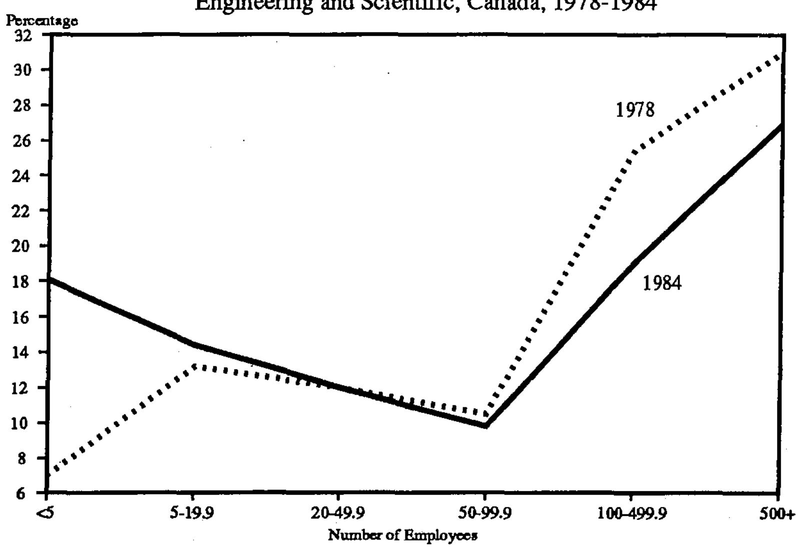
Consulting engineers have a national association, the Association of Consulting Engineers of Canada (ACEC), representing their interests as well as provincial organizations in most of the provinces and territories.[10] Membership in these organizations is voluntary and, as of 1986, the ACEC had 800 member firms.[11] The ACEC does not provide a breakdown of member firms by size.[12] However, the Consulting Engineers of Ontario (CEO) do provide such data.

Figure 27
Distribution of Firms by Number of Employees
Engineering and Scientific, 1978-1984



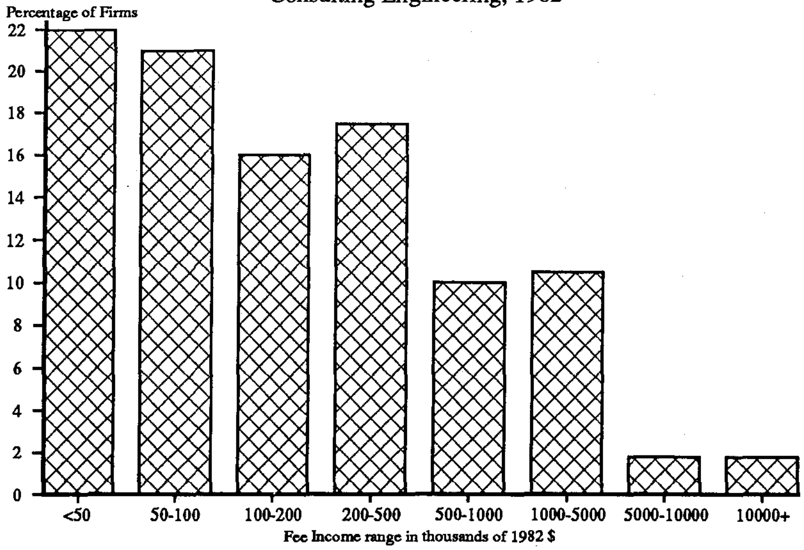
Source: Business Microdata, LEAP.

Figure 28
Percentage of Employment by Size of Firm
Engineering and Scientific, Canada, 1978-1984



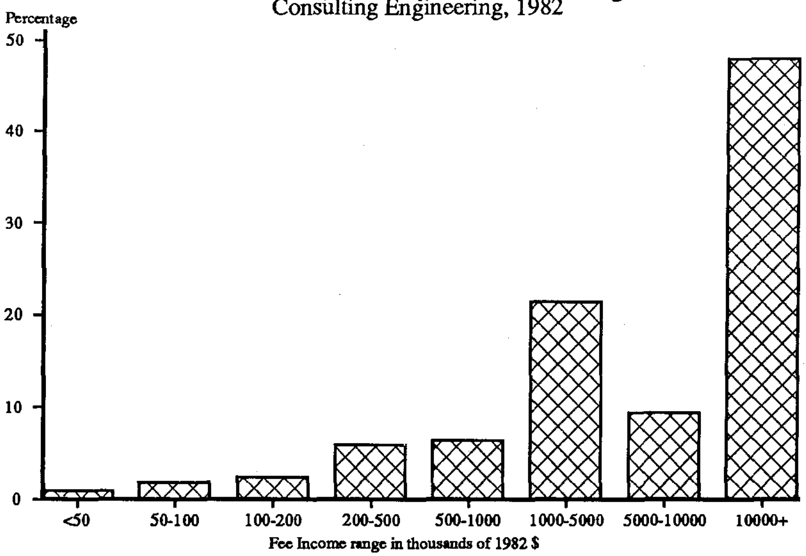
Source: Business Microdata, LEAP.

Figure 29
Size Distribution of Firms by Fee Income
Consulting Engineering, 1982



Source: Statistics Canada, catalogue 63-537, occasional, 1985.

Figure 30
Total Fee Income by Fee Income Range
Consulting Engineering, 1982



Source: Statistics Canada, catalogue 63-537, occasional, 1985.

For 1984, a comparison between the distribution by firm size derived from LEAP data, which is a virtual census for SIC 864, may be compared with the similar distribution derived from the CEO data. In 1984, the CEO comprised 350 member firms, roughly 44 percent of the total member firms of the ACEC. Figure 31 presents the two distributions. As can be seen from the figure, the size distribution of membership in the trade association, at least in Ontario, tends to over-represent those firms having five to 500 employees and under-represent the smallest firms.[13]

As a point of reference, the American Consulting Engineers Council[14] (the American CEC) publishes membership data very similar to that of the CEO. In 1987, there were 4,659 member firms of the American CEC totalling 143,107 employees. Figure 32 gives the distribution for the American CEC by size of firm.[15] The distributions of the two industrial trade organizations, the CEO and the American CEC, are quite similar.

Degree of Foreign Ownership and Influence

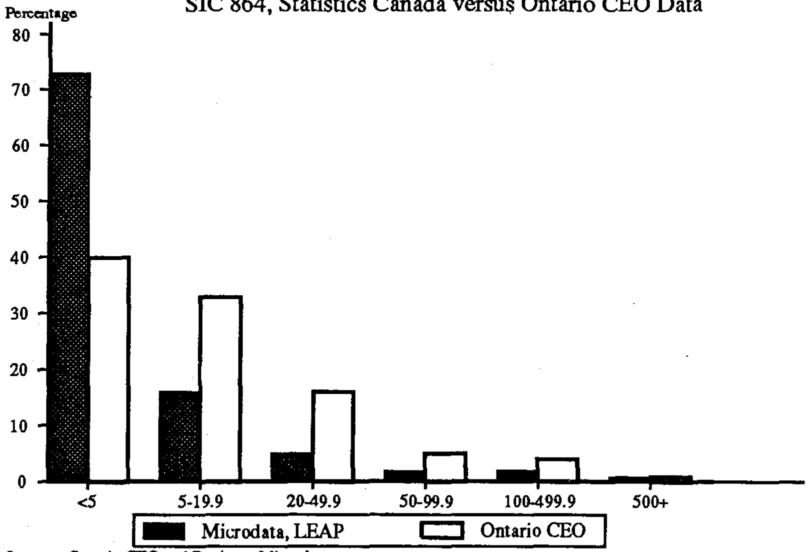
Almost all firms in this industry are wholly Canadian-owned, most often by their employees. What little foreign presence exists is among firms, usually headquartered in the United States, tending to specialize in large scale petroleum and natural gas projects. In recent years, with the dramatic fall in the price of oil, activity and employment by these foreign-controlled firms has declined.

CHANGES AND GROWTH IN NUMBER OF FIRMS

Data from Statistics Canada's Longitudinal Employment Analysis Program (LEAP) for the years 1978 to 1984 provide measures of growth in the engineering industry for that period. The data, as discussed in chapter 1, are collected on an establishment basis, so provides an approximate look at the entire SIC 864. As such, LEAP data include more than the engineering industry of interest, however, for growth rates, birth rates and the like, the LEAP data are the best proxy measure extant.[16]

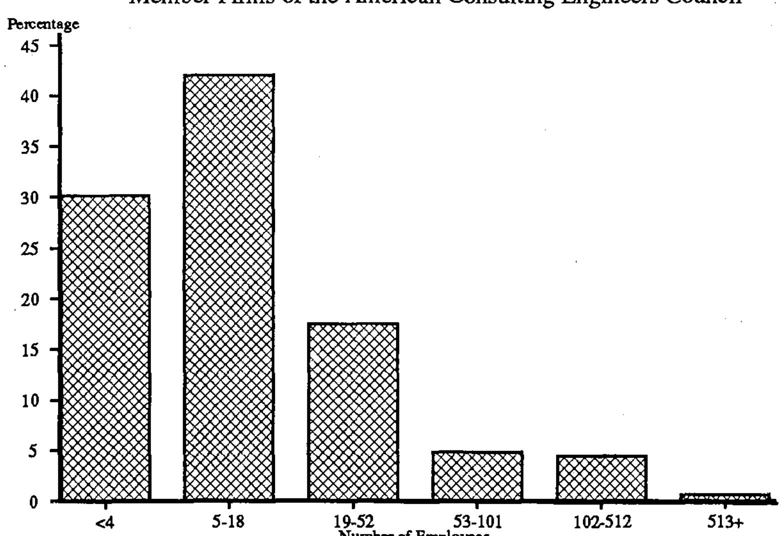
Figure 33 gives the percentage growth in the absolute number of firms in all industries (All), SIC 864 Canada-wide and then for SIC 864 in the four geographical regions of the country over the period 1978 to 1984. The number of firms comprising SIC 864 has grown at almost twice the rate as the aggregate of all firms in the nation. The Western region has seen the greatest growth in the number of firms in SIC 864, with absolute numbers rising almost 70 percent over the six-year period, an annual average growth rate of some 8.8 percent.

Figure 31
Comparison of 1984 Distribution of Firms by Size
SIC 864, Statistics Canada versus Ontario CEO Data



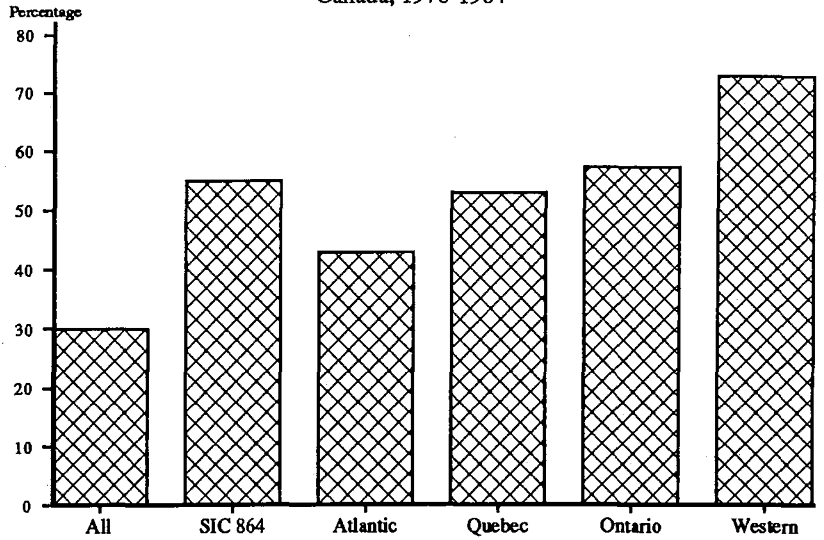
Sources: Ontario CEO and Business Microdata.

Figure 32
Percentage of Total Firms by Size of Firm, 1987
Member Firms of the American Consulting Engineers Council



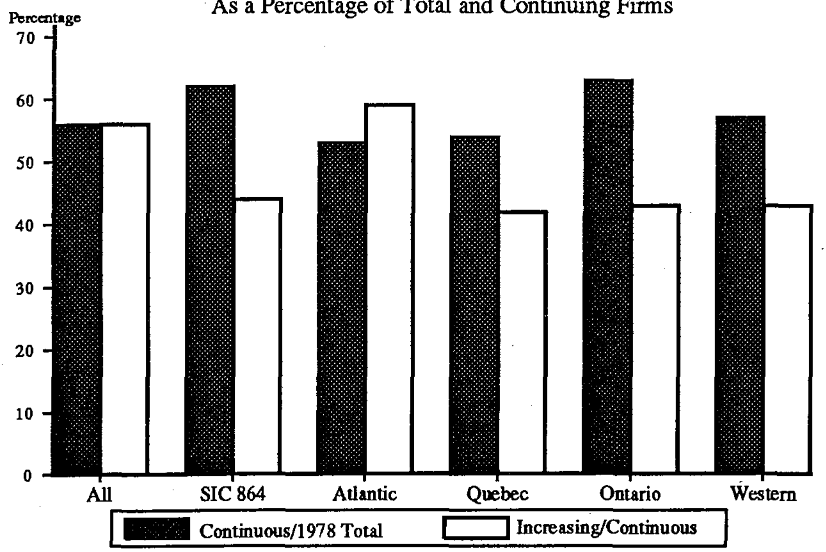
Source: American Consulting Engineers Council.

Figure 33
Percentage Growth in Number of Firms
Canada, 1978-1984



Source: Business Microdata, LEAP.

Figure 34
Continuous and Increasing Employment Firms
As a Percentage of Total and Continuing Firms



Source: Business Microdata, LEAP.

Figure 34 presents both the percentage of firms in the country (All), SIC 864 Canada-wide and by regions which have been in business in both 1978 and 1984, termed "continuous," and the percentage of those continuous firms with increases in employment. The first percentage is given relative to the total number of firms in each category in 1978. In the figure it is apparent that there has been very similar behaviour in the SIC in the three non-Atlantic regions. SIC 864 firms in the Atlantic region, meanwhile, had about the same percentage of firms in continuous business over the period as the other regions, but of these continuing firms about 60 percent experienced employment increases as compared to just over 40 percent in the other regions.

Figure 35 shows birth rates for all firms, all SIC 864 firms and the SIC 864 firms by region. The birth rate here is defined as the number of firms which did not exist in 1978 but did exist in 1984 (births), divided by the number of firms which existed in 1978 but did not exist in 1984 (deaths). A value of one would indicate that there had been no change in the number of firms over the period as each birth would be offset by a death. A value of two would indicate two births per death and so on.

The average birth-to-death rate for all firms is 1.7 over the period. For SIC 864, the number is in excess of 2.4, and the regional behaviour varies widely with the birth rate rising from 1.9 in the Atlantic region to 2.65 in the West.

Figure 36 presents birth rates by size of firm for all industries and SIC 864 where size is measured by the number of employees. It is obvious that firms of the smallest size, less than five employees, have had the greatest birth-to-death rate over the period for both all industries and SIC 864. Notable is the fact that firms of all sizes have experienced a net birth gain (births outnumbering deaths). Only in the largest firm size, 500-plus employees, is the "all industries" birth rate above that of SIC 864.

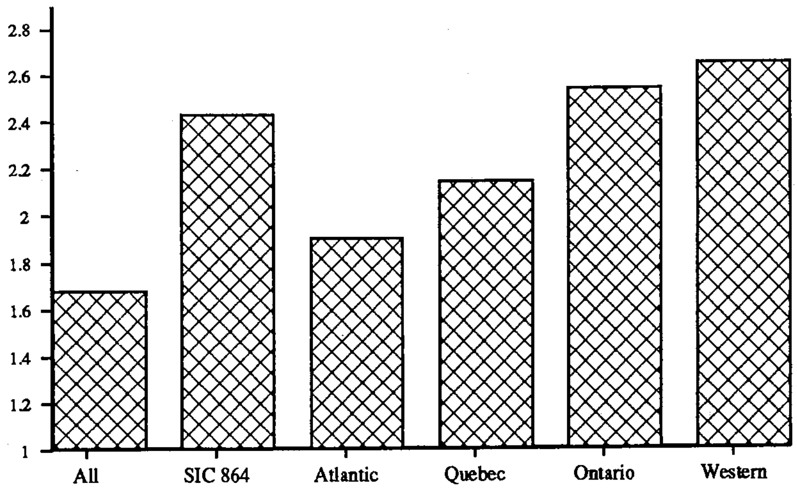
To sum up, activity in SIC 864, as measured by LEAP data, is robust. Relative to all firms in the country, SIC 864 has had greater percentages of new firms created, a greater percentage of existing firms continuing business and higher birth rates of firms in every size category except the largest.

ESTIMATES OF ENGINEERING DONE WITHIN INDUSTRY AND GOVERNMENT

Preliminary Considerations

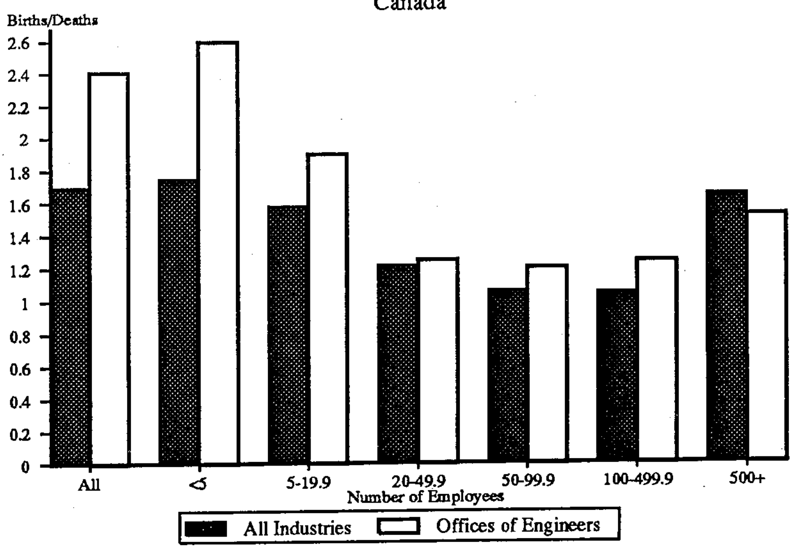
Clearly, not all engineering is done by consultants.[17] Firms may find that, just as with other inputs, it is sometimes cheaper to provide them in-house. On the other hand, there may be times when it is cheaper to buy the service

Figure 35
Birth Rate by Region from 1978 to 1984
Births Divided by Deaths



Source: Business Microdata, LEAP.

Figure 36
Birth Rate by Size of Firm from 1978 to 1984
Canada



Source: Business Microdata, LEAP.

from an outside supplier. This is sometimes referred to as the "make or buy" decision. It is a decision made with respect to all inputs and also made by public, that is government, departments and Crown corporations in addition to private firms.

The make or buy decision relates to the degree of vertical integration of an enterprise. If, for example, firms provide their own inputs, they are said to be more highly vertically integrated than firms which contract for the provision of inputs with other firms. To the extent that work currently done in-house has the potential of moving "out-of-house," there will be impacts on the market for the input. These impacts would be on both the supply and demand sides. On the supply side, if public and private firms move work out-of-house, those inputs currently employed in the sectors would not continue to be.

For example, consider an automobile manufacturer with an engineering division. The engineers working in that division are classified to manufacturing in the industry statistics collected by national statistical agencies. Now, suppose the automobile maker chooses to purchase engineering from out-of-house sources, releasing its engineers. It may be that those very same engineers provide the engineering for the automobile maker through a firm they set up. The statistics would show a rise in the number of consulting engineers and an equal size decline in the number of employees in the manufacturing sector. While not all engineers leave industry, some might find their way to consulting. Consequently, when public and private firms choose out-of-house provision, the supply of consulting engineers can be expected to increase.

Similarly, the demand for consulting engineers is expected to rise as more work is contracted out-of-house. This demand may be partially met by consulting arms of other firms in the industry, but to a large extent it may well go to new and existing consulting firms.[18] Note that the growth in employment in consulting engineering and the matching decline in manufacturing employment is largely a statistical illusion. There is still the same amount of engineering being carried out.[19]

There are three important dimensions characterizing transactions which influence the governance structures, or degree of vertical integration, of firms: uncertainty, the frequency with which transactions recur, and the degree to which durable transaction-specific investments are incurred.[20]

The more uncertain the supply of an input is the greater the incentive to bring the input in-house or form "quasi-firms."[21] On the other hand, the more uncertain the demand for an input the greater the incentive to order the input, when needed, from outside sources. The more frequent a transaction (hiring an input) the more likely it is that it will be provided in-house. This is because

the costs associated with continual contracting out will increase with the number of contracts. When the input is used on a regular basis, contracting costs may be minimized by writing one contract of longer length—the typical employment contract.[22]

The final dimension, transaction-specific investment, is sometimes referred to as "asset specificity." This characteristic refers to the amount of job-specific knowledge an input gains when on the job. The more job-specific knowledge an input gains the higher the cost to the firm if it cannot use that input when needed. Consequently, if an input becomes highly specialized within the firm, there is an incentive for the firm to provide that input rather than hire it from outside. This also lowers the incentive for the input to "hold up" the firm once a contract has been written.[23]

This may be a little abstract as presented. Imagine a firm with a printing machine. The operator of the machine will learn all the idiosyncrasies of the machine over time as he or she uses it.[24] The more specialized the machine, that is the fewer people who can walk in and operate it, the more "asset specific" are the operator's skills. Once the operator realizes this fact, there is great incentive on his or her part to extract a greater payment from the firm than that for which he or she originally contracted. This is known as the problem of "post-contractual hold up." Along with it go work stoppages and increased downtime of the machine. One way around it is to form longer term contracts with those employees who gain specific knowledge on the job.

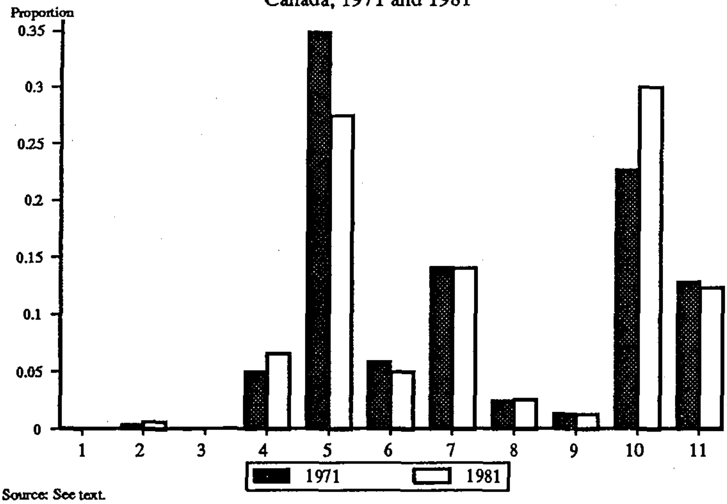
The above points relate directly to the question of firms, public and private, and their provision of engineering inputs within the firm or contracting the work out. Clearly, it cannot be expected that all engineering be done on an out-of-house basis. The dimensions of the transactions involved, their uncertainty, frequency and asset-specific nature may all give the firm incentives to provide some engineering inputs in-house.

Evidence

Estimates of consulting engineers' value added or employment relative to national totals mask the fact that engineering is done in-house by industry and government. The degree to which this is done is hard to quantify.[25] As a first approximation, figure 37 gives the proportion of engineers and architects employed in a particular division of the economy for the years 1971 and 1981.[26]

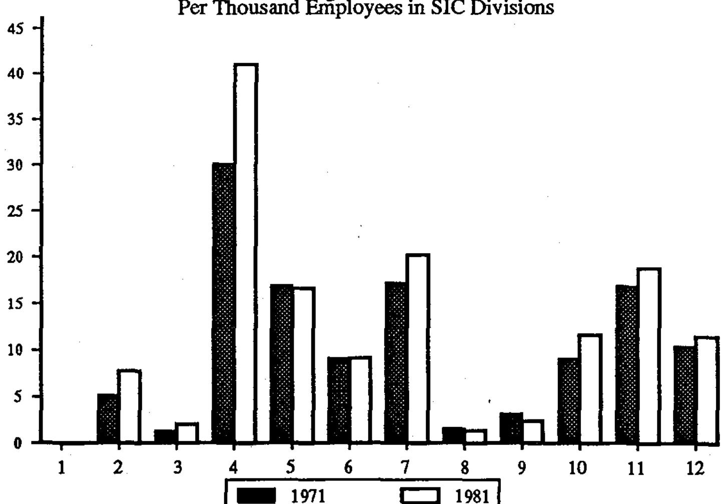
In 1971, about 36 percent of engineers and architects worked within the manufacturing industries.[27] In that same year, about 22 percent were employed within the "community, business and personal service industries."[28] In 1981, the percentage employed in the manufacturing in-

Figure 37
Proportion of Engineers and Architects Employed in SIC Division i
Canada, 1971 and 1981



Source: See text.

Figure 38
Number of Engineers and Architects
Per Thousand Employees in SIC Divisions



Source: See text.

Specialties:

1—Agriculture
2—Forestry
3—Fisheries
4—Mining, Quarrying and Oil
5—Manufacturing
6—Construction
7—Transportation, Communications and Utilities
8—Trade
9—Finance, Insurance and Real Estate
10—Community, Business and Personal Services
11—Public Administration and Defence
12—All Industries

dustries fell to 28 percent and those employed in community, business and personal service industries rose to 31 percent.[29] These are the two divisions with the largest changes, although it is apparent that over the decade the proportion of engineers in mining, quarries and oil wells grew while it fell in construction industries.

Figure 38 presents the number of engineers and architects per thousand employees in the various divisions for the two years 1971 and 1981.[30] For example, approximately 30 per 1,000 employees in mining, quarries and oil wells in 1971 were engineers. In 1981, in the same division, approximately 42 out of every 1,000 employees were engineers. This division became more "engineer intensive" over the decade.

Other divisions becoming more engineer intensive are forestry, fishing and trapping; transportation; communication and utilities; community, business and personal service industries; and public administration and defence. Overall, the nation's labour force became significantly more engineer intensive in the decade, moving from about 10.5 to 11.5 engineers per 1,000 employees.

Figures 37 and 38 taken together give a mixed answer to the so-called question of vertical dis-integration. Figure 37 shows that the proportion of engineers employed in all divisions *except* mining, quarries and oil wells and community, business and personal service industries (which includes the offices of engineers) falls from 1971 to 1981. This lends support to the dis-integration hypothesis.[31]

However, this must be leavened with evidence from figure 38, which shows that in terms of engineer intensity, as measured by engineers per 1,000 employees, the labour force in many divisions, not just community, business and personal service industries, has become more engineer intensive.

Diffusion of Technological Know-How and Information

The make or buy discussion above and the evidence on numbers and distribution of engineers as presented in figures 37 and 38 sheds light on the issue of engineers as diffusers of technological know-how and information.

If a firm wishes engineering help it may either provide it in-house or contract for it from a consultant. When the consultant has the comparative advantage—costs sufficiently low enough to overcome the transaction cost disadvantages of hiring him—the firm will hire engineering services from outside the firm. When the opposite is the case, engineering will be provided in-house. Lacking evidence on the age, education or technical qualifications of engineers in-house versus consultants hired from the outside, the presump-

tion must be that on average the diffusion abilities of each type of engineer are equal.

The evidence indicates that engineers are employed in all industries. Therefore, studies of technological diffusion through engineering services recognize that the consulting engineering industry is much too narrow to study alone on this question. The rapid growth in consulting engineering may reflect a comparative advantage based on better technological know-how, but it may also represent cost considerations which make consultants cheaper relative to in-house inputs. Evidence on human capital and other characteristics might help answer this question, but on the evidence available to date, no definitive answer seems possible.

FUTURE POSSIBILITIES FOR GROWTH THROUGH CONTRACTING OUT AND PRIVATIZATION

Private Firms

A recent *Market Perception Study* (Consulting Engineers of British Columbia, May 1986) surveyed private firms to assess the degree to which they felt they could contract out additional work. The response was that these firms felt that they had been forced by economic necessity to rationalize their operations more fully with the long run in mind. On this issue the report concluded that this avenue "should not be viewed by consulting engineers as a significant potential source of new business" (p. 32).

Public Enterprise

For consulting engineering services, little documentation is available of the extent of in-house work performed by level of government or in the private sector. The federal government has at least had a policy stance that favours contracting out. In 1981, the federal Department of Supply and Services let contracts for engineering services whose value was ten times the estimated value of in-house provision of engineering services. Although in-house provision of engineering services may be falling at the federal level, it is also true that the federal government is cutting back on capital project expenditures.[32]

In contrast to the U.S., where the Army Corp of Engineers design and build almost all defence installations, in Canada the Department of National Defence contracts with private firms for design and construction with in-house staff limited to supervisory work. Fisheries and Oceans does all fish stock assessments in-house, but otherwise contracts out all harbour dredging,

building of wharves and other infrastructure design and construction to the private sector. According to a Treasury Board study, the federal government contracted out for about 80 percent of the engineering services required in 1981.[33]

The record at the provincial level is spotty. Quebec, as has been widely noted, has contracted out over the years for most of its highways and hydroelectric sites. As a point of contrast, Ontario Hydro, the provincial Crown corporation responsible for the generation of non-nuclear powered energy, has not followed an overt policy of contracting out.

To estimate the impact these two different policies have had, consider that Hydro-Québec and Ontario Hydro are roughly the same size in terms of assets and sales, yet in 1982 consulting engineers in Quebec-based consulting engineering firms received roughly twice the fee income of Ontario-based consulting engineers for power generation, distribution and transmission work.[34] No doubt this is a factor in explaining why the more important players in the industry nationally are Quebec-based. Ontario, which has not followed similar contracting-out practices, has more consulting engineering firms, but they are, on average, smaller and do not do as much international work.[35]

A recent New Brunswick survey revealed that of all engineering and construction work being done within the province only 15 percent was undertaken by New Brunswick based firms, 20 percent by other Canadian firms and 65 percent was done in-house, either by government or private sector non-engineering firms. The situation is believed to be roughly the same in Nova Scotia. Municipal information is especially sketchy. The City of Winnipeg is known to contract out for most of its engineering services.[36]

The *MPS* cited above also surveyed public agencies and had the same negative conclusions for growth in engineering coming from the public sector.

Privatizing Government Operations[37]

Government purchasing of goods and services under contract, as opposed to the supply of these services in-house by public agencies and departments, helps to build capabilities in the private sector.[38] More importantly, it provides such services to the tax-paying customer at lowest cost.[39] However, the very process of requesting proposals and letting contracts may make it difficult to keep contract work permanently in the private sector as time passes.[40]

For government, as compared to private firms, the profit motive does not impinge with immediacy. There are rarely competing producers offering similar services to threaten the existence of the firm or management when mistakes are made. In fact, competition is often illegal. Nor is there the self-interest of ownership willing to sever poor managers from their positions. Government has different constraints under which it produces goods and services. Consequently, the decision to make or buy inputs, including service inputs, will be carried out under a different set of constraints than it is in the private sector.

Recent discussions on the limits of government provision of goods and services may help bring more engineering work into the private sector through privatizing Crown corporations and other agencies.[41] As many of these corporations and agencies, especially at provincial levels, currently do much of their engineering in-house within an agency or department, a move to the private sector by the entire agency or department would force a closer look at the make or buy decision with respect to inputs.

Privatization will probably lead to greater growth for the engineering industry than any moves toward encouraging Crown entities to "rationalize" their productive process while staying Crown owned and operated. This is because managers of government operations and departments are judged by a structure that rewards the number of employees supervised. There are no incentives for a manager to shed staff by contracting out to the private sector, rather his incentives are to maintain and build staff even in the absence of work.[42] Even when work is contracted out initially, there are incentives for the government agency to "internalize" it over time.

It would seem that the privatization of provincial and municipal engineering work and the privatization of Crown business enterprises would lead to growth in the consulting engineering industry as engineering manpower moves from government to the private sector. It is less clear that total engineering work will increase, especially in the short run. However, to the extent that public enterprises have responded slowly, if at all, to consumer demands for new services and products, there will be an increase in activity as innovation is encouraged in these sectors. Also, the movement of resources over time away from sectors where rewards were kept artificially high and toward other sectors should raise aggregate activity and spur growth.

Growth through privatization will also influence the size structure of the engineering industry as specialist engineering firms wishing to diversify will have additional engineering specialties, previously publicly provided, in which to compete for work. This increase in size, through broadened scope, allows additional pooling of risk as activity in all sectors does not peak nor trough at the same time or have cycles of the same amplitude.[43]

In British Columbia there is a strong push to privatize provincial government operations. With special interest to engineers are the plans to privatize road and bridge maintenance throughout the province.[44] Evidence is sketchy from other provinces. Some mining exploration and operating activities were privatized in Quebec,[45] and moves are afoot to put more public sector activity into the private sector in Alberta and Saskatchewan.

THE INDEPENDENT CONSULTING ENGINEER

The connection between design, planning and construction, and management of projects seems a natural one and "frequently foreign consultants have direct linkages with manufacturers and construction contractors and offer packages involving these links."[46] However, for the most part, the Canadian consulting engineering industry is not characterized by fully-integrated operations offering substantial turnkey packages featuring "made in Canada" components.[47]

Explanations of the independence of Canadian consulting engineering from more complete integration with Canadian manufacturers must lie in the economics of doing their business rather than the sometimes espoused "independent tradition" of the industry. Clearly, to offer an integrated engineer/procure/construct (EPC) package competitively, the integrated firm must be able to do so at less cost than a buyer could assemble the constituent parts separately. For Canadian engineers, the lack of such an EPC capability springs from the failure to be able to offer the entire package at lower cost.[48] The conceivable reasons for the cost disadvantage are many, ranging from higher costs at each stage of the EPC package to single component cost disadvantages outweighing cost advantages on other parts of the package.

As a simple test, observe that Canadian consulting engineers, the first stage or component in a potential EPC package, are demonstrably competitive in sales abroad. Therefore, it is in the interest of consulting engineers to avoid alliances which will lower their chances of obtaining current and future business. If engineers were to specify Canadian machinery and equipment for a job and if the cost disadvantage of these manufactured goods outweighs the cost advantage of the engineering input, the buyer would be less likely to buy Canadian engineering currently and in the future. There is no hesitation on the part of Canadian consulting engineers in recommending Canadian machinery and equipment when the products are suitable and cost effective for the job, however, there seems to be little interest in being coerced into recommending Canadian goods just to get export assistance from the government.[49]

To see why a competitive consulting engineer need be very vigilant in the cost and applicability of the equipment and products he specifies, remember the *ten percenter* nature of his position in the cost structure of a project. Suppose the total cost of a project is $100. Let engineering costs be $10 of the total, and all other costs sum to $90. If all other costs rise from $90 to $91, a rise of 1.1 percent, engineering costs must fall 10 percent to $9 to keep total costs $100. Therefore, contemplating a recommendation of plant and equipment that costs just over one percent more than that offered by alternative suppliers would necessitate a 10 percent drop in the fees accruing to the engineer in order to keep the job and be considered for future projects. Unfortunately, Canadian goods are not always that closely priced to alternatives offered by manufacturers in other countries.[50] Consequently, there is an independence of the competitive consulting engineers from the sometimes non-competitive manufacturing sector—an independence better understood by appealing to the economics of the sector. Any policy to alter industry structure must be done so as to make a Canadian EPC presence more competitive through changes which make project costs, other than engineering costs which are competitive, competitive with those of other international suppliers of manufactured goods. A lowering of trade barriers is probably the single most effective method of forcing Canadian manufacturers to deal with their higher cost structure.[51]

IMPORTANCE OF THE INFORMATION REVOLUTION FOR RECENT FIRM FACTOR INPUT DEVELOPMENTS

The extent and impact of computer-aided design and drafting (CADD) technology is very hard to quantify. A survey done in the U.S. indicates that 47 percent of respondents in the architecture/engineering design industry used CADD technology in 1985, up from 40 percent in 1984.[52]

Cost savings are equally hard to measure, but the common feeling is that CADD allows increases in productivity on an order of magnitude of at least four to one.[53] The advantages are in the facility with which impacts of incremental changes in design and cost are assessed. The design process is more interactive with clients, consequently, industry representatives feel that "the customer wants CADD so you have to have CADD."

In the engineering office, getting the experienced designers onto CADD technology has changed the input combination between professional engineers and technicians/draftsmen. In 1974, 45.7 percent of the staff were technicians and draftsmen, while 28.7 percent were professional engineers. By 1982, the percentage for technicians/draftsmen had fallen to 40 percent and that of professional engineers had risen to 32.1 percent.[54] The rise in the

ratio of professional engineers to technicians/draftsmen was on the order of 33 percent over that period.

This change in proportions has been characterized as "narrowing the base of the pyramid." In the past, as a rule of thumb, one professional engineer at the top of the pyramid was supported by three draftsmen at the base. With the introduction of CADD, one professional engineer needs fewer draftsmen in support.

SUMMARY

This chapter ranges over the industrial organization of the consulting engineering industry. The industry appears to be competitive in the sense of having low concentration ratios, with the top four firms generating roughly 30 percent of the industry's revenue. Equally important, entry barriers into the industry are limited only by the licensure of the profession. Over the 1978 to 1984 period, there has been a growth in the number of firms and that growth has been at rates greater than that for firms in all industries. This growth has been concentrated mainly in the number of mid- and smaller-sized firms.

The tradition of the independent engineer—independent of providing goods as well as the engineering service—is explained by reference to the general conditions in the manufacturing sector. The lack of competitiveness of the domestic manufacturing sector probably explains most of the reason Canadian consulting engineers remain independent relative to foreign engineers.

Currently, more than three-quarters of all professional engineers are employed outside the offices of engineers. The industry, defined as offices of engineers, will expand if engineering now done within government and private business shifts to the private consulting sector. Whether or not this happens depends on relative costs for private firms currently providing their own engineering services. Survey data suggest this avenue of growth, while real, is limited. At any rate, it is likely to be incremental growth, not sudden sharp increases or decreases in industry activity that typifies this industry.

For governments, moves toward privatizing services indicate growth potential and an absolute increase in size for the consulting engineering sector. To the extent that engineering intensive activities are privatized, private industry will grow. However, this growth in demand carries with it the growth in supply of engineers to fill it. Engineers presently employed in the government sector will presumably shift to employment within the private engineering industry.

Longer run predictions are less easy to make. Questions of public versus private sector productivity, wage levels and the like are all factors. In any event, it is unlikely that government privatizations, especially at the provincial level, will lead to a more highly concentrated industry.

Finally, the ratio of technicians and draftsmen to professional engineers is changing as advances in computer-assisted design and drafting are incorporated within firms. This indicates a changing factor mix within the industry toward professional engineers and away from lesser skilled inputs.

NOTES

1. See D. DeMelto, "Discussion: Consulting Engineers and Architects," in McKae, J.J. and Dasbois, M.M. (eds.) *Traded and Non-Traded Services: Problems of Theory, Measurement and Policy*, Institute for Research on Public Policy, Victoria, B.C., 1988.
2. This section is based on The Engineering Profession Act of Saskatchewan, Chapter E-10; The Engineers Act, 1979, RS Chapter 109, of British Columbia; and the Professional Engineers Act, Bill 123, Chapter 13, Statutes of Ontario, 1984. Other provinces and the territories have similar clauses, penalties, et cetera, with respect to the practise of engineering.
3. In "Occupational Licensing and Professional Incomes in Canada," *Canadian Journal of Economics*, XIII, no. 4, November 1980.
4. See Y. Barzel, "Measurement Cost and the Organization of Markets," *Journal of Law and Economics*, vol. XXV, April 1982.
5. See G.A. Akerlof, "The Market for 'Lemons': Qualitative Uncertainty and the Market Mechanism," *Quarterly Journal of Economics*, vol. 84, pp. 488-500, August 1970.
6. This result is even more striking given the fact that LEAP data do not include single person firms.
7. This cannot be compared with earlier surveys as all three survey years used identical *nominal* dollar classes. Unfortunately, when the value of a dollar changes over time it makes little sense to compare two or more size distributions from different years based on the same nominal dollar classes.

   Deflation into constant dollars does not help. The class boundaries defined in nominal dollars have different real values one year to the next. Consequently, one would have to arbitrarily assign firms across constant dollar classes. This is clearly unacceptable.
8. Source for both figures 28 and 29 is the industry survey done by Statistics Canada for 1982, table 9, p. 29.
9. See C. Green, *Canadian Industrial Organization and Policy*, 2nd ed., McGraw-Hill Ryerson Limited, Toronto, 1985, pp. 59-72.
10. Only Newfoundland, Prince Edward Island and the Northwest Territories have no associations for consulting engineers.
11. *Canada Consulting Engineers*, 14th ed., vol. 1, 1986. Association of Consulting Engineers of Canada, 130 Albert Street, Suite 616, Ottawa, Canada, K1P 5G4, p. xv.
12. At least not to me.

13. Since membership is voluntary, I do not mean that trade organizations do not properly represent members. However, relative to the industry, distribution of membership in the Ontario CEO differs somewhat.

14. Address: 1015 Fifteenth Street, N.W., Washington D.C. 20005.

15. While the class sizes are not identical with those in figure 31, they are close enough to make useful comparisons.

16. To the degree that "other engineering and scientific services" establishments have had greater birth and growth rates than "offices of engineers," when the LEAP data is used as a proxy to illustrate changes in "offices of engineers," it will overstate activity in the narrower engineering industry of interest here. One could, alternatively, use data from the quadrennial surveys, however, that suffers the obvious shortcoming of numbers and percentages responding differing from survey to survey. As well, survey data do not identify continuing firms, new firms and the like. Given these problems, the LEAP data were used in this section with the caveat that activity in the growth of "offices of engineers" is only imperfectly proxied by LEAP data.

17. Indeed, census data would seem to indicate that at least three-quarters to eight-tenths of engineers are employed in industries other than consulting engineering.

18. For example, some of the fastest growing firms in Michigan are engineering firms supporting automobile manufacturing. See, "Two Tier Workforce and Outside Contractors," *Wall Street Journal,* May 4, 1986.

19. This results from the way the illustration is set up and is intentional. It is important to note that there are real reasons firms choose to switch inputs from in-house to out-of-house provision and vice versa. Costs are expected to fall. If this indeed happens, national output rises through more efficient factor use and combination. With larger national incomes and output, it may well be that there is further demand for the input due to an increase in demand for products it helps produce. This is real growth and not a statistical illusion.

20. The literature is voluminous, but see O.E. Williamson, "Transaction-Cost Economics: The Governance of Contractual Relations," *Journal of Law and Economics*, vol. XXII(2), October 1979, pp. 233-261.

21. See R. Eccles, "The Quasifirm in the Construction Industry," *Journal of Economic Behavior and Organization,* vol. 2, December 1981, pp. 335-358.

22. See K. Monteverde and D. Teece, "Supplier Switching Costs and Vertical Integration in the Automobile Industry," *Bell Journal of Economics,* 13, Spring 1982, pp. 206-213.

23. See S. Masten, "The Organization of Production: Evidence From the Aerospace Industry," *Journal of Law and Economics,* 27 October 1984, pp. 403-417.

24. In the same way that "no one knows my car like I do."

25. A request for such data was contained in the first set of recommendations in *Realizing the Potential,* S.J. Cunliffe, Chair (1982), a report of the Canadian Consultative Committee on the Canadian Consulting Engineering Industry to the Department of Industry, Trade and Commerce and Regional Economic Expansion. Recommendations 1, 4, 7, 8, 9, and 10 deal specifically with the issue of quantifying the amount of work contracted out at federal, provincial and municipal levels of government as well as in the private sector. Recommendation 1 is representative:

> That a task force be set up under the direction of the joint Association of Consulting Engineers of Canada (ACEC)/Department of Regional and Industrial Expansion (DRIE) Committee with a sufficiently comprehensive membership to determine:
>
> a) The total amount of engineering done in Canada in-house by federal, provincial and municipal governments including their various agencies, universities, utilities and crown corporations.
>
> b) The amount of engineering done in-house in Canada by construction, industrial and manufacturing corporations.
>
> c) The proportion of the engineering identified in (a) and (b) that could conceivably be done by the consulting engineering industry.

The government's response to the entire Cunliffe report is contained in *Response of the Federal Government to the Recommendations of the Consultative Committee on the Canadian Consulting Engineering Industry,* authorship unknown, September 1983.

The response to the recommendation quoted above is as follows:

> The Department of Industry, Trade and Commerce and Regional Economic Expansion (ITC/REE) carried out a preliminary survey of in-house work of some 15 federal government departments and agencies during the work of the committee. While a global estimate was developed as stated in the report, major limitations were also

> identified relating for instance to difficulties in defining the work contracted out. The survey demonstrated, however, that substantial progress has been achieved in the volume of work contracted out by the federal government. Further, departments continuously evaluate their practices in order to better meet the requirements of the policy.
>
> The government recognizes the need to improve the referenced data base. However, the costs of generating more detailed statistics on federal departments contracting-out activities may not be warranted considering the available estimates. It is proposed that the ITC/REE survey should be maintained up-to-date annually. Further, ITC/REE will cooperate in initiatives undertaken by the ACEC/Industry and Trade Liaison Committee to develop improved statistics with respect to contracting-out for other government levels and other industry sectors (p. 1).

There is little evidence that systematic, annual statistics exist on this issue despite the proposal to maintain the ITC/REE survey on an annual basis. Of course, ITC/REE has metamorphosed several times since the above words were written.

26. Recall that in 1981 the census total of engineers was approximately 135,000 (architects, about 6,000). For 1971, engineers about 83,000, architects, about 4,200.

    Sources for figure 38: for 1981, Statistics Canada, *Population—Labour Force-Industry by Occupation,* catalogue 92-923, vol. 1, February 1984; for 1971, Statistics Canada, unpublished census, database tabulation.

27. It should be noted that some of these engineers working within some industries, primarily manufacturing and utilities, are in divisions of companies that act as consulting engineering arms of the company. For the purposes of Statistics Canada and the voluntary consulting engineering organizations, these engineers are not categorized as being in the consulting engineering industry at all.

28. About 14 percent of the total of engineers and architects were employed in the offices of engineers, SIC 864, in 1971. This was about 67 percent of the total working in the community, business and personal service industries.

29. Again, about two-thirds of those were in SIC 864, offices of engineers.

30. Sources: for 1981, Statistics Canada, catalogue 92-923, vol. 1, Feb. 1984; for 1971, Statistics Canada, 1971 Census, catalogue 94-739, vol. III, part 4, May 1976.

31. Also lending support is the fact that in 1971 about 11,800 engineers worked in the offices of engineers. In 1981 that figure had risen to about 27,000, an increase of 15,200. The increase in total engineers over the decade was approximately 52,000. Therefore, approximately 30 percent of the increase in numbers went to work in SIC 864, offices of engineers. This propels the proportion of the nation's total engineers working in the offices of engineers from 14 to 21 percent as noted above—a 50 percent growth. No other subdivision or division had comparable figures.

32. *Market Perception Survey*, 1986, p. 9.

33. Excepting work done by the Atomic Energy Commission Limited which does a great proportion of its engineering work in-house.

34. Statistics Canada, 1985, p. 27.

35. Contracting out and large federal government funded export contracts alone do not ensure profitability and success for the private firms involved. Good management practice, luck and skill all play roles. This is apparent in Quebec where two of the "Big Three" have followed a very different road than the third firm. Two of the firms diversified away from engineering, purchasing other businesses, including manufacturing compact discs and producing ammunition. The third firm, buying minority interests in some other lines while focusing on engineering, has not weathered the recent recession nearly as well.

36. Attempts have been made to use Canadian Engineering Manpower Board Inventory data to quantify some of these magnitudes, but the data are unreliable. Response rates are about 50 percent, and some of the results are quite anomalous. For example, in the March 1987 Inventory, under "technical services," Quebec lists 48 licensed engineers in the utility-electric category. In the same category, Ontario lists 784 licensed engineers. This would seem to corroborate the Quebec Hydro contracting-out story with a vengeance. However, under provincial/territorial government, Quebec lists 3,328 to Ontario's 275 licensed engineers. It is not impossible to assume that some Quebec Hydro engineers have placed themselves in the category of provincial employees.

37. Some might argue that if government is going to be the manufacturer and provider of goods and services, then input use is optimal as currently arranged. That is, arguments against contracting out, given government provision, may be valid. All this says is that given the constraints under which they work, governments are efficient. Even if the argument of efficient government is accepted, overall efficiency in the economy may be encouraged by making governments smaller through

their giving up the role as manufacturer, a role for which they may not be particularly well suited.

38. The reader should take care to note that in what follows I am not saying that government provision has necessarily been bad for the consulting engineering industry. If governments have spent tax dollars on capital and other "engineering intensive" projects to a greater extent than private citizens would have, and if engineering on these projects has been contracted to private sector engineers, then it is certainly the case that government has benefited private consulting engineers relative to the private market. This may explain the nature of consulting engineering in Quebec relative to other provinces—Ontario and British Columbia come to mind—where large project development was done in-house by government.

    Whether or not all the links in the above chain are connected is another matter. The large numbers of engineers in government would indicate that all the links are not connected. Ultimately, if governments spend tax dollars in a different fashion than taxpayers would have, the mix of output is different and certain producers and consumers benefit at the expense of others. This naturally brings to mind the public choice aspects of political markets and the role of lobby and trade organizations in the political process.

    The comments of one reviewer on the first draft of this work are instructive: "In Quebec it is clear that the growth of its engineering industry owes much to the state, whether one approves of such interference or not. This private sector/public sector complicity may be gauged, for example, by simply looking at the number of ex-ministers employed by Lavalin. This complicity is often informal, difficult to measure, but exists nonetheless. If we could do a re-run of history, it would be interesting to see how the Quebec engineering industry would have fared without the nationalization of Hydro-Québec, without important public investments in l'Ecole Polytechnique, without CIDA?"

39. See J. McDavid, "Privatizing Local Government Services in Canada," in M.A. Walker, ed., *Privatization: Tactics and Techniques, Proceedings of an International Symposium*, The Fraser Institute, Vancouver, B.C., 1988.

    McDavid found that the contracting out to private firms of municipal services such as solid waste disposal leads to smaller crews and larger vehicles being used relative to public waste disposal. For this and other reasons, McDavid finds costs were lower for private firms than they

were for public departments at the same quantity and quality levels of service in the same jurisdictions.

These results are not found only in Canada. In C.F. Valente and L.D. Manchester, *Rethinking Local Services: Examining Alternative Delivery Approaches*, The International City Management Association, Washington, D.C. 1984, it is demonstrated in 32 different case studies in the U.S. that private alternatives to government production are less costly per unit of service for taxpayers. These cases include public works and transportation services, public safety services, health and human services, parks and recreation services and other support services.

40. This is because contracts require monitoring/supervision and this requires personnel. Over time and contracts, supervisory personnel build up specialized skills. These skills are in the language or specifications of requests for proposals (RFP) and contracts. Having to "train" every private bidder to write in the idiosyncratic argot they have chosen may make public engineers think that they, rather than private providers, can perform the entire job faster and at less expense. This leads to larger staffs in public departments and fewer and smaller contracts let out to the private sector over time. The intent is not malicious, but the process of empire building is insidious. My prediction is that work that is contracted out to the private sector by government departments will be more often on a subcontract basis, relatively small in value and ultimately "internalized" and performed within the government departments. This leads to larger and larger government departments.

41. A wide variety of services at all levels of government may be provided by the private market. For example, in the U.K., the Ministry of Transport has selected a proposal for the private design, financing, construction and operation of a bridge over the Thames. See "U.K. Will Build Its First Privately Funded Bridge," *Engineering News Record*, October 9, 1986, p. 18.

On an even larger scale, the private sectors in both France and Britain have been licensed by their respective parliaments to fund, build and have sole rights until the year 2020 to the channel tunnel linking the countries. See "Lots More Chunnels" and "The Channel Tunnel," both in *The Economist*, October 10, 1987, pp. 13 and 21-24.

In the U.S., the State of South Carolina is requesting proposals for the private financing, designing and building of prisons. "It opted to privatize the job when it became clear that it had exhausted its general obligation bond funding capacity and that no new bonds could be issued soon." See "A Private Prison Job Placed on the Docket," *ENR*, August, 6, 1987, p. 14.

42. In addition to being constrained by public sector union agreements, public sector union contracts often inhibit the letting of contracts to outside consultants. For example, in British Columbia, article 29 of the provincial government's agreement with the B.C. Government Employees' Union, respecting the letting of work, specifies that all work be done in-house unless there are no qualified and able people within the bargaining unit capable of performing the work.

    McDavid finds a higher capital/labour ratio for private versus public firms. In other words, the public firms use more labour per unit of output than do the private firms.

    The *Market Perception Study* also concluded that government sources felt that there is little scope for increasing the amount of work done out-of-house. Of course, managers and department heads would have an interest in claiming that employment in their department had been pared to the bone and could go no lower.

43. Under public ownership, the Crown corporation is often hesitant (or unable due to public sector contract clauses) to lay-off or release employees when demand for the product declines. In such cases, the Crown corporations (i.e., taxpayers) bear all the risk of doing business. Without a bottom-line profit motive to guide its actions, any reorganization of inputs is likely to be slower and less exacting than under private ownership.

44. Highway and bridge maintenance is currently done by the private sector on a large scale in the United States. About one-quarter of the estimated (US) $4.8 billion worth of expenditures on highway and bridge maintenance to be done in 1988 is to be done by private contractors. This is up 14 percent from 1987. See G. Mason, "States Using Contractors for Road Repairs," *Vancouver Sun*, January 27, 1988, A10. The story quotes a recent issue of *Engineering News Record* as the source.

45. See P. Matuszewski, "Partial Public Privatization in Quebec, SOQUIEM/CAMBIOR," in M.A. Walker, ed., *Privatization: Tactics and Techniques*, The Fraser Institute, 1988.

46. See *Realizing the Potential*, 1982, pp. 83-84.

47. The exceptions to this are the largest companies. Therefore, in terms of total industry revenue as opposed to number of firms the statement in the text may be misleading. "Turnkey" refers to the type of project where the engineer provides all the services and construction, delivering a plant, dam or whatever, that is ready for operation by just "turning the key."

48. As noted above, the largest Canadian firms in the engineering industry offer a competitive EPC capability. However, relative to the U.S., the structure of the Canadian engineering market is not as EPC-oriented.

49. This view was made clear in conversations with consulting engineers. One other factor these engineers made clear was that much of what appears to be "Canadian" manufacturing is foreign owned and controlled. Therefore, trying to put together a package often involves dealing not with the Canadian office but with the home office in, for example, the United States. It is the structure of the Canadian manufacturing sector that explains, to a large degree, the independence of the consulting engineer in Canada.

    There is evidence that Canadian manufactured machinery and equipment is less competitive relative to its engineering services abroad. For example, note that Canada has run a deficit (value of imports greater than the value of exports) in real, 1981 dollars, of $100.352 billion from 1978 to 1987 on the machinery and equipment account. This averages out to a deficit of $10 billion per year over that period. As shown elsewhere, Canada's engineering trade balance is in surplus.

    Source: "Report on the Nation," Outlook '88, *Financial Post*, Winter 87/88, p. 104.

50. Nor is this foreign cost advantage a factor in export work alone. The power turbines purchased by B.C. Hydro for use in the Peace River dam were supplied by the U.S.S.R.

51. These considerations also indicate that the engineering industry is not likely to be a great generator of "follow-on" exports, the export of manufactured goods following after service exports.

52. *U.S. Industrial Outlook 1987—Architecture/Engineering*, U.S. Department of Commerce, p. 65-1.

53. A. Radford and G. Stevens, *CADD Made Easy*, McGraw-Hill, 1987, p. 275. See also "The Integrated Office," *B.C. Business*, September 1987.

54. Statistics Canada surveys on the industry for 1974 and 1982, catalogues 63-528, occasional, and 63-537, occasional, respectively.

CHAPTER 5

CHARACTERISTICS OF THE ENGINEERING LABOUR FORCE

INTRODUCTION

Earlier chapters give the reader a feel for the size, location, structure and growth potential of the consulting engineering industry. While there was reference to the size and location of the work-force, specific characteristics were not covered. This chapter is about who the engineer is, where he works, and what his area of specialization is.

There are several issues of interest from a broader perspective which this view will help address. Age, educational attainment and the sex of engineers are covered in detail. Areas of engineering specialization as well as location of employment are revealed. Rates of remuneration by province and specialization are discussed. This latter topic is important when considering the "bi-modal income hypothesis," which is often raised when considering the service economy.

CHARACTERISTICS OF EMPLOYEES

Sex

The field of engineering has been, and remains, overwhelmingly populated by men. The census of 1941 shows that, in Canada, there were no female engineers. The proportion of the 142,000 engineers and architects that were female in 1981 was 6 percent, up from 1.65 percent in 1971.[1]

Occupation by Industry

To focus more clearly on the consulting engineering industry, census data allow the calculation of the proportion of total employment of engineers employed in offices of engineers and other scientific and technical services

establishments for the year 1981.[2] SIC 864 more closely approximates the industry of interest than does the broader occupational classification which includes engineers working in all manufacturing and service industries. In 1981, approximately 27,500 engineers worked with SIC 864, about 20 percent of the total. A further breakdown shows that about one-third of all civil engineers and 25 percent of all mechanical engineers are employed in SIC 864.

The ratios for men and women appear to differ significantly in the total for engineers. While slightly more than 20 percent of male engineers are employed in SIC 864, only about 15 percent of female engineers are similarly employed.

Age

Age profiles of the two sexes for 1981 provide an explanation for the difference in employment noted above. Highlighting the recent nature of female participation in the field, there is a skewed distribution towards youth in the population of women in engineering. As of 1981, fully 52 percent of the women and only 24 percent of the men in these two occupations were 29 years of age or younger. At the other end of the distribution, 30 percent of men and about 11 percent of women were 45 years of age or older.[3] Being younger on average, women are less likely to have acquired the experience working in the field necessary to enter the consulting profession. On average, women in engineering are younger than women in the labour force as a whole. For men, the opposite is true.

Education

In terms of educational attainment, census data show slightly more than 60 percent of engineers in 1981 possessed a university degree. This result was invariant across the sexes. These figures are far higher than the average of 30.8 percent for the community, business and personal service industry as a whole.

Type of Worker

Classified by type of worker, labour force data for 1981 show that roughly 83 percent of engineers are paid workers with the remaining 17 percent self-employed, most with incorporated businesses.[4]

CHARACTERISTICS OF THE LABOUR FORCE EMPLOYED

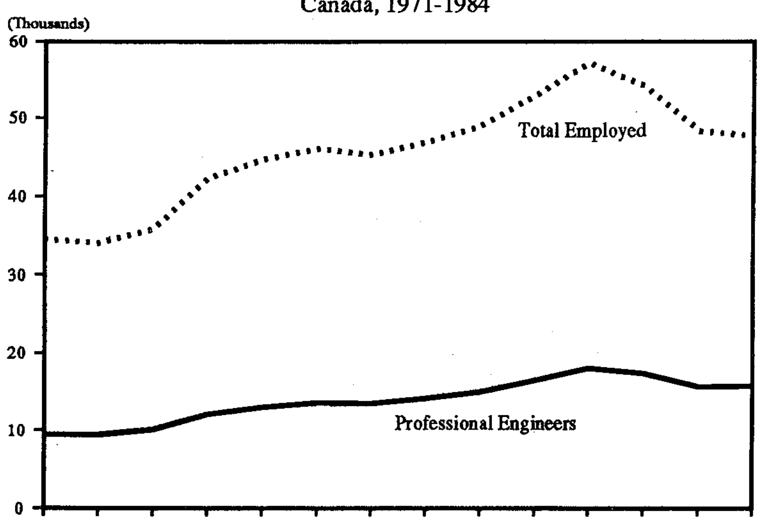
Number of Employees

The surveys dissected to this point to reveal some of the inner details of the consulting engineering industry have one great flaw. The coverage is less than perfect. Census data, on the other hand, while much more complete, allow individuals to self-classify their occupation. As a consequence, survey results undoubtedly understate the number of consulting engineers and the total employment in the industry, while census data may well overstate that number.

A third source, mentioned earlier, is Statistics Canada publication *Employment, Earnings and Hours*, catalogue 72-002, monthly. This is the result of monthly survey/interviews of a sample of establishments.[5] Finally, a private organization, the Canadian Engineering Manpower Board (CEMB), has begun publishing an Inventory of Professional Engineers. The inventory for 1986 is a "study of a sample group of engineers."[6]

Figure 39 based on Appendix 10 presents an estimate of total employment and number of consulting engineers in the offices of consulting engineers for the years 1971 to 1984.[7] Industry employment has fluctuated absolutely, not just in growth rates over the 13-year span. The impact of the recession of the early 1980s is evident.

Figure 39
Employment in Offices of Consulting Engineers
Canada, 1971-1984



Source: Estimates from Statistics Canada 72-002.

Figure 40 presents indices of employment, both total industry and professional engineers. From this figure, it is clear that the number of professional engineers has grown at a faster rate than employment in the industry in total.

Employee Mix

Figure 41, derived from the Statistics Canada surveys, gives information on the mix of personnel in consulting engineering firms. The rising proportion of professional engineers is evident as is the decline in proportions of technicians and other professionals.[8]

Education

Figures 42 and 43, derived from 1981 Census sources, give the highest level of educational attainment in age groups, 15 to 24, 25 to 44, and 45 to 64 as a proportion of the size of each age group for both sexes.[9] For example, in figure 42, roughly one-half of those males aged 45 to 64 have at least one university degree, and about 19 percent have "some university." For women, the proportion in the age group 45 to 64 with at least one university degree is substantially lower.[10]

EMPLOYMENT IN THE INDUSTRY

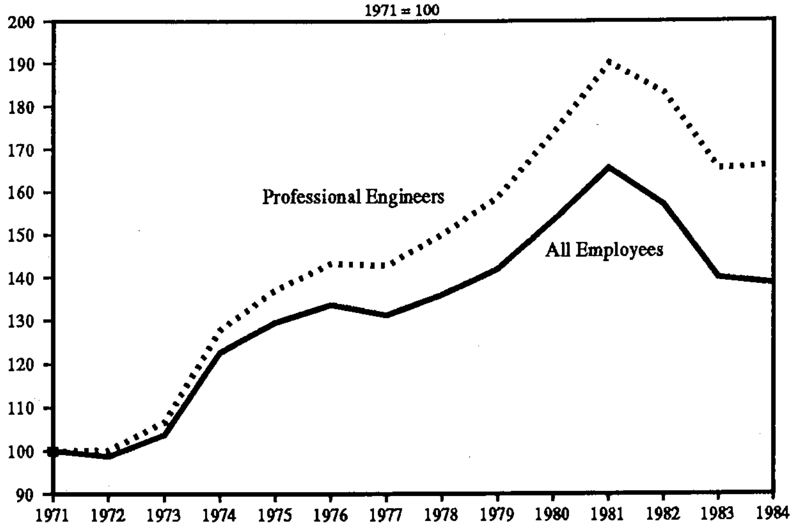
Survey Data by Regions

As shown in figure 18, employment in consulting engineering as a proportion of the total employed varies widely from survey year to survey year, especially in Quebec and the Western region. The influence that relatively few very large projects may have in any one year is evident here. Also readily apparent is the much lower ratio of engineers per total employed in the Atlantic provinces relative to the other regions.

Census Data by Regions

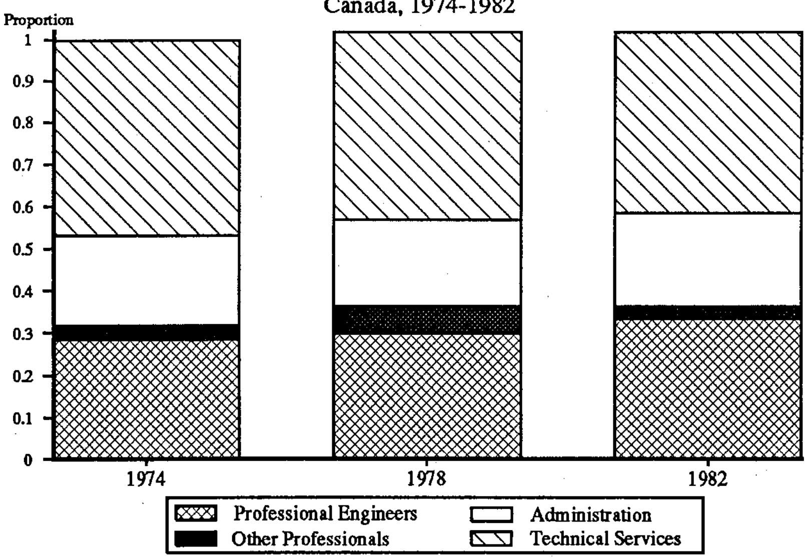
Census data provide another look at the regional employment question. In figures 44 and 45, the total number of self-reported engineers, architects and labour force as a whole per region are given relative to total engineers, architects and national labour force. For example, figure 44 gives data from the Census of 1971. The Atlantic region had about 8 percent of the national labour force, 5 percent of all architects and almost 5 percent of the nation's engineers. Those percentages do not change over the decade 1971 to 1981 as

Figure 40
Indices of Employment in SIC 864
Canada, 1971-1984
1971 = 100



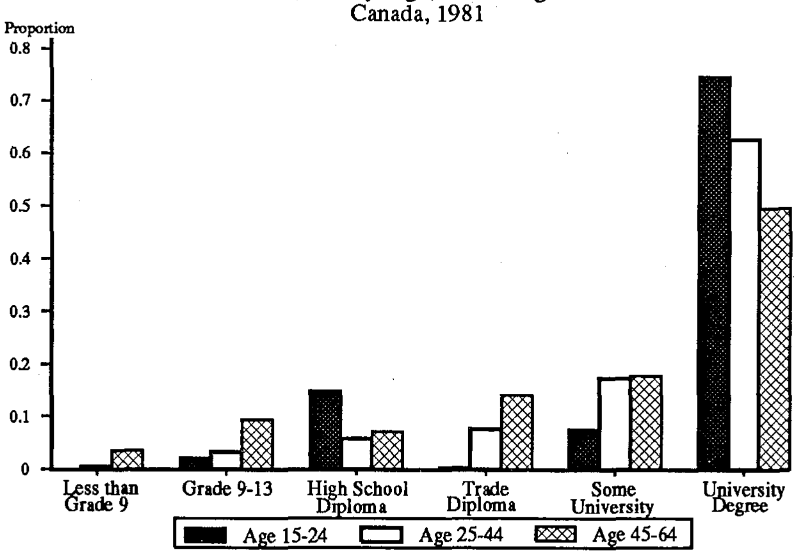
Source: Estimates from Statistics Canada, catalogue 72-002.

Figure 41
Personnel of Consulting Engineering Firms
Canada, 1974-1982



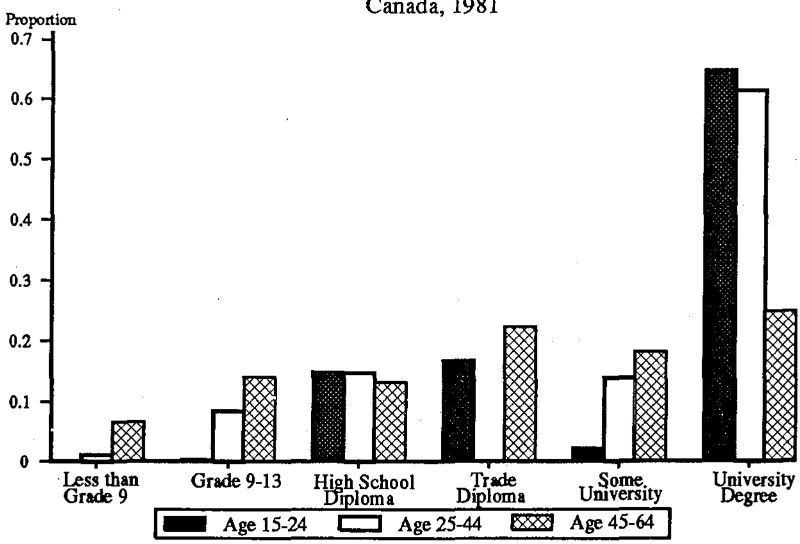
Source: Statistics Canada industry surveys.

Figure 42
Education by Age, Male Engineers
Canada, 1981



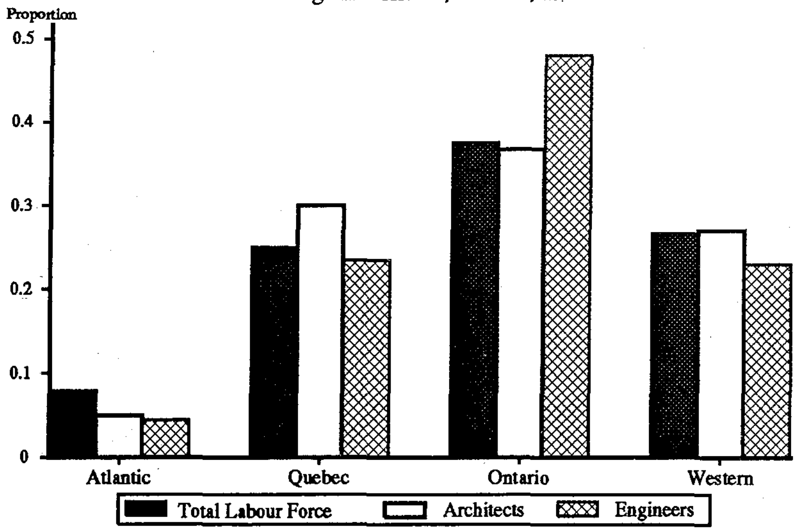
Source: 1981 Census of Canada, catalogue 92-917.

Figure 43
Education by Age, Female Engineers
Canada, 1981



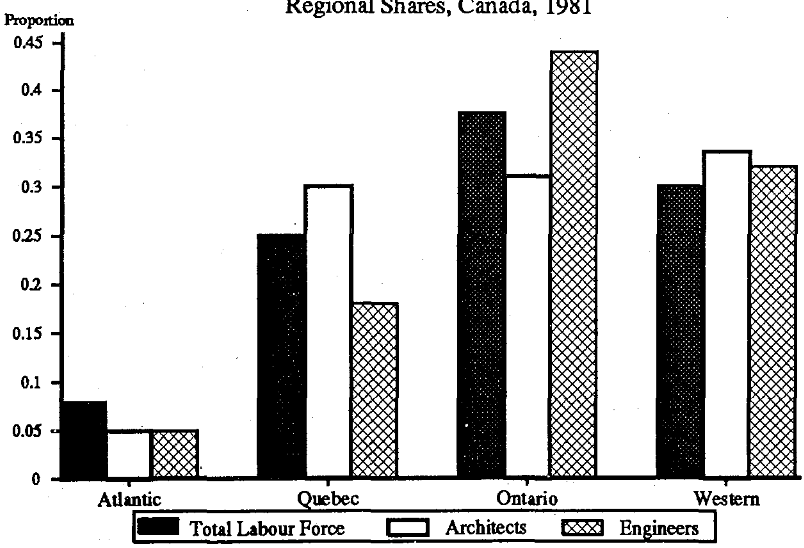
Source: 1981 Census of Canada, catalogue 92-917.

Figure 44
Proportion of Employment
Regional Shares, Canada, 1971



Source: 1981 Census of Canada, catalogue 92-920.

Figure 45
Proportion of Employment
Regional Shares, Canada, 1981



Source: 1981 Census of Canada, catalogue 92-920.

a comparison with figure 45 shows. However, in Quebec, the proportion of the national labour force stays around 26 percent while the percentage of engineers falls from 24 to 19 percent of the nation's total. In Ontario, the proportion of the nation's engineers is above the proportion of the nation's labour force, and in the West there has been a dramatic rise in the proportion of engineers relative to the proportion of the nation's total labour force resident in the West.

Figures 46 and 47 detail the proportion of engineers with a particular specialty, living in a particular region, for the census year 1981. Of all the mechanical engineers, 4 percent lived in the Atlantic region, 16 percent lived in Quebec, 55 percent lived in Ontario, and about 25 percent lived in the Western region.

These figures give a feel for what type of engineering is especially important in a region, at least based on engineering residents' specialized talents relative to the national total. The glaring disparity is the overwhelming preponderance of petroleum engineers resident in the Western region. Approximately 90 percent of the nation's petroleum engineers lived in the Western region during the 1981 Census. In the Atlantic region, civil and electrical engineers are the best represented of all the specialties at about 8 and 7 percent, respectively. The Western region has the highest proportion of civil engineers, with about 40 percent of the total, and Ontario has the highest proportion of electrical engineers, with about 50 percent of the total.

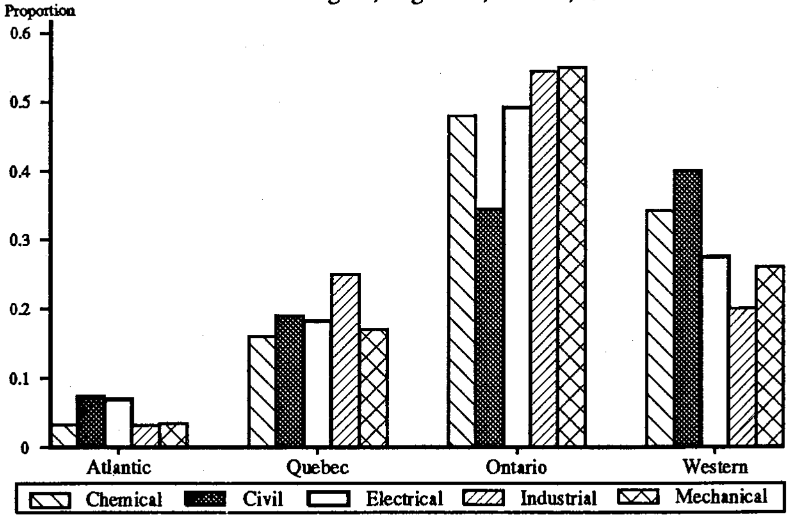
Finally, figure 48 reveals the pattern of specialties of the engineers *within* a region. For example, of all the engineers in the Atlantic region, approximately 33 percent are civil engineers, 25 percent are electrical engineers, 12 percent industrial engineers and so on. The Western and Atlantic regions have higher proportions of civil engineers and lower proportions of industrial engineers than do Ontario and Quebec, reflecting the relatively weaker industrial base of the outermost regions. The proportion of mining and petroleum engineers within the outermost regions, on the other hand, is greater than it is in the central regions. Again, this reflects the resource base of the West and Atlantic provinces relative to the nation's centre.

EARNINGS AND INCOME

The Issue

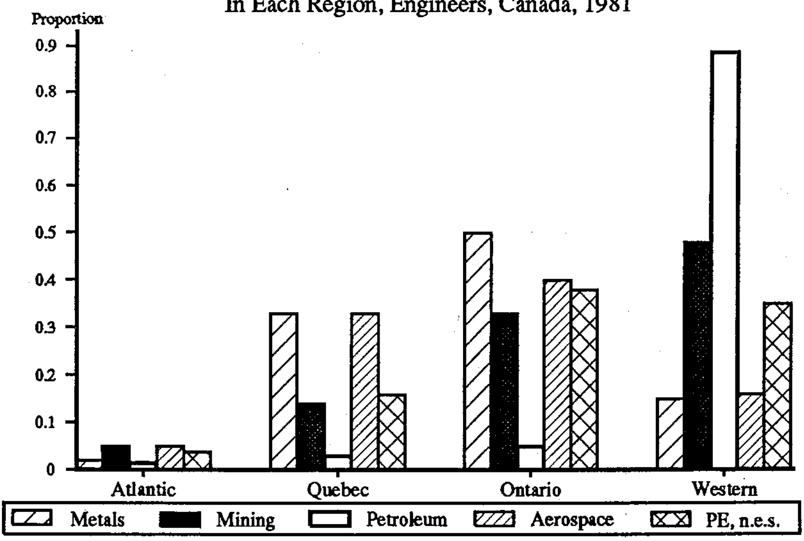
An issue raised in discussions of the service-oriented growth in western economies has been the nature of the resulting income patterns. Several authors make the claim that in the American economy a situation is occurring where income patterns are becoming bi-modal, resulting in a shrinking

Figure 46
Proportion of Total Sub-Field Employment
In Each Region, Engineers, Canada, 1981



Source: 1981 Census of Canada, catalogue 92-920.

Figure 47
Proportion of Total Sub-Field Employment
In Each Region, Engineers, Canada, 1981



Source: 1981 Census of Canada, catalogue 92-920.

middle class.[11] Most, if not all, of that work is based on a final consumer demand view of services. A view from consumer services makes the possibility of a dichotomous distribution, featuring low wage service jobs at the fast food counter and high wage managerial jobs, seem likely. It is not as clear that these authors have gone beyond consumer services to producer or even government services.[12] In this section, a short examination of income distributions in engineering will be presented to test the bi-modality hypothesis in a knowledge intensive, producer service setting.

Income Distributions from Census Data

Figure 49 shows the absolute number of engineers and architects, Standard Occupational Classifications (SOC) 214/215, and engineering technologists and technicians, SOC 2165, with earnings in 1980 in a given income class.[13] The third line in the figure plots the sum of the two SOCs, 214/215 and 2165. There were approximately 130,000 males in SOC 214/215 with employment income. Of those, more than 50,000 had incomes of $30,000 or more. The absolute number of men in SOC 2165 was 44,705 in 1980.[14]

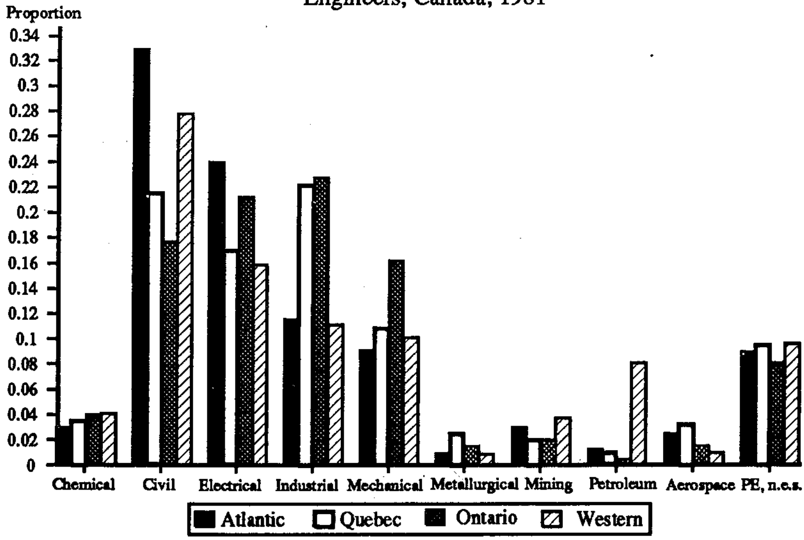
Figure 50 shows the proportions in each of the SOCs, 214/215 and 2165, and the sum of the two that fall in the various income classes. Nearly 40 percent of engineers and architects earned in excess of $30,000, their mode, in 1980. Of SOC 2165, the mode, about 25 percent, was in the $20,000 to $25,000 income range.

Figure 51 contrasts the distribution of the sum of SOCs 214/215 and 2165 with that of the male labour force having employment earnings in 1980. It is evident from the figure that engineers and engineering technologists and technicians have a far higher proportion of the members of their SOC earning in excess of $30,000, about 33 percent, relative to those in the male labour force as a whole, where 11 percent fall in that highest of income classes.

Table 3 lists the average and median income levels for the engineering, engineering technician/technologists and male labour force as a whole. The table also includes the average income for those in the various groups who were full-time, full-year employees. From the table it is clear that engineers have a substantially higher average employment income than either technician/technologists or the average male income earner. Technicians/technologists average employment earnings are much closer to the labour force average. The above facts are true for the groups of full-time, full-year employed as well.

If past trends in employment in the offices of engineers continue, we may expect to see the number of technicians and technologists relative to en-

Figure 48
Distribution of Employment Within Occupation Within Region
Engineers, Canada, 1981



Source: 1981 Census of Canada, catalogue 92-920.

Figure 49
Distribution of SOC 214/215 and 2165 by Income Range
Canada, 1980

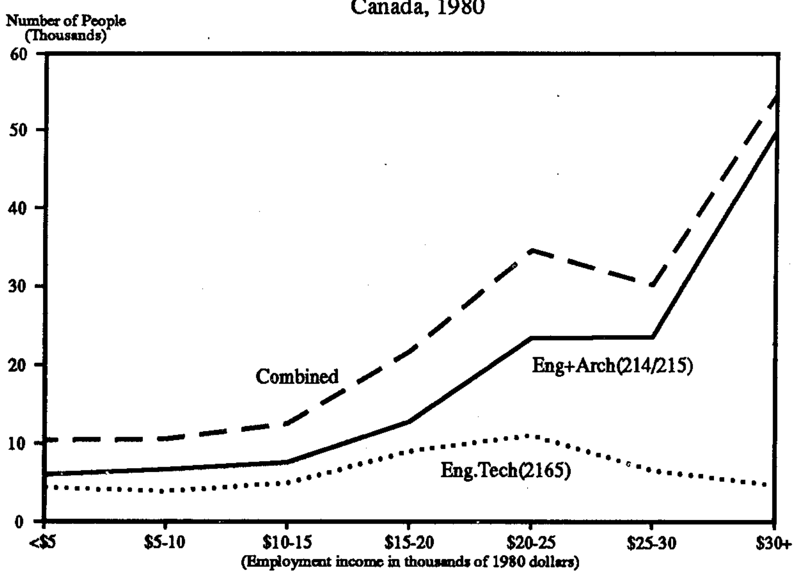


Figure 50
Distribution of SOC 214/215 and 2165 by Income Range
Canada, 1980

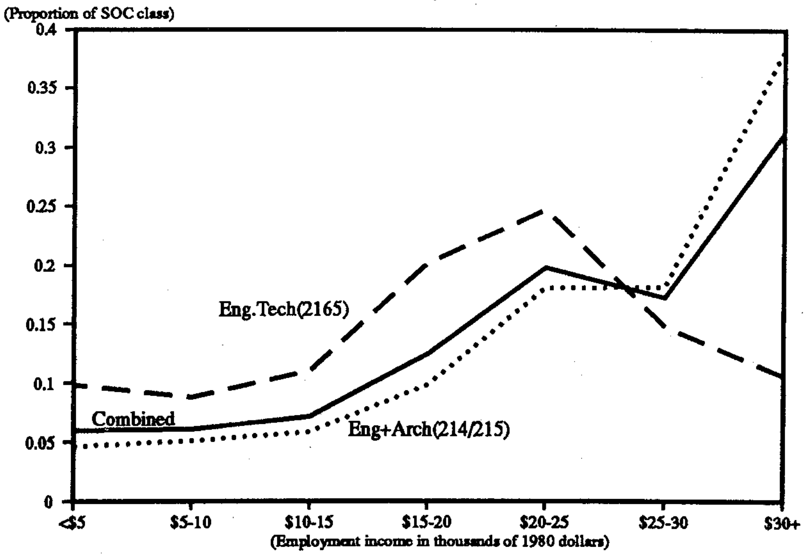


Figure 51
SOC 214/215 and 2165 and All Occupations by Income Range
Canada, 1980

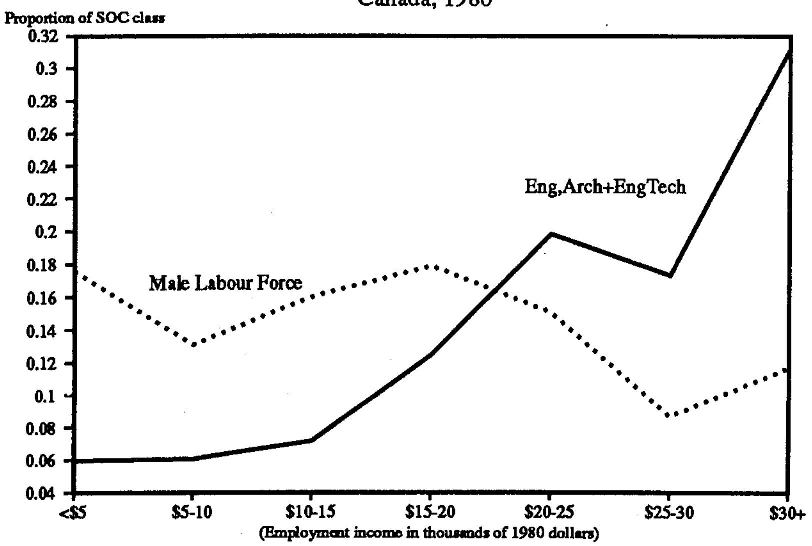


Table 3
Average and Median Income Levels
Canadian Census of 1980, Specified Sectors
(In 1980 dollars)

	SOC 214/215	Soc 2165	Labour Force Males
Average	26,918	18,965	16,988
Median	26,455	20,028	15,804
Average for Full-time + Full-year	29,804	22,400	21,441
Percentagte Full-time and Full-year	77.4	69.6	58
Total with Employment	130,195	44,705	7,207,6515

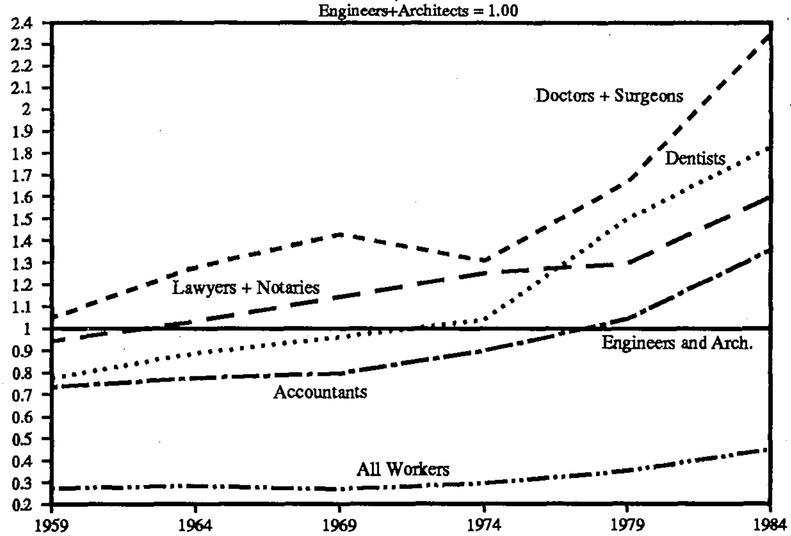
Source: Statistics Canada, Census of Canada, 1981, catalogue 92-930, table 1.

gineers fall even further.[15] This will have the impact of making the distribution of engineers and technicians/technologists (the sum of SOCs 214/215 and 2165) appear even more similar to the distribution for SOC 214/215 alone.

The distribution of SOC 214/215 and 2165 appears slightly bi-modal at the two income classes, $20,000 to $25,000 and $30,000-plus, however, these are values much higher than the national labour force mean of approximately $17,000.

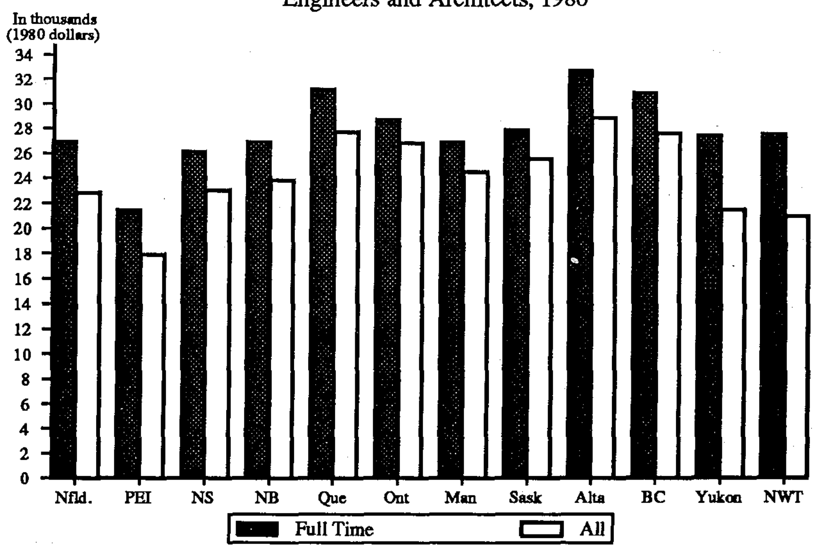
Figure 52, based on *Taxation Statistics* from Revenue Canada, presents evidence of a decline in the net income of engineers and architects relative to other professional groups and all workers among the self-employed in each category.[16] If this trend continues in conjunction with the trend noted in the paragraph before last, it may be that the income distribution of engineers will become uni-modal and move slightly leftwards, so that the difference in mean and median incomes present in table 3 becomes smaller. There is, however, no reason to expect the return to engineering to fall to the average of the labour force as a whole, especially as provincial associations have the power to set the criteria for licensing and practice.

Figure 52
Relative Average Net Incomes Among Self-Employed
Canada, 1959-1984
Engineers+Architects = 1.00



Source: Revenue Canada, Taxation Statistics, various years.

Figure 53
Mean Employment Earnings by Province
Engineers and Architects, 1980



Source: 1981 Census of Canada, catalogue 92-930.

Employment Income by Province and Specialty

Figure 53 presents census data from 1980 on incomes, by province, for all engineers working full-time and full-year. Engineers in the Atlantic region seem, on average, to have lower incomes than the same groups in Quebec, Ontario and in the West. There is little difference in incomes of engineers in Quebec, Ontario and the Western region.[17]

Figures 54 and 55 present mean and median employment income for engineering specialties, again from census material. Petroleum, nuclear, mining and chemical engineers had median incomes above $28,000 in 1980. Two things are obvious here. First, the year 1980 was one of great activity in the energy sectors of the economy; figures 54 and 55 highlight the returns to that activity. And secondly, the more "employment stable" specialties have the lower average and median income levels. This is to be expected as those specialties, such as industrial and mechanical engineering, provide employment opportunities in sectors where booms and busts are of smaller magnitudes than in the resource sectors of petroleum, oil drilling, mining and the like. Consequently, a lower mean income is associated with a low relative variance in employment.

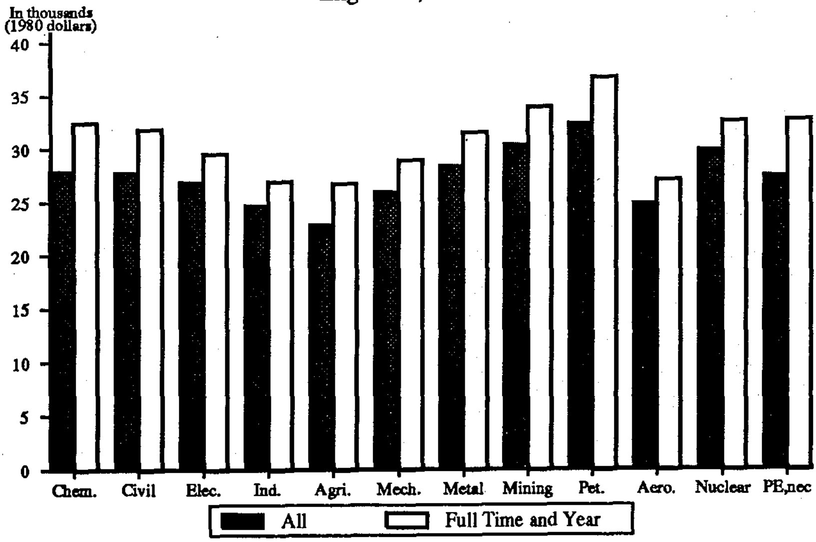
Taken together, figures 46 and 47 above and figures 53 through 55 provide an explanation of the high average levels of income of western-based engineers in 1980, especially Alberta and B.C. That explanation rests on the resounding boom in the western-based resource sectors of the economy—in full swing in 1980. This information also provides an explanation for the demise of engineering activity in the Western region as the resource boom turned into a bust in the early and mid-1980s as resource prices fell.

There appears to be little support in this industry for a serious bi-modal earnings/income distribution thesis. While the distribution for the sum of SOCs 214/215 and 2165 appears to be slightly bi-modal, the class with the highest modal value—almost 40 percent of the total individuals in the distribution—is also the highest income class at $30,000-plus. If there is bimodality, it is at income levels significantly above the mean income level in the labour force as a whole.

It is important to note that these comparisons do not and are not intended to imply that adjusted for employment instability and the risk of unemployment, and time invested in becoming an engineer, comprising years of schooling and experience, these incomes are "abnormally" high relative to the labour force average. The comparisons do not, however, point to any sort of validation of the vanishing middle class hypothesis.

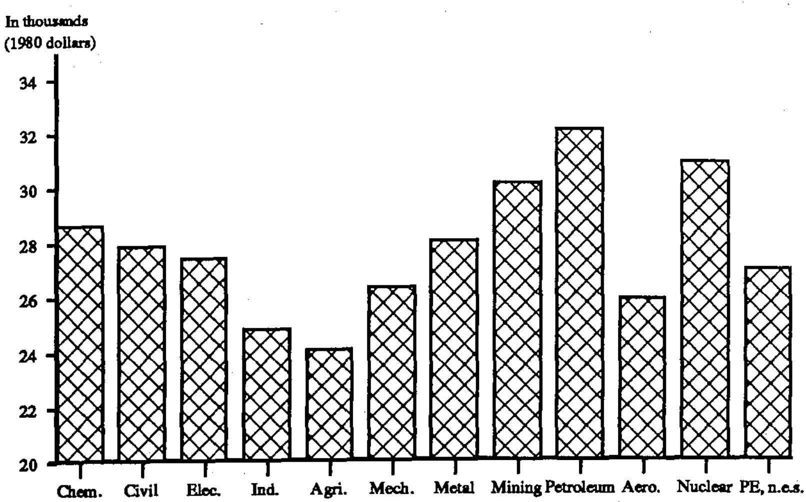
By province or region, annual average incomes are higher in the provinces west of the Atlantic region. The mean value for Quebec, Ontario and the

Figure 54
Mean Employment Income
Engineers, Canada 1980



Source: 1981 Census of Canada, catalogue 92-930.

Figure 55
Median Employment Income
Engineers, Canada, 1980



Source: 1981 Census of Canada, catalogue 92-930.

West is between $25,000 and $30,000. In the Atlantic region, the mean value of employment income is around $22,500.

SUMMARY

From survey and census data we have the following picture of the "average" engineer. He is most likely male, nearly 39 years old and a university graduate. In the 1980s, he is most likely a civil, electrical or mechanical engineer working in Ontario in either the manufacturing sector or the community, business and personal services sector. (Of course, consulting engineers work in the latter industry by definition.) On average, the census engineer earns more if he is located in the Western region or Quebec, which is a function of the higher average employment income associated with the engineering specialties required there.[18]

NOTES

1. The 1941 Census of Canada, vol. VII, and 1981 Census of Canada, catalogue 92-920.

   While the percentage of women is low in consulting engineering, the annual average rate in their increase was 18.2 percent per year over the 1971 to 1981 decade. The corresponding rate of increase for males is 5.2 percent per year. If these rates persist, one-half of all consulting engineers will be women by the year 2005.

2. Offices of engineers and other scientific and technical establishments are classified as Standard Industrial Classification SIC 864 (1970). The 1980 classification for consulting engineers is SIC 7752, and for other scientific and technical establishments, SIC 7759. Unfortunately, data are still primarily available only at the three-digit SIC. For brevity, the 1970 SIC 864 number is used in the text when referring to this classification.

   The following material is derived from Statistics Canada, 1981 census publication 92-923, vol. 1.

3. In 1981, the average age for male and female engineers was 38.9 years and 32.0 years, respectively.

4. Statistics Canada, *The Labour Force*, catalogue 71-001, monthly, February 1986, p. 98.

5. This publication is seen as a complement to Statistics Canada, *The Labour Force*, catalogue 71-001, monthly; see H. Pold, "Employment Estimates from the Labour Force Survey and the Survey of Employment, Payrolls and Hours," *The Labour Force*, June 1987, pp. 87-101. Pold shows that because the labour force survey, which is based on a sample of households, picks up self-employed, aggregate estimates of employment are higher than estimates based on the employment, earnings and hours establishment-based surveys. The long-term trends in the two, however, are similar.

   Catalogue 72-002 until very recently reported information on SIC 864 only nationally and for Ontario. The sample size was apparently not large enough for the other provinces to support a more detailed provincial breakdown than the services to business management grouping. Since 1984, Quebec's SIC 864 is also broken out separately. In any event, this source is not detailed enough to produce regional employment patterns in this classification. Recall that SIC 864 includes offices of consulting engineers and other scientific and technical services establishments.

6. The *1986 Canadian Engineering Manpower Inventory Report*, March 1987, CEMB, p. iii. The address for the CEMB: Suite 401, 116 Albert Street, Ottawa, Ontario. The CEMB inventory is potentially very useful. A questionnaire is included with the annual provincial professional engineers' association licence renewal form. All members receive this but, given the voluntary nature of the questionnaire, not all fill it out. A response rate is not published. On page 7 of the same report, readers are told that "this composite picture is based on a *sample survey* of 67,171 professional engineers" (emphasis added).

7. The series on total employment is estimated from SIC 864 in catalogue 72-002. The Statistics Canada surveys are also used in this estimation as they provide a breakdown of the proportion of SIC 864 that belongs to engineering and the proportion belonging to other scientific and technical services establishments. Between survey years one interpolates between the two known fractions. Outside of survey years 1971 and 1984, extrapolating at the last rate of change—that between 1978 and 1982—is used.

   The number of professional engineers was derived from the number of total employees using Statistics Canada catalogue 72-002, various issues. Knowledge from the Statistics Canada industry surveys was again used for the proportion of the total who are professional engineers in the three years. Interpolation was used in the intra-survey years and extrapolation used in the years outside the survey period. These numbers are suggestive but limited in use by the likely errors introduced in their construction.

8. Other professionals are primarily architects. The proportion of administrative personnel has stayed roughly constant at about 20 percent of the total.

9. I am assuming what is true of the census respondents is a good proxy for the employees of the consulting engineering industry. In the 1986 CEMB inventory of professional engineers discussed above, it is the case that over 95 percent of responding professional engineers have at least one university degree.

10. The number of women is very small relative to men. In the 1986 CEMB inventory, less than 2 percent of responding consulting engineers were female. As reported above, census figures from 1981 indicate the proportion at approximately 6 percent.

11. K.L. Bradbury, "The Shrinking Middle Class," *New England Economic Review*, September/October 1986, pp. 41-55; and R. Kuttner, "A Shrinking Middle Class Is a Call For Action," *Business Week*, September 16, 1986, p. 16.

12. This bi-modality hypothesis is apparently overstated, see B. Bartlett, "The Chicken Little Theory of the Vanishing Middle Class," *Backgrounder*, Thomas A. Roe Institute for Economic Policy Studies, The Heritage Foundation, April 13, 1987.

13. The source for figures 49-55 is Statistics Canada, *1981 Census of Canada—Population, Worked in 1980—Employment Income by Occupation*, catalogue 92-930, March 1984, table 1.

    Only the distribution of males was plotted as they are the great majority of SOCs 214/215 and 2165.

    Of SOC 214/215, engineers make up approximately 95 percent, architects the remainder.

14. There were 4,000 women in SOC 2165 in 1980.

15. Recall that the number of engineers as a proportion of total employees in offices of engineers rose from 28.7 percent to 32.1 percent over the years 1974 to 1982. Over the same period, the proportion of technicians/draftsmen fell from 45.7 percent to 40 percent of total employees.

16. Being self-employed is an alternative open to almost every engineer, doctor, dentist, lawyer, accountant and member of the labour force. As such, the decision at the margin, whether to work for someone or one's self, is affected by the perceptions of returns to the two forms of employment. As the return to self-employment in engineering falls, more self-employed engineers will choose to become employees. This, in turn, lowers the average return to existing employee-engineers. Consequently, figure 52, while based on data pertaining to the self-employed only, may serve as a useful proxy for movements in the relative incomes, self-employed or not, of the groups included.

17. There are many more engineers and architects in Alberta and B.C. relative to Manitoba, Saskatchewan and the territories, so a weighted average of those six provincial incomes would be closer to the figures for B.C. as opposed to the lower values, for example, for Manitoba.

18. One important caveat is to recall that the census data upon which this sketch is drawn were collected prior to the recession of 1982.

CHAPTER 6

COSTS AND PRODUCTIVITY

INDUSTRY PRODUCTIVITY: LEVELS AND TRENDS

In chapter 2, figures on output and sales of the consulting engineering industry were presented. An examination of the costs of producing that output is now undertaken. As one expects, in a highly labour intensive service industry such as engineering consulting, labour costs predominate. Knowledge of costs and outputs makes a measure of productivity possible and these measures are derived and discussed.

One issue that comes up time and time again is that "stagnant" productivity in the service sector "reins in" the economy by offsetting productivity gains in the manufacturing sector. While that specific issue is beyond the scope of this study, an analysis of productivity within the consulting engineering industry may shed light on the periphery.[1]

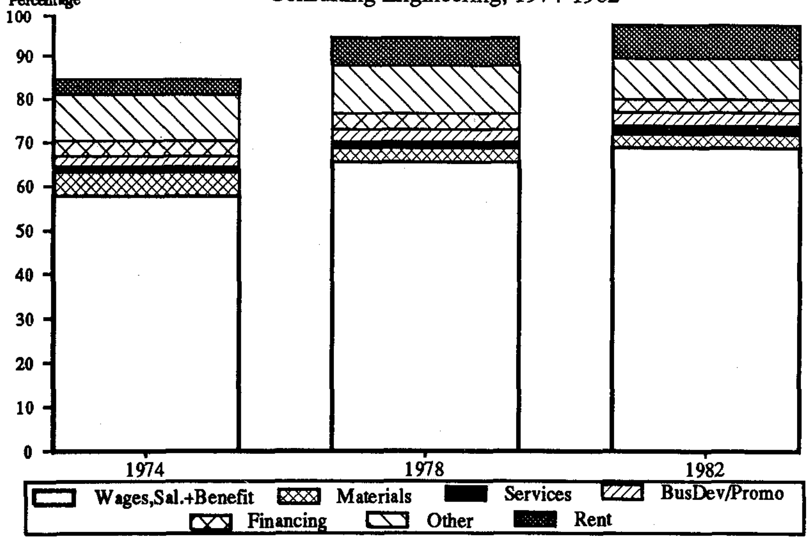
To consider productivity within the industry, costs of production will have to be discussed. The surveys of the industry produced by Statistics Canada provide the most finely detailed information on the costs of production.[2] Given the infrequent number and quadrennial separation of surveys, data is insufficient to estimate production functions and elasticities of substitution between inputs.[3] However, data are sufficient to give the levels and trends in input use over the 1974 to 1982 period.

EXPENDITURES ON INPUTS INTO THE INDUSTRY'S OUTPUT

A Proportion of Fee Income

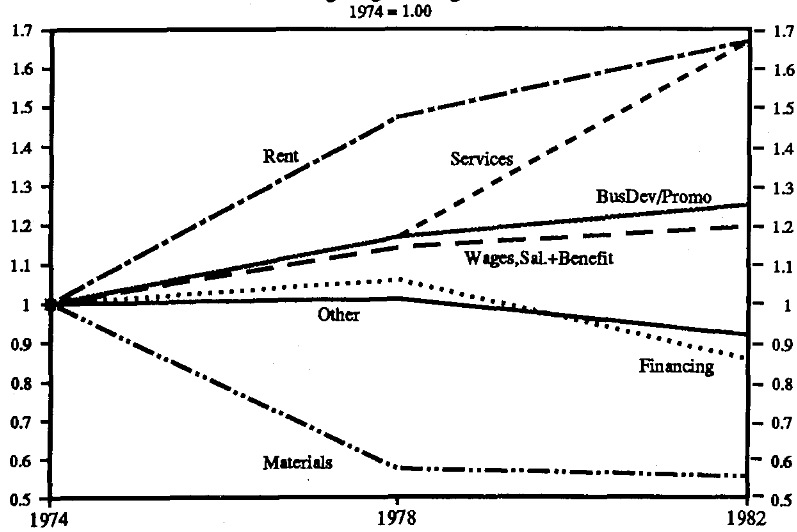
Figure 56 gives the percentage of fee income going to the major input groups in the offices of consulting engineers in the three survey years 1974, 1978 and 1982. Note that total costs as a percentage of fee incomes have risen. Interpreted by profits, total revenue minus total costs, we see profits have fallen.

Figure 56
Expenses as a Percentage of Fee Income
Consulting Engineering, 1974-1982



Source: Statistics Canada, catalogue 62-528 (1977), 63-537 (1980 & 1985).

Figure 57
Indices of Changes in Relative Input Costs
Consulting Engineering, 1974-1982
1974 = 1.00



Source: Statistics Canada, catalogue 62-528 (1977), 63-537 (1980 & 1985).

Figure 57 presents indices of change in the "relative" input costs for the three years. To construct the indices in figure 57, the 1974 expenses as a percentage of fee income for each input are used as a base for the inputs in 1978 and 1982. A ratio is formed using this figure in the denominator and the relevant input cost to fee income figure for 1978 and 1982 in the numerator.

Labour

WSB designates wages, salaries and benefits paid to all employees and outside consultants used on projects.[4] From figures 56 and 57 it is evident that WSB are a large and rising proportion of total costs. From 57.8 percent of total fee income in 1974, WSB rose to 69 percent in 1982, an average growth rate of 2.2 percent per year over the period.[5]

Materials

Purchases of materials and supplies (Mat.) constitute a small and declining proportion of fee income. These purchases fell from 5.4 percent of fee income in 1974 to 3 percent in 1982.

Services

Service (Serv.) inputs in the first two surveys are limited to the costs of communications, telephones, and the like and are a negligible proportion, less than 1.5 percent, of fee income. The survey done for 1982 is more detailed. Services include legal, accounting, auditing and/or management fees as well as fees for the services of data processing equipment.[6] Despite the detail, services as a proportion of fee income are only 2 percent in 1982.

Business Development and Promotions

Business Development and Promotional expenses (BD/Promo) include entertainment, travel, brochures and advertising and are services used in search of future business. From 2.4 percent of fee income in 1974, these costs rose to 3 percent of fee income by 1982.

Financing and Depreciation Charges

Interest, bank charges and depreciation costs comprise this category. Costs, as a percentage of fee income, have varied from 3.5 percent in 1974 to 3.7 percent in 1978 and down to 3 percent in 1982.

Other Expenses

After WSB, the other expenses category is the largest. Other expenses are roughly 11 percent of fee income in both 1974 and 1978 and 10 percent in 1982. These other expenses do not include income taxes paid.

The slight reduction in importance of other costs may be due to the slightly greater detail in the 1982 survey which specifies items presumably lumped into the other category in earlier survey years. An example of this may be the previously discussed legal, accounting, auditing and management fees which were not detailed in 1974 nor 1978.

Rent

Occupancy costs as a percentage of fee income have risen from 3.6 to 6 percent over the 1974 to 1982 period. As is evident from figure 57, rent, along with services, had the greatest rate of increase over the eight-year period.

Levels of Real Output Costs

Figure 58 presents total cost information derived from information on total real fee income and the percentages of fee income attributable to each input.

The total wages, salaries and benefits bill has grown by over 50 percent in the eight years bounding the surveys. Other input categories have increased more dramatically, for example, services, business development and promotions and rent all appear to have doubled in that period. But the sheer magnitude of WSB swamps other movements in costs.

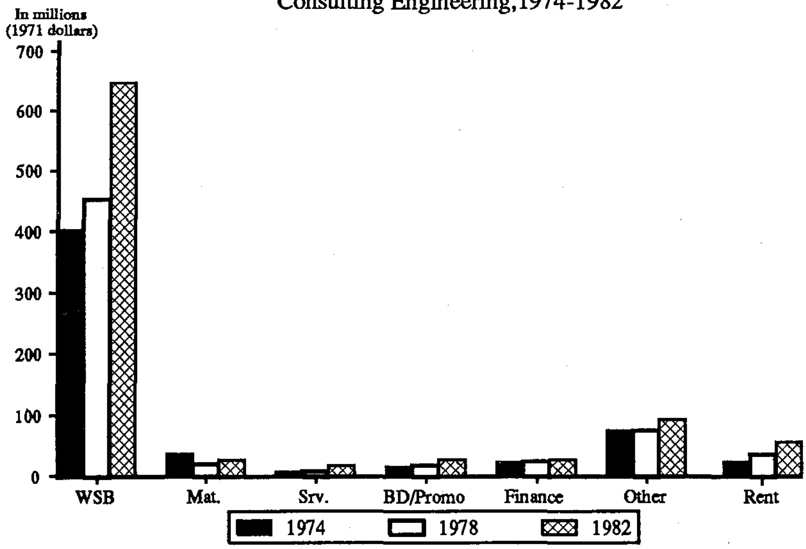
PRICES OF SERVICES SOLD

Unit Costs

In an earlier chapter, the difficulties inherent in defining engineering output were briefly discussed. Suffice it to say that these difficulties are again relevant when discussing unit costs. In the surveys, cost information is given as a percentage of fee income. There is no standard unit of output upon which one may focus.[7]

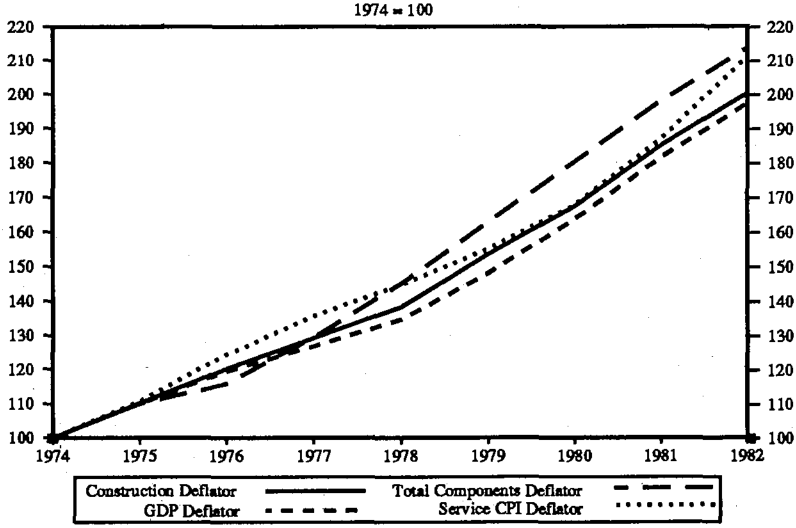
In chapter 2, several different price indices were introduced as potential deflators of nominal dollar values. The various price indices used and their inter-relationships will be discussed at greater length below.

Figure 58
Real Total Costs of Inputs
Consulting Engineering, 1974-1982



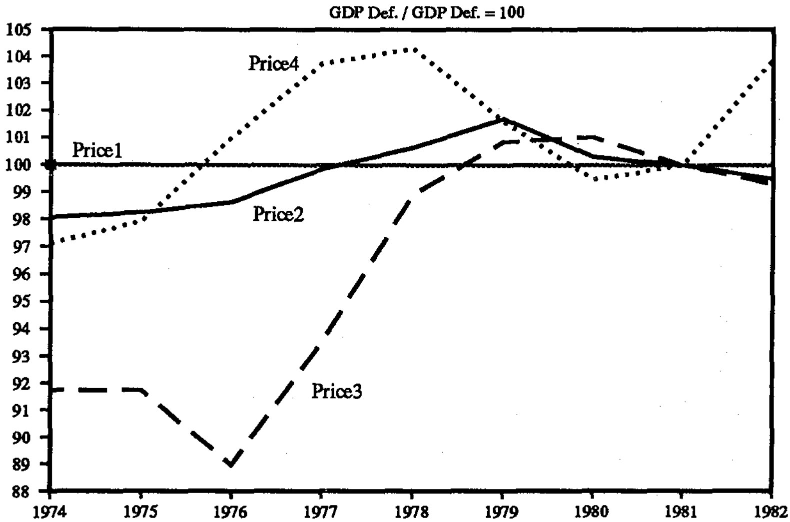
Source: Statistics Canada, catalogue 62-528 (1977), 63-537 (1980 & 1985).

Figure 59
Price Indices
Various Deflators, 1974-1982
1974 = 100



Source and Explanation: See text.

Figure 60
Ratios of Price Indices Relative to the GDP Deflator
1974-1982



Source and Explanation: See text.

Price Indices

Prices of engineering services are assumed to be best proxied by one of three different price indexes.[8] These are the GDP deflator, the implicit price index for total construction in the construction industry, and the implicit price index for total components in the construction industry. These last two indices are a weighted sum of the indices for building construction and engineering construction in the construction industry and a weighted sum of the indices for building and engineering construction *and* machinery and equipment in the construction industry, respectively. For comparison, the price index for consumer services is included in this section.[9]

Figure 59 shows the four indices described above using 1974 as 100 for all four indices.[10] The first thing to notice is the great similarity in the time-paths of the four indices.

Figure 60, which expands the vertical axis, presents relative to GDP deflator prices and shows that relative to the GDP deflator the other deflators move a little more erratically than figure 59 indicates. Price1 is the GDP deflator relative to itself and always has a value of 100. Price2 and Price3 are the construction price deflator relative to the GDP deflator and the total components deflator, respectively. Price4 is the CPI consumer services price deflator relative to the GDP deflator.

In figure 60 one sees that the paths of relative prices of engineering services, as proxied by the two construction price indices relative to the GDP deflator, Price2 and Price3, are varied but move roughly together. Over the entire period, 1974 to 1982, both indices rise relative to the GDP deflator. Price2 shows a small variation in movement relative to the GDP deflator over the period. Price3, which is roughly 10 percent lower than the GDP deflator at the start of the period, rises sharply relative to the GDP deflator between 1976 and 1980. Price4, the consumer price index of services relative to the GDP deflator, rises over the 1974 to 1978 period. During the last year shown, the rise is substantial.

While these indices are probably very crude approximations to the unobserved "true" prices of engineering output, both Price2 and Price3 show the relative prices of construction activity—hence, engineering activity—rising relative to the GDP deflator, over the period in question.

PRODUCTIVITY OF THE LABOUR FORCE[11]

Real Output Value Per Professional Engineer and Per Employee

Figure 61 presents information on the gross and value added productivity of the total number of employees in the offices of consulting engineers and professional engineers in consulting engineering, respectively.

Gross productivity per consulting engineer is measured by total real fee income divided by the number of professional engineers in the offices of consulting engineers.[12] This value is denoted as line 1 in figure 61. By this measure, the gross productivity per engineer in real 1971 dollars appears to be in the $60,000 to $70,000 range, having its greatest value in 1982.

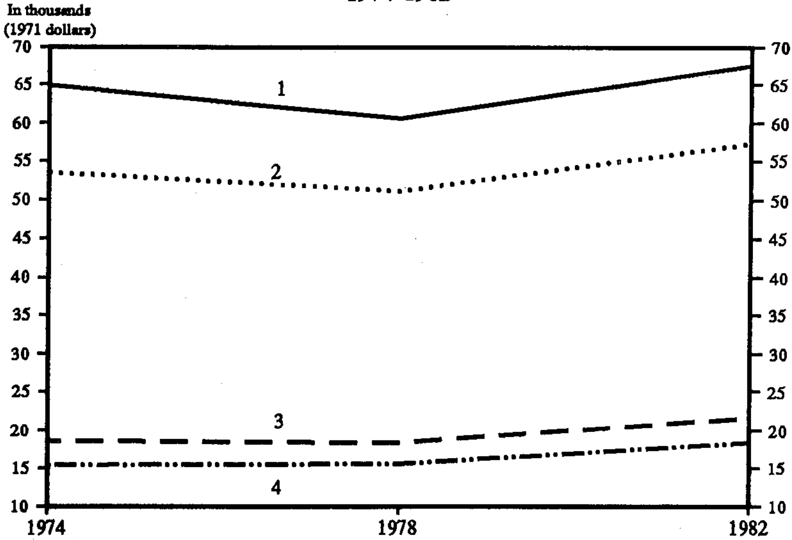
From the same sources, gross productivity measures for all employees in offices of consulting engineers are calculated and appear as line 3 also in figure 61. In 1971 dollars, the gross productivity per employee is approximately $20,000.

Value added productivity measures for professional engineers and all employees are also given in figure 61.[13] These values are denoted by lines 2 and 4, respectively.

Indices of Productivity

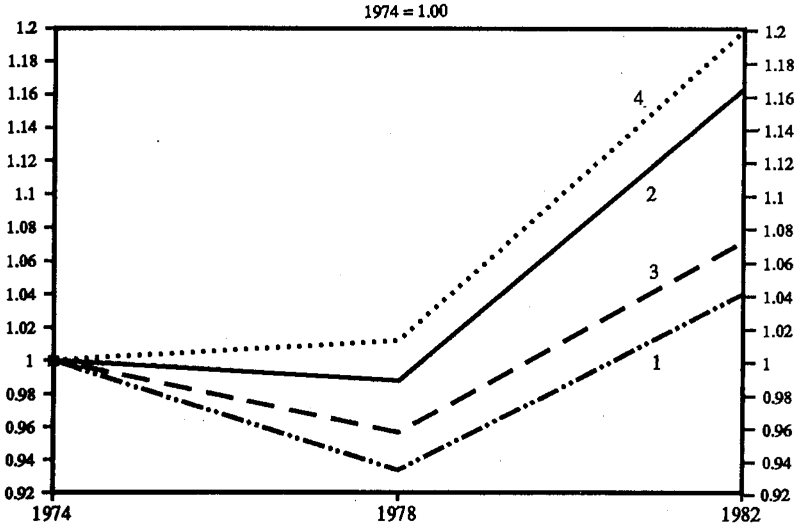
Figure 62 shows the changes in the gross productivity and value added productivity measures for both inputs using the initial value in 1971 as the base. The numbered lines represent the same variables as in figure 61. For

Figure 61
Productivity per Employee and per Professional Engineer
1974-1982



Sources: Statistics Canada, catalogues 62-528 (1977) and 63-537 (1980 & 1985).

Figure 62
Indices of Productivity, 1974-1982
Gross and Value Added in Engineering
1974 = 1.00



Source and explanation: See text.

example, lines 1 and 2 show the indices of gross and value added productivity for professional engineers, respectively. Lines 3 and 4 repeat that information for all employees in the offices of engineers.

It is notable that the productivity of all employees increased by a greater percentage than did that for professional engineers over the eight-year period covered by the surveys. The growth rate in productivity for all employees was approximately 2.1 percent per year and 0.5 percent per year for professional engineers.[14]

An explanation for these differences in productivity trends hinges on the fact, discussed in chapter 4, that there has been an increase in the proportion of professional engineers to total employees in consulting engineering over the time period involved. The change in factor proportions has lowered the growth rate of productivity for professional engineers relative to all employees. However, total productivity levels have risen in the profession as a whole. This is true because professional engineers with average productivities of around $60,000 replace other employees with average productivities of around $20,000.[15]

From figure 62 it is apparent that over this period, in consulting engineering at least, the measures of gross productivity and value added productivity track one another reasonably closely, independent of which input—total number of employees or number of professional engineers—is used. Therefore, for rates of change in productivity of a particular input, either the gross or value added measure gives approximately similar results.

SUMMARY

This chapter has focused on costs and productivity measures in the consulting engineering industry. In real terms, survey evidence indicates that productivity has increased in this industry, but at relatively modest rates of anywhere from one-half to 2 percent per year. If the trend in the office of consulting engineers towards having more professional engineers relative to other staff continues, overall productivity in the industry will continue to rise at rates nearer the top of the range just given. This will occur even if productivity per professional engineer remains constant.

On the larger issue of economy-wide productivity, these findings are less helpful. An important consideration is that there are a great number of engineers employed in other industries and sectors. For example, in four sectors—forestry; mining, oil and quarrying; transportation, communications and utilities; and public administration and defence—engineering "intensity" rose from 1971 to 1981.[16] In manufacturing, construction and trade, the intensity remained about the same over the ten-year period. For the economy

as a whole, intensity rose roughly 10 percent. Clearly, engineers' efforts as employees in these sectors has added to the productivity gains they have experienced.

NOTES

1. The interested reader should see H.G. Grubel and M.A. Walker, *The Canadian Service Industries*, The Fraser Institute, 1988.
2. References given in chapter 1. In each of the three surveys a table appears giving the selected expenses of consulting engineering firms, expressed as a percentage of fee income. For example, in the 1982 survey, this table appears on page 21.
3. The three surveys provide figures for the inputs as a percentage of fee income. This makes the inputs a linear function of the output measure, rendering regression technique powerless to provide an estimation. If this obstacle could be overcome, there is the remaining problem of insufficient degrees of freedom to perform any useful estimations in this case.
4. In the surveys for 1974 and 1978, there is no distinction made between wages, salaries and benefits paid to employees and payments made to consultants hired for project work. All payments were aggregated into one measure. In 1982, the distinction was made. Of the 69 percent of fee income that went to WSB, 7 percent were fees related to projects paid to outside consultants.
5. From 1974 to 1978, the average annual growth rate in WSB as a percentage of fee income was 3.2 percent, from 1978 to 1982 the growth rate was 1.2 percent.
6. I include these rental fees in services as it is the service of the machine one is procuring. An argument can be made for including the rental fees elsewhere, for example, in the purchase of materials and supplies, in which case materials and supplies would be one percent higher and services one percent lower in 1982. The magnitudes involved are so small that statistical error undoubtedly overwhelms all but the largest cost categories.
7. The discussion on billing is apposite here, too. Fee income is the "quantity" one has to work with; it is the aggregate of all billings. There is no credible way to work backwards through total fee income to some non-dollar value unit measure, for example, hours, number of designs or number of drawings. The best that can be done is to choose one or more price deflators and convert nominal values to constant dollar values. These are obviously not the preferred measures but may serve to give some reasonable proxy for output.
8. Citations in chapter 2, note 9.
9. Statistics Canada, *The Consumer Price Index*, catalogue 62-001, monthly, June 1987.

10. The years 1974 to 1982 are used as these are the years bounded by the three industry surveys undertaken by Statistics Canada and for which fee income data was available.

11. This discussion of productivity deals with productivity as traditionally defined, that is, a measure of consulting engineering industry output divided by inputs.

    There are arguments that services may well enhance the productivity of other industries, e.g. manufacturing, but that this increase in productivity will be attributed to inputs into manufacturing other than the service input. This, so the argument goes, erroneously understates the productivity of services. Such an argument holds only when the difficulty of measuring outputs and/or inputs into the activity in question exists. When service inputs into manufacturing are measurable, their productivity may be measured as that of any other input.

    Alternatively, if outputs are hard to quantify, for example, consumers' production of shopping or shopping effort, then the addition of another input into shopping, for example an additional store, may well increase productivity by reducing average shopping times. Consumers' shopping productivity will rise if shopping time falls by a greater percentage than the percentage rise in inputs.

    Implicit in the following discussion is that outputs of industries consulting engineers contribute to are measurable and that consulting engineering inputs into the construction and manufacturing process are also measurable and measured by their fee revenues. In short, we measure productivity by looking at the value of industry output divided by the value of industry input, all in constant dollars.

12. Gross product per consulting engineer is derived from fee income levels and employment levels reported in the Statistics Canada surveys.

13. Value added is total revenue minus all payments to intermediate inputs purchased from other firms. Here materials, services and other expenses were considered to be intermediate inputs. Wages, salaries and benefits, business development and promotion, financing charges and rent were considered to be part of value added. These payments represent payments to labour, capital and land, respectively.

    Business development and promotional fees are not a clear-cut payment to capital, however the amounts involved are so small that their inclusion or omission have negligible impact on the results.

14. These are approximate averages of the gross and value added productivity growth rates for each input. The rates of growth differed over the different subperiods, as is evident from figure 62.

15. Both in 1971 constant dollars.

16. Where, again, "intensity" is measured as engineers per 1,000 employees.

CHAPTER 7

CANADIAN ENGINEERS INTHE WORLD MARKET

INTRODUCTION

As shown in chapter 1, the share of the consulting engineering industry's total fee income generated by foreign clients, private and public, has fluctuated over the period 1974 to 1982. On average, the foreign market is about 12 percent of total fee income in the industry.[1] This is not substantially different from the U.S. numbers.

Of the foreign business, roughly half was generated from private sector clients and half from governments—foreign and Canadian—in both 1974 and 1982. In 1978, the government sector accounted for 60 percent of foreign fees generated, with private sources generating the remainder.

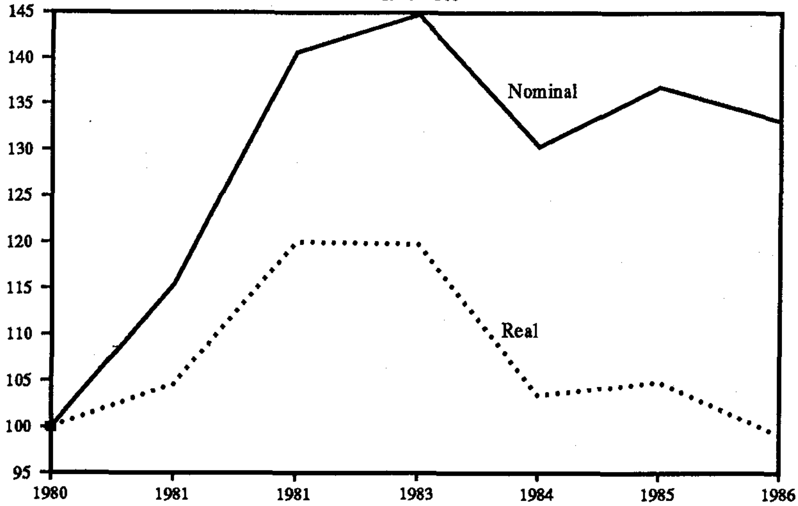
In this chapter, using trade industry and survey data, the size and scope of the international market will be assessed. In addition, the changing nature of business, especially in the Third World, will be discussed. These changes are primarily in the financing of foreign projects. Requirements for joint ventures, guaranteed financing and the like, will have implications for those wishing to enter Third World markets.

THE MARKET AND CANADA'S SHARE

Industry Data

Figure 63 shows the nominal and real patterns of fee income from foreign billings of the top 200 international design firms as calculated by *Engineering News Record* for 1980 to date.[2] The market for the top 200 international firms proxies the total international market and shows a steep decline, especially in real terms, in the mid-1980s.

Figure 63
Indices of Foreign Income
Derived by Top 200 International Design Firms
1980 = 100



Source: Engineering News Record, various issues.

Table 4
Canadian Share of the International Design Market
Top 200 Firms, 1982–1986
(Percentage)

Region	1982	1983	1984	1985	1986
Middle East	4.1	3.7	2.3	1.7	1.7
Asia	5.8	5.5	9.1	7.8	5.2
Africa	6.8	9.2	9.4	9.9	3.9
Latin America	10.5	8.7	8.6	6.1	4.2
Europe	3.6	3.6	5.0	0.6	1.6
North America	82.7	71.0	75.3	49.3	52.9

Source: *Engineering News Record,* various August issues.

Note: Difficulties comparing 1986 to prior years is discussed in note 3.

Canada had 14 firms (all but two of which were consulting engineers) in the top 200 in 1986 and received, in nominal value, (US) $204 million, which represented 5.8 percent of total foreign billings. The United States, with 25.9 percent, Britain, with 13.6 percent, the French with 8.6 percent, the Germans with 8.0 percent, the Dutch with 7.3 percent, and the Japanese with 6.2 percent of the international market had greater shares than Canada.[3]

Including Lavalin, the Canadian total is (US) $354 million, representing a share of 10.1 percent in 1986, up from 8.3 percent and (US) $265.8 million in 1985. Canada's share in the various international markets over the period 1982 to 1986, excluding Lavalin in 1986, is given in table 4.

Asia, at almost (US) $1 billion, the Middle East at just over (US) $900 million, and Africa at (US) $855 million, have the largest markets in terms of value of design work. North America, up 14 percent, Africa, up 8 percent, and Asia, up 6.9 percent, have been the fastest growing markets from 1985 to 1986. These growth rates can change direction and size dramatically from year to year. For example, in the period 1984 to 1985, the Latin American market grew by 64.6 percent, while in the period 1985 to 1986 it declined 29.6 percent.

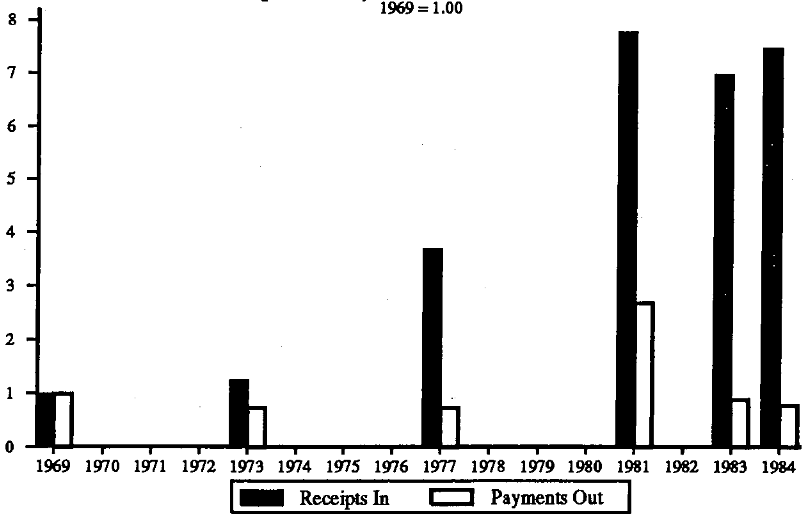
In a comment on profits, the *Engineering News Record* reports that "only 81% of 165 respondents profited on their foreign work, down from 86% in 1985. But their average profit margin was 7.6%, compared with 7% the previous year. Their median profit margin held at 5% for the third year. Only 84% reported making a profit on domestic work."[4]

Statistics Canada Data

Another view of the international market for business and consulting services is provided by Statistics Canada in *Canada's International Trade in Services* (catalogue 67-510, June 1986). Unfortunately, the aggregative nature of the data does not allow the consulting engineering industry to be isolated from all consulting and other professional services.[5] However, if one assumes that movements in international receipts and payments in the aggregate "consulting and other professional services" is a valid proxy for consulting engineering, then we may get further information on engineering services in the international market.

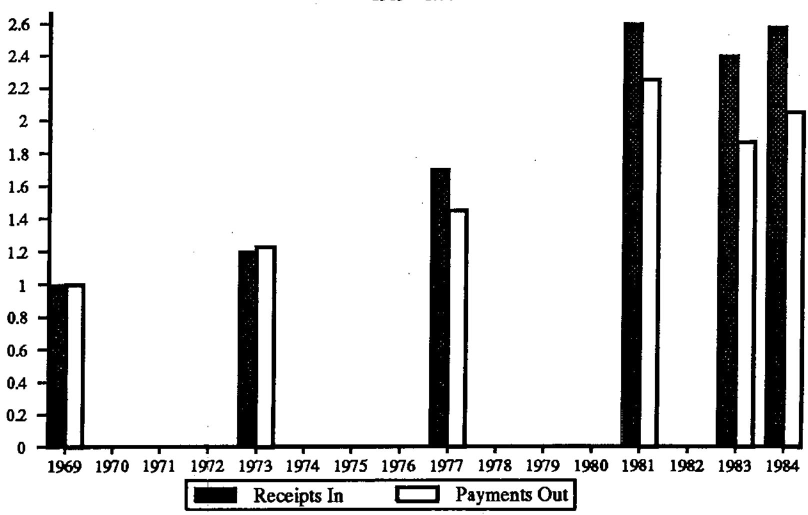
Figure 64 shows the growth in real receipts by Canadian firms and real payments by Canadians to foreign firms for consulting and other professional services using the value in 1969 as the base. Real receipts, or Canadian exports of consulting services, have risen by a factor of 7.5 from 1969 to 1984. Meanwhile, real payments, Canadian imports, have not changed in value from 1969 to 1984. Consequently, Canada's balance of trade in consulting

Figure 64
Index of Growth of Foreign Transactions
By Canadian Consulting and Other Professional Services
Receipts and Payments, Canada, Selected Years
1969 = 1.00



Source: Statistics Canada, catalogue 67-510, table 4.

Figure 65
Index of Growth of Foreign Transactions
In Total Business Services In Canada
1969 = 1.00



Source: Statistics Canada, catalogue 67-510, table 4.

services has been moving toward a larger and larger surplus over the years. In nominal dollars, in 1969, receipts in this category were $42 million and payments were $98 million. By 1984, receipts were $938 million and payments $257 million.

Figure 65 shows the growth in real receipts and payments for total business services, the larger aggregate of which consulting and other professional services are but a part.[6] Again, growth in real receipts has outpaced growth in real payments, but neither category has grown more than two and one-half times over the 15-year period 1969 to 1984. Notice, too, that receipts and payments have grown at similar rates. In nominal dollars, in 1969, receipts for total business services were $572 million and payments $1,089 million. By 1984, the relevant figures were receipts of $4,486 million and payments of $6,667 million.

Clearly, consulting and other professional services contributed disproportionately to the growth in total business service receipts (exports) over the 1969 to 1984 period. However, the growth in payments (imports) for total business services was not contributed to by any growth in payments for consulting and other professional services. While Canada's balance of trade in total business services has worsened,[7] its balance of trade in consulting and other professional services has improved.

Government Export Assistance

Export assistance by the federal government is handled through trade commissioner services and two organizations within the Ministry of External Affairs (MEA). These two organizations are the Canadian International Development Agency (CIDA), which provides funding for foreign aid projects built with Canadian expertise and material, and the Export Development Corporation (EDC), which provides long-term loans to foreign buyers of Canadian capital equipment and technical services. The EDC also acts as an insurer for Canadian firms selling abroad. These two organizations provide the major source of industry/Canadian government interaction. In 1982, CIDA and the EDC financed $58 million worth of Canadian consulting engineering abroad. This represented 23 percent of total foreign fee income earned by responding Canadian firms. In fiscal year 1985/86, approximately $70 million was spent on international trade development activities by the MEA.[8]

The MEA also operates the Program for Export Market Development (PEMD) which provides funds for specific project bidding, market identification trips, participation in trade fairs abroad, invitation to incoming buyers, formation of export consortia, sustaining export market development

activities and export marketing for agricultural, fisheries and food products. Consulting engineers use PEMD grants for the first two purposes, specific project bidding and market identification trips, almost exclusively.

From fiscal year 1980/81 to fiscal year 1983/84, approximately $42 million was granted through the PEMD. Of that, $26.5 million or 63 percent went to manufacturers of goods.[9] If the remaining $15.5 million went entirely to consulting engineers, which is highly unlikely, the engineering industry would be receiving about $5 million per year through PEMD grants. This is an upper, upper-limit figure.

RELATIONSHIP BETWEEN DOMESTIC AND FOREIGN MARKETS

Introduction

The relationship between domestic and foreign engineering markets explains the services which contribute to the export success in the industry. Any changes in the nature of the domestic market may have implications for the type and nature of services that Canadian consulting engineers export in the future.

The particular goods and services a country will be successful in exporting are those in which it enjoys a *comparative* advantage in production. This comparative advantage springs from relative input cost advantages one country might enjoy over others in production and the level of the exchange rate. As these factors change, so too will the pattern of comparative advantage. In engineering, comparative cost advantages are in part a direct function of the stock of similar work done previously. Experience gained through extensive earlier work may be reflected in lower per unit costs on succeeding work of the same nature.

In Canada, this general theme of comparative advantage has been evident in the exports of consulting engineering services as shown in chapter 2. The specialties that have been highly developed in order to service the domestic market have been those in which Canadian consulting engineers have traditionally enjoyed export success. These specialties cluster around services provided to Canada's resource base and include power generation, transmission and distribution systems, mining, forestry, and plant process and design.

Domestic Growth and Foreign Markets

The nature of the domestic market is changing. In the public sector, smaller projects are more likely as the government perceives its role as shifting from

developer to caretaker. In the private sector, growth will be slow in the primary resource sector, with upgrading of existing facilities and improvement of production methods highlighted.[10]

Domestic growth prospects seem to lie in the newer, so-called unbundled services as well as in repair/upgrading of existing facilities rather than more new construction and other traditional services.[11] This conclusion is tempered somewhat by the growth potential in contracting out and outright privatization of government services.

Innovation, through research and development by private industry, educational and other institutions, may provide cost advantages leading to comparative advantage and increased trade. While private research and development is most often driven by the profit motive, universities and other research-oriented institutions have the ability to do pure research and transmit that knowledge to the market through licensing and royalty agreements and more slowly through the diffusion of students into the market. This increased knowledge may lead to a comparative advantage in the export of newer services facilitated by the "electronic revolution."

Unbundled services allow for the export of more generalized engineering services, perhaps in the form of a problem-solving algorithm available on software as well as job-specific services. Traditional, capital project related services tend to be project and site specific. One implication of this is that input costs for unbundled services will play a larger role in determining competitive advantage as extensive domestic sector experience is no longer a prerequisite nor a main selling point for export success.[12]

The emergence of the market for unbundled services breaks down the almost uni-directional relationship between the domestic and foreign markets for engineering services. For traditional services, expertise gained on-site in the domestic market leads to comparative advantage and consequent success abroad. For unbundled services, the solution to a general problem is required, a programme is prepared and marketed, and then any specific application—whether it be domestic or foreign—is just a particular case of the general form. Foreign experience is just as important as domestic, and comparative advantage comes with increased volume, coming from either foreign or domestic markets, leading to lower unit costs.

While the future appears bright for unbundled services, it is not clear that consulting engineers are the ones who wish to go in that direction.[13]

CHANGES IN THE STRUCTURE OF FOREIGN OPPORTUNITIES

Introduction

The engineering industry's success abroad has been outlined. What promises to be more instructive is the response made to the changing climate of how business must be done, especially in the fast growing Third World markets. Requirements that firms form technology-transferring joint ventures, provide innovative financing, undertake competition from Crown corporations and deal with a plethora of new non-governmental organizations now providing aid to Third World countries mean that engineers face a new set of challenges in their dealings in foreign markets.

Barriers to Trade

Barriers to trade in the Third World are primarily non-tariff in nature. Barriers are meant to encourage the transfer of technology and the development of local skills, to ensure that local skills and materials are used to the full extent possible, and to make sure that scarce foreign exchange doesn't escape the country for non-essential purchases. These barriers are of the nature of traditional protection for local industry.

Upcoming rounds of multilateral trade talks may lead to a lowering of barriers of this last type. However, they are not likely to do much about barriers raised in the pursuit of public policy objectives other than protection of local industry. Nor will they do anything about the ultimate restriction on the size of these markets which is the result of low gross national products. Firms in the Canadian consulting engineering industry, it seems, will for the most part be left to their own devices to do what they can to surmount the trade obstacles that do in fact exist if they want to secure business in Third World markets.[14]

An important distinction in the trade of services is that between trading the service through the transfer of knowledge embedded, for example, in a set of plans, blueprints or a computer programme, as opposed to having the right to establish an office and have personnel within the foreign country. In the case of many services, it is the sale of knowledge embedded within a good or transmitted over wire or through satellite systems which is of primary importance.[15] For consulting engineers working on highly geographic- specific projects such as water and power systems, the right of establishment may be much more important.

Currently, in order to surmount barriers and improve market access, firms are increasingly compelled to propose the development of projects on the

basis of joint ventures with host country firms and offer attractive packages for financing projects.

Joint Ventures

Traditionally, the consulting engineer sought to develop projects as joint ventures when he needed the expertise or specialized goods of a partner to complement limited in-house capabilities for the term of the project. Though joint ventures are still motivated by this consideration, more and more they are formed for the purpose of undertaking co-operative marketing or in some other way improving market access. This second type of joint venture calls for the venture partner to bring non-engineering skills and capabilities to the Canadian partner's engineering know-how.

Statistics Canada reports that total fee income derived from joint ventures in 1982 comprised 15 percent of total fee income for Canadian consulting engineering firms engaging in at least one joint venture and 5 percent of total fee income of all consulting engineering firms in the country. Roughly 80 percent of that business was done by 13 firms in the highest fee income range of $10 million and over. Regionally, Quebec-based firms generated half of that fee income with B.C. firms generating another 25 percent.[16]

Unfortunately, from the information as published there is no way to determine the proportion of this business which is done jointly on domestic projects and the proportion done on foreign projects. Nor is there any way to determine joint venturing done with another Canadian firm as opposed to that done with a foreign firm.[17]

There are a wide variety of government policies and programmes to support the efforts of firms to find joint partners. These include those administered by CIDA as part of Canada's foreign aid as well as trade commissioner services, PEMD trade missions, the insurance and finance facilities of the EDC and many others.[18] Joint venturing is supported from the earliest stage of the examination of sectoral opportunities in particular markets to the final stages of supporting specific projects and joint ventures for their development.

There are now numerous projects being financed by international financial institutions (IFIs) that they insist be developed jointly with a local company.[19] The joint venture may have become crucial to obtaining foreign work, so much so that some large firms have and are continuing to develop highly sophisticated information networks linking themselves to potential venture partners and enabling them to stay advised on a timely basis of opportunities to undertake projects.

Requirements imposed by foreign governments that Canadian firms form a joint venture to get work in another country represent the foreign country conferring a comparative advantage to the skill mix (in this case the nationality) of indigenous firms. To the extent that private sources fund projects requiring low-cost Canadian (or other foreign) firms to take on a joint partner to meet local content regulations, the foreign government imposing such restrictions will have to balance the political goodwill generated in its consulting engineering sector against the ill-will generated among purchasers of the projects. When government itself is the client, there is no balancing act to perform.

CIDA and EDC funded projects are intended to be foreign aid from the Canadian government to lesser developed countries. This is done by a gift or loan of funds for a capital project. Attendant upon this is the transfer of technology and training to some citizens of the lesser developed recipient country—acquired on the job—as a joint partner. In 1982, CIDA and the EDC financed $58 million worth of Canadian consulting engineering abroad. This represented about 23 percent of total foreign fee income earned by Canadian firms.

In an effort to foster awareness of foreign opportunities, External Affairs is developing the WIN Exports system. One component of this, in addition to the services of trade commissioners which is of interest to consulting engineers, is a WIN Exports Importers' directory. The directory will provide each DEA foreign post with the same sort of information about larger local companies that they can now access for sourcing goods and services from Canadian companies. This represents a resource to those small and medium-sized Canadian companies lacking the resources to keep abreast of foreign markets. The likely cost to taxpayers is low. However, firms in any specific industry are aware that the material on the opportunities for their industry in any particular region may quickly become dated as many industries are asking for the services of the trade commissioners. There will still be an incentive for self-interested industry and business associations to form their own marketing/information gathering bodies in search of higher sales abroad through awareness of joint venture opportunities.[20]

The trend in foreign work toward developing projects as joint ventures may favour larger Canadian companies and encourage mergers of smaller firms. This is a rational response to the increased costs of doing foreign ventures jointly. Market presence and local knowledge require added expense. These are the costs of continually operating networks to keep abreast of foreign market opportunities. Smaller firms may find the costs—in time and money—of participating in the foreign market prohibitive. Only larger firms, spreading the cost over larger revenues, may choose to stay in the foreign

market.[21] Smaller, more specialized firms wishing to export may choose amalgamation with other smaller firms or with larger firms. Some smaller firms may choose to retain control over their operations and eschew the foreign market altogether.

Innovative Financing

Another trend in doing business internationally is the requirement, when bidding for foreign engineering work, that a proposal be submitted indicating the long-term financing for the project. The proposed financing then becomes an important consideration in post-bid evaluations. This forces firms wishing to do business in the Third World to be not only physical engineers but also to become financial engineers.[22] Again, for the larger firms, with higher volumes of work over which to spread the additional costs, these added responsibilities may not mean the end of competition for foreign work. For smaller and even medium-sized firms, these new costs may eliminate their ability to compete abroad or, if they wish to compete, may induce them to become larger through merger with other firms. It should be noted that the change in structure of the industry is not necessarily bad nor does it represent a loss to Canada of the skills previously harnessed by smaller firms.

Canadian government assistance through the EDC attempts to help smaller firms, though EDC credits are sometimes priced out of the market and/or risks are adjudged to be so great in some poor countries that the government will not agree to provide new export credits at all.[23]

Another, non-governmental avenue of financing is for the firm to take an equity position in projects it develops. There are indications that the World Bank, through the International Finance Corporation (IFC), is prepared to cooperate. The IFC invests side-by-side with private sector investors.

World Bank equity participation in a project—in 1985 the IFC took a stake in 85 projects in 39 countries—helps the private sector partner feel more secure in the project. Now the Inter-American Development Bank (IADB) has developed an equity financing facility, modelled after the IFC, which is to support smaller scale projects in Latin America. Emulation of these financing facilities in Africa and Asia are likely to follow.

Another important development in this area is the Multilateral Investment Guarantee Agency (MIGA) which was expected to open for business in 1987. MIGA will provide direct investors from member countries with a guarantee against non-commercial risk in another member country. Non-commercial risk will be comprehensively defined, and insurance will be against the risk of expropriation or nationalization, war and civil unrest, breach of government contractual obligations and the risk of currency con-

trols. All these developments suggest that direct equity participation will become more important in financial engineering.

For small and medium-sized Canadian firms, deciding to go the route of equity participation has two advantages. The first advantage is that national institutions, which may not be able to offer competitive financing, may be bypassed. Secondly, managerial control, which would be subsumed in a merger or amalgamation with another firm, may be retained. However, it must be emphasized that equity participation adds to the risk involved in project development.[24] This risk will, at times, be too great for smaller firms to assume.

As a matter of public policy, it is not clear that either joint financing or innovative financing requirements are a comparative impediment to exports of Canadian engineering services relative to other developed nations. However, these requirements—and the higher risk export business in general—may be an impediment to smaller firms, both in Canada and in other countries. Canadian government responses aimed at encouraging the exports of smaller firms serve to restrain the amalgamation of firms which would otherwise occur as potential exporters took on partners or merged with larger firms. This will mean that the size structure of the industry will be skewed towards more smaller and fewer medium- to larger-sized firms than otherwise would be present. Given the very large numbers of small firms in the industry, this effect is, at best, only of minor importance in the domestic market.

The practice of encouraging exports through government action, whether it be assistance to large or small firms, bears scrutiny. One common argument for such assistance is that in times of economic recession at home foreign business can take up the slack. Governmental assistance to firms to exploit foreign opportunities is seen as a cheap way of keeping domestic resources employed in that industry until domestic conditions improve. However, the market may be signalling to those resources to find alternatives, and government intervention will only serve to mask those signals.

Government programmes that encourage export policies act to increase the return to export activity and will encourage such activity by firms of all sizes and, if consciously aimed at the smaller firms, will encourage them differentially. With flexible markets, subsidizing engineering exports will induce a larger stock of engineers than would the market acting alone. This impact is undoubtedly small, given the size of aid and the relative sizes of the domestic and foreign markets, however, the distortion of the labour market may be unnecessary.[25]

If conditions in foreign markets, especially fast growing Third World markets, have changed—requiring joint ventures with local firms, financing packages and the like—smaller exporters will be disadvantaged. It may be

better government policy to recognize that exporting firms, actual and potential, will have to make adjustments if they wish to stay in those markets. Foreign countries that impose such venture/financing arrangements also have to realize that they will pay higher prices for engineering services imported. Fewer suppliers will be forthcoming and only at higher prices as the restrictive terms imposed become more harsh. This case, made by exporter nations, is an important one to make and may be better policy than trying to out-compete other exporting countries in the levels of subsidies and aid granted to exporters.

Firms wishing export markets may have to give something up in order to attain those markets. If smallness for the average entrepreneurial engineer means not having the financial resources, willingness to take risk, or work volumes over which to spread the additional costs of export-seeking activity, then the small engineer who wishes to export may have to join with other Canadian firms—both in and out of engineering—to form a firm large enough to reap the advantages associated with the export market. That some firms would wish to remain small, retain full control and enjoy export success is understandable, but that they do it through the largess of government and at the expense of other Canadian firms willing to put in the resources to exploit this market is less compelling.

COMPETITION FROM CROWN CORPORATIONS

In recent years there has been a growing tendency for public utilities and other Crown corporations to seek contracts in export markets. Based on the 1985 and 1986 *ENR* surveys, Hydro-Québec International, a subsidiary of the provincial Crown corporation, is the seventh largest Canadian engineering firm in terms of export earnings. Industry spokespersons argue that this may involve unfair competition.[26]

Crown corporations do not have the same "bottom line" as private firms against which projects are measured. The borrowing capability and authority of the government supports their activities. Consequently, Crown activities in competition with private sector suppliers may appear to be subsidized by political rather than market considerations. At a minimum, it is hard for the Crown corporation to escape the appearance of cross-subsidizing competitive export activity by virtue of excess profits accruing to a domestic, government created monopoly.

From a market perspective, it is preferable that these Crown activities be sold and operated privately. Short of selling an entire corporation or agency, the export arms of Crown agencies, for example Hydro-Québec International, provide the ideal candidates for first round privatizations.

SUMMARY

Foreign markets, especially Third World ones, promise great growth potential. Relatively few of Canada's consulting engineering firms actively participate in the foreign market. However, those that do have a major proportion of the international market. For these firms, and for those who contemplate entry, capturing the benefits of foreign work is becoming increasingly costly.

In some markets, joint venturing is almost requisite for winning a contract. Taking an equity position or other *avant garde* financing arrangement bares an engineering firm to risks it is unfamiliar with calculating let alone dealing with. These all seem like areas that a willing government could aid in.

In explaining why a minimum of government intervention is preferable even in these risky markets, it is necessary to go back to the reasons consulting engineering is perceived as a model for other service industries wishing to export. In the past, with very little or no government assistance, the Canadian consulting engineering industry built itself into the third largest exporter of its services in the world. There has never been a time, nor will there be, when foreign markets are not in a state of change. Engineers always had to go out and find their market and sell their services. This they did, and apparently did very well.

The worry on the part of government today seems to be that the mass of smaller and newer firms will miss out on the rising foreign market unless they have assistance from governments. This has not been true in the past and need not be in the future. Small and medium-sized operations with world class ideas may get abroad in a number of ways. That some sacrifices may have to be made in organizational structure or level of risk-taking acts as a self-screening mechanism to ensure that the engineer truly believes his service and the market are suitable. Government intervention only serves to lower the costs of entry and means that taxpayers will subsidize export activity through the assumption of part or all of the risk.

Government programmes operated through trade commissions already in place and supplementing plentiful private market information are probably of value to industry equal to what the industry pays for the service. For the taxpayers, the additional cost seems small in relation to the possible web of assistance programmes, insurance schemes and the like that could be dreamt up and imposed.

NOTES

1. However, for some 200 or so firms who are active in the export market, fee income from foreign sources may comprise upward of 40 percent of their total fee income.

2. *Engineering News Record* is a trade weekly published by McGraw-Hill Publishing, New York. In August of each year it publishes a survey of international revenues titled "The Top 200 International Design Firms."

3. Year-to-year comparability based on the *Engineering News Record* surveys is made especially difficult in the case of Canada after 1985. This is because Lavalin International Inc., the third ranked international design firm in the *ENR* survey in 1985, is now designated an international contractor and is included in that publication's Top 250 International Contractors list. Lavalin reported $340 million in foreign contracts for 1986, see *Engineering News Record*, July 16, 1987. Of this $340 million, Lavalin says $150 million came from consulting engineering services provided abroad.

   Lavalin's absence from the 1986 international design survey accounts for the drop in Canada's relative standing. If Lavalin's $150 million in foreign engineering contracts were included in the 1986 results, Canada would have 10.1 percent of the foreign market as opposed to the reported 5.8 percent. This would place Canada third, behind the U.S. and the British. It would also represent a strong rise in Canada's share of the foreign market from 7.3 percent in 1985 (as reported in the 1986 survey).

   These problems of re-assignment are not particular to Canada. However, Lavalin's pre-eminent position and re-assignment seriously skews the top 200 results in the survey of 1986 reported in the August 6, 1987, issue of *ENR*. Another problem is coverage, again not isolated to Canada. A conversation with a representative of a medium-sized Vancouver-area based firm revealed that they were not surveyed yet would have qualified handily for inclusion in the most recent *ENR* survey of the top 200.

4. *ENR*, August 6, 1987, p. 31.

5. The aggregate is "consulting and other professional services" and comprises "services in areas such as engineering, architecture, law, accounting, marketing, planning, taxation, finance, drilling and development of natural resources." See catalogue 67-510, p. 48.

6. The category "business services" is comprised of the following services: consulting and other professional; transportation related;

management and administrative; research and development; commissions; royalties, patents and trademarks; films and broadcasting; advertising and promotional; insurance; computer; equipment rentals; franchises and similar rights; communications; refining and processing; tooling and other automotive charges; and other. See catalogue 67-510, pp. 16, 17 and 24.

7. On a regional basis, in both 1983 and 1984, the Atlantic provinces, Ontario and the western provinces all had deficits, that is, payments greater than receipts, on the business services account. Only Quebec had surpluses on that account for those two years. See catalogue 67-510, pp. 20 and 46.

8. For CIDA and EDC estimates: Statistics Canada, *Architectural, Engineering and Scientific Services 1982*, catalogue 63-537, occasional, 1985, p. 32. The percentage of foreign billings attributable to CIDA and EDC work for 1978 and 1974 are 45 percent and 24 percent, respectively. Of those percentages, 59 percent, 43 percent and 66 percent were funded by CIDA in 1982, 1978 and 1974, respectively. Therefore, CIDA funding accounted for 14 percent, 19.4 percent and 15.8 percent of foreign-derived fee income in 1982, 1978 and 1974, respectively.

   For international trade development activities: *Government of Canada, Public Accounts of Canada, 1985-1986, Details of Expenditures and Revenues*, vol. II, part 1, p. 8.11.

9. *Promoting Canadian Exports: The Trading House Option*, Report of the Trading House Task Force, November 1984, p. 24.

10. This is from the *Market Perception Study* (1986) for British Columbia. Obviously, all conclusions may not hold across the country.

11. Data from Statistics Canada (*Construction In Canada*, July 1986, table 1, p. 11) indicates that the percentage of total real construction value expended (constant 1971 dollars) on repairs of existing facilities rose from 15.9 percent in 1977 to 18.2 percent in 1984. This is a growth rate, on an average annual basis of 2 percent per year. Over the same period, the real value of total construction work purchased was virtually unchanged. As a percentage of real (constant 1971 dollars) GNE, the total real value of construction work purchased fell from 16.1 percent to 13.8 percent from 1977 to 1984.

12. With these new services, other services, for example advertising and marketing, will play a larger role in the success or failure of an engineering venture.

13. Discussion with representatives from medium- to large-sized firms in the industry in Vancouver stressed them planning to stick to what they know best. There may be natural integrations possible, for example,

pulp and paper engineers entering the mapping and remote sensing of forests to gauge their pulp potential, but on the whole these participants were publicly skeptical of their role in non-traditional pursuits. This professed skepticism and unwillingness may be a strategic response to being seated with seven or eight competitors in the same room.

14. Not all firms view the Third World as a chosen target. The view expressed by industry representatives I spoke with was that there was engineering to be done in the U.S. and other developed countries which promised greater return and less risk.

15. Many methods have been devised to get such plans across the border with the U.S. prior to the ease of electronic transmission. The story is told of how "white prints" (blue lines on white paper) arose in response to problems at customs with getting blueprints (white lines on blue paper) across the border. When the officials became aware of the white print substitution, microfilm was substituted for white prints. Second generation microfilm had "made in the U.S.A." imprinted on the edge to vouch for its origins and allow its duty free passage southward.

16. Statistics Canada, *Architectural, Engineering and Scientific Services 1982*, catalogue 63-537, occasional, p. 34. This information was not provided in the two earlier surveys carried out on the industry by Statistics Canada in 1974 and 1978.

17. New surveys being designed by Statistics Canada are sensitive to this issue and will try to capture the quantitative significance of joint venturing domestically and abroad.

18. An important complaint of non-Ontario and non-Quebec engineering firms is that the absence of CIDA decision authority in their provinces makes competition for funds unduly harsh for them relative to central Canadian competition. This is because they have to have a presence in Ottawa to have their voices heard. This takes time and money.

19. It has been reported that *all* work done in China will have to be through joint ventures with local firms. See *Engineering News Record*, August 7, 1986, p. 35.

20. In addition to having representatives abroad, firms may also hear of foreign opportunities through a number of private newsletters. These newsletters assist firms to find out where, when and what value proposed projects will be around the world. For example, McGraw-Hill's publication, *International Construction Weekly*, serves the market along with a host of others. That these publications are not free, the weekly cited above costs (US) $700 per year, reflects the strength of the market for this type of information.

21. According to the *MPS*, a foreign presence is very important in gaining foreign work. "In this regard, the survey respondents strongly emphasized the importance of a local presence, either in the form of a local representative or a tie to a local firm... Without this local presence and regular contact, there is virtually unanimous agreement that a foreign consulting engineering firm stands little, if any, chance of success" (1986, p. 70).

22. In talks with industry representatives, it was stressed that the problems associated with innovative financing and the uncertainties of doing business in the Third World—for example, management control of equity partnerships, currency controls making removal of fees difficult or impossible, et cetera—made the North American market, especially the U.S., look increasingly attractive relative to the Third World.

23. B.C. and Canadian engineers are perceived as being expensive relative to some competitors, for example, those in Korea and India. However, quality-adjusted this perception may be different as B.C. and Canadian engineers are also perceived of as innovative and as doing high quality work. See *MPS*, 1986, chapter V.

24. This risk is having to be a captive, silent, minority partner in an enterprise whose majority interest has different motives and operating skills.

25. This distortion is a chronic over-supply of engineering labour. It should be noted that provincial and federal governments in Canada are not alone in offering assistance to exporters of goods and services. Most, if not all, foreign countries offer forms of assistance to their own exporters.

    Current problems with world-wide agricultural policies should serve as an example of the dangers involved with trying to "out-compete" foreign countries by offering larger and larger subsidies to domestic producers or foreign purchasers of our services.

26. In 1984 and again in 1986 Ontario Hydro signed an "Agreement with the Consulting Engineers of Ontario" pledging to withdraw from bidding on a project whenever a private Ontario firm is also in the bidding. The agreement may be more cosmetic than real as Ontario Hydro has no explicit export mandate.

CHAPTER 8

GOVERNMENT AND THE INDUSTRY

INTRODUCTION

The close relationship between government and industry is evident on almost every page. In both domestic and foreign markets, Canadian governments are major buyers of consulting engineering services. In this section, a brief reprise of the main areas in which there is contact will be followed by discussion of the procurement policies of federal, provincial and local governments as they affect consultants. The chapter ends with a discussion on the implications of the free trade agreement recently signed with the United States.

PAST POLICY... A REPRISE

In the past, governments have targeted few explicit policies at consulting engineers. Most importantly, at the provincial level, engineers have been granted the rights of professional licensure. This allowed provincial associations to control supply and gave them the power to raise returns to members above those that would exist under free entry.

Governments, at all levels, have carried out much engineering work in-house, though the post-World War II construction of social infrastructure provided so much work that many consulting engineers also received government contracts.[1] Of total fee income for consulting engineers, surveys show roughly half has been generated from government sources.[2]

Hydro-Québec, Quebec's provincial Crown corporation responsible for power generation and transmission, is the single well-known exception to the policy of doing public utility engineering in-house. That provincial government's stated policy to be "masters of our own house" and the consequent letting of contracts to Quebec-based engineering firms made it probable that Hydro-Québec's policy engendered the growth of large consulting engineering firms in Quebec compared with other provinces.[3]

Local preference policies have been and still are in place which call for purchase from local, in-province suppliers of goods and services unless similar quality and quantities can be purchased from out of province suppliers at a savings of at least 10 percent. These policies are the main interprovincial barrier to trade in engineering services.

Finally, export assistance by the federal government is handled through trade commissioner services and two organizations within the Ministry of External Affairs. These two organizations are the Canadian International Development Agency, which provides funding for foreign aid projects built with Canadian expertise and material, and the Export Development Corporation (EDC), which provides long-term loans to foreign buyers of Canadian capital equipment and technical services. The EDC also acts as an insurer for Canadian firms selling abroad. These two organizations provide the major source of industry/Canadian government interaction in the market for international work.

The MEA also operates the Program for Export Market Development (PEMD), which provides funds for specific project bidding, market identification trips, participation in trade fairs abroad, invitation to incoming buyers, formation of export consortia, sustaining export market development activities and export marketing for agricultural, fisheries and food products. Consulting engineers use PEMD grants for the first two purposes, specific project bidding and market identification trips, almost exclusively.

PROCUREMENT

With the drive toward privatization, the issues surrounding procurement policies and practices may subside. However, until then these issues remain topical.

Complaints from firms in the industry are that government procurement practices sometimes place a needless burden upon them. A 1986 survey of consulting engineering firms who have never participated in federal government work showed the reasons "never being asked" and "preferential procurement policies" rated as "important" to two-thirds of the respondents.[4] Other reasons, with percentage listing this reason as important in parentheses, included: "no Ottawa office" (43.2 percent), "payment too slow" (20.9 percent), "prefer not to work for governments" (17.2 percent), "don't need the work" (15.3 percent), and "contract terms and conditions" (14.7 percent).

For those firms dissatisfied with aspects of their last direct federal contract, respondents to the same survey showed "length of time before notification," "speed of processing invoices" and "appropriateness of payment

schedule" as the most problematical. Comparing government practice to the private sector, at least three-fourths of respondents agreed with each of the propositions that the private sector "awards contracts faster," "has less complicated paperwork" and "terms and conditions of contract are less demanding/complex in private sector." However, only 37.6 percent agreed that the "private sector processes payments faster."

On a regional basis, federal contracts are harder to obtain the further from Ottawa the firm is located. While the government may have offices of a department spread throughout the country, the Ottawa office may be the one where the majority of the engineering work is carried out. This gives the consulting engineers in central Canada with close ties to Ottawa an advantage over those more geographically dispersed.[5]

Finally, the general attitude toward federal procurement systems are that they call for "too detailed bids for small contracts" (70.4 percent), that the "decisions favour lowest price" (66.6 percent), and at least half of respondents feel "terms are too demanding/complex," "RFP should indicate price" and "need standardised terms and conditions."

There is one other aspect of involvement with the government system that bears noting. Only 27 percent of respondents who have experience with both federal government contract work and international work felt that federal government contracts for domestic work were important to their international competitiveness. This result is surprising and may be a function of the sample size for this question (63) or the fact that much government work that has translated into experience for international work has been initiated by provincial public utilities and the like.

Evidence suggests that provincial government selection processes are more flexible. Geographic location is an important factor. However, cost-conscious provincial governments are seen to be moving more toward the federal model of procurement where cost is an important determining factor. The quantity of provincial work in B.C. to be contracted out is seen to be declining, however, strong areas will be in transportation, health and waste management systems. Staff reductions at the provincial level seem to be much slower than at the federal or municipal levels.[6]

At the municipal level, the selection and procurement process varies substantially, depending on project nature and size of community. Local and/or regional preference is important as is direct sourcing. Competitive bidding is making inroads. Opportunities for work at the municipal level are in renovation and upgrading of existing physical infrastructure, notably roads, bridges, water supply systems and sewage disposal systems. Funding problems are inhibiting work at the municipal level.[7]

TAX POLICIES

This short section is not intended to be exhaustive, however, it serves to alert the reader to an area that is often overlooked and where much more research could go.

From the perspective of the industry of consulting engineering, there does not appear to be any major differential tax treatment relative to other industries.[8] There are, however, some tax code provisions which act as a boon to activities into which engineering skills are a major input.

In the area of research and development the Canadian government has increasingly been interested in stimulating activity through tax-based incentives. These incentives are in the form of deductions from taxable income and investment tax credits for scientific research and experimental development. Unfortunately, changes to the tax act have been frequent and, consequently, firms have not faced a consistent environment in which to operate. However, the thrust is toward encouraging research.[9]

In addition, investors in certain industrial sectors are encouraged through the tax system. For example, a tax-based inducement (currently under review) for exploration and development[10] work in the mining industry presently exists. Investors are allowed a "write off" of $1.33 for every $1 invested in exploration and development of mines in Canada. To the extent that these stages in mining are engineering intensive relative to the operation of the mine, engineers in mining benefit.[11]

In the area of foreign trade, tax policy and engineering are also intertwined. For example, if taking an equity position is a requirement for gaining business in markets, then Canadian government tax policy should reflect this. Equity held by Canadian engineering firms in foreign plants and operations should not be taxed until it is patriated to Canada.

IMPACT OF FREE TRADE WITH THE UNITED STATES

As of this writing, Prime Minister Brian Mulroney has just announced the completion of a free trade agreement with the United States. While details are sketchy it appears that

> the agreement will provide, for the first time, a set of disciplines covering a large number of service sectors. The agreement will provide that the two governments in future will extend the principles of national treatment, right of commercial presence, and right of establishment to each other's providers of services. Additional sectoral annexes will clarify this general obligation with respect to transportation, enhance telecommunications and computer services, tourism and architecture.[12]

While engineering services are not expressly mentioned, there is enough room in the statement to see the inclusion of this sector, and the following comments assume that further negotiations will include engineering services.[13]

At present, the federal border with the U.S. is not an overwhelming barrier to trade in engineering services. Canadians have typically been the top foreign engineering presence in the U.S., taking well over one-half of the foreign billings in the U.S. market. The U.S. is probably the major foreign presence in the Canadian engineering market, as well. In 1986, the size of the U.S. market going to the top ten foreign firms with a presence there was (US) $116.4 million, and Canadians received just over one-half of that. The Canadian market taken by the top ten foreign firms represented (US) $16.3 million.[14]

The barriers to trade in engineering services between the two countries are, if anywhere, in the provincial/state regulations as imposed by the professional licensing bodies.[15] Currently, some jurisdictions are harder to get licensed in than others.[16] However, from conversations with industry representatives, it seemed to be the case that entry into the U.S. market, though having some federal red-tape binding the granting of work permits, was not a major problem at the moment. Further, it is not immediately clear that these new federal agreements will have binding force on matters, especially licensing for temporary practice, currently under state/provincial aegis.

Where the free trade agreement may mean more for the Canadian economy and Canadian engineers is in three other clauses, one on government procurement, a second on trade in energy, and the third involving relaxing investment restrictions on U.S. investment in Canada.

The government procurement clause opens the large non-defence U.S. government market to Canadian bidders, though presumably it does not alter state and local government preference programmes. The value of procurement opportunities to be opened to Canadians by the agreement is estimated at approximately (US) $3 billion. The opportunities opened to U.S. businesses are approximately one-sixth of the above total.[17] While there are no current provisions for services under the GATT agreements, access to this U.S. market will be beneficial for Canadian engineers indirectly through the ability of Canadian goods suppliers to acquire additional business.

The trade in energy clause will make it easier to export Canadian hydroelectricity, petroleum and natural gas to the U.S. This may have a dramatic impact on construction and industrial activity in the western provinces as well as in central Canada. Recently, the National Energy Board blocked a $3 billion export deal Hydro-Québec had signed with the New England states.[18] Although unclear at this writing, under the new trade agreement

such exports may not be subject to review. Consequently, construction activity would rise in Quebec as generation, transmission and distribution facilities were built and augmented. Similar activity can be expected in the western provinces[19] and, as Canada has a comparative advantage in this type of engineering expertise, most of the additional work will stay in this country.

Making investment in Canada less onerous may bring projects and plants on-line at a faster rate than previously planned by domestic investors and may enlarge the absolute size of construction and other economic activity in this country.

While the numbers are impossible to estimate at this early stage, the qualitative impact of the agreement is clear. Canadian consulting engineers stand to gain through free trade with the United States. Opening the borders to the export of Canadian energy products will build on the skills and technical know-how already present in the country. Allowing U.S. investors to seek opportunity in Canada will encourage growth and construction. Making access to the U.S. market more open for trade in services and access to federal government procurement contracts also encourages the employment of the current stock of engineers.

Given that physical laws seem a constant world-wide, the Canadian engineering community may have much more to gain from the trade agreement than many others in the services to business management industries. For example, lawyers have to contend with different legal frameworks country to country, and accountants may have different standards and definitions of common terms. These differences necessitate learning a new system for these professionals. For engineers, gravity, chemistry, hydraulics, fibre optics and the physical world in general are not something that have to be relearned from country to country. Widening the door to the U.S. market represents a golden opportunity for more economic activity, both here and in the U.S. This increase in activity will bolster the market for engineers in both Canada and the U.S.

SUMMARY

The new material covered in this chapter deals with the procurement practices of governments, tax policy and possible impacts of the free trade agreement. Consulting engineers generally feel that federal government procurement practices could be re-designed, making the process of contracting out much less burdensome.

A brief section on tax policy shows that some current federal practices may benefit engineering activity through encouraging research and develop-

ment activities. As well, some federal tax provisions may encourage industries which are engineer intensive. The issue of taxation is thorny, and any complete discussion with relevance for engineers must include taxation policies at the provincial level.

Aspects important to the engineering industry in the recently signed free trade agreement with the United States were also discussed. Briefly put, the free trade agreement, if ratified, will encourage investment in Canadian industries that typically employ significant engineering inputs.

NOTES

1. Roughly 10 percent of all census engineers work in one level of government or another. Not all of these people are necessarily doing engineering for the government.

   Contracts with public sector unions often inhibit the letting of contracts to outside consultants. For example, in British Columbia, article 29, of the provincial government's agreement with the B.C. Government Employees' Union respecting the letting of work, specifies that all work be done in-house unless there are no qualified and able people within the bargaining unit capable of performing the work.

2. Statistics Canada, surveys 1974, 1978 and 1982.

3. The three largest Canadian consulting engineering firms, which account for roughly one-fourth of the Canadian market, all have their headquarters in Quebec.

4. *The Impact of the Federal Government Procurement System on Selected Service Industries: Final Technical Report*, Ekos Research Associates, submitted to DRIE, May 1986.

5. This is apparently the case with the Department of Communications (DOC), where there is little use of consulting engineers in British Columbia as there is little engineering work of any sort done by the DOC in B.C. Meanwhile, the DOC group in Ottawa use consulting engineers extensively for a wide variety of conceptual, feasibility and design studies on advanced communications systems. See *MPS*, 1986, p. 10.

6. *MPS*, 1986, pp. 39-41. As outlined in the *MPS*, the procurement procedure scores proposals on several criteria and then uses cost as the choice criterion amongst the short-listed applicants. The capability to carry out work, management of work, methodology proposed, quality of proposal and geographic location are the criteria scored and summed to compile the short list. Those surviving this hurdle are then judged on a least-cost criterion.

   In the U.S., the federal government and over half the states follow the Federal Architect-Engineer Selection Law, Public Law 92-582 (the Brooks Act, passed in 1972). The Brooks Act calls for "the Federal Government to publicly announce all requirements for architectural and engineering services and to negotiate contracts for architectural and engineering services on the basis of demonstrated competence and qualification for the type of professional services required and at a fair and reasonable price" (section 902). Further, the agency head is to

determine what a fair and reasonable level of compensation is for the government to pay and then negotiate with the most qualified firm. Should the agency head be unable to negotiate a satisfactory contract with that firm, negotiations should be formally terminated. Negotiations should then be undertaken with the second-most qualified firm, third most and so forth (section 904).

7. This paragraph is based on the *MPS*, 1986, pp. 15 and 40.

8. One industry representative has suggested a "corporate" form of the registered retirement savings plan to allow the tax-deferred savings of income in good years to be withdrawn during leaner times.

9. See J.A. Zinn, "Tax Incentives for Canadian Research," chapter VI, in D.R. Bereskin, ed., *Research and Development in Canada*, by Rogers, Bereskin & Parr, Butterworths, Toronto and Vancouver, 1987.

10. Operating expenses are not included.

11. Again, these tax incentives do not necessarily benefit consulting engineers if the firms doing the exploration and development do their engineering in-house.

    This brief section omits any discussion of taxation at the provincial level. Provincial taxation on natural resource-based activity in particular may affect engineering activity greatly.

12. This is from the summary of the tentative free trade agreement reached between Canada and the United States released by the Prime Minister's Office, as published in the *Vancouver Sun*, October 7, 1987, B7 and B11. The agreement also "will provide for improved and easier border crossing by business persons trading in goods and services."

13. Indeed, some commentators in the industry have already done so. See "Professional Groups Happy With New Access to U.S.," *Vancouver Sun*, October 9, 1987, F5.

14. *ENR*, August 6, 1987, p. 31.

15. Licensing engineers is also a state prerogative in the U.S.

16. California is one state where temporary licences to practise are hard for foreigners to obtain. However, the state of Washington has lower barriers. Consequently, Canadian engineers wishing to work in California gain a Washington licence and then exercise the reciprocity relations existing between the two states to gain admittance to California.

17. These figures from *Canada—U.S. Free Trade Agreement, Elements of the Agreement*, preliminary transcript, 7/10/87, p. 9.

18. See "Energize Policy," *Financial Post*, August 31, 1987, and "Quebec Hydro Exports Face U.S. Outcry," *Financial Post*, October 19, 1987, p. 6.

19. See "Guidance Needed On This Voyage," *Financial Post*, October 19, 1987, p. 15.

CHAPTER 9

SUMMARY AND CONCLUSIONS

The consulting engineering industry, when measured by output and employment, appears small in comparison to the entire Canadian economy. However, in the fast-growing services to business management sector, consulting engineers make up a significant proportion of employment. Consulting engineers are under-represented in the Atlantic region relative to their employment and output in the rest of the country. However, this under-representation in the Atlantic region is a feature common to the entire services to business management sector, not engineering alone.

The demand for consulting engineering services is a direct and statistically significant function of the level of real construction activity in the country. The fall in real domestic construction activity during the recent recession had a dramatic impact on employment in the industry. This was exacerbated by the appreciation of the Canadian dollar relative to some foreign competitors' currencies, for example Korean currency, which made competing in foreign markets harder.

The process of innovation in engineering is often an informal one and is almost totally "market driven." Rather than direct attempts at innovation, engineers may visit old plants to see how the owners have altered the original designs and processes to meet changing needs. Additionally, engineers may pass on technological knowledge through informal chats, in-house technical bulletins and the like. An oral tradition exists which makes the explicit spread of an idea or technique hard to map. Studies in manufacturing have shown that most processes and designs are copied by the competition within 12 to 18 months of introduction.

For these reasons, explicit policies to encourage research and development in this industry must recognize the human knowledge or human capital aspects of it.

Some important clients, most often local and provincial governments, do not wish innovations be tried on projects they require. On large public works packages, for example, sewage treatment and water delivery systems, the

"tried and true" is preferred. This is because the expected costs associated with a failure of the system are viewed as outweighing the expected savings of innovations.

The industry is characterized by a size structure skewed heavily toward firms of five or fewer employees. Growth in the number of firms in all size ranges of employees, except "500 or more employees," was above the national norms in the 1978 to 1984 period. By traditional concentration ratio measure, the industry is competitive. The three largest firms account for approximately 25 percent of industry revenues. There is no evidence of excess profits in the industry. Entry barriers are low if the engineer is licensed by provincial associations empowered by provincial legislation to set membership criteria and rules of practise.

Technological change is altering the input mix within the consulting engineering firm. With the advent of low cost computer-aided drafting and design, the engineering office features fewer technicians and draftspersons supporting the professional engineers.

Any discussion of industry structure must recognize that more than three-quarters of all engineers are employed in industries other than consulting. Growth potential is therefore significant if private and public industries find it cheaper to hire engineering services from consultants. Since the shift toward hiring consultants would also release engineers from those sectors, the supply of consulting engineers may be expected to rise. Consequently, short-run impacts of government privatizations may encourage both more demand and more supply of engineering services in the private sector.

The average engineer is nearly 40 years old, male, and a university graduate. Employment incomes are higher in the Western region. This is a function of the types of engineering skills required and must be leavened with knowledge that employment in those specialties, for example oil exploration, may be less stable.

Productivity in engineering is positive, but slight. The changing factor mix toward more professional engineers within firms, noted above, will raise industry productivity. Another dimension to the productivity issue in engineering is that so many engineers are employed in other industries. Clearly, the productivity of engineers in manufacturing, for example, may be an important contributor to manufacturing productivity. In many industries, the number of engineers employed per thousand employees rose over the 1971 to 1981 period.

Canadian firms, especially the larger ones, are important suppliers of services to foreign purchasers. Canadian firms, as a whole, account for approximately one-tenth of the volume of international business, ranking

behind the U.S. and Britain in the international market. A significant amount of Canadian industry fee income derived from foreign projects is actually funded by Canadian government sources, for example CIDA.

The foreign market, especially in the developing world, is changing shape. Requirements to form joint ventures with local firms are coming to be normal practice. Providing financing up to and including equity partnership in projects is placing emphasis on financial engineering in order to win bids. These considerations make the Third World nations a costlier place to seek business. This, in turn, makes the relatively stable North American market look more attractive to exporters.

Exporting, especially great distances, has always imposed costs on firms. These costs act as a screen to ensure that only those who think they can successfully compete abroad do. The Canadian government provides some export assistance for first-time exporters through the Program for Export Market Development (PEMD) as well as providing some "market intelligence" through trade commissioner services. These programmes lower the costs of doing business abroad. However, there is little evidence that successful exporters rely on these services to any great extent.

Firms that have a substantial export business have their own network of affiliates and contacts in foreign markets. This is because Canadian government services in the field are not always available nor are they considered to be up to date. Trade commissioners, while earning praise for their attempts on behalf of the Canadian engineering industry, are seen as having too many competing tasks to be completely effective. There are many exporters who call upon trade commissioners for services. Consequently, the opportunity to build up specialized knowledge and contacts about the engineering possibilities in a particular market are slight. This also means that trade commissioners are not always aware of contemplated projects in the earliest stages of development when the Canadian firm could bid on the project.

Program for Export Market Development (PEMD) grants and loans are viewed by some in the industry as being a gift for one-time exporters. The paperwork associated with the programme has also been criticized.

Programmes of the PEMD type, supported because engineers are believed to be the "thin edge of the wedge" into foreign markets, have been relatively low in cost, but probably poorly aimed. There are no reasons to favour first-time exporters rather than established exporters in the engineering industry. Successful exporting, as opposed to subsidized, single shot exporting, depends on firms being willing to expend their own resources to ensure that the risks are borne by the correct party, in this case the prospective exporter and not the Canadian public. Often there is an argument of "public interest" raised to justify such government programmes. Engineers are seen to be able

to stimulate the demand for other Canadian products through their design and procurement responsibilities on projects. However, there is little evidence that Canadian engineers are able to "spin off" significant foreign business for Canadian manufacturers. Where possible, this is done, but engineers must provide their services in a competitive market. If higher cost Canadian follow-on exports make the project more costly than it would otherwise be, foreign clients will be hesitant to hire Canadian engineers in the future. This is true in domestic work as well. The best way to encourage exports of manufactured goods is to encourage that sector to be competitive in the world environment.

On work that is financed by the government of Canada, for example that funded by CIDA, regulations require a certain percentage of "Canadian content." This hardly makes a case for supporting engineers. These projects should be viewed as gifts from the Canadian people to the foreign country involved *and* to Canadian producers. Figures vary from year to year, but CIDA-funded work is a significant portion of the Canadian engineering industry's foreign revenues.

All levels of government account for roughly one-half of the revenues generated in this industry. However, there is a great deal of engineering done in-house by all levels of government. To the extent that the government retains the role of provider of certain goods and services, this will remain unchanged as complete "contracting out" for engineering services in every instance is likely to be inefficient. However, the role governments play in making and providing goods and services should be closely examined. Increasing levels of private provision may encourage an increased demand for consulting engineers, but it must be recognized that not all work will go "out of house" no matter whether the goods are produced publicly or privately.

Currently, much engineering work done by private industry is done in-house and will remain organized that way until out of house provision is demonstrably cheaper. Over time this has been happening, but not at the same rate in every industry.

New trade policies on the horizon could significantly increase the demand for engineering services as energy and investment practices change. If the free trade agreement with the U.S. is ratified in both countries, it could also serve as a model for the negotiations on services in future GATT discussions.

The Canadian consulting engineering industry is competitive when measured by number of firms; robust, if measured by birth and growth rates; but highly susceptible to fluctuations in real construction activity. These changes do not always move contemporaneously with the business cycle, consequently, movement in real gross domestic product is not the best measure of the industry's fortunes.

Engineers serve many sectors in the economy which wax and wane in different patterns. Consequently, specific policy may be suitable for certain specialties while at the same time being unsuited for others. While stability in the growth of construction activity might best serve the industry, there is no evidence that governments acting alone or in concert have the prescience to foretell future conditions and act accordingly. Consequently, this industry can expect to have its fortunes tied to domestic construction behaviour.

This prediction is attenuated to the degree that for some firms (approximately 200 out of 4,000 in Canada) foreign revenues are a significant portion of total revenues. When foreign construction cycles differ from domestic, a smoothing out of revenues may be possible over time. However, firms should be the ones to make the decision to seek foreign work. The costs and risks associated with exporting should not be borne by the Canadian taxpayer.

One other consideration which may partially break the dependence the industry has on the domestic construction cycle is the ability to perform new engineering services that are not bundled with construction activity. While there is scanty evidence that the industry is doing more of this type of activity, it must be recognized that it still represents a minor portion of the total. It is also apparent that existing firms are hesitant to leave the fields that are their strengths. Consequently, younger engineers entering the field with non-traditional skills may well join firms which are classified not as offices of engineers but rather as being other scientific and technical services establishments. Current statistical practise makes the separation of engineers from other scientific and technical services establishments difficult. However, there can be little doubt that much of the growth and energy in the larger aggregate is due to the dramatic increase in activity in the latter category. Current statistics indicate that growth in real construction activity is slowing and that repair and remodeling construction is growing as a percentage of the total. This latter type of construction is less engineering intensive. At the same time, the foreign market is very competitive and will remain so. These facts, coupled with the growth in non-traditional pursuits, point to a change in the nature of the consulting engineering industry in the future.

Driven by the demands of the consumer of engineering services, the skill mix and activity in engineering offices must change over time if there is to be continued growth in the industry. If skill mixes do not change, many firms typically not classed as engineering establishments will continue to grow at the expense of consulting engineering. This should not be viewed as a problem for the economy or for governments. The services and training of resources in the newer, non-traditional areas will be employed by industry in

Canada. Yet, for the traditional consulting engineering industry the implications are real. If the industry concentrates on past strengths and fails to incorporate newer techniques along with traditional services, it will decline in importance in the economy.

APPENDICES

Appendix 1
Labour Force Census Data

Year	Labour Force	Number of Engineers
1941 *	4,195,951	18,547
1951	5,286,153	27,036
1961	6,471,850	43,066
1971	8,813,340	76,625
1981	12,267,075	134,490

Sources: Dominion Bureau of Statistics, 1941 Eighth Census of Canada, vol. VII; Dominion Bureau of Statistics, 1951 Ninth Census of Canada, vol. IV; Dominion Bureau of Statistics, 1961 Census of Canada, vol. III (part 1); Statistics Canada, 1981 Census of Canada, Population, catalogue 92–920.

Note: *1941 totals do not include those in active military service.

Appendix 2
Engineers—Age by Education

	Less than Grade 9	Grade 9 to 13	High School Diploma	Trade Diploma	Some University	University Degree	Total
Males							
15–24	5	180	1,250	20	690	6,220	8,365
25–44	450	2,775	4,580	5,795	14,760	54,370	82,730
45–64	1,255	3,215	2,325	4,910	6,555	18,655	36,915
Females							
15–24	0	15	215	0	90	875	1,195
25–44	40	275	530	150	555	2,805	4,355
45–64	40	105	90	50	140	225	650

Source: Statistics Canada, 1981 Census of Canada, Population, catalogue 92–917.

Appendix 3
Labour Force by Region, 1971 and 1981

	Total Labour Force	Architects	Engineers
1971			
Atlantic	715,045	215	3,845
Quebec	2,242,840	1,180	18,215
Ontario	3,410,830	1,505	36,745
Western	2,444,635	1,135	17,825
1981			
Atlantic	986,805	375	7,135
Quebec	3,100,425	2,065	25,690
Ontario	4,548,410	2,240	59,495
Western	3,631,420	2,425	42,180

Source: Statistics Canada, 1981 Census of Canada, Labour Force-Occupation Trends, catalogue 92–920.

Appendix 4
Engineers, Specialties by Regions, 1981

	Atlantic	Quebec	Ontario	Western
Architects	375	2,065	2,240	2,425
Chemical	190	845	2,610	1,890
Civil	2,415	5,950	11,020	12,630
Electrical	1,825	4,850	13,005	7,040
Industrial	850	6,410	14,025	5,030
Mechanical	750	3,130	10,325	4,790
Metallurgical	40	550	850	280
Mining	195	475	1,115	1,640
Petroleum	65	170	270	3,885
Aerospace	140	800	1,045	510
Engineers, n.e.s.	655	2,510	5,230	4,475

Source: Statistics Canada, 1981 Census of Canada, Labour Force-Occupation Trends, catalogue 92–920.

Appendix 5
Labour Force and Sectors Employing Engineers, 1971 and 1981

	Engineers & Architects	Total Labour Force
1971		
Total	83,287	8,813,340
Agriculture	50	481,195
Forestry	390	74,380
Fisheries	35	25,440
Mining, Quarrying and Oil	4,185	139,035
Manufacturing	29,092	1,707,330
Construction	4,946	538,220
Transportation, Communications and Utilities	11,767	678,910
Trade	2,100	1,269,290
Finance, Insurance and Real Estate	1,156	358,060
Community, Business and Personal Services	18,840	2,041,390
Public Administration and Defense	10,726	631,740
1981		
Total	136,190	12,267,075
Agriculture	50	486,995
Forestry	800	102,960
Fisheries	80	37,790
Mining, Quarrying and Oil	8,885	216,445
Manufacturing	37,765	2,279,365
Construction	7,040	767,105
Transportation, Communications and Utilities	19,375	960,770
Trade	2,840	2,004,135
Finance, Insurance and Real Estate	1,525	636,070
Community, Business and Personal Services	40,740	3,477,245
Public Administration and Defense	17,090	908,155

Sources: 1981, Statistics Canada, Population—Labour Force-Industry by Occupation, catalogue 92–923, vol. I, Feb. 1984; 1971, engineers, Statistics Canada, unpublished census, database tabulation; total labour force, Statistics Canada, 1971 Census, catalogue 94–739, vol. III, part 4, May 1976.

Appendix 6
Distribution of Income, Male Engineers, 1980
(15 years and over)

	SOC 214/215 Engineers and Architects	SOC 2165 Engineering Technicians	Male Labour Force
Total	130,195	44,705	7,207,615
Income:			
Less than $5,000	6,055	4,385	1,267,290
$5,000–$10,000	6,685	3,925	944,915
$10,000–$15,000	7,630	4,955	1,154,145
$15,000–$20,000	12,800	9,015	1,287,845
$20,000–$25,000	23,565	11,055	1,085,805
$25,000–$30,000	23,620	6,620	626,420
Over $30,000	49,850	4,750	841,200
Average Employment Income	$26,918	$18,965	$16,988
Median Employment Income	$26,455	$20,028	$15,804
Average Employment Income for Full Year Employees	$29,804	$22,400	$21,441
Number of Full Year Employees	100,745	31,130	4,181,160

Source: Statistics Canada, 1981 Census of Canada, Worked in 1980-Employment Income by Occupation, catalogue 92–930, March 1984.

Appendix 7
Engineers and Architects,
Mean Employment Earnings by Province, 1980
(Males 15 years and over)

	All Engineers & Architects	Full Time and Full Year
Newfoundland	$22,725	$26,630
Prince Edward Island	18,288	20,894
Nova Scotia	23,238	25,965
New Brunswick	23,877	26,564
Quebec	27,514	30,928
Ontario	26,370	28,950
Manitoba	24,432	26,786
Saskatchewan	25,405	28,421
Alberta	29,152	32,590
British Columbia	27,966	30,923
Yukon	21,233	27,030
Northwest Territories	20,988	27,545

Source: Statistics Canada, 1981 Census of Canada, Worked in 1980-Employment Income by Occupation, catalogue 92–930, March 1984.

Appendix 8
Distribution of Income, Male Engineers, 1980
Average Employment Income

	All Engineers & Architects	Full Time and Full Year	Median Employment Income
Architects	$25,917	$28,896	23,379
Chemical	28,267	32,388	28,447
Civil	28,111	31,311	27,788
Electrical	26,907	29,379	27,408
Industrial	25,020	26,870	24,796
Agricultural	23,579	26,561	24,046
Mechanical	26,302	28,889	26,224
Metallurgical	28,574	31,306	28,199
Mining	30,505	33,980	30,064
Petroleum	32,537	36,882	31,893
Aerospace	25,509	27,349	25,806
Nuclear	30,103	32,027	30,979
Engineers, n.e.s.	28,501	32,188	27,008

Source: Statistics Canada, 1981 Census of Canada, Worked in 1980-Employment Income by Occupation, catalogue 92–930, March 1984.

Appendix 9
Employment

All Industries

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Canada	9,477,000	9,651,000	9,987,000	10,395,000	10,708,000	11,006,000	10,644,000	10,734,000	11,000,000	11,311,000
Atlantic	717,000	718,000	744,000	770,000	795,000	801,000	775,000	789,000	810,000	822,000
Quebec	2,456,000	2,476,000	2,530,000	2,619,000	2,694,000	2,726,000	2,584,000	2,642,000	2,722,000	2,804,000
Ontario	3,643,000	3,708,000	3,835,000	3,993,000	4,053,000	4,171,000	4,067,000	4,096,000	4,243,000	4,402,000
Western	2,662,000	2,748,000	2,877,000	3,012,000	3,166,000	3,308,000	3,216,000	3,208,000	3,227,000	3,283,000

Services to Business Management

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Canada	297,000	307,000	336,000	380,000	407,000	446,000	442,000	442,000	453,000	498,000
Atlantic	14,000	14,000	15,000	19,000	18,000	19,000	19,000	20,000	21,000	20,000
Quebec	74,000	73,000	76,000	89,000	89,000	97,000	94,000	98,000	102,000	117,000
Ontario	127,000	133,000	146,000	157,000	170,000	187,000	184,000	190,000	196,000	215,000
Western	82,000	87,000	98,000	115,000	130,000	143,000	145,000	134,000	134,000	143,000

Source: Statistics Canada, The Labour Force, catalogue 71-001, Feb. 1986, pg.102.

Appendix 10
Employment, Consulting Engineers

Year	All Employees	Professional Engineers
1971	34,500	9,499
1972	34,100	9,520
1973	35,800	10,135
1974	42,300	12,143
1975	44,700	13,011
1976	46,100	13,606
1977	45,300	13,557
1978	46,900	14,245
1979	49,000	15,078
1980	52,900	16,506
1981	57,100	18,066
1982	54,200	17,405
1983	48,300	15,713
1984	47,800	15,782

Sources: All Employees—"Profile of the Canadian Consulting Engineering Industry," prepared by Consulting Services Division, Department of Regional Industrial Expansion, July 1987, table IV; Professional Engineers—known proportion of professional engineers to total employees of consulting engineering firms from Statistics Canada surveys of industry for 1974, 1978 and 1982. Interpolation used in non-survey years.

Appendix 11
Prices and Output 1969 to 1985

Year	CPI Services (1981=100)	GDP Implicit Price Deflator (1981=100)	Implicit Price Index for Total Construction (1971=100)	Implicit Price Index for Total Components (1971=100)	Real GDP (1981 prices)	Value of Construction Work Performed (Nominal)
1969	40.0	—	89.1	96.4	—	—
1970	42.3	—	93.8	98.0	—	—
1971	44.4	41.9	100.0	100.0	$232,137,000,000	$15,865,334,000
1972	46.7	44.3	105.8	102.4	$245,441,000,000	$17,288,921,000
1973	49.6	48.2	114.2	107.2	$264,369,000,000	$20,173,764,000
1974	53.5	55.1	131.4	121.2	$276,006,000,000	$24,215,354,000
1975	59.3	60.6	144.8	133.3	$283,187,000,000	$27,249,186,000
1976	66.5	65.8	157.8	140.4	$300,638,000,000	$34,905,931,000
1977	72.5	69.9	169.7	156.7	$311,504,000,000	$35,803,000,000
1978	77.4	74.2	181.6	176.0	$325,751,000,000	$38,190,000,000
1979	82.9	81.6	201.8	197.3	$338,362,000,000	$43,023,000,000
1980	89.7	90.2	220.0	218.5	$343,384,000,000	$48,327,000,000
1981	100.0	100.0	243.2	239.8	$355,994,000,000	$56,884,000,000
1982	112.9	108.7	263.0	258.8	$344,543,000,000	$56,065,000,000
1983	120.2	114.1	290.6	285.1	$355,445,000,000	$55,948,000,000
1984	124.8	118.0	259.4	259.8	$377,755,000,000	$56,574,000,000
1985	129.7	121.7	286.5	296.8	$393,817,000,000	$61,449,000,000

Sources: CPI, Statistics Canada, The Consumer Price Index, catalogue 62-001, monthly, various issues; Implicit price deflator for GDP and value of real GDP, Statistics Canada, Canadian Statistical Review, catalogue 11-003E, monthly, September 1987; Implicit price indices, total construction and total components, Statistics Canada, Fixed Capital Flows and Stocks, catalogue 13-568, occasional, various issues; Value of construction work performed, Statistics Canada, Construction in Canada, catalogue 64-201, various issues.

Appendix 12.

Trade in Consulting and Other Professional Services and Total Business Services

	Consulting and Other Professional Services		Total Business Services	
Year	Receipts (Nominal)	Payments (Nominal)	Receipts (Nominal)	Payments (Nominal)
1969	$ 42,000,000	$ 98,000,000	$ 572,000,000	$1,089,000,000
1973	68,000,000	89,000,000	840,000,000	1,619,000,000
1977	265,000,000	136,000,000	1,723,000,000	2,860,000,000
1981	810,000,000	637,000,000	3,631,000,000	5,908,000,000
1983	857,000,000	289,000,000	3,979,000,000	5,978,000,000
1984	938,000,000	257,000,000	4,486,000,000	6,667,000,000

Source: Statistics Canada, Canada's International Trade in Services, catalogue 67-510, table 4, June 1986.

Appendix 13

Exchange Rates

	1979	1980	1981	1982	1983	1984	1985
$Cdn/$US	1.1681	1.1947	1.1859	1.2294	1.2444	1.3214	1.3975
$Cdn/Pound	2.597854	2.849360	2.262697	1.984866	1.805127	1.528199	2.018689
$Cdn/Franc	.2905721	.2645483	.2063152	.1828104	.1490746	.1377606	.1848300
$Cdn/Yen	.0048732	.0058852	.0053929	.0052315	.0053592	.0052624	.0069701
$Cdn/Wan	.0024134	.0018104	.0016929	.0016418	.0015643	.0015971	.0015699

Source: International Monetary Fund, International Financial Statistics, July 1986.

Appendix 14
Births and Deaths of Firms (SIC 864) by Size

	Number of Employees					
	Less than 5	5–19.9	20–49.9	50–99.9	100–499.9	500 Plus
1978						
Number of Firms	3,851	1,105	326	125	103	19
Employment in FYE Person Years	5,933	10,938	9,882	8,637	21,589	26,108
1984						
Number of Firms	6,587	1,363	347	131	107	20
Employment in FYE Person Years	15,546	12,156	10,175	8,211	16,497	23,872
1984						
Number of Firms (Consulting Engineers of Ontario)	139	118	58	18	15	2
Deaths—SIC 864 (Firms existing in 1978 not existing in 1984)	1,726	280	73	26	14	2
All Industries	223,177	30,240	6,431	1,992	1,202	125
Births—SIC 864 (Firms not existing in 1978 existing in 1984)	4,462	538	94	32	18	3
All Industries	385,789	46,744	7,922	2,125	1,265	207

United States Firms by Size, 1987

	Less than 4	4–18.9	19–52.9	53–101.9	102–512.9	513 Plus
Number of Firms	1,406	1,961	819	230	209	34

Sources: Statistics Canada, Business Microdata Integration and Analysis, A064A-2—07-86; and Consulting Engineers of Ontario, CEO Statistics, March 1987; American Consulting Engineers Council, Profile of ACEC By Index Number and Employees, July 16, 1987.

Appendix 15

Births and Deaths of Canadian Firms by Region, 1978–1984

	All Industries	Total SIC 864	SIC 864 by Regions Atlantic	Quebec	Ontario	Western
Number of Firms in 1978	601,450	5,529	515	957	1,758	2,920
Number of Firms in 1984	782,335	8,555	732	1,459	2,751	4,980
In operation in both 1978 and 1984 (Continuous)	338,283	3,408	275	520	1,116	1,671
Increases in number of employees from 1978 to 1984 (Increasing)	189,098	1,502	162	216	480	713
Decreases in number of employees from 1978 to 1984 (Decreasing)	149,185	1,906	113	304	636	958
DEATHS	263,167	2,121	240	437	642	1,249
BIRTHS	444,052	5,147	457	939	1,635	3,309

Source: Statistics Canada, Business Microdata Integration and Analysis, A064A-20-07-86.

Appendix 16
Consulting Engineers Fee Income by Source and Region and Number of Firms by Region

	1974	1978	1982
Fee Income Source—Level of Government			
Municipal	$152,208,300	$145,205,000	$186,560,000
Provincial	$146,111,100	$177,273,000	$233,019,000
Federal	$ 50,416,100	$119,084,000	$138,021,000
Foreign Government	$ 33,408,300	$ 99,005,000	$104,060,000
Fee Income by Region—Canadian Projects			
Atlantic	$ 29,114,967	$ 36,827,000	$ 60,966,000
Quebec	$228,927,900	$235,680,000	$484,915,000
Ontario	$248,368,700	$361,342,000	$690,033,000
Western	$263,801,833	$304,496,000	$743,801,000
Fee Income by Region—Foreign Projects			
Atlantic	$ 1,120,100	$ 2,130,000	$ 457,000
Quebec	$ 28,075,300	$ 66,271,000	$ 66,285,000
Ontario	$ 24,418,300	$ 85,852,000	$ 76,650,000
Western	$ 26,780,600	$ 22,453,000	$105,232,000
Number of Firms Per Region			
Atlantic	104	103	128
Quebec	263	213	320
Ontario	554	552	773
Western	669	654	1,015

Sources: Statistics Canada, Consulting Engineering Services, 1974, catalogue 63-528, occasional; Engineering and Scientific Services, 1978, catalogue 63-537, September 1980; and Architectural, Engineering and Scientific Services, catalogue 63-537, occasional, January 1985.

Appendix 17

Consulting Engineering Fee Income and GDP, 1974–1982

	Engineering Fee Income (Nominal)	Engineering Fee Income (Real, 1981 dollars)	GDP (Nominal)	GDP (Real, 1981 prices)
1974	$1,104,000,000	$2,003,600,000	$152,111,000,000	$276,006,000,000
1975	1,274,000,000	2,102,300,000	171,540,000,000	283,187,000,000
1976	1,438,300,000	2,185,900,000	197,924,000,000	300,638,000,000
1977	1,544,700,000	2,209,900,000	217,879,000,000	311,504,000,000
1978	1,749,400,000	2,357,700,000	241,604,000,000	325,751,000,000
1979	2,082,500,000	2,552,100,000	276,096,000,000	338,362,000,000
1980	2,560,400,000	2,838,600,000	309,891,000,000	343,384,000,000
1981	3,146,200,000	3,146,200,000	355,994,000,000	355,994,000,000
1982	3,403,800,000	3,125,600,000	374,442,000,000	344,543,000,000

Sources: Statistics Canada, Employment, Earnings and Hours, catalogue 72-002, monthly; for revenue, which is derived from employment, catalogues 93-528, occasional (1974), 63-537, occasional (1978), and 63-537, occasional (1982); Statistics Canada, Canadian Statistical Review, catalogue 11-003E, monthly, December 1987.

Appendix 18
Offices of Consulting Engineers
Personnel and Costs

	1974	1978	1982
Number of Personnel			
Administration	7,804	6,877	8,479
Technical	17,217	14,582	15,886
Other professional	1,263	2,209	1,131
Professional engineers	10,819	10,459	12,761
Expenses as a Percentage of Fee Income			
Wages, salaries and benefits	57.8	65.7	69
Materials	5.4	3.1	3
Services	1.2	1.4	2
Business development/promotions	2.4	2.8	3
Financing	3.5	3.7	3
Rent	3.6	5.3	6
Other	10.9	11	10
Value added as a proportion of total fee income	.754	.755	.76
Real Fee Income (1971 dollars)	$701,000,000	$633,600,000	$861,000,000
Total Employment	37,689	34,435	39,739
Professional Engineers	10,819	10,459	12,761

Source: Same as Appendix 16.

Appendix 19
Consulting Engineering Fee Income (Nominal) by Specialty, Domestic and Foreign, 1974–1982

	Domestic			Foreign		
	1974	1978	1982	1974	1978	1982
Agriculture, fisheries forestry, forest products	$ 43,520,000	$ 54,973,000	$ 76,671,000	$13,316,400	$16,162,000	$43,510,000
Air and seaports, harbours and terminals, coastal works	17,909,500	21,434,000	85,383,000	3,320,700	5,920,000	4,931,000
Bridges, tunnels, highways and railways	61,597,200	59,774,000	136,581,000	6,627,000	2,442,000	9,153,000
Buildings	173,484,600	184,924,000	302,290,000	3,537,700	5,769,000	13,176,000
Dams, irrigation and flood control	27,800,300	17,458,000	87,937,000	1,122,900	10,826,000	11,182,000
Plant process design	52,655,300	111,193,000	218,839,000	13,550,200	37,397,000	28,293,000
Mining and metallurgy	60,343,500	43,379,000	159,906,000	13,294,900	11,126,000	35,335,000
Municipal services	144,502,200	174,364,000	225,229,000	4,039,300	7,454,000	20,305,000
Petroleum and natural gas	63,913,100	71,476,000	221,265,000	2,656,700	6,648,000	17,434,000
Power generation, transmission and distribution	47,608,200	115,072,000	161,940,000	11,730,900	62,132,000	46,103,000
Telecommunications	5,680,800	8,765,000	13,974,000	2,612,300	4,869,000	14,737,000
Miscellaneous and unspecified	71,198,800	75,533,000	289,700,000	4,585,500	5,961,000	4,465,000

Sources: Statistics Canada, catalogues 63-528, occasional, 63-537, 1980, and 63-537, occasional, 1985.

Appendix 20
Fee Income by Region of Project, 1982

	Atlantic	Quebec	Ontario	Western
Agriculture, fisheries, forestry, forest products	$ 7,619,500	$13,998,000	$ 7,817,000	$ 46,845,500
Air and seaports, harbours and terminals, coastal works	5,231,000	11,028,000	23,165,000	42,426,000
Bridges, tunnels, highways and railways	3,591,000	48,456,000	33,729,000	49,028,000
Buildings	15,457,000	49,503,000	97,224,000	136,106,000
Dams, irrigation and flood control	365,000	59,973,000	5,286,000	21,893,000
Plant process design	5,854,000	35,614,000	139,493,000	36,927,000
Mining and metallurgy	12,572,000	49,024,000	36,537,000	59,906,000
Municipal services	12,324,000	34,095,000	67,884,000	108,097,000
Petroleum and natural gas	11,088,000	20,630,000	25,326,000	163,814,000
Power generation, transmission and distribution	14,812,000	24,027,000	33,615,000	88,493,000
Telecommunications	702,000	4,778,000	5,637,000	2,276,000
Miscellaneous and unspecified	13,359,000	29,444,000	68,271,000	74,610,000

Source: Same as for Appendix 19.

Appendix 21
Offices of Consulting Engineers
Number of Firms and Total Fee Income, 1982

Fee Income Range	Number of Firms	Total Fee Income
<$50,000	484	$ 14,069,000
$50K–99.9K	463	$ 33,138,000
$100K–199.9K	356	$ 50,301,000
$200K–499.9K	410	$ 130,688,000
$500K–999.9K	223	$ 156,055,000
$1,000K–4,999.9K	232	$ 498,786,000
$5,000K–9,999.9K	34	$ 220,324,000
$10,000K+	34	$1,124,978,000

Source: Statistics Canada, Architectural, Engineering and Scientific Services, catalogue 63-537, occasional, January 1985.

Appendix 22
Regional Employment,
All Industries and Consulting Engineering

	1974	1978	1982
Atlantic	702,000	755,000	804,000
Quebec	2,427,000	2,520,000	2,540,000
Ontario	3,519,000	3,847,000	4,078,000
Western	2,490,000	2,848,000	3,153,000
Canada	9,138,000	9,970,000	10,575,000
Consulting Engineering			
Atlantic	1,450	1,282	1,582
Quebec	11,374	9,831	8,982
Ontario	12,010	13,555	14,578
Western	12,855	9,767	14,597
Canada	37,689	34,435	39,739
Canada*	42,300	46,900	54,200

Sources: All industries, Statistics Canada, Canadian Statistical Review, various issues, section 4, table 5.2, "employed;" Consulting engineering, Statistics Canada, catalogues 63-528, occasional, 1974, 63-537, September 1980, and 63-537 Occasional, January 1985.

Note: * Estimates based on Statistics Canada, Employment, Earnings and Hours, catalogue 72-002, various issues.

Appendix 23
Fee Income for Consulting Engineering and GDP, by Region, 1974–1982

	1974	1978	1982
Fee Income by Region (Nominal dollars)			
Atlantic	$ 29,780,375	$ 36,894,027	$ 67,091,053
Quebec	257,003,236	301,951,016	551,199,930
Ontario	272,787,029	447,193,991	766,682,985
Western	291,037,160	329,011,966	843,365,032
Canada	850,607,800	1,115,051,000	2,228,339,000
GDP by Region (Nominal dollars)			
Atlantic	$ 8,623,000,000		
Quebec	35,425,000,000	56,553,000,000	84,009,000,000
Ontario	60,433,000,000	91,334,000,000	137,232,000,000
Western	45,926,000,000	76,457,000,000	128,103,000,000
Canada	150,407,000,000	238,201,000,000	370,105,000,000

Sources: Fee Income, Statistics Canada, catalogues 63-528, occasional, 1974, 63-537, occasional, September 1980, and 63-537, occasional, January 1985; GDP by Region, Statistics Canada, GDP by Province, catalogue 11-213, annual.