JOHN R. BALDWIN and PAUL K. GORECKI

The Role of Scale in Canada-U.S. Productivity Differences in the Manufacturing Sector 1970-1979

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JOHN R. BALDWIN
AND
PAUL K. GORECKI

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FOREWORD

When the members of the Rowell-Sirois Commission began their collective task in 1937, very little was known about the evolution of the Canadian economy. What was known, moreover, had not been extensively analyzed by the slender cadre of social scientists of the day.

When we set out upon our task nearly 50 years later, we enjoyed a substantial advantage over our predecessors; we had a wealth of information. We inherited the work of scholars at universities across Canada and we had the benefit of the work of experts from private research institutes and publicly sponsored organizations such as the Ontario Economic Council and the Economic Council of Canada. Although there were still important gaps, our problem was not a shortage of information; it was to interrelate and integrate — to synthesize — the results of much of the information we already had.

The mandate of this Commission is unusually broad. It encompasses many of the fundamental policy issues expected to confront the people of Canada and their governments for the next several decades. The nature of the mandate also identified, in advance, the subject matter for much of the research and suggested the scope of enquiry and the need for vigorous efforts to interrelate and integrate the research disciplines. The resulting research program, therefore, is particularly noteworthy in three respects: along with original research studies, it includes survey papers which synthesize work already done in specialized fields; it avoids duplication of work which, in the judgment of the Canadian research community, has already been well done; and, considered as a whole, it is the most thorough examination of the Canadian economic, political and legal systems ever undertaken by an independent agency.

The Commission's research program was carried out under the joint direction of three prominent and highly respected Canadian scholars: Dr. Ivan Bernier (*Law and Constitutional Issues*), Dr. Alan Cairns (*Politics and Institutions of Government*) and Dr. David C. Smith (*Economics*).

Dr. Ivan Bernier is Dean of the Faculty of Law at Laval University. Dr. Alan Cairns is former Head of the Department of Political Science at the University of British Columbia and, prior to joining the Commission, was William Lyon Mackenzie King Visiting Professor of Canadian Studies at Harvard University. Dr. David C. Smith, former Head of the Department of Economics at Queen's University in Kingston, is now Principal of that University. When Dr. Smith assumed his new responsibilities at Queen's in September 1984, he was succeeded by Dr. Kenneth Norrie of the University of Alberta and John Sargent of the federal Department of Finance, who together acted as Co-directors of Research for the concluding phase of the Economics research program.

I am confident that the efforts of the Research Directors, research coordinators and authors whose work appears in this and other volumes, have provided the community of Canadian scholars and policy makers with a series of publications that will continue to be of value for many years to come. And I hope that the value of the research program to Canadian scholarship will be enhanced by the fact that Commission research is being made available to interested readers in both English and French.

I extend my personal thanks, and that of my fellow Commissioners, to the Research Directors and those immediately associated with them in the Commission's research program. I also want to thank the members of the many research advisory groups whose counsel contributed so substantially to this undertaking.

DONALD S. MACDONALD

INTRODUCTION

At its most general level, the Royal Commission's research program has examined how the Canadian political economy can better adapt to change. As a basis of enquiry, this question reflects our belief that the future will always take us partly by surprise. Our political, legal and economic institutions should therefore be flexible enough to accommodate surprises and yet solid enough to ensure that they help us meet our future goals. This theme of an adaptive political economy led us to explore the interdependencies between political, legal and economic systems and drew our research efforts in an interdisciplinary direction.

The sheer magnitude of the research output (more than 280 separate studies in 70+ volumes) as well as its disciplinary and ideological diversity have, however, made complete integration impossible and, we have concluded, undesirable. The research output as a whole brings varying perspectives and methodologies to the study of common problems and we therefore urge readers to look beyond their particular field of interest and to explore topics across disciplines.

The three research areas, — *Law and Constitutional Issues*, under Ivan Bernier; *Politics and Institutions of Government*, under Alan Cairns; and *Economics*, under David C. Smith (co-directed with Kenneth Norrie and John Sargent for the concluding phase of the research program) — were further divided into 19 sections headed by research coordinators.

The area *Law and Constitutional Issues* has been organized into five major sections headed by the research coordinators identified below.

- Law, Society and the Economy — *Ivan Bernier and Andrée Lajoie*
- The International Legal Environment — *John J. Quinn*
- The Canadian Economic Union — *Mark Krasnick*

- Harmonization of Laws in Canada — *Ronald C.C. Cuming*
- Institutional and Constitutional Arrangements — *Clare F. Beckton and A. Wayne MacKay*

Since law in its numerous manifestations is the most fundamental means of implementing state policy, it was necessary to investigate how and when law could be mobilized most effectively to address the problems raised by the Commission's mandate. Adopting a broad perspective, researchers examined Canada's legal system from the standpoint of how law evolves as a result of social, economic and political changes and how, in turn, law brings about changes in our social, economic and political conduct.

Within *Politics and Institutions of Government*, research has been organized into seven major sections.

- Canada and the International Political Economy — *Denis Stairs and Gilbert Winham*
- State and Society in the Modern Era — *Keith Banting*
- Constitutionalism, Citizenship and Society — *Alan Cairns and Cynthia Williams*
- The Politics of Canadian Federalism — *Richard Simeon*
- Representative Institutions — *Peter Aucoin*
- The Politics of Economic Policy — *G. Bruce Doern*
- Industrial Policy — *André Blais*

This area examines a number of developments which have led Canadians to question their ability to govern themselves wisely and effectively. Many of these developments are not unique to Canada and a number of comparative studies canvass and assess how others have coped with similar problems. Within the context of the Canadian heritage of parliamentary government, federalism, a mixed economy, and a bilingual and multicultural society, the research also explores ways of rearranging the relationships of power and influence among institutions to restore and enhance the fundamental democratic principles of representativeness, responsiveness and accountability.

Economics research was organized into seven major sections.

- Macroeconomics — *John Sargent*
- Federalism and the Economic Union — *Kenneth Norrie*
- Industrial Structure — *Donald G. McFetridge*
- International Trade — *John Whalley*
- Income Distribution and Economic Security — *François Vaillancourt*
- Labour Markets and Labour Relations — *Craig Riddell*
- Economic Ideas and Social Issues — *David Laidler*

Economics research examines the allocation of Canada's human and other resources, the ways in which institutions and policies affect this allocation, and the distribution of the gains from their use. It also considers the nature of economic development, the forces that shape our regional and industrial structure, and our economic interdependence with other countries. The thrust of the research in economics is to increase our comprehension of what determines our economic potential and how instruments of economic policy may move us closer to our future goals.

One section from each of the three research areas — The Canadian Economic Union, The Politics of Canadian Federalism, and Federalism and the Economic Union — have been blended into one unified research effort. Consequently, the volumes on Federalism and the Economic Union as well as the volume on The North are the results of an interdisciplinary research effort.

We owe a special debt to the research coordinators. Not only did they organize, assemble and analyze the many research studies and combine their major findings in overviews, but they also made substantial contributions to the Final Report. We wish to thank them for their performance, often under heavy pressure.

Unfortunately, space does not permit us to thank all members of the Commission staff individually. However, we are particularly grateful to the Chairman, The Hon. Donald S. Macdonald; the Commission's Executive Director, J. Gerald Godsoe; and the Director of Policy, Alan Nymark, all of whom were closely involved with the Research Program and played key roles in the contribution of Research to the Final Report. We wish to express our appreciation to the Commission's Administrative Advisor, Harry Stewart, for his guidance and advice, and to the Director of Publishing, Ed Matheson, who managed the research publication process. A special thanks to Jamie Benidickson, Policy Coordinator and Special Assistant to the Chairman, who played a valuable liaison role between Research and the Chairman and Commissioners. We are also grateful to our office administrator, Donna Stebbing, and to our secretarial staff, Monique Carpentier, Barbara Cowtan, Tina DeLuca, Françoise Guilbault and Marilyn Sheldon.

Finally, a well deserved thank you to our closest assistants: Jacques J.M. Shore, *Law and Constitutional Issues*; Cynthia Williams and her successor Karen Jackson, *Politics and Institutions of Government*; and I. Lilla Connidis, *Economics*. We appreciate not only their individual contribution to each research area, but also their cooperative contribution to the research program and the Commission.

IVAN BERNIER
ALAN CAIRNS
DAVID C. SMITH

PREFACE

The Role of Scale in Canada/U.S. Productivity Differences in the Manufacturing Sector, 1970–1979 is one of three special studies on the economics of industrial structure conducted for this Royal Commission. Support for the study was also provided by the Economic Council of Canada.

In their analysis, John Baldwin and Paul Gorecki proceed along two related paths. First, they measure and investigate the determinants of inter-industry differences in the relative scale of Canadian and U.S. manufacturing plants. They find that, on average, Canadian plants operate at a scale disadvantage relative to U.S. plants. This disadvantage is generally greater the smaller the relative size of the Canadian market, and is particularly severe in industries characterized by high seller concentration and high tariff protection. The authors conclude that the expansion in the size of the market faced by Canadian producers which might be expected to accompany a free trade arrangement with the United States would be sufficient to eliminate this scale disadvantage.

The second path of analysis followed by the authors involves the measurement and investigation of inter-industry differences in the relative productivity of Canadian and U.S. manufacturing plants. They find that, depending on how it is measured, productivity in Canadian plants was something under four-fifths of the U.S. level at the end of the 1970s. This productivity gap would be cut by between one-quarter and one-third if Canadian plants were to produce at U.S. scales.

Baldwin and Gorecki then ask whether the remainder of the productivity gap is systematically related to industry characteristics (such as ownership, R&D intensity, or employee training levels), and thus is amenable to remedial public policies. They find no evidence that this is the case. Their results do show, however, that the largest (scale-corrected) productivity gap occurs in the leather, textiles and knitting mills industries. The latter might be expected to continue their contraction regardless of the trade strategy Canada adopts. Much of the rest of the manufacturing sector would be as productive as its U.S. counterpart if it were able to operate at the same scale.

In this study Baldwin and Gorecki make a number of important contributions. Their work helps to inform the trade strategy debate in which Canada is now engaged. It tends to support those who argue that Canada has more to gain than to lose from a free trade arrangement with the United States. It also lends support to the argument that trade liberalization is a necessary if not a sufficient industrial policy for Canada. Finally, it makes a significant methodological contribution, emphasizing the complexity of the task of measuring international productivity differences and avoiding many of the errors found in earlier research.

D.G. McFetridge

ACKNOWLEDGMENTS

We should like to thank Peter Cornell and David Slater of the Economic Council and Donald McFetridge and David Smith of the Commission for giving us the opportunity to undertake this study, which builds upon our earlier work for the Council. Many individuals provided valuable advice and criticism, including Donald Daly, David Gillen, Christopher Green, Donald McFetridge, Someshwar Rao, Arnold de Silva, Thomas Wilson and several anonymous referees. The data base used could not have been constructed without the efforts of John McVey of Statistics Canada and Richard Caves of Harvard University. Parts of the study have been presented at the annual meetings of the Canadian Economics Association and the Third John Deutsch Round Table on Economic Policy, where a number of useful comments were received. Ian Cromb and Katherine Meredith rendered valuable research assistance, Mary Richardson provided very useful computing advice, Ruth Crow diligently edited the text, assisted by Eloise Sheppard, and the manuscript was ably prepared by the Council's Text Processing Unit.

Any errors are the responsibility of the authors alone. The views expressed do not necessarily reflect those of either of the respective institutions with which the authors are associated.

J.R. BALDWIN
P.K. GORECKI

Chapter 1

Introduction: *Setting the Context*

Understanding the reason for the productivity differences between Canadian and U.S. manufacturing industries is important if a sound industrial strategy is to be followed in the next decade. This is particularly the case if Canada implements its policy of closer economic ties with the United States — either in the form of the previous Trudeau Administration's sectoral free trade approach[1] or the present Mulroney Administration's attempt to enhance access of Canadian goods to the United States.[2]

Numerous studies of the Canadian manufacturing sector have focussed on the Canadian productivity slowdown. While that slowdown is worrisome, it is not unique to Canada. Perhaps more important is Canada's position relative to its major industrial trading partner — the United States.

Evidence indicates that Canada's manufacturing sector is less productive than that of the United States for a number of reasons, each of which leads to a different set of policy prescriptions.

- For any given output level Canada's manufacturing sector may require more resources than the United States to produce the given output because the Canadian manufacturing sector is technically less efficient. Greater diffusion of new ideas and technology are likely policy prescriptions here.
- For a given output level Canada and the United States require the same level of inputs but output per unit of input is lower in Canada than that in the United States because of scale economies and the much greater size of the U.S. economy. Scale disadvantage can perhaps be overcome by freer trade between the two countries.

- Canadian plants may suffer from allocative inefficiency. That is, given the factor price ratios of (say) labour and materials, they may combine factors inefficiently. Policy in this case may involve attempts to introduce a stronger competition policy in Canada and perhaps freer trade.
- Canadian industry may suffer simply because relative factor endowments in Canada make some industries uncompetitive relative to foreign industry because factor costs per unit of output are higher in Canada than elsewhere. The policy prescriptions are more difficult in this case.

In this monograph we are primarily concerned with the second factor — the role of scale in explaining Canada/U.S. productivity differences. Scale is used in rather a broad sense to include plant size, number of products per plant, and length of production run. Hence the term scale embraces a number of separate but related components. These are frequently treated separately from each other, with a link assumed to the level of productivity. In this monograph we go a step further than these previous studies by explicitly taking into account the role of scale in explaining Canada/U.S. productivity differences and considering the determinants of plant scale, product diversity, and length of production run.

Our results suggest that about one-third of the difference between Canadian and U.S. productivity levels in the Canadian manufacturing sector can be attributed to scale differences between the two countries. Thus our work affirms that a good part of the Canadian "problem" is related to the scale effect — an effect whose importance has been downplayed recently. Hence, while size does matter if one gets into bed with the elephant, it is not all encompassing.

In any attempt to "explain" the causes of Canada's lower productivity compared with the United States — and thus provide some insights into possible policy prescriptions — we undertake two separate sets of analysis. First, we studied the determinants of plant scale and product diversity. This should provide us with insights into the one-third of the Canada/U.S. productivity differences accounted for by scale. Second, we attempted to explain the scale corrected measure of Canada/U.S. productivity — the remaining two-thirds of Canada/U.S. productivity differences accounted for by factors 1, 3, and 4 above.

Our results suggested that greater imports led to smaller specialist plants, which carved out specialist niches, since as imports increased plant size fell but length of production run increased. In those industries where Canada possessed a comparative advantage, plant size was usually larger. Although direct links between diversity and production run length, on the one hand, and trade on the other, were not strong, there was an indirect link because plant size was an important determinant of diversity and length of production run.

We also find that high tariffs, combined with imperfect market structure — high concentration, detrimentally affect relative plant scale. Here the policy implications are clear. Improvements can result from decreasing tariffs in markets which are relatively concentrated. Trade liberalization can help in this area.

Previous studies that did not correct Canada/U.S. relative productivity for scale in the appropriate fashion reported that Canadian inefficiency was related to such variables as foreign ownership, research intensity, or the percentage of management personnel. The implications of such findings are that the position of Canadian industry can be affected by specific policies aimed at each of these variables: FIRA restrictions on foreign investment may raise efficiency; government subsidy programs may increase the stock of R&D; and management can be exhorted to economize on resources in the white collar field.

In contrast to earlier work, our regressions of inter-industry variability of relative Canada/U.S. efficiency indicate that it is the openness of the Canadian industry to both goods and investment flows that has a beneficial effect. While there are several other variables that enter occasionally, their significance does not stand up to slight changes in model specification or sample choice and as such they cannot be said to be robust. We do not deny the relevance of such variables as research and development spending to the efficiency of individual industries — just that it does not have a strong cross-industry correlation to success as we measure it. Instead, we find that trade matters. Barriers to trade (whether they be tariff barriers, low import levels, or low foreign investment) also negatively affect the scale-corrected relative productivity measures studied here. As such, a strong argument can be made that the trade liberalization process over the postwar period has improved the competitiveness of Canadian industry and that continued emphasis on a reduction of trade barriers or their maintenance at present low levels is in Canada's best interests.

Chapter 2

Industrial Structure, Trade and Productivity

Most economists feel that free trade offers Canadians substantial benefits. Wonnacott (1975) argued that Canada/U.S. free trade would increase Canadian GNP by 8.2 percent. More recently Harris and Cox (1984), using a general equilibrium model that also includes specific assumptions about the behaviour of firms in oligopolistic markets, estimate even greater gains from free trade. Moreover, they stress that there is no reason to fear that such a move will leave Canadians as only "hewers of wood and drawers of water." While some industries would decline as a result of freer trade, many would benefit.

The theme that tariffs and trade protection are detrimental to the Canadian economy can be found not only in the trade literature but also in the studies of applied industrial organization that hypothesize that the inefficiency associated with tariffs go beyond the static welfare losses from incomplete or incorrect specialization. Not only has it been argued that tariffs lead to an expansion of sectors where Canada has a comparative disadvantage, but it has also been suggested that those industries that received tariff protection do not operate as efficiently as they might. Eastman and Stykolt (1967), in their pioneering study of the degree of sub-optimality in Canadian plant size, focused on the tariff as one of the chief determinants of inefficiency. Their conclusion was:

> The evidence in this study points to the detrimental effect of excessive tariff protection that permits firms to operate plants of sub-optimal scale in Canada. The frequency with which industries are found with a number of plants of inefficiently small size existing side by side in national or regional markets in Canada indicates that the height of the Canadian tariff is greater than necessary to preserve those industries in Canada. (p. 106)

The Royal Commission on Corporate Concentration (RCCC) reiterated the same theme in its 1978 report. Canadian plant scale was too small and this was a result of tariff protection.

> The small and dispersed Canadian market, combined with a policy of economic nationalism designed to aid the manufacturing and skilled labour sectors, has led to an economy whose firms and plants in many industries tend to be relatively small and unspecialized by international standards. (RCCC, 1978, p. 45)

In recent years, it has been claimed that sub-optimal plant size is not as important as short production runs (RCCC, 1978, p. 45). The latter, of course, accompanies the former even if Canadian plants are relatively specialized. But studies (Daly et al., 1968; Caves, 1975) have suggested that Canadian plants are probably so diversified that rationalization of product lines would bring substantial cost savings. As such, "excessive" diversity is said to exacerbate the problem of short production runs arising from small plant scale. Thus the problems of sub-optimal plant size, short production runs, and the crowding of too many products into one plant are seen to be at the heart of Canada's productivity gap with the United States.

The prescription for resolution of these problems has been a reduction in tariffs. Indeed, in 1967, after the Kennedy Round of trade negotiations was completed, the Economic Council of Canada predicted that the upcoming reduction in tariffs would decrease the amount of inefficiency in Canadian industry.

> The recently concluded Kennedy Round of trade negotiations under the General Agreement on Tariffs and Trade has resulted in the largest and most wide-ranging programme of tariff reduction on industrial products achieved since the Second World War . . . [it] will offer opportunities for more efficient use of resources, important gains in productivity, and reductions in various types of unit costs and prices. (Economic Council of Canada 1967, p. 168)

In 1975, the Economic Council of Canada, in a study recommending continued movement to freer trade, once again listed improvements in plant scale as one of the benefits to be expected (Economic Council of Canada, 1975, pp. 32–33).

While economists have long pointed to the problems the tariff created and predicted benefits should tariffs be reduced, empirical studies based upon the observation of the economy's reaction to falling tariffs have been relatively few (e.g. Lermer, 1973, Baumann, 1974). Yet trade liberalization has been an ongoing process since World War II. The Kennedy Round of tariff reductions (begun in 1966) reduced the average nominal tariff from 11.9 percent in 1966 to 7.8 percent in 1978. (See Table 2-1, which calculates the ratio of tariffs collected to total value of dutiable imports.) Effective tariff rates fell from 16.4 to 11.7 percent over the same

TABLE 2-1 Nominal and Effective Tariffs on Imports and Proportion of Imports not Subject to Tariffs, by Industry Group[a], Canada, 1966, 1970, 1975, and 1978 or 1979

	Nominal Tariffs[b]				Effective Tariffs[c]				Imports not Subject to Tariffs		
	1966	1970	1975	1978	1968	1970	1975	1978	1970	1975	1979
Food & Beverages (10)	21.1	21.2	11.2	9.9	27.8	20.4	15.7	10.1	23.5	22.7	41.1
Tobacco Products (15)	55.6	50.9	41.9	28.3	94.8	79.5	94.8	22.9	—	—	1.0
Rubber & Plastics (16)	13.4	10.0	9.0	12.2	19.3	16.0	13.3	19.6	20.7	10.2	14.6
Leather (17)	19.7	19.0	18.4	17.6	31.8	30.0	27.6	27.5	4.7	4.2	8.7
Textiles (18)	16.3	14.2	14.2	12.5	22.9	17.9	20.3	18.7	9.9	7.4	13.3
Knitting Mills (23)	26.2	27.6	24.1	22.9	37.4	43.0	34.5	35.0	—	0.1	8.0
Clothing (24)	22.5	21.6	21.9	20.3	28.8	25.0	28.2	25.7	0.2	1.3	6.6
Wood (25)	6.1	5.2	6.0	4.4	11.4	10.5	10.6	7.9	58.9	59.3	72.3
Furniture & Fixtures (26)	18.9	15.5	15.6	15.7	24.7	19.5	20.8	20.6	1.4	1.0	5.2
Paper & Allied Products (27)	10.5	8.7	9.6	7.7	16.6	15.4	17.1	13.8	29.2	22.8	36.6
Printing & Publishing (28)	5.1	4.9	6.5	6.8	2.8	3.8	5.7	7.1	59.5	58.9	65.7
Primary Metals (29)	4.8	4.6	4.7	4.2	8.0	7.2	9.8	8.7	50.4	49.0	50.4
Metal Fabricating (30)	10.7	9.0	8.6	8.0	13.9	11.4	11.8	10.8	19.6	13.4	22.3
Machinery (31)	8.3	6.9	5.9	5.9	8.0	6.1	5.6	6.0	48.8	59.2	61.6
Transportation Equipment (32)	4.1	2.7	3.2	2.5	1.9	1.0	1.7	0.6	77.5	78.4	84.0
Electrical Products (33)	14.1	10.9	10.3	9.5	18.1	14.0	12.9	12.3	21.3	19.9	29.6
Non-Metallic Mineral Products (35)	8.9	6.2	5.5	5.7	9.8	8.8	7.5	8.1	30.5	31.6	37.4
Petroleum & Coal Products (36)	5.4	6.3	1.5	3.1	35.7	44.1	7.9	59.7	23.4	92.8	88.7
Chemicals & Chemical Products (37)	9.5	7.9	6.8	6.7	14.5	11.7	10.3	11.1	45.2	46.3	51.2
Miscellaneous Manufacturing (39)	12.6	11.6	10.3	9.1	17.4	15.9	14.4	13.2	29.0	28.2	32.8
All Industries	11.9	10.7	8.8	7.8	16.4	13.8	12.8	11.7	35.4	36.2	45.8

Source: Statistics Canada, special tabulations.

a. For each industry group the relevant variable is the weighted average for all the constituent 4-digit industries. The weights used are the industries' total value added in the year for which the variable was estimated (except for 1966 and 1978, where 1970 and 1979 weights were used, respectively). All 167 4-digit manufacturing industries were employed.

b. The nominal tariffs (NRP) are calculated as the ratio of duty paid to the value of dutiable imports.

c. Simple effective tariff rates (SERP), calculated as the decline in value added that may occur if tariff protection is removed.

TABLE 2-2 **The Importance of International Trade in Manufactured Products, Canada, 1966–1982**

	Export Share[a]	Import Share[b]
1966	18.8	21.0
1967	21.1	22.4
1968	23.4	24.0
1969	24.3	25.6
1970	26.2	25.5
1971	25.3	26.0
1972	25.8	27.6
1973	26.6	28.7
1974	25.0	29.1
1975	23.9	28.8
1976	26.2	29.2
1977	28.5	30.6
1978	30.4	31.6
1979	30.3	32.6
1980	30.6	31.3
1981	29.9	31.5
1982	31.4	29.8

Source: Canada, Department of Industry, Trade and Commerce, *Manufacturing Trade and Measures, 1966–1982* (Ottawa: Department of Industry, Trade and Commerce, 1983).

a. Exports/domestic shipments.

b. Imports/total Canadian market, where the denominator is defined as (domestic sales − exports + imports).

period. Just as significant, the percentage of imports not subject to duty increased from 35.4 percent in 1970 to 45.8 percent in 1978. The Tokyo Round promises more tariff reductions in the 1980s.

While most of the Kennedy Round tariff cuts were completed by 1970, the process of liberalization continued throughout the 1970s — probably because the adaptation process lagged that of tariff reductions. Concomitant with the decline in tariffs has been a dramatic increase in the importance of trade. In Table 2-2, the importance of exports (exports/domestic shipments) and imports (imports/the total Canadian market) for the Canadian manufacturing sector is evident. The average export share increased from 19 percent to over 30 percent between 1966 and 1982. The average import share went from 21 to 30 percent over the same period.

Within the manufacturing sector, industries have fared rather differently in terms of their trade performance. Table 2-3 presents the export and import intensity of 2-digit or industry-group manufacturing industries in 1966, 1972, and 1982. Wood, Primary Metals, Paper and Allied Products, and Transportation Equipment all have had high export intensity and each has improved its export performance during the period — with Transportation Equipment doing so dramatically as the result of the 1965 Auto Pact. Primary Metals, Machinery, and Transpor-

TABLE 2-3 Export and Import Performance at the 2-Digit Canadian Industry Group Manufacturing Level, 1966, 1972, 1982

	Exports as Percent of Shipments[a]			Imports as Percent of Domestic Market[b]		
	1966	1972	1982	1966	1972	1982
Food & Beverages (10)	9.6	9.7	12.6	6.6	7.8	8.7
Tobacco Products (15)	0.5	0.7	0.8	1.0	1.1	2.2
Rubber & Plastics (16)	4.1	5.3	17.4	14.5	19.6	20.8
Leather (17)	4.4	5.9	9.4	14.4	26.3	36.1
Textiles (18)	4.8	4.6	8.5	25.2	25.1	25.9
Knitting Mills (23)	1.8	2.5	1.5	11.3	30.1	28.8
Clothing (24)	2.2	5.2	6.2	5.1	7.7	15.0
Wood (25)	38.9	45.7	51.7	8.0	9.8	8.4
Furniture & Fixtures (26)	2.1	4.2	13.6	5.1	7.1	11.2
Paper & Allied Products (27)	49.9	49.9	56.8	5.5	6.9	10.6
Printing & Publishing (28)	1.3	2.1	3.7	12.3	13.5	15.3
Primary Metals (29)	42.2	42.7	56.8	23.5	23.0	34.8
Metal Fabricating (30)	2.7	4.9	7.4	11.6	14.1	14.2
Machinery (31)	33.0	39.2	54.8	64.2	67.6	74.7
Transportation Equipment (32)	31.2	68.9	82.5	39.1	69.0	80.2
Electrical Products (33)	9.2	13.0	24.7	21.9	30.5	39.9
Non-Metallic Mineral Products (35)	5.8	7.8	11.5	15.3	15.1	17.8
Petroleum & Coal Products (36)	1.0	6.1	7.0	10.8	8.1	3.1
Chemicals & Chemicals Products (37)	14.4	15.7	27.5	23.0	27.3	30.4
Miscellaneous Manufacturing (39)	22.4	19.9	29.8	46.2	50.5	59.2
All Manufacturing	18.8	25.8	31.4	21.0	27.6	29.8

Source: Canada, Department of Industry, Trade and Commerce, *Manufacturing Trade and Measures, 1966–1982* (Ottawa: Department of Industry, Trade and Commerce, 1983).

a. Exports/domestic shipments.

b. Imports/total Canadian market, where the denominator is defined as (domestic production − exports + imports).

tation Equipment each also started with a high import intensity which has grown. Thus intra-industry trade has become even more important for these industries.

Chemicals, Electrical Products, Rubber and Plastics have had increasing import intensity but are still at a somewhat lower level than those just described. However, their increases in export intensity have matched the changes in import intensity. Thus these industries too have become specialized in the sense that two-way trade has become increasingly important.

The Leather, Textiles, and Knitting Mills industries have higher import than export intensity. Moreover, import intensity has generally been growing. These are the industries which have been regarded as the sick members of the manufacturing sector.

In a number of industries, either trade is relatively unimportant or there are no distinct trends in export or import intensity. Tobacco

Products has the least involvement in trade, both in exports and imports. Food and Beverages has had no discernable trends in either export or import intensity. In Printing and Publishing and Metal Fabricating, imports are more important than exports but there is no movement of note in the importance of either. Finally, Furniture and Fixtures has relatively little trade, though there has been a recent tendency for both export and import intensity to increase.

While considerable change has occurred in the exposure of some industries to trade, the distribution of manufacturing employment by 2-digit industry or industry group has not been as dramatically affected. The percentage of total manufacturing employment by major 2-digit industry is presented in Table 2-4. A two percentage point change over two decades between 1962 and 1981 is rare. Food and Beverages declines slightly; Leather, Textiles, Knitting Mills and Clothing decline by about five points jointly. Metal Fabrication, Machinery, and Transportation Equipment — the industries which have increased two-way trade — together increase by about 4.5 percentage points. The adaptation to a trade liberalization process has therefore not resulted in a radical reallocation of resources within the manufacturing sector at the 2-digit or industry group level.

If trade liberalization had the beneficial effect on productivity that was predicted for it, then we might expect Canadian productivity to have improved in the post-1966 Kennedy Round period. Two partial productivity measures are presented in Table 2-5. The first is relative Canada/U.S. output per employee. The second is relative output per dollar capital invested. Output is measured in value-added terms (constant $ 1972) and no adjustment has been made for Canada/U.S. price differences. Thus the ratios indicate trends only. The precise adjustments needed to draw conclusions about the level of productivity differences are discussed at greater length in Chapter Five. Partial productivity measures such as these suffer from a number of well-known defects in that they do not allow for scale economy effects or differences in factor intensities. Nevertheless, provided that the latter have not changed dramatically, they probably yield valid conclusions about the general trend in relative Canada/U.S. productivity.

Both the labour and capital partial productivity measures indicate an improvement in productivity in the post-1966 Kennedy Round period. The tariff reductions that came out of this negotiation were mainly implemented by 1970. Looking at Table 2-5, partial labour productivity increases in both the second and third periods into which the post-1966 period is divided. Capital productivity lags labour productivity but improvements occur by the 1970s. Of interest is the fact that the improvements in labour productivity do not continue into the latter half of the decade.

Nevertheless, the trend in relative productivity that has accompanied

TABLE 2-4 The Distribution of Manufacturing Employment in Canada by Industry Group, 1962, 1972, 1981

	1962		1972		1981	
	Number	Percent	Number	Percent	Number	Percent
Food & Beverages (10)	129,093	13.3	145,009	12.0	159,703	11.9
Tobacco Products (15)	8,422	0.9	6,885	0.6	5,606	0.4
Rubber & Plastics (16)	15,664	1.6	36,076	3.0	45,681	3.4
Leather (17)	28,009	2.9	23,616	1.9	22,577	1.7
Textiles (18)	52,769	5.4	59,115	4.9	53,073	4.0
Knitting Mills (23)	19,161	2.0	21,752	1.8	17,851	1.3
Clothing (24)	76,729	7.9	90,745	7.5	83,418	6.2
Wood (25)	70,279	7.2	87,733	7.2	94,328	7.1
Furniture & Fixtures (26)	27,601	2.8	38,483	3.2	44,328	3.3
Paper & Allied Products (27)	77,141	7.9	91,188	7.5	99,491	7.4
Printing & Publishing (28)	42,849	4.4	49,877	4.1	63,964	4.8
Primary Metals (29)	71,127	7.3	86,335	7.1	92,337	6.9
Metal Fabricating (30)	79,241	8.1	105,219	8.7	120,450	9.0
Machinery (31)	31,015	3.2	49,975	4.1	70,784	5.3
Transportation Equipment (32)	75,601	7.8	118,384	9.8	136,102	10.2
Electrical Products (33)	58,029	6.0	76,149	6.3	84,282	6.3
Non-Metallic Mineral Products (35)	33,680	3.5	39,149	3.2	40,145	3.0
Petroleum & Coal Products (36)	7,494	0.8	6,583	0.5	8,457	0.6
Chemicals & Chemical Products (37)	31,602	3.2	37,578	3.1	46,398	3.5
Miscellaneous Manufacturing (39)	38,551	4.0	43,263	3.6	48,354	3.6
Total Manufacturing	974,057	100.0[a]	1,213,114	100.0[a]	1,337,329	100.0[a]

Source: Canada, Statistics Canada, *General Review of the Manufacturing Industries of Canada*, Cat. #31–203, various issues.
a. Percentage may not total 100 due to rounding.

TABLE 2-5 Canada/U.S. Productivity in the Manufacturing Sector, 1961–1980 in 1972 Dollars

	Average Ratio of Value Added[a] per Employee[b]	Average Ratio of Value Added[a] per $ Capital[c] Invested in Machinery and Equipment
1961–65	0.79	0.68
1966–70	0.81	0.68
1971–75	0.84	0.72[d]
1976–80	0.84	0.72[d]

Source: Various Canadian and U.S. statistical publications and data supplied by statistical agencies in both countries.

a. Value added is total activity value added deflated by a price index. The U.S. value added deflator was supplied by the U.S. Department of Commerce, Bureau of Economic Analysis for 1967 onward. It was extended back to 1961 using the implicit GDP deflator relevant to manufacturing found in various issues of the U.S. Department of Commerce, *Business Statistics*. For Canada, we used the Canadian GDP deflator found in Statistics Canada, *Real Domestic Product by Industry, 1961–1971*, Cat. #61–516, July 1977 and data supplied by the Industry Product Division for post 1971. No correction has been made for relative price differences.

b. Employees are defined as production and non-production workers.

c. Capital is defined as gross value of machinery and equipment and has been calculated for Canada and the United States using comparable assumptions. For further discussion see Chapter Five.

d. This average is for the period 1970–79. It was 0.75 for the period 1971–75 and 0.69 for 1976–79. The latter is strongly influenced by the two years 1978 and 1979. If the labour productivity variable had been average over the years 1976–79, it too would have fallen.

trade liberalization is unmistakeably upward. Frank (1977) has also looked at the productivity performance of Canadian industries relative to American and found a sharp increase over a part of this period (1967–74). But his study was limited to a small number of matched industries (33) and has been questioned for its representativeness (Denny and Fuss, 1982).

At a less aggregated level, there is considerable variance in the rate of improvement in Canada/U.S. partial labour productivity levels. We present, in Table 2-6, the ratio of Canada/U.S. value added per employee at the 2-digit or industry-group level for 1967 and 1979. The relative value added measure is deflated to remove inflation effects in each country, to allow comparison of the trend in productivity. A price correction is not made for differing absolute prices for the base year (1972), since we are not interested in the absolute level but only the trend here.[1] Other corrections, besides those for different prices, are necessary to compare absolute price levels and we leave this until Chapter Five.

Table 2-6 shows that in the Food and Beverages, Furniture and Fixtures, Paper and Allied Products, Electrical Products and the Miscellaneous Manufacturing industry groups, there has been a reduction in

TABLE 2-6 Relative Canada/U.S. Value Added per Employee for the Manufacturing Industry Group Level, 1967 and 1979 (in constant 1972 dollars)

	Relative Value Added[a] Per Employee 1967	Relative Value Added[a] Per Employee 1979	Ratio[c] 1979/1967
Food & Beverages (10)	0.73	0.66	0.91
Tobacco Products (15)	0.70	0.75	1.08
Rubber & Plastics (16)	0.99	1.00	1.01
Leather (17)	0.77	0.89	1.15
Textiles[b] (18 & 23)	0.79	0.94	1.20
Clothing (24)	0.82	0.83	1.00
Wood (25)	1.04	1.02	0.98
Furniture & Fixtures (26)	0.87	0.76	0.87
Paper & Allied Products (27)	0.82	0.73	0.89
Printing & Publishing (28)	0.70	0.93	1.33
Primary Metals (29)	0.72	0.89	1.23
Metal Fabricating (30)	0.78	0.84	1.07
Machinery (31)	0.79	0.76	0.96
Transportation Equipment (32)	0.80	0.93	1.17
Electrical Products (33)	0.80	0.69	0.86
Non-Metallic Mineral Products (35)	0.83	1.07	1.29
Petroleum & Coal Products (36)	0.57	0.69	1.22
Chemicals & Chemical Products (37)	0.56	0.57	1.02
Miscellaneous Manufacturing (39)	0.69	0.62	0.90

Source: See Table 2-5.

a. Value added is total activity manufacturing for Canada, employees is the total employee count. These correspond most closely to the U.S. 2-digit industry group level data. The U.S. value added data at this level are essentially total activity value added but employee count excludes head office in the United States while it is included in Canada.

b. The U.S. data included Knitting Mills (23) in Textiles (18). Therefore we have done the same for Canada.

c. Since we have not corrected for relative prices in 1972, this table only should be used to infer relative growth rates in productivity. A comparison of levels requires correction for different price levels in Canada compared to the United States. This is dealt with at greater length in Chapter Five.

Canadian relative productivity. In Rubber and Plastics, Metal Fabricating, Machinery, as well as Chemicals and Chemical Products, there has been relatively little change. The largest gains have occurred in Transportation Equipment, Petroleum and Coal Products, Non-Metallic Mineral Products, Primary Metals, Printing and Publishing, Textiles, and Leather. This is enough variance across even this level of aggregation to justify an examination of the determinants of the variability of these relative productivity estimates at a more disaggregated level.

Outline of Study

While concern has been expressed about the continuing Canada/U.S. productivity gap in the manufacturing sector, there have been, in comparison, relatively few comprehensive cross-sectional studies of inter-country productivity differences at the individual industry level. Without such studies it is difficult to examine the reasons for the disadvantages suffered by Canadian industry or to determine whether the problem is specific to a relatively small number of sectors rather than to manufacturing as a whole. There have also been few studies of the extent to which structural characteristics of Canadian industry are related to the productivity disadvantage. There are even fewer studies that link these structural differences to productivity differences and that ask whether the differences in productivity disappear when the effect of plant scale differences is taken into account.

Those that have studied the productivity issue have generally focused on only one side of the problem — either on sub-optimal plant scale or the productivity problem. Moreover, little empirical attention has been paid to product diversity problems at the plant level. Those studies that have examined plant scale problems often suffer from either having concentrated on only a small number of industries or from having focused only on Canada without comparing it to some international standard. One study that has actually sought to explain Canada/U.S. productivity differences (Spence in Caves et al., 1980) did not integrate the plant scale difference into its analysis — relying on only market size differences to proxy the scale effects.[2] Bernhardt's (1981) productivity study does include both relative market size and relative plant scale, but relies on an extremely small data sample.[3] Moreover, as we argue more extensively below, these studies generally do not properly incorporate the extent of scale economies and sub-optimal plant size.[4] If the importance of scale economies in explaining Canada/U.S. productivity differences is to be evaluated, then a rigorous framework relying on production theory is required (see Cowing and Stevenson, 1981). The effects of scale can be examined by obtaining outside information on their importance industry by industry and, as we demonstrate below, by using the resulting estimate of scale economies and the relative plant scale term to produce a scale corrected productivity statistic. It is this approach that we adopt.

A related problem with the conventional literature is that some widely quoted measures that are used to show the "inefficiency" of the Canadian manufacturing sector do not allow us to draw specific conclusions about the cause of the difficulties. It is not uncommon to find comparisons of the unit labour cost of output being used to show Canada to be a high cost producer of manufactured goods. This is, of course, just a variant of a partial labour productivity measure; but it takes into account relative labour rates. Ultimately we must be interested in the reason for the differences between countries in such a measure. It could arise from technical inefficiency — being on a lower production frontier, from being at a different point on a production frontier that exhibits economies of scale. Or it could simply be the result of high wage costs associated with a Canadian comparative advantage that lies elsewhere than in manufacturing.

It is important for policy purposes to specify which of these factors leads to the disadvantage suffered by the manufacturing sector as measured by unit labour cost comparisons. If it is technical inefficiency, then something may be done to encourage technology transfer and improved management techniques. If it is a matter of scale disadvantage, then it is the determinants of size (perhaps freer trade and deregulation of transport services) that should concern us. If it is factor costs, then the policy prescriptions are more difficult.

In this monograph, we analyze the extent to which Canadian industry can be said to be relatively inefficient vis-à-vis that of our major trading partner — the United States — and the extent to which commonly used partial labour productivity measures indicate a disadvantage that is explained by scale disadvantages. We do so by examining the comparative labour productivity of matched Canada/U.S. industries. We then correct these partial productivity measures for scale economies and capital/labour intensities to produce a total factor productivity measure — a measure that can be interpreted as a measure of relative efficiency.

The paper's primary contribution, then, is the use of an improved conceptual framework to analyze the importance of sub-optimal plant scale. But it also attempts to overcome the lack of generality inherent in some of the previous studies that used only a small number of industries. We develop an extensive data base for 1970 and 1979 on the 167 4-digit industries into which the Canadian manufacturing sector is divided.[5] This permits a more comprehensive analysis than previously.

We directly examine the extent to which suboptimal plant scale is a major problem facing Canadian industry. We then estimate scale economies at the industry level using establishment data and incorporate the resulting scale estimates into the productivity analysis. We also examine the average level of plant product diversity at the industry level. We do so by developing indices of industry plant level diversity that have been hitherto unavailable. Finally, we examine the determinants of Canada/U.S. plant scale, diversity and productivity using cross-sectional regression analysis. We model the effect of trade and tariffs in a manner that is more in keeping with the Eastman/Stykolt (1967) hypothesis; that is, we ask whether the primary effect of trade restrictions is to be found in imperfectly structured (high concentration) markets. By having two cross-sections separated by a decade we can test for stability in the determinants of the inter-industry variability in these variables.

The Extent of Plant Scale Inefficiency

Before we examine the effect of Canadian plant scale disadvantage on productivity, it is important to ask whether there is evidence that suboptimality is a general problem for the Canadian economy or a greater problem for Canada than for other industrialized nations. A recent review article by Muller (1982) asked only whether there are meaningful cross-sectional explanations of inter-industry differences in Canadian plant scale, not whether plant scale was less than American on average, or only in a small subset of industries.

The work of Gorecki (1976a), Scherer et al. (1975) and Eastman/Stykolt (1967) all have suggested that Canadian average plant size is too small, but they focused primarily on a comparison of Canadian plant size to an engineering estimate of minimum efficient sized plant (MES). They were restricted to relatively small samples (13, 12, and 16 industries, respectively) and generalization of the importance of the problem from this work is difficult. Moreover, comparing plant mean size to an engineering MES estimate is likely to result in a ratio of less than 1 for any country. Only Scherer et al. (1975) examine Canada in relation to other countries but, as indicated, their sample of industries is limited. Two other studies (Dickson, 1979; Gupta, 1979) have a somewhat larger sample of industries (70 and 67 respectively), but both focus on Canada alone, by measuring scale inefficiency as the percentage of output above or below a measure of MES. Once again, there is little to indicate whether the distribution of plant sizes is any different for Canada than for its major trading partner, the United States.

The confusion as to whether plant scale is a general problem has been heightened by several studies that focused on Canada/U.S. comparisons and that have been cited as showing little Canadian plant scale disadvantage. The Economic Council of Canada (1967) reported that for a sample of 50 matched U.S./Canadian industries, plant size in terms of average number of employees was actually larger in Canada. But their use of geometric averages reduced "the influence of the relatively large number of big U.S. plants drastically" (Daly et al. 1968, p. 19, note 1).[6]

More recently, a background study by Spence (1977) for the Royal Commission on Corporate Concentration also found plant sizes in Canada and the U.S. to be similar. The study noted that "Canadian value-added per establishment is below the U.S. figure more often than it is above; but not that much more often" (p. 256). His finding referred to 83 matched U.S./Canadian industries at the 3-digit level with data for 1967 and 1968 (p. 243). However his sample is not representative of the Canadian manufacturing industry as a whole. Average industry value added per establishment in Canada for his entire sample (123 industries) was $19,515, while for the matched sample (83 industries) it was $25,400. For the United States the comparable numbers are $22,100 and $22,300, respectively (p. 256 and appendix table A.3). Thus the restricted sample used was biased against a finding of Canadian plant scale inefficiency.[7]

In contrast, several earlier studies have found a Canadian scale disadvantage. Rosenbluth (1957, p. 82), working with 53 matched U.S. and Canadian industries for 1947, found the median ratio of average firm size (sales) to be 1.2. The most comprehensive evidence is provided by Industry, Trade and Commerce (ITC) (1975) in a comparison of Canada/U.S. relative plant size for 1963, 1967, and 1972.[8] Using 93, 99, and 137 matched industries, the mean ratio of Canadian to U.S. plant size was reported as .81, .82, and .85, respectively, if employment is the unit of measurement, and .64, .66, and .71 if shipments are the unit of measurement (.59, .61, and .71 if simple exchange rate corrections are made to account for possible differences in prices).

Even the ITC comparison contains problems that probably understate that scale problem faced by Canadian industry. The Canadian census at both 2-digit and 4-digit levels includes employees in head offices and auxiliary units in its employment count but does not include these units in its establishment count. The U.S. census excludes these employees in their counts at the 4-digit industry level. Therefore comparisons of Canada/U.S. relative plant size at the 4-digit level using published employment data will be biased upwards. Moreover, different coverage of small establishments may also bias the comparison.[9]

In order to overcome the problems inherent in previous comparisons of Canadian and U.S. plants, we used EFF1T, the ratio of larger plants in Canada to larger plants in the corresponding U.S. industry. Larger plants are defined as the average size of those accounting for the top 50 percent of industry employment (see Appendix A for full details). Scherer et al. (1975) and Muller (1979) point out that it is only by comparing the same parts of the plant size distribution that meaningful comparisons of scale can be made between different countries. We focus on the top half of the size distribution in order to minimize differences in coverage of small establishments in the two countries.

EFF1T, as a measure of relative size, has a second advantage. The denominator has been widely used as a proxy for U.S. MES (Caves et

TABLE 2-7 Relative Plant Scale (EFF1T) for 125 Matched Canadian and U.S. Manufacturing Industries, 1970 and 1979

EFF1T[a]	1970[c]	1979[c]
Unweighted Mean		
No adjustments to EFF1T[b]	0.691	0.736
If EFF1T greater than 1, then EFF1T set equal to 1	0.560	0.605
Weighted Mean[d]		
No adjustment to EFF1T[b]	0.762	0.818
If EFF1T greater than 1, then EFF1T set equal to 1	0.608	0.641

Source: Statistics Canada, special tabulations.

a. EFF1T is defined as the ratio of the size of larger plants in Canada to larger plants in the corresponding U.S. industry. Larger in this context refers to the average size of the smallest number of plants accounting for 50 percent of industry employment.

b. As above.

c. While the headings refer to 1970, and 1979, only the Canadian data were drawn from this year. The American data come from the census years 1972 and 1977 and are converted to a 1970 and 1979 basis using the 1972 and 1977 exchange rates and then a Canadian gross price index.

d. The weights were total employees, Canadian industry. If total industry value-added was used as the weights, then instead of means of 0.762, 0.818, 0.608 and 0.641, the corresponding numbers are 0.852, 0.859, 0.638 and 0.663 respectively.

al., 1980). Indeed it has been found to be highly correlated with most other such measures.[10] Therefore EFF1T can also be interpreted to measure the efficiency (in terms of size relative to MES) of Canadian plants.[11]

Table 2-7 presents the means of EFF1T for 125 matched Canadian and U.S. industries.[12] A substantial scale disadvantage for Canada is evident. On average, the unweighted average of EFF1T was 0.691 in 1970 and 0.736 in 1979.[13] The corresponding weighted averages — using employment weights — were 0.672 and 0.818. These averages suggest there is a scale difference and that the difference is more important in small than in large industries.

One potential disadvantage with EFF1T is that it may be unduly influenced by instances of very large plants that the large U.S. market makes possible. A ratio of median plant sizes would overcome this difficulty but the requisite data for the United States are unavailable from published sources. Nevertheless, the reasonableness of EFF1T can be tested by examining those industries in which Canada exports a substantial proportion of output. In such industries, Canadian plants

TABLE 2-8 Distribution of Relative Plant Scale (EFF1T)[a] Above and Below Unity, 1970 and 1979

	EFF1T greater than 1		EFF1T less than 1	
	No. Industries	Mean EFF1T	No. Industries	Mean EFF1T
EFF1T 70	23	1.710	102	.461
EFF1T 79	26	1.630	99	.541

Source: Statistics Canada, special tabulations.
a. See note a to Table 2-7 for a definition of EFF1T.

should be at or above MES. At the two-digit level, there are five industries which exported 30 percent or more of their output in 1970. These are Wood Industries, Paper and Allied Products, Primary Metals, Machinery and Transportation Equipment (Economic Council of Canada, 1983, table 9-3, p. 114). For 1970, EFF1T is above 1 for all these, with the exception of Transportation Equipment.

The use of an average of EFF1T to measure aggregate sub-optimality implicitly assumes that instances where Canadian plants are larger than MES offset instances where the converse is the case. However, if the cost curve is "L" shaped, then there is no advantage in having plant size greater than MES. Individual values of the index EFF1T then should not take on values greater than unity when calculating its average.

The distribution of EFF1T above and below unity is presented in Table 2-8. Approximately 18 to 21 percent of the 125 industries had values of EFF1T greater than unity. However, for the 80 percent where plant size is less than MES, EFF1T is dramatically below unity. Mean relative plant scale was also estimated, with all instances in which Canadian plants are greater than MES set equal to unity. The results are reported in Table 2-7. The resulting unweighted averages were 0.560 and 0.605 in 1970 and 1979, respectively, while the corresponding weighted averages were 0.608 and 0.641. This indicates that lack of appropriate scale is of more significance than simple averages suggest and sub-optimal plant size is more important than some of the recent literature suggests.

Plant Level Diversity and the Length of the Production Run

In recent years it has been argued that sub-optimal plant size is not as important a problem as short production runs (Royal Commission on Corporate Concentration, 1978, p. 45). This view, as previously indicated, is based on the evidence that plant size in Canada is not all that different from the United States — evidence which we believe is misleading. Notwithstanding this, it may still be the case that short production runs and excessive product diversity may be a cause of lower productivity in Canada.

Plant diversity is difficult to study because of the lack of data at the plant level on number of products produced. Using a new set of data on the size distribution of ICC (Industrial Commodity Classification) products produced per plant, we devise a measure of diversity at the plant level. We use both the 4- and 5-digit ICC to define a plant level diversity index within 4-digit SIC industries (PHERF4D, PHERF5D both defined in Appendix A). Across the 167 4-digit SIC industries into which the Canadian manufacturing sector is divided, there are 6,126 5-digit ICC products and 2,336 4-digit products. Table 2-9 presents details of the number of 4- and 5-digit ICC products per industry. Use of two different levels of product classification allows us to test the sensitivity of our results to the level of aggregation. The index chosen is a Herfindahl that uses share of sales of each ICC product produced in a plant. This index varies between 1 when all output is confined to one product group and 1/N, where N is the maximum number of products to which a plant could allocate its output — the number of ICC products for a given industry.[14] We also calculate an industry average diversity measure (HERF4D, HERF5D) which is just the weighted average of the plant measures (PHERF4D, PHERF5D), the weights being the plant's share of industry shipments. These measures will vary directly with the degree of specialization and inversely with the degree of diversity.

While the measures of diversity we use that are based on the ICC are not so detailed as to catch all product line differences, they are likely to differentiate between products with important associated cost differences because of the manner in which the ICC classification is derived. This classification uses mainly supply side criteria — such as whether products are made from similar raw material or are generally processed in the same plant — that should catch the most important heterogeneity in the production process. That our diversity index, calculated at the plant level using this classification, differs from 1 indicates that the diversity problem extends well beyond just too many tire or automobile types per plant.

Since the plant level diversity of an industry will vary depending upon the number of ICC products produced, we define a relative diversity variable

$$\text{RELDIV4D} = (1 - \text{HERF4D})/[1 - (1/N)]$$

where HERF4D is the 4-digit ICC level index of diversity and N is the number of products per industry; then RELDIV4D will vary indirectly with the degree of product specialization. Table 2-9 presents the average values of RELDIV4D and RELDIV5D, both weighted and unweighted, at the 2-digit industry level, as well as the average values of N at the 4- and 5-digit ICC level. Between 1974 and 1979, the weighted and unweighted averages of RELDIV have gone down, indicating a movement to greater specialization.

TABLE 2-9 Level of Relative Plant Product Diversity, Measured at the 4-Digit and 5-Digit ICC, Grouped by Industry Group, 1974 and 1979

Number of Constituent 4-Digit Industries	Industry Group	RELDIV4D[a] Weighted Average[b] 1974	RELDIV4D[a] Weighted Average[b] 1979	RELDIV4D[a] Unweighted Average[b] 1974	RELDIV4D[a] Unweighted Average[b] 1979
17	Food & Beverages (10)	0.3632	0.3418	0.3302	0.3066
2	Tobacco Products (15)	0.1491	0.1549	0.1341	0.1601
—	Rubber & Plastics (16)	—	—	—	—
4	Leather (17)	0.2978	0.2577	0.3528	0.3001
14	Textiles (18)	0.4541	0.3575	0.4571	0.3705
2	Knitting Mills (23)	0.3375	0.3502	0.3470	0.3510
7	Clothing (24)	0.3650	0.3350	0.2427	0.2031
9	Wood Products (25)	0.2840	0.2486	0.2042	0.1911
2	Furniture & Fixtures (26)	0.2270	0.3552	0.2591	0.3806
5	Paper & Allied Industries (27)	0.3044	0.2691	0.3163	0.2482
3	Printing & Publishing (28)	0.3056	0.3255	0.3052	0.3782
6	Primary Metals (29)	0.3688	0.4382	0.3114	0.3220
9	Metal Fabricating (30)	0.3643	0.2976	0.3866	0.3099
3	Machinery (31)	0.5319	0.3927	0.4774	0.3605
9	Transportation Equipment (32)	0.4370	0.3901	0.3775	0.3334
8	Electrical Products (33)	0.3955	0.3262	0.3878	0.3248
12	Non-Metallic Mineral Products (35)	0.0962	0.1045	0.1192	0.1291
2	Petroleum & Coal Products (36)	0.7572	0.7259	0.5929	0.5427
8	Chemical & Chemical Products (37)	0.4745	0.4792	0.3764	0.3499
13	Miscellaneous Manufacturing (39)	0.3587	0.3324	0.3496	0.3285
135	Weighted 2-digit industry average	0.3635	0.3372	0.3288	0.2963

TABLE 2-9 (cont'd)

Number of Constituent 4-Digit Industries	Industry Group	RELDIV5D[a] Weighted Average[b] 1974	RELDIV5D[a] Weighted Average[b] 1979	RELDIV5D[a] Unweighted Average[b] 1974	RELDIV5D[a] Unweighted Average[b] 1979
17	Food & Beverages (10)	0.4353	0.4285	0.4259	0.4217
2	Tobacco Products (15)	0.3483	0.3931	0.2562	0.2991
—	Rubber & Plastics (16)	—	—	—	—
4	Leather (17)	0.3354	0.2864	0.3600	0.3034
14	Textiles (18)	0.5018	0.4386	0.4979	0.4186
2	Knitting Mills (23)	0.3469	0.4115	0.3629	0.4117
7	Clothing (24)	0.4410	0.4077	0.4414	0.4097
9	Wood Products (25)	0.4454	0.3990	0.3164	0.2859
2	Furniture & Fixtures (26)	0.4382	0.4674	0.3545	0.4017
5	Paper & Allied Industries (27)	0.3380	0.2990	0.2897	0.2405
3	Printing & Publishing (28)	0.2933	0.3079	0.2663	0.3175
6	Primary Metals (29)	0.4070	0.4807	0.3884	0.3954
9	Metal Fabricating (30)	0.3737	0.3331	0.3969	0.3658
3	Machinery (31)	0.5543	0.4493	0.4993	0.4208
9	Transportation Equipment (32)	0.4628	0.4490	0.4479	0.4359
8	Electrical Products (33)	0.4731	0.4005	0.5054	0.3907
12	Non-Metallic Mineral Products (35)	0.1502	0.1907	0.2389	0.2785
2	Petroleum & Coal Products (36)	0.7394	0.7225	0.5875	0.5409
8	Chemical & Chemical Products (37)	0.5436	0.5364	0.4092	0.3845
13	Miscellaneous Manufacturing (39)	0.3855	0.3570	0.3916	0.3540
135	Weighted 2-digit industry average	0.4149	0.3981	0.3975	0.3714

Number of Constituent 4-Digit Industries	Industry Group	Number of Products[b]					
		4-Digit ICC			5-Digit ICC		
		Unweighted Average[b]	Weighted Average[b]		Unweighted Average[b]	Weighted Average[b]	
		—	1974	1979	—	1974	1979
17	Food & Beverages (10)	14.6	19.5	19.9	39.1	50.5	50.7
2	Tobacco Products (15)	7.0	5.7	5.6	23.5	17.2	16.7
—	Rubber & Plastics (16)	—	—	—	—	—	—
4	Leather (17)	10.3	14.9	14.7	33.5	67.7	62.5
14	Textiles (18)	6.6	9.1	8.4	17.2	27.2	25.4
2	Knitting Mills (23)	9.5	6.9	9.2	29.5	24.9	28.9
7	Clothing (24)	6.9	9.9	10.1	20.7	29.9	30.3
9	Wood Products (25)	3.8	5.8	5.7	16.1	32.4	32.3
2	Furniture & Fixtures (26)	5.0	6.6	6.7	16.5	22.7	23.2
5	Paper & Allied Industries (27)	7.4	21.8	21.8	21.0	66.5	66.6
3	Printing & Publishing (28)	9.3	12.7	13.2	23.3	31.1	31.5
6	Primary Metals (29)	13.2	24.3	34.0	33.0	60.7	62.4
9	Metal Fabricating (30)	16.1	18.8	19.5	38.9	45.4	46.2
3	Machinery (31)	23.7	28.9	31.7	67.0	79.2	83.9
9	Transportation Equipment (32)	10.3	15.3	15.8	27.6	42.1	43.7
8	Electrical Products (33)	20.5	30.3	31.0	60.4	12.5	11.8
12	Non-Metallic Mineral Products (35)	4.7	4.9	4.7	11.3	87.0	90.2
2	Petroleum & Coal Products (36)	10.5	17.3	17.1	17.5	30.6	30.3
8	Chemical & Chemical Products (37)	10.1	18.6	18.6	28.6	43.0	44.1
13	Miscellaneous Manufacturing (39)	13.4	17.8	18.8	29.2	35.2	36.4
135	Weighted 2-digit industry average	10.8	17.4	17.5	28.9	47.6	48.0

Source: Statistics Canada, special tabulations.

a. See text for definition.

b. Averages estimated across all constituent 4-digit industries within an industry group. The weighted averages use employment weights, where employment includes both wage and salary earners.

The average length of a production run can be derived from the Herfindahl index of product diversity by dividing average plant size by the Herfindahl product numbers equivalent (1/HERF4D). The change in average production run length between 1974 and 1979 is presented in Table 2-10. Between 1974 and 1979, product diversity in Canadian industry was somewhat reduced, and the size of an average plant increased substantially. The net effect has been to increase the average production run by about 55 percent in the sample used in our regression analysis.

Because of its uniqueness, our data on plant diversity have no U.S. counterpart. Contrary to our investigations of relative plant scale, we cannot therefore draw direct conclusions about whether Canadian industry is too diversified. We did, however, investigate the extent to which plants grow larger by adding product lines rather than by expanding production run length. Total output or size of plant is, of course, just average production run length multiplied by number of products. Thus the three concepts are linked via an identity. But the relationship between diversity or production run length and size is nevertheless suggestive of the extent to which Canadian small plant scale may lead to higher costs via excessive diversity.

Larger plants may have lower average costs than small plants because of plant economies associated with larger size, because of longer production runs associated with larger plant size, or because of multi-product economies that may be associated with increased plant diversity of larger sized plants. If plants grow over the smaller size ranges both by adding product lines and by increasing production run length, but eventually just by increasing production run length, it may be concluded that diversity is being used over the small size ranges to exploit plant economies or multi-product economies, but that eventually it is the production run length economies that dominate. Small market size is therefore costly in that diversity is being used to exploit plant scale economies at the expense of production run length economies that in a larger market would be fully exploited by longer production run length across a smaller number of products — without the resulting loss of production run length economies.[15]

In order to investigate the relationship between diversity and average plant size within an industry, we regressed diversity for each plant (PHERF4D, PHERF5D) on plant size (TSH), plant size squared (TSHSQ), the extent to which the plant's owning enterprise was a multi-plant firm (NOEST), and foreign ownership dummies for each industry (OCON = ownership by a non-resident, non-U.S. firm; and USCON = ownership by a U.S. firm). The signs and significance of the coefficients for 1970 in 75 4-digit industries where there are sufficient data for the regressions are reported in Table 2-11.[16]

The regression results show that plant diversity increases with plant size. The regression results for average production run length (not

TABLE 2-10 Average Plant Product Diversity and Length of Production Run, Measured at the 4-Digit and 5-Digit ICC Across 4-Digit Industries, 1974 and 1979

	Degree of Product Diversity		Size of Production Run		Average Plant Size[a] (000's)	Number of Industries
	HERF4D	HERF5D	PR4D	PR5D		
Maximum number of industries data available[b]						
1974	0.701	0.623	3202.5	2856.2	5391.9	161
1979	0.731	0.650	4649.2	4047.2	7553.7	161
1979–74	0.029	0.027	1446.7	1191.0	2161.8	161
Excluding miscellaneous industries						
1974	0.712	0.630	3585.3	3197.1	5978.6	135
1979	0.739	0.653	5231.1	4541.7	8477.9	135
1979–74	0.027	0.024	1645.8	1344.5	2499.3	135
Industry sample, regression analysis[c]						
1974	0.702	0.617	3407.2	2980.4	6073.4	119
1979	0.729	0.644	5333.8	4603.3	8906.0	119
1979–74	0.028	0.026	1926.7	1622.9	2832.6	119

Source: Statistics Canada, special tabulations.

a. Measured in 1971 constant dollars. For 1974 average plant size refers to 1970.

b. Excludes those industries for which no ICC products exist and one industry where none of the plants classified to the industry reported product diversity data.

c. Discussed in Chapter Seven.

TABLE 2-11 Summary of Regression Results of Plant Size, Ownership and Multi-Plant Operations on Plant Diversity for Each of 75 Canadian 4-Digit Manufacturing Industries, 1970

Independent Variable	Number of Regression Coefficients			
	Positive		Negative	
	Significant[a]	Insignificant	Significant[a]	Insignificant
TSH				
PHERF4D[b]	2	20	25	28
PHERF5D[b]	4	12	27	32
TSHSQ				
PHERF4D[b]	15	36	5	19
PHERF5D[b]	19	34	3	19
NOEST				
PHERF4D[b]	8	28	8	31
PHERF5D[b]	7	34	9	25
OCON				
PHERF4D[b]	2	30	5	19
PHERF5D[b]	1	30	6	17
USCON				
PHERF4D[b]	11	37	3	22
PHERF5D[b]	8	38	2	25

Source: Baldwin and Gorecki (1983a), based on Statistics Canada, special tabulations.

Notes: In some instances there are no observations for OCON and/or USCON. In these cases the regression equation is estimated without OCON and/or USCON. Hence summing across the row for these two variables need not sum to 75.

Definition of Variables: PHERF4D = the Herfindahl index of plant diversity using the 4-digit ICC; PHERF5D = the Herfindahl index of plant diversity using the 5-digit ICC; TSH = plant size measured in dollars; TSHSQ = TSH squared; NOEST = number of establishments possessed by the owning enterprise; OCON = dummy variable for ownership by non-resident, non-U.S. firm; and USCON = dummy variable for ownership by U.S. firms.

a. At 0.10 level, using a one-tailed test.

b. The corresponding dependent variable.

reported here)[17] show that this is also the case with average production run length — where the latter is defined as the plant size divided by the Herfindahl numbers equivalent of products produced. Plants therefore get larger both by including more products and by increasing production run length. In most industries, the rate at which diversity increases declines with size (a positive sign on TSHSQ), thereby suggesting that multi-product economies that encourage product diversity are eventually exhausted.

Plants therefore get larger by including more products and by increasing the length of the production run. In most industries, the rate at which the first occurs declines with size, thereby suggesting that plant scale economies or agglomeration economies (product number economies) that would lead to greater diversity are eventually exhausted. Production run length also increases at a decreasing rate–but with less frequency than for diversity. In a number of industries, the rate at which the production run increases with plant size actually increases. This suggests there are a number of industries where production run economies outweigh agglomeration economies. Thus the emphasis on production run length economies found in the Royal Commission on Corporate Concentration (1978) and elsewhere is not misplaced.

We took our investigation of the relationship between plant scale and diversity one step further and asked how the ratio of Canadian average plant size to an estimate of minimum efficient sized (MES) plant derived from U.S. data was affected by average industry plant diversity (Baldwin and Gorecki, 1985). The relative size variable is defined both using the average size of all plants in an industry and using just the largest plants, those accounting for the top 50 percent of employment. Besides the diversity variable, additional regressors were included to pick up other influences that were posited to affect relative plant size. The results show that higher levels of diversity increase relative plant size for both relative size measures. This suggests that product packing is used in both small and large plants as a method of taking advantage of plant scale economies.

We also examined the differences in diversity of Canadian and U.S.-owned plants. When grouped by size class, Canadian plants on average appear to be more specialized. This accords with Caves (1975, p. 39), who showed for 1973–74 that U.S.-owned plants in Canada produced a more varied output of manufactured products than their Canadian counterparts in the same size category. However, grouping by size class alone does not allow for differences in potential diversification. U.S. plants may be concentrated in industries with a greater potential number of products. When we disaggregate and group Canadian and U.S.-owned plants by size class as well as potential number of products, U.S. plants in both 1974 and 1979 are frequently more specialized, not more diversified, than their Canadian counterparts.

Caves' result has been cited by a number of commentators (Daly, 1979,

p. 49; Saunders 1982, p. 473) as suggesting that U.S. plants are more diversified than Canadian plants. Strong conclusions have been drawn, in part, upon the basis of this sort of evidence. In particular, it is seen as consistent with the miniature replica effect. Our finding is that U.S. ownership more often than not increases production run length and reduces product diversity, suggesting that the impact of U.S. foreign investment is ambiguous — certainly that the miniature replica effect is not general.

In conclusion, excessive product diversity and inadequate production run length may be a problem for Canadian industry but it is inextricably bound up with the plant size problem. We found that with a small market size, demand for individual products was so small that firms product-pack in order to take advantage of plant scale economies.

Canada/U.S. Productivity

The focus of this study is two-fold. First because of the evidence on Canadian plant scale disadvantages, we attempt to quantify the extent to which often-perceived productivity disadvantages experienced by Canadian industry are the result of plant sub-optimality. In order to do so, we calculate two measures of productivity, a measure that presumes no economies of plant scale and one that corrects for the effects of scale economies in the face of smaller Canadian plant size. Second, we ask whether the variability of the productivity measures is "explained" by the degree of openness of the industry to trade. To do so, we employ cross-sectional regression analysis at the 4-digit SIC level to determine whether trade intensity (the importance of exports, imports or tariff protection) is correlated with relative Canada/U.S. productivity. Since an analysis of Canadian productivity is at the heart of the study, it is important to discuss the concept itself, because it can take on different meanings.

Productivity measures are used to indicate the efficiency with which inputs are transformed into outputs. A number of different measures have been used that vary in terms of sophistication and completeness. These measures are either output per unit of input, or unit cost relative to factor prices. In a world of one input and one output, there is little difficulty in defining the relevant units for the creation of a productivity index. In a world of multiple outputs and inputs, derivation of an appropriate aggregation index is essential. Ultimately the relationship between outputs and inputs used to define a measure of productivity must depend upon the nature of the production function. Knowledge of the nature of the production function allows the specification of the relevant total factor productivity (TPF) indices that should be used to aggregate outputs and inputs to derive a productivity measure. In the absence of such knowledge, a general aggregation procedure that allows for differences in underlying production technology is required.

Partial measures of factor productivity, especially labour productivity (output per unit of labour), have long been the mainstay of productivity comparisons — mainly because of the difficulty in measuring other inputs such as capital. Total factor productivity measures have become more popular, due to both the increasing efforts made to generate capital stock estimates and the evolution of duality theory which emphasizes an alternate methodology requiring only factor input prices as opposed to the inputs themselves.

Partial productivity measures, such as labour productivity, have been criticized for dealing only partially with the production process. For example, labour productivity may differ across countries because of different capital stock levels, and thus cross-country differences in this variable may be explained by different capital intensities rather than efficiency differences. In effect, such criticisms seek an explanation in partial productivity measures of intercountry differences based upon either an implicit or explicit notion of a production function. Countries can be adjudged to be equally productive or equally efficient as long as they operate on the same production function. Partial measures may differ because they operate at different points on the production function. With a properly specified production function, a partial productivity ratio can be decomposed into components that consist of relative factor intensity, relative scale (if economies matter), and a residual. The latter has come to be known as a measure of total factor productivity and can be said to provide a measure of the difference in technical efficiency between countries.

Consider an industry where the production process can be represented by a Cobb-Douglas production function whose labour and capital elasticities are the same in Canada and the United States, but which differs in the two countries by a shift coefficient. Then

$$Q_c = A_c L_c^{a} K_c^{b} \tag{2.1}$$

$$Q_u = A_u L_u^{a} K_u^{b} \tag{2.2}$$

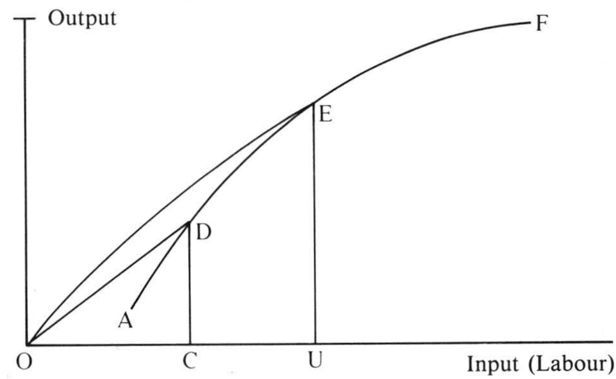
where c ≡ Canada, u ≡ United States, and $\xi_{cQ} \lesseqgtr 1$ as $a + b \gtreqless 1$. Then the ratio of output per worker in the two countries is

$$\frac{Q_c/L_c}{Q_u/L_u} = \left(\frac{A_c}{A_u}\right)\left(\frac{L_c}{L_u}\right)^{(a+b-1)}\left(\frac{K_c/L_c}{K_u/L_u}\right)^{b} \tag{2.3}$$

Thus the labour partial factor productivity measure depends upon the relative size of the two industries (L_c/L_u) and the degree of scale economies ($a + b - 1$); the relative capital/labour ratios $(K_c/L_c)/(K_u/L_u)$ and the capital output elasticity (b); and the ratio of the shift coefficients A_c/A_u. The latter, in this context, can be taken as a measure of total factor productivity (TFP) of the Canadian industry relative to the American.

A TFP index, such as A_c/A_u above, is more appropriately called a

FIGURE 2-1 The Relationship Between Output and Input, Canada and the United States



relative efficiency measure, because it accounts for the unexplained difference in output per unit of input once other relevant factors have been considered. Two countries may be characterized as equally efficient in transforming inputs into outputs in the sense that they both utilize the same production function, but may differ substantially in terms of the amount of output obtained per *unit* of input. When economies of scale are present, the country with the smaller market may produce "efficiently" in the sense that it is on the same production function, but may require more inputs per unit of output (i.e., have a lower measure of productivity) because of scale disadvantages.

The difference between the conventional measure of relative productivity that does not consider scale economies and the measure of relative efficiency that does can be usefully illustrated with reference to Figure 2-1. In Figure 2-1, we assume that there is only one factor input (labour) and that both countries operate on the same production frontier (AF). Canada uses OC units of labour to produce CD units of output; the United States uses OU units of labour to produce UE units of output. Both countries could be said to be equally efficient in that they are operating on the same production function; but the conventional labour partial productivity measure would indicate greater productivity for the United States, since UE/OU is greater than CD/OC. The scale-corrected efficiency measure in this case would be 1, since both countries are on the same production frontier.

Rewriting (2.3),

$$\ln \frac{A_c}{A_u} = \ln \frac{Q_c/L_c}{Q_u/L_u} - (a + b - 1) \ln \frac{L_c}{L_u} - b\ln \left(\frac{K_c/L_c}{K_u/L_u} \right). \qquad (2.4)$$

Thus the total factor productivity measure can be regarded as the difference in relative labour productivity, corrected for other measurable considerations. In this case, these considerations are economies of scale and factor intensity. Thus TFP measures may produce quite different results, depending upon the factors that have been considered. Moreover, it may be the case that if all relevant considerations are incorporated into the analysis, the residual effect should disappear — that is, the value of TFP should take on a value of 1, indicating to the reader uninitiated in the meaning of such measures that the two countries are equally efficient. That, of course, does not mean the two countries are equally productive — only that the differences in productivity have been accounted for by the other factors incorporated into the analysis.

Since efficiency has such an emotive connotation and has been used in different ways, it is important to note the meaning that is attached to its use here. *Allocative* inefficiency occurs when, for a given production function, factor inputs are not combined in the proportions justified by factor price ratios for cost minimization purposes. An industry may be defined as *technically* efficient if its production frontier is similar in all respects to that of another country. If a country's production function is the same as that of another country except that it is lower, it is said to be technically inefficient relative to the latter. An industry may be relatively *X-inefficient* even if it is technically efficient (i.e., possessing the same production frontier) if it possesses more establishments or a greater proportion of sales at points below the common production frontier than in another country. Finally, an industry may have a cost disadvantage even if it is not characterized by technical, allocative, or X-inefficiency. It may simply have relatively high unit (labour) costs because the comparative advantage of a country may lie elsewhere, such as in services or natural resources.

In this study, we measure only the technical efficiency of a Canadian industry relative to its American counterpart. We believe that this measure captures an important aspect of the debate over the efficiency of Canadian industry. Those who argue that Canadian industry is slow to adopt the newest technology and cannot compete because of such inefficiency are implicitly arguing that total factor productivity, in the manufacturing sector as we measure it, is less than that of the United States.

It should be noted that the partial productivity measure adequately reflects this total factor productivity measure if the industries are the same size or there are constant returns to scale, and if factor intensities (capital/labour ratios in this instance) are the same. Therefore in subsequent chapters we examine whether economies of scale exist in Canadian industry and hence whether the total factor productivity measure is likely to be significantly different from the partial labour productivity ratio for that reason. Differences in capital/labour ratios are also investigated but they are of less importance and therefore have less of an impact on the validity of conclusions about inefficiency that might be drawn from partial labour productivity measures.

Chapter 3

Definitions of Variables, Measurement Problems and Sample Characteristics

One of the major contributions this work makes to the comparison of Canada/U.S. relative productivity in the manufacturing sector is the use of scale-corrected productivity measures. For this we need an estimate of scale economies within individual manufacturing industries. The second and third sections of this chapter define the variables used to estimate individual industry production functions and discuss the problems that arise in measuring such variables. The next section describes the data set and the selection criteria used to choose a subsample for estimation purposes. The estimation procedures are discussed in the next chapter. The chapter concludes with a brief summary and conclusion.

A production function is a characterization of the relationship between output and inputs

$$Y = f(x) \tag{3.1}$$

where Y is the output of a plant and x is a vector of inputs that would include labour, capital, fuel and power, and materials used. In estimating this function we are restricted to the data available in the Census of Manufactures. The basic data in the census is collected at the establishment level. This is:

> The smallest unit which is a separate operating entity capable of reporting the following principal statistics:
>
> Materials and supplies used
> Goods purchased for resale as such
> Fuel and power consumed
> Number of employees and salaries and wages
> Man-hours worked and paid
> Inventories
> Shipments or sales (Canada, Statistics Canada, 1979b, p. 11)

The concept of an establishment is considered by the census authorities to be equivalent to a factory, plant or mill.[1] In 1970 there were 31,928 establishments in the census of manufactures and in 1979 the corresponding number was 34,578 (Canada, Statistics Canada, 1982, Table 1, p. 2). However, for various reasons, outlined below, we did not use all these establishments for estimation purposes.

A considerable amount of data is collected for the individual establishment by the annual census of manufactures (see Canada, Statistics Canada, 1979b, pp. 67–74). It is possible to supplement this information by linking the census of manufactures with other data sets in Statistics Canada, such as those relating to ownership of the establishment as well as various financial and non-financial characteristics of the enterprise which owns the establishment. The variables used in this project at the establishment level to estimate industry production functions are presented and discussed in this chapter. In addition, a substantial number of industry level variables were generated for subsequent comparison of Canadian and U.S. productivity differences. These are described in Appendix A. Since we are intent on comparing Canadian and U.S. industries, some care was given to either defining or choosing variables so that they would match as closely as possible across the two countries. The U.S. variables are also presented in Appendix A. They were kindly provided by R. Caves of Harvard University.

Variables Provided by Statistics Canada

Our variables can be divided into three basic groups: (1) those taken directly from the census of manufactures and related surveys undertaken by Statistics Canada; (2) special variables, usually requiring substantial data manipulation, created by Statistics Canada for this project; and (3) variables generated by the authors. In this section, we confine our attention to the first two sets.

The variables, unless otherwise stated, did not change definition between 1970 and 1979, the two endpoints for this study. Usually data are available for both years. In a number of instances an adjacent year had to be used, frequently because the data were not available in machine-readable form and substantial expense was entailed in making the data machine readable. Exceptions will be noted in the text and summarized in tabular form below. In what follows we outline the variables used to estimate the industry production functions.

Labour

The variables available from the census reflecting the labour input of an establishment are:[2]

NW the number of production and related workers;

NS the number of administrative office and other non-manufacturing employees;

VW gross earnings of production and related workers;

VS gross earnings of administrative office and other non-manufacturing employees; and

MHRSWR manhours worked by production and related workers.

NW and NS are the average number employed during the census reporting period. For plants or establishments which start operations part way through the year or are seasonal in nature, NS and NW are expressed as the equivalent in man-years. NW and NS roughly translate into production and non-production workers. Some of the tasks performed by NS include operating cafeterias, engaging in new construction, major repairs and alterations. VW and VS refer to the gross earnings of NW and NS before *any* deductions, including unemployment insurance and pensions. Employer contributions to pay and benefit programs are not included. Overtime earnings are included. Finally, MHRSWR refers only to NW, since such data were not collected for NS. As with VW, overtime hours are included.

Materials and Electricity

The other variable cost inputs at the establishment level captured by the census are:[3]

FELEC cost of fuel and electricity;

MATSUP cost of materials and supplies used in manufacturing activity; and

TOTMAT cost of materials and supplies used in manufacturing activity and non-manufacturing activity.

FELEC refers to *all* fuel and electricity consumed by the establishment, except that produced *and* consumed by the establishment itself. FELEC is valued at the plant gate and includes both taxes/duties and transportation costs. MATSUP refers to commodity items or physical goods which are used as materials and supplies in the manufacturing process. Hence services such as advertising are excluded.[4] As with FELEC, MATSUP is defined as the laid-down cost at the establishment gate. Materials and supplies transferred from one establishment to another, within the same firm, are included in MATSUP.

An establishment usually has some non-manufacturing activity which, when added to manufacturing activity, is referred to as total activity. In the case of materials and supplies, non-manufacturing activity refers to two items — purchased goods for resale; and non-manufacturing materials and supplies. The former might consist of a transfer of a good from one establishment to another for resale in the same condition as received;[5] the latter refers to such items as inputs into construction by the establishment for own use. The sum of the non-manufacturing and manufacturing materials and supplies is TOTMAT.

Capital

At the level of the individual establishment, data on the stock of capital and the flow of services it yields are not available. But capital expenditure and repair data accumulated over the period 1970–1979 and expressed in constant (1971) dollars have been collected. These variables are:[6]

RNCTOT gross capital expenditure on new construction over the period 1970-1979, expressed in constant (1971) dollars;

RNMETOT gross capital expenditure on new machinery and equipment over the period 1970-1979, expressed in constant (1971) dollars;

RRCTOT repair expenditures on construction over the period 1970–1979, expressed in constant (1971) dollars;

RRMETOT repair expenditures on machinery and equipment over the period 1970–1979, expressed in constant (1971) dollars.

Capital expenditure data refer to the purchase of assets by the establishment with a life of more than a single year. RNCTOT is the gross expenditure on new buildings, engineering structures and land improvements. RNMETOT includes the installed cost of machinery and motors, etc., and the delivered cost of office furniture and fixtures, motor vehicles and other transportation equipment. For RNCTOT, expenditures represent construction work put in place for a given year, irrespective of the time payment was made. For RNMETOT no deduction is made for scrap or trade-in value.

RRCTOT and RRMETOT refer respectively to repairs to construction and to machinery and equipment, where repair is defined so as "to maintain the operating efficiency of the existing stock of durable assets" (Canada, Statistics Canada, 1981a, p. 38). In those instances where repairs result in major improvements in either of the two classes of expenditure that are "large enough to materially lengthen the expected serviceable life of the assets, increase its capacity or otherwise raise its productivity" (p. 38) then this is included with RNCTOT or RNMETOT.

The data on capital expenditure and repair are collected on an annual survey basis. In order to estimate a constant dollar value for the four expenditure variables, 2-digit price deflators were used. One price deflator was used for construction (both new and repair) and another for machinery and equipment (again the same one for both new and repair).[7]

Output

The various measures of plant output that are available in the census at the establishment level are:[8]

TSH	total activity value of shipments;
MSH	manufacturing activity value of shipments;
TVP	total activity value of production;
MVP	manufacturing activity value of production;
TVA	total activity valued added;
MVA	manufacturing activity value added;
CST	convention adopted in valuing production/shipments by establishment.

MSH refers to "net selling value . . . of shipments of goods produced by the establishment on its own account and made under contract for it from its materials, together with revenue from repair work and from custom manufacturing done for others using material owned by others" (Canada, Statistics Canada, 1979b, p. 30). In this context net selling value excludes "discounts, returns, allowances, sales taxes and excise duties" (pp. 29–30). TSH is MSH plus shipments of non-manufacturing activity defined to include goods purchased and resold in the same condition and such items as book value of new construction by the establishment's labour force for own use. TVP and MVP are analogous to TSH and MSH, respectively, except that an adjustment has been made for changes in inventories. Specifically, the relationship between (say) TVP and TSH is:

$$\mathrm{TSH} = \mathrm{TVP} + (\mathrm{OYI} - \mathrm{CYI}) \tag{3.2}$$

where OYI = opening inventory, beginning of the year and CYI = closing inventory, end of the year. Thus, TVP is the amount actually produced in the plant during the year, and TSH is the amount actually flowing out of the factory gates in the same period.

Value added or net output is a measure of the increase in value that is added to the purchased or intermediate inputs by the primary inputs of labour and capital. Crudely speaking, it is the difference between output and intermediate inputs. In terms of an earlier notation it is defined, using total activity, as follows:

$$\text{TVA} = \text{TVP} - \text{FELEC} - \text{TOTMAT}. \tag{3.3}$$

Census value added is not pure value added because services and property taxes are not deducted from TVP while subsidies on production are included.[9]

CST is a classification variable that refers to the way shipments are valued on the census form by respondents. Each establishment has a choice of four methods of reporting: at "cost"; at "book transfer value"; at "final selling price"; and "other." This variable is used in this analysis to test whether different reporting methods may result in significantly different sales values. Earlier work by Maule (1969, pp. 8–9) suggested that differences in reporting practices of sales may understate Canadian shipments and value added relative to the United States.

Product Diversity

Since product diversity has been posited to be an important factor in determining productivity levels, an index of product diversity at the level of individual plant was derived. This is,

$$\text{PHERF4D} = \sum_{i=1}^{N} S_i^2 \tag{3.4}$$

where S_i is the proportion of the plant's shipments (MSH) classified to the Nth 4-digit Industrial Commodity Classification (ICC). Since commodity data are not collected at the total activity level, but only for manufacturing activities, this index relates only to the latter. PHERF5D is defined analogously to PHERF4D, except at the 5-digit ICC level of classification. Across the whole manufacturing sector there are 6,126 5-digit ICC commodities and 2,336 4-digit ICC commodities, compared with 167 4-digit SIC industries. The ICC is created specifically for use in conjunction with the SIC and refers to domestic production of commodities. Both systems use supply-side criteria in delimiting an industry or commodity. From the viewpoint of studying the costliness of plant diversity, supply-side criteria — whether products are made from a similar raw material or processed in the same plant — are likely to be much more relevant than demand-side considerations. For further details and discussion of this measure of product diversity as well as some empirical results relating diversity to trade and tariffs, see Baldwin and Gorecki (1983a).

Definitions of Variables for Analysis

In the previous section we outlined the variables which were available from the census of manufactures and the capital expenditure survey, as well as those that have been specifically calculated from these underlying data for this project. In this section we outline and define the variables used in the estimation of the industry production functions, drawing on the previous section. In several instances it is possible that the same concept — output, for example — can be approximated by several variables — TSH, MSH, TVP, MVP, TVA, MVA. We discuss the alternatives and the sensitivity of the results to alternate specifications.

The census makes an important distinction between manufacturing activity and non-manufacturing activity, the sum of the two being total activity. Non-manufacturing activity consists mainly of goods for resale purchased in the same condition — a retailing or wholesaling function, not production. Table 3-1 summarizes the activity over which variables are defined. In some instances, separate variables relating to the same concept are available for both total and manufacturing activity — number of employees, materials and supplies, and all the output definitions. In other cases, data are available only for total activity (FELEC) or manufacturing activity (MHRSWR, MHRSPD, PHERF4D and PHERF5D). Because of the need to use data that can eventually be compared to the United States — whose industry aggregates refer to total activity — our analysis also focuses on total activity. Since some variables are available only for manufacturing activity, selection criteria were devised to exclude those instances where total activity substantially exceeds manufacturing activity. By doing so, we believe we essentially capture the characteristics of the manufacturing process in the production function that we estimate, even when we have to use total activity variables.

Output Measurement

Our measure of output used in the estimation of the production function is:

$$Y = TVA = TVP - FELEC - TOTMAT. \tag{3.5}$$

Y is the difference between the value of gross output, excluding taxes and transport cost, at the factory gate, and the laid down cost at the plant, including transportation costs and taxes, of intermediate inputs. Y corresponds with the value added by the primary factors labour and capital.[10] The sum of value added when all purchased inputs other than labour and capital are included in materials provides a measure of total output of the economy, with no double counting. The measure Y

TABLE 3-1 Variable Coverage: Total vs. Manufacturing Activity

Manufacturing Activity	Total Activity
NW	NW + NS
VW	VW + VS
MHRSWR	—
—	FELEC
MATSUP	TOTMAT
—	RNCTOT
—	RNMETOT
—	RRCTOT
—	RRMETOT
MSH	TSH
MVP	TVP
MVA	TVA
CST	CST
PHERF4D	—
PHERF5D	—

Note: See text for more extensive variable definition as well as a description of the distinction between total and manufacturing activity.

Definition of Variables:

NW —number of production workers
NS —number of non-production workers
VW —earnings of production workers
VS —earnings of non-production workers
MHRSWR —hours worked by production workers
FELEC —cost of fuel and electricity
MATSUP —cost of materials and supplies in manufacturing
TOTMAT —cost of materials and supplies used in total activity
RNCTOT —new construction investment
RNMETOT —new machinery investment
RRCTOT —construction repair expenditures
RRMETOT —machinery repair expenditures
MSH —manufacturing activity value of shipments
TSH —total activity value of shipments
MVP —manufacturing activity value of production
TVP —total activity value of production
MVA —manufacturing activity value added
TVA —total activity value added
CST —convention adopted in valuing shipments
PHERF4D —establishment product diversity at 4-digit ICC
PHERF5D —establishment product diversity at 5-digit ICC

employed here is similar to that employed by Griliches and Ringstad (1971, pp. 22–23) in their study of industry production functions for the Norwegian manufacturing industry.

Recently, TVP has been used rather than Y in studies that examined productivity differentials across firms or productivity growth over time. The use of gross (TVP) as opposed to net (Y) output may potentially yield very different productivity estimates, either in terms of levels or variability across industries, if materials usage differs either across firms or over time.

The decision as to whether to include materials (i.e., use TVP as opposed to Y) also depends upon the extent to which they can be included without causing serious estimation problems in deriving scale economies estimates. Griliches and Ringstad (1971, pp. 108-109) outline the reasons for favouring Y over TVP. One reason is that Y improves comparability both across differing material intensities and within an industry if individual establishments differ in their degree of vertical integration. Furthermore, any short run variation in demand is much more likely to lead to a corresponding change in FELEC and TOTMAT than labour or capital, thus leading to greater simultaneous equation bias if TVP is used to estimate the production function. Inclusion of materials may also obscure the more interesting relationships between output and labour and capital because of fewer substitution possibilities with regards to materials use. As a practical matter, Griliches and Ringstad (1971, pp. 108–23) suggest that for cross-section work the results using Y or TVP are much the same. On a cross-section basis, they used this information to decide whether to use Y or TVP and decided on the former. While some researchers such as Denny and May (1977) have used TVP, their studies have usually focused on time series. Since our study deals with a cross-section, admittedly at two points in time, we have chosen to concentrate on net output.

Product Diversity Measurement

Our measure of heterogeneity of plant output is defined as:

$$\text{H4} = \text{PHERF4D for the 4-digit ICC classification} \tag{3.6}$$

$$\text{H5} = \text{PHERF5D for the 5-digit ICC classification} \tag{3.7}$$

In previous work, (Baldwin and Gorecki, 1983a) we normalized industry level diversity with an index calculated from the number of products produced per industry, because we were working at the industry level. However, there is no need to normalize H4 or H5 when estimating industry production functions using establishment data, since the number of 4- and 5-digit ICC products classified to an industry is a constant for all establishments in the industry.

Valuation of Output

Shipments (and hence Y) may be valued in different ways across establishments within a given industry and also by comparison with the practices of the U.S. census. The variable designed to capture the way shipments are valued is defined as a series of dummy variables:

$$D1 = 1 \text{ where shipments are valued at cost, 0 otherwise;} \quad (3.8)$$

$$D2 = 1 \text{ where shipments are valued at book transfer value, 0 otherwise; and} \quad (3.9)$$

$$D3 = 1 \text{ where shipments are valued at other, 0 otherwise.} \quad (3.10)$$

The excluded category is valuation at "final selling price." As will be noted below, in those instances where the establishment failed to answer the valuation question on the census form, the valuation code for the plant is assigned to the "other" (i.e., D3 = 1) category.

Labour Measurement

One measure of labour input that could be used is the number of employees:

$$L_1 = NW + NS. \quad (3.11)$$

This measure has two problems. First, it assumes that all workers and salaried employees are equally productive per unit of input, and second, that all employees work equal hours. To correct for the second problem we use hours worked. However, hours worked is available only for NW. Hence, we define a second measure of labour input as follows:

$$L_2 = MHRSWR + VS \frac{MHRSWR}{VW} \quad (3.12)$$

which expresses labour input in production and related worker-hours-equivalent. In estimating the production functions, we decided to use L_2, but did some experimental runs with L_1, NW and NS as well. We also broke L_1 into its components to test whether significant differences emerge in the regression results.

Capital Measurement

Unfortunately, we do not have a measure of the stock of capital or the services from such capital at the level of the individual plant. Hence we make use of a number of proxies. The first proxies rely on capital expenditure. They are:

$$K_1 = RNCTOT + RNMETOT \quad (3.13)$$

$$K_2 = RRCTOT + RRMETOT \quad (3.14)$$

K_2 will be a good proxy to the extent that repairs and maintenance are proportionate to the available capital stock and proxy depreciation. This is more likely to be the case if all plants have the same vintage of capital equipment. K_1 will be a good proxy to the extent that investment is a constant proportion of existing capital stock. Once again, this assumption depends upon plants being the same age as well as plant growth rates being the same.

We also make use of proxies based on intermediate inputs — assuming that they are highly correlated with capital usage. These variables are:

$$K_3 = \text{FELEC} \tag{3.15}$$

$$K_4 = \text{TOTMAT} \tag{3.16}$$

K_3 and K_4 will be good proxies to the extent that these variables are highly correlated with the flow of capital services. While clearly an approximation, it may be no worse than having actual capital stock and having to make an assumption about the rate at which such stock is utilized — since at least input flows should be highly correlated with capital services and will vary with utilization rates.

Sample Selection Criteria

Census reporting units can be divided in at least three ways: head offices, sales offices and auxiliary units; short-form establishments; and long-form establishments.[11] The first category conduct little or no manufacturing or production activity and hence can be excluded. However, there are some manufacturing plants with a large proportion of non-manufacturing activities, and these too will be excluded. The short-form establishments are usually quite small and do not report inputs and outputs in as much detail as long-form establishments or, in some instances such as value added, use the same concept. Hence, it was decided to exclude short-form establishments. In the 1970s such establishments usually accounted for well under 5 percent of the manufacturing sector shipments: 2.0 percent in 1970[12] and 3.8 percent in 1979.[13] In contrast, short-form establishments accounted for 40.0 percent of all manufacturing sector establishments in 1970 and 56.1 percent in 1979.[14] In the discussion in the previous sections the concepts and definitions followed those used for the variables reported by long-form establishments. If economies of scale diminish with size, the use of the larger establishment sample should bias our estimates of scale economies downward.

Table 3-2 lists the suggested criteria for excluding establishments from the initial set of long-form establishments. Most of these are self explanatory. Establishments with output but no input (meeting criteria 2, 3, 6 to 9, but not 4) or vice versa are omitted. Smaller establishments are also excluded (criteria 1) because there may be problems with respect to income reporting due to the tax laws. The choice of a cut-off size to define small establishments is somewhat arbitrary; a labour force of 4 or less is chosen to provide comparability to the U.S. data used later. For a number of establishments the method of reporting valuation of output is

TABLE 3-2 Selection Criteria Used to Exclude Establishments[c]

Criteria no.	1	WINW $\leqslant$ 4
	2	MHRSWR $\leqslant$ 0
	3	VW $\leqslant$ 0
	4	Y $\leqslant$ 0
	5	TP[b] $\leqslant$ 0
	6	$K_3 \leqslant 0$
	7	$K_4 \leqslant 0$
	8[a]	$K_1 \leqslant 0$
	9[a]	$K_2 \leqslant 0$
	10	CST = Missing Value
	11	$WIH_4 \leqslant 0$

a. Applicable only to 1979.
b. TP = MVP/TVP
c. One additional criterion that was used on the initial sample of 17,591 long form establishments in 1979 and 19,565 in 1970 was to exclude records which had missing values. Such establishments would meet all of the criteria in the table. Hence 757 in 1979 and 771 in 1970 establishments are omitted from any further consideration.

TABLE 3-3 Distribution of Number of Establishments[c] for Selected Cut-Off Points for the Ratio of MVP to TVP for 1970 and 1979

	Year	
Category[a]	**1970**	**1979**
0.95–1.00	74.8	76.3
0.90–0.949	6.1	6.0
0.80–0.89	7.2	6.8
0.70–0.79	4.3	4.0
0.60–0.69	2.8	2.5
0.50–0.59	2.0	1.9
Other[b]	2.7	2.4

Source: Statistics Canada, special tabulations.
a. Ratio of MVP to TVP.
b. Includes establishments for 1979 which MVP/TVP marginally greater than 1.00 but less than 1.004 (16 of these); those between 0 and 0.49, amounting to 2.3 percent; and those for which TVP = 0 (31). For 1970, includes those between 0 and 0.49, amounting to 2.7 percent; one instance where MVP/TVP was less than zero; and two instances where TVP = 0.
c. Long-form establishments only.

not stated. This then becomes another possible criteria for exclusion — though not a terribly important one since this variable turns out later not to be significant in the production function estimates (criteria 10). A somewhat similar result obtained for those establishments for which product diversity data were unavailable (criteria 11). The cut-off value selected for the importance of manufacturing activity relative to total activity (TP = MVP/TVP, criteria 5) was chosen after some experimentation. The distribution of number of establishments is presented in Table 3-3 for selected cut-off points for TP. Based on these percentages,

TABLE 3-4 Number of Establishments[d] Left in Sample Upon Application of Exclusion Criteria, 1970

		Plants Remaining After Criteria Applied			
		Cumulatively		Separately	
Criteria[a]		Number	Percent	Number	Percent
—		18,794	1.000	18,794	1.000
NW	≤ 4	15,432	0.821	15,432	0.821
MHRSWR	≤ 0	15,432	0.821	17,944	0.955
VW	≤ 0	15,432	0.821	17,944	0.955
Y	≤ 0	15,414	0.812	18,763	0.998
TP	≤ 0.90[b]	12,394	0.659	15,195	0.809
K_3	≤ 0	11,596	0.617	17,077	0.909
K_4	≤ 0	11,583	0.616	18,753	0.998
K_1	≤ 0	n.a.	—	n.a.	—
K_2	≤ 0	n.a.	—	n.a.	—
CST	= MV[c]	7,953	0.423	11,734	0.624
H4	≤ 0	7,536	0.401	13,633	0.725

Source: Statistics Canada, special tabulations.
a. See text for definition.
b. TP = MVP/TVP. If TVP = 0, then this is classified as $\leq$ 0.90.
c. MV = missing value.
d. Long-form establishments only.
n.a. = not applicable.

a TP value of 0.90 or greater was selected as the cut-off. Using a lower criterion does not increase the number of observations substantially, but makes manufacturing activity numbers increasingly unreliable proxies for total activity and vice versa.

In Tables 3-4 and 3-5 the number of remaining establishments is presented when the 11 criteria in Table 3-2 are applied to the 1970 and 1979 data. For both tables each criterion is applied separately and cumulatively to the universe of long-form establishments extant in the year. For 1970 the criteria relating to K_1 and K_2 are not used since these two variables are only defined and available for 1979. Applying all 11 of the criteria for 1979 reduces the sample size quite drastically (Table 3-5), to only 33 percent of the population. The major omissions result from having to use capital expenditure variables. In 1970 the pattern is similar. Application of all the criteria causes the sample size to fall, but the major omissions arise where CST and H4 are required for estimation purposes.[15] Tables 3-4 and 3-5 tell us that sample size is quite sensitive to the criteria employed for selection of the sample to be used for estimation of the production function.

These findings raise the issue of whether the successive deletions bias the sample and whether the deletions are concentrated in particular industries. If some deletions bias the sample, it may be better to avoid the use of the variables that require these deletions. The appropriate

TABLE 3-5 Number of Establishments[d] Left in Sample Upon Application of Exclusion Criteria, 1979

Criteria[a]		Plants Remaining After Criteria Applied			
		Cumulatively		Separately	
		Number	Percent	Number	Percent
—		16,865	1.000	16,865	1.000
NW	≤ 4	15,101	0.895	15,101	0.895
MHRSWR	≤ 0	15,100	0.895	16,480	0.977
VW	≤ 0	15,100	0.895	16,481	0.977
Y	≤ 0	15,024	0.891	16,715	0.991
TP	≤ 0.90[b]	12,326	0.731	13,872	0.823
K_3	≤ 0	10,124	0.600	13,568	0.805
K_4	≤ 0	10,121	0.600	16,827	0.998
K_1	≤ 0	5,980	0.355	9,171	0.544
K_2	≤ 0	5,804	0.344	9,161	0.545
CST	= MV[c]	5,719	0.339	13,743	0.815
H4	≤ 0	5,537	0.328	13,012	0.772

Source: Statistics Canada, special tabulations.
a. See text for definition.
b. TP = MVP/TVP.
c. MV = missing value.
d. Long-form establishments only.

trade-off between quality and sample size must be examined in considering these issues.

In Tables 3-6 and 3-7, we examine the effect of successive deletions on plant size (number of employees) distribution of the sample. We do not display the impact of every criterion, but only those where Tables 3-4 and 3-5 suggest that significant numbers of establishments were eliminated. Criteria 1 to 4 are regarded as the minimum set to be used. They exclude small establishments and those for which there are no labour inputs or outputs. Criteria 5 to 7 exclude establishments with non-manufacturing activity of some importance and those that do not report intermediate inputs. Criteria 8 to 11 exclude observations where new or repair capital expenditure data, the method of reporting value, and the product diversity index are missing. The tables suggest that for both 1970 and 1979 the application of criteria 1 to 4 and/or 1 to 7 does not greatly affect the size distribution of plants. However, in 1979 (Table 3-7), when all 11 criteria are imposed, in contrast to just criteria 1 to 7, the size distribution becomes more concentrated in the larger groups, with L_1 = 51–100, 101–500 gaining at the expense of L_1 = 11–50, in particular. This is the result of the fact that the capital expenditure survey appears to sample only larger establishments. Hence, if capital expenditure data are required (criteria 8 and 9) we can expect to lose some of the smaller establishments in the upper portion of the LRAC curve. As a result our findings may be biased toward finding lower returns to scale.

TABLE 3-6 Impact of Successive Criteria Applied to Establishments[c] on the Plant Size Distribution, 1970

Number of Employees (L_1)[a]	Distribution of Number of Establishments[b]					
	Criteria 1–4		Criteria 1–7		Criteria 1–7, 10–11	
5	0.9	(4.7)	0.7	(4.3)	0.5	(3.3)
6	1.5	(4.7)	1.3	(4.3)	1.0	(3.5)
7	2.3	(4.2)	2.2	(3.9)	1.5	(3.3)
8	2.8	(3.6)	2.6	(3.3)	2.2	(2.6)
9	2.8	(3.5)	2.7	(3.4)	2.1	(2.9)
10	2.4	(3.8)	2.5	(3.5)	1.9	(3.2)
11–50	52.2	(47.6)	52.5	(47.9)	48.9	(46.1)
51–100	15.7	(13.3)	15.7	(14.0)	17.6	(15.8)
101–500	16.7	(13.1)	17.0	(13.8)	20.8	(17.1)
501–1000	1.7	(1.0)	1.8	(1.1)	2.4	(1.5)
1001–2000	0.6	(0.4)	0.6	(0.4)	0.8	(0.6)
2000+	0.2	(0.1)	0.3	(0.1)	0.3	(0.2)

Source: Statistics Canada, special tabulation.
a. L_1 is defined in the text. (L_1 = NW + NS).
b. The figures in parentheses refer to the size distribution if NW is used instead of L_1.
c. Long-form establishments only.

TABLE 3-7 Impact of Successive Criteria Applied to Establishments[c] on the Plant Size Distribution, 1979

Number of Employees (L_1)[a]	Plant Size Distribution[b]					
	Criteria 1–4		Criteria 1–7		Criteria 1–11	
5	1.1	(2.7)	0.2	(1.8)	0.1	(0.6)
6	1.3	(2.8)	0.3	(2.0)	0.2	(0.7)
7	1.8	(3.1)	0.9	(2.3)	0.2	(0.8)
8	1.7	(3.2)	1.0	(2.6)	0.3	(1.1)
9	2.0	(3.1)	1.5	(2.5)	0.4	(1.0)
10	2.2	(3.4)	1.9	(2.8)	0.6	(1.4)
11–50	50.8	(49.7)	50.0	(48.7)	34.6	(39.5)
51–100	17.0	(14.9)	18.8	(17.0)	23.6	(22.4)
101–500	19.0	(15.0)	21.9	(18.0)	34.2	(28.4)
501–1000	2.0	(1.3)	2.3	(1.6)	4.0	(2.7)
1001–2000	0.7	(0.5)	0.8	(0.6)	1.5	(1.0)
2000+	0.3	(0.1)	0.3	(0.2)	0.5	(0.3)

Source: Statistics Canada, special tabulation.
a. L_1 is defined in the text. (L_1 = NW + NS).
b. The figures in parentheses refer to the size distribution if NW is used instead of L_1.
c. Long-form establishments only.

Table 3-6 reveals a somewhat similar pattern for 1970 when criteria 1 to 7, 10 and 11 are all applied, but the increase in the importance of larger groups is not as significant.

We also examine the *proportion* of individual industry total establishments that remain after the application of the various criteria and the

TABLE 3-8 **Impact of Selection Criteria on Industry Coverage[a]: Percentage of Establishments[c] Deleted Using Various Criteria, 1970–1979**

Proportion of Establishments Left in the Industry after Application of Various Criteria	Number of Industries per Category					
	Criteria 1–4		Criteria 1–7		Criteria 1–11[b]	
	1970	1979	1970	1979	1970	1979
0.90–1.00	97	127	12	12	0	2
0.80–0.89	42	25	31	14	4	4
0.70–0.79	14	7	35	30	8	6
0.60–0.69	5	3	33	43	23	13
0.50–0.59	6	2	31	30	38	32
0.40–0.49	1	2	12	15	41	19
0.30–0.39	0	0	5	11	24	36
0.20–0.29	0	0	6	5	16	24
0.10–0.19	1	0	1	3	4	18
0.01–0.09	0	0	0	0	7	6
0.00	1	1	1	4	2	7

Source: Statistics Canada, special tabulations.
Note: See Table 3-2 for a list of the criteria.
a. Applied to all 167 4-digit manufacturing industries.
b. For 1970, criteria 8 and 9 were not used.
c. Long-form establishments only.

corresponding number of establishments. These data are presented in Tables 3-8 and 3-9, respectively. Table 3-8 shows that for both 1970 and 1979, application of criteria 1 to 4 sees a very small decrease in sample coverage; all but three of the 167 4-digit manufacturing industries retain at least 50 percent of sample size. The application of criteria 1 to 7 causes a further drop in sample coverage; well over 100 industries in both 1970 and 1979 retain at least 50 percent of sample size. It is with the application of criteria 1 to 7, 10 and 11 in 1970 or 1 to 11 in 1979, however, that a very appreciable drop in sample size is recorded. In 1970 only 73 or 43.7 percent of the 167 industries retain at least 50 percent of sample size, while for 1979 the corresponding numbers are 57, or 34.1 percent. Hence the decline in coverage is fairly widespread among industries if all the relevant criteria are applied.

The problem of declining coverage may not be that much of a concern if industries contain large numbers of establishments and sampling is random. There will be less of a problem if the number of establishments remaining after the application of the relevant set of criteria is sufficiently large to be able to estimate production functions. Table 3-9 shows how the distribution of the number of establishments per industry is affected by the application of various criteria. As more stringent criteria are applied, the number of observations declines. If we select an arbitrary cut-off of 20 or more observations per industry, then using 1979

TABLE 3-9 Impact of Selection Criteria on Industry Coverage[a]: Number of Establishments[c] Per Industry after Application of Various Criteria, 1970–1979

Number of Establishments Left in the Industry After Application of Various Criteria	Number of Industries per Category					
	Criteria 1–4		Criteria 1–7		Criteria 1–11[b]	
	1970	1979	1970	1979	1970	1979
0	1	1	1	4	2	7
1–4	0	0	2	4	9	11
5–9	4	5	22	20	27	28
10–19	28	28	21	30	34	47
20–29	27	25	28	28	25	17
30–39	11	21	17	13	15	15
40–49	18	10	13	12	12	15
50–74	19	20	16	18	15	8
75–99	16	13	15	10	10	6
100–149	15	13	12	10	7	8
150–199	6	11	7	7	5	3
200–299	12	10	6	6	4	1
300+	10	10	7	5	2	1

Source: Statistics Canada, special tabulations.
Note: See Table 3-2 for a list of the criteria.
a. Applied to all 167 4-digit manufacturing industries.
b. For 1970, criteria 8 and 9 were not used.
c. Long-form establishments only.

as an example, application of criteria 1 to 4 sees the sample decline by 20.4 percent; criteria 1 to 7, 34.7 percent; and finally, criteria 1 to 11, 55.7 percent. The magnitude of the decline is somewhat less for 1970. It is not so much the miscellaneous industries which have 19 establishments or less remaining after all 11 criteria are applied, but relatively well defined industries such as Fur Goods Industry (149 establishments to 16), and Manufacturers of Soap and Cleaning Compounds (64 to 14) that are removed from our sample if all criteria are applied.

In conclusion, there is a significant trade-off between the number of observations and the implementation of all of our criteria. Application of all of relevant criteria leaves us with 40.1 percent of the original sample for 1970 (Table 3-4) and 32.8 percent in 1979 (Table 3-5). While this range encompasses the Griliches and Ringstad (1971, p. 34) figure of "37.7 per cent of the establishments in the industry group selected," it nevertheless leaves in many industries a sample size which is too small to estimate meaningful production functions.

The final decision as to which criteria should be used need not be made before estimation. For instance, should a variable like H4 or CST not turn out to be significant, there is little reason to restrict the estimation to the reduced sample required for these variables (criteria 10 and 11). We found that the use of K_1 or K_2 as proxies for capital yielded scale estimates similar to those provided by the use of K_3 or K_4. As a result, criteria 8 and 9 did not have to be imposed. We also found that our diversity measure and the valuation variable (CST) did not affect our scale estimates and therefore these variables and the associated criteria could be avoided. As a result, the decision was made to use only criteria 1 to 7 except when H4 was in the regression equation, when criteria 1 to 11 were used. Full results together with explanations may be found in Appendix B.

Summary and Conclusion

This chapter has carefully specified the arguments to be used in estimating individual industry production functions on a cross-section basis at the establishment level. Output is measured using value added, the primary inputs (labour and capital), total manhours, and fuel and electricity, respectively. The use of fuel and electricity reflects the fact that good data on capital at the establishment level are presently unavailable. Two other possible arguments to the production functon were also defined, one on economic grounds — product diversity, and one on measurement grounds, to take into account differing methods of the valuation of shipments across establishments. Finally, sets of criteria were selected to maximize the number of establishments to be used for estimation purposes while at the same time excluding establishments which, for one reason or another, were deemed unusable — output with no input, substantial non-manufacturing activities, etc. We are now in a position to select the appropriate production function and to estimate scale economies in Canadian manufacturing industries in the 1970s.

Chapter 4

Returns to Scale, Product Diversity and Output Valuation Procedures

Since Canadian plants are on average smaller than U.S. plants, differences in Canada/U.S. productivity may be the result of a failure to exploit plant scale economies. Whether this is the case depends on the degree of these economies. This chapter presents evidence concerning the degree of returns to scale in Canadian manufacturing industries. In doing so, we assess the significance of returns to scale, ask whether the degree of returns to scale varies between 1970 and 1979, and highlight the industries where scale returns are highest and lowest (the fourth and fifth sections of this chapter). However, a necessary prior step is the specification and discussion of the choice of production function and estimation techniques (the second and third sections). The impact of plant heterogeneity on output is analysed in the sixth section. The effect of valuation techniques is examined in the seventh section. The chapter concludes with a brief summary.

Choice of Production Function

A wide range of production functions is available to the researcher interested in estimating the extent of economies of scale. They range from the simple Cobb-Douglas (CD) to less restrictive forms such as the constant elasticity of substitution (CES) and the variable elasticity of scale (VES), to the generalized translog (GT).

The Cobb-Douglas, while the simplest, imposes restrictions of unitary elasticity of substitution between factors, homotheticity, and a constant scale elasticity. The more general translog allows for considerably more flexibility in that the elasticity of substitution and the returns to scale can vary across the input/output space. As such, it has become more prevalent in recent statistical applications.

While the translog allows more flexibility than the Cobb-Douglas, it is accomplished at a cost. The Cobb-Douglas can be written as:

$$\log Q_t = a_0 + a_1 \log L_t + a_2 \log K_t. \tag{4.1}$$

The translog can be expressed as:

$$\log Q_t = b_0 + b_1 \log L_t + b_2(\log L_t)^2 + b_3 \log K_t + b_4(\log K_t)^2 + b_5 (\log L_t \cdot \log K_t). \tag{4.2}$$

As is evident, the translog requires estimation of considerably more parameters, with the inclusion of extra variables $[(\log L)^2, (\log K)^2, (\log L \cdot \log K)]$ that tend to be highly collinear with the variables used in the Cobb-Douglas. The result may therefore be considerably less precise in the estimates due to multicollinearity.

Previous researchers have chosen to test whether the translog can be said to provide significant improvements over the Cobb-Douglas. Many researchers, using time series data at an aggregated level, have rejected some of the assumptions of the Cobb-Douglas in favour of the translog (e.g., Rao and Preston, 1983). However, there are a number of cross-sectional studies (Griliches and Ringstad, 1971, Layard et al., 1971, Corbo and Meller, 1979) that have not been able to reject the Cobb-Douglas when tested against the most general form.

Many of these tests are complex because the authors have chosen a more difficult task than ours. They have attempted to choose the production function that is best for a large number of purposes — and therefore necessarily ask whether any or all assumptions embedded in a particular form can be rejected upon relaxation of those assumptions in a more general form. In this study, we are interested primarily in an estimate of the scale elasticity. Thus the question we posed was simpler. Did the choice of the more flexible translog form as opposed to the Cobb-Douglas affect the estimated scale elasticity?

Experimentation with the translog indicated extreme instability in the parameter estimates between 1970 and 1979, thereby confirming the lack of robustness of this formulation (see Appendix C for details). On the other hand, the Cobb-Douglas individual parameters were much more stable. However, we tested to see whether the extra variables included in translog as opposed to the Cobb-Douglas were jointly significant, and concluded that in a majority of our 167 industries they were. Use of intermediate variants that allowed for some but not as much flexibility, such as the CES, did not suggest that any gain could be made by adopting such an approach — at least using this same criterion.

Since the translog did therefore appear to be yielding additional information, we asked whether the additional information lay in very different estimates of the scale elasticity variable. We were interested in knowing whether allowing for greater flexibility would produce a very different scale elasticity estimate from that which we derived from a Cobb-Douglas. At the geometric mean we found that the translog estimates of scale elasticity were very similar to those derived from the Cobb-Douglas.[1] Appendix C outlines the tests. In the end we concluded that there was little to be gained from using the translog when it comes to estimating scale elasticity, and so we settled for the Cobb-Douglas.

Estimation Techniques

With the form of the production function chosen, a decision on the choice of estimation technique was required. The production function can be estimated either directly or indirectly. Direct estimation uses the production function by itself. Indirect estimates are obtained when one, several, or all the first order side conditions for factor use (equating marginal revenue product derived from the assumed production function to the factor marginal cost) are imposed. In addition, these side conditions can be substituted into the production function to yield a supply function which has output as a function of factor prices. Still further substitutions can be made to yield a profit or cost function with factor prices or some residual inputs as explanatory variables. These alternate methods are summarized in Fuss et al. (1978).

The indirect approaches have two advantages. First, they generally reduce the problem of multicollinearity. Second, they are claimed to reduce the problem of simultaneity if the production function is estimated directly. The direct estimation of the production function has long been recognized to suffer from simultaneity bias, since the error term is likely correlated with factor input decisions (Nerlove, 1965). Use of the side order conditions can reduce this problem, since in this case the estimation equation reduces to one with factor prices as explanatory variables. Since the latter are less likely to be correlated with the residual error in the indirect formulation being used, especially at the level of disaggregation being used here, bias in the estimated coefficients may be reduced.

However, there are costs associated with the use of the indirect approach. First, data may be more readily available on inputs than on factor prices. In this respect, data on the cost of capital at the plant level are generally not available, while a proxy for capital services (fuel and electricity) is available. However, this problem is potentially surmountable if a hybrid indirect approach such as that used by Lau and Yotopoulos (1971) is adopted. Second, the use of the side conditions may introduce an unknown specification error if the profit maximization or cost minimization assumptions upon which they are based are incorrect. Once again, this can be incorporated into the analysis, as is done in the frontier production function estimates used by Schmidt and Lovell (1979) — but only at the cost of considerable computational complexity.

Third, the advantage of the indirect techniques can be substantially reduced if there are errors in measurement of the variables (Fuss et al., 1978). In our case, the dependent variable, value added, is measured subject to error, because non-materials inputs like advertising, travel, and telephone are not excluded from value added. As long as the production function is estimated directly, these errors are subsumed directly into the error of the equation. Measurement error in the dependent variable does not lead to bias, except in the intercept. But the indirect approach to production function estimation often transforms the estimating relationship so that the error in measurement occurs in one of the explanatory variables. The estimates of input elasticities are based generally on the shares of value added going to the various factors. These shares are badly biased. In the case of labour, census wages underestimate the total remuneration package and value added is overestimated because it does not exclude non-materials inputs. Therefore the share of labour is measured with a large downward bias. Thus the indirect approach essentially replaces simultaneity bias with an error-in-variables bias — a bias which we believe is more important than the simultaneity problem. Appendix C investigates the magnitude of the measurement error in greater detail.

After consideration of these various problems, a recent survey of econometric estimation problems concluded that the direct estimation of the production function using ordinary least squares or an instrumental variable technique was preferable (Fuss, et al. 1978, pp. 262–65). It was this approach that we adopted after some experimentation reported in Appendix C. The criteria that we adopted during these experiments were that the resulting scale elasticities should be reasonable a priori and that they be stable, though not identical, between 1970 and 1979. In the end we used ordinary least squares with the Durbin (1954) ranking variable (on the basis of size) as an instrument for the estimation of the capital coefficient, since capital was proxied with fuel and electricity usage (see Maddala, 1977, p. 304).

For simplicity of presentation we usually do not estimate

$$\log Y = k + a \log L_2 + b \log \ddot{K}_3 \tag{4.3}$$

where Y, L_2 and K_3 are output, labour, and a capital proxy as defined in Chapter Three and $\log \ddot{K}_3$ is estimated using the predicted values from the equation

$$\log \ddot{K}_3 = h + c \text{ UNCRK} \tag{4.4}$$

where UNCRK is the rank of the unconsolidated firm owning the ith establishment. Rather we estimate the equivalent to equation 4.3:

$$\log (Y/L_2) = k + b \log (\ddot{K}_3/L_2) + z \log L_2 \tag{4.5}$$

where $z = a + b - 1$. The manufacturing industry then has decreasing, constant, or increasing returns to scale as z is less than, equal to, or greater than 0, respectively.

Returns to Scale: An Overview

We first examine returns to scale at a fairly aggregate level — the 2-digit or major group level of the manufacturing sector — before proceeding to the level of the individual 4-digit industries. These results are obtained by pooling all observations within a 2-digit industry category. This procedure provides us with an overview of returns to scale and permits us to analyze whether the results are sensitive to the level of aggregation.

Table 4-1 provides estimates of a and b from equation 4.3 and z from equation 4.5, which is referred to as RTS in the table, for each of the 20 major groups, together with the number of observations used to estimate both equations 4.3 and 4.5. The final entry in the table provides estimates for the production function when all establishments in the manufacturing sector are pooled together.

Table 4-1 shows that across the manufacturing sector as a whole, in both 1970 and 1979, Canadian industry experienced increasing returns to scale. Furthermore, the incidence of returns to scale is quite similar in 1970 and 1979 (RTS = 1.155 and 1.153, respectively). The elasticities of output with respect to labour are always greater than for capital. These results for 1970 are quite similar to the Norwegian estimates of Griliches and Ringstad (1971, Table 4-1, p. 63) for 1963. They find significant increasing returns to scale (1.064), also with labour having the larger elasticity. Our estimated capital elasticity for the manufacturing sector as a whole was 0.133 in 1970, while theirs is 0.199. Our labour coefficient is somewhat larger than the wage share reported in the census,[2] and vice versa for capital. But we note, as Griliches and Ringstad did (p. 97), that this does not necessarily imply that our economies of scale estimate is biased in any particular direction.

In terms of the individual 2-digit or major group estimates of returns to scale we find some variability, but overall they are in accord with those reported for the manufacturing sector as a whole. In both 1970 and 1979, sixteen industry groups exhibit significant increasing RTS, four are not significantly different from zero and therefore can be said to have constant returns to scale. None exhibits decreasing returns to scale. The sixteen industries with increasing returns to scale accounted for 90.4 percent in 1970 and 94.0 percent in 1979 of manufacturing sector value added. Six of the twenty industry groups (#15, #17, #23, #31, #36, #39) changed the category to which they were classified between 1970 and 1979. Furthermore, the estimates of the degree of RTS between 1970 and 1979 are reasonably stable for most of the industry groups, although there are several prominent exceptions, such as Tobacco Products and Petroleum and Coal Products. Later when analyzing 4-digit

TABLE 4-1 Returns to Scale in Canadian Manufacturing Industries at the Industry Group Level, 1970–1979

Major Group Title	L_2	$\ddot{K}_3$	R^2	F-Ratio	N	RTS
	(regression coefficients and t-values[a])					
Food & Beverages (10)						
1970	0.987	0.290	0.8286[b]	3,847.67	1,595	0.277
	(61.53)[b]	(11.79)[b]				(14.21)[b]
1979	0.826	0.443	0.7680[b]	2,146.71	1,300	0.269
	(44.33)[b]	(16.22)[b]				(11.61)[b]
Tobacco Products (15)						
1970	1.362	−0.186	0.8407[b]	50.15	22	0.176
	(7.89)[b]	(−0.77)				(0.99)
1979	1.275	0.172	0.9229[b]	83.74	17	0.447
	(6.23)[b]	(0.87)				(3.95)[b]
Rubber & Plastics (16)						
1970	0.888	0.273	0.8864[b]	1,081.31	280	0.161
	(24.44)[b]	(7.33)[b]				(6.28)[b]
1979	0.774	0.327	0.8317[b]	823.09	336	0.101
	(24.50)[b]	(8.74)[b]				(3.44)[b]
Leather (17)						
1970	0.946	0.152	0.9366[b]	1,773.78	243	0.098
	(44.07)[b]	(6.00)[b]				(4.61)[b]
1979	0.911	0.185	0.7258[b]	219.65	169	0.096
	(17.56)[b]	(2.76)[b]				(1.48)
Textiles (18)						
1970	1.016	0.113	0.9193[b]	2,613.60	462	0.129
	(53.70)[b]	(5.32)[b]				(7.26)[b]
1979	0.998	0.099	0.8299[b]	841.45	348	0.098
	(32.76)[b]	(3.09)[b]				(3.25)[b]
Knitting Mills (23)						
1970	0.755	0.291	0.8619[b]	689.60	224	0.045
	(21.87)[b]	(7.54)[b]				(1.52)
1979	0.834	0.227	0.8783[b]	602.76	170	0.061
	(21.56)[b]	(6.23)[b]				(1.98)[c]
Clothing (24)						
1970	0.955	0.077	0.8520[b]	3,663.36	1,276	0.033
	(76.91)[b]	(2.64)[b]				(1.23)
1979	0.827	0.212	0.7583[b]	1,518.64	971	0.039
	(46.60)[b]	(6.37)[b]				(1.29)
Wood (25)						
1970	0.982	0.286	0.8569[b]	3,312.76	1,109	0.268
	(63.74)[b]	(7.89)[b]				(8.73)[b]
1979	1.085	0.171	0.8703[b]	3,664.28	1,095	0.256
	(64.14)[b]	(6.89)[b]				(12.84)[b]
Furniture & Fixtures (26)						
1970	0.945	0.191	0.9230[b]	3,715.88	623	0.136
	(60.40)[b]	(7.48)[b]				(6.99)[b]
1979	0.821	0.329	0.8109[b]	999.03	469	0.150
	(29.33)[b]	(7.82)[b]				(4.58)[b]

TABLE 4-1 (cont'd)

Major Group Title	L_2	$\ddot{K}_3$	R^2	F-Ratio	N	RTS
	(regression coefficients and t-values[a])					
Paper & Allied Products (27)						
1970	1.136 (54.64)[b]	0.082 (3.39)[b]	0.9239[b]	2,392.39	397	0.218 (10.42)[b]
1979	1.188 (43.86)[b]	0.344 (0.91)	0.8715[b]	1,369.38	407	0.222 (6.77)[b]
Printing & Publishing (28)						
1970	0.995 (72.22)[b]	0.184 (9.72)[b]	0.9277[b]	6,343.29	991	0.179 (13.41)[b]
1979	0.958 (58.54)[b]	0.267 (11.54)[b]	0.8912[b]	3,690.20	904	0.224 (12.49)[b]
Primary Metals (29)						
1970	0.995 (40.01)[b]	0.182 (6.28)[b]	0.9302[b]	1,539.30	234	0.177 (7.35)[b]
1979	0.893 (23.50)[b]	0.235 (5.17)[b]	0.8443[b]	558.53	209	0.128 (3.36)[b]
Metal Fabricating (30)						
1970	0.963 (71.31)[b]	0.176 (9.88)[b]	0.8880[b]	5,550.45	1,403	0.139 (10.43)[b]
1979	0.886 (53.88)[b]	0.250 (12.38)[b]	0.8394[b]	3,335.50	1,279	0.135 (8.55)[b]
Machinery (31)						
1970	1.026 (42.20)[b]	0.023 (0.61)	0.8967[b]	1,419.87	330	0.048 (1.61)
1979	0.976 (37.55)[b]	0.096 (2.25)[b]	0.8560[b]	1,195.05	405	0.072 (2.13)[b]
Transportation Equipment (32)						
1970	1.033 (61.55)[b]	0.093 (3.69)[b]	0.9393[b]	3,180.39	414	0.127 (6.23)[b]
1979	1.025 (53.68)[b]	0.099 (2.66)[b]	0.9058[b]	2,009.32	421	0.124 (3.85)[b]
Electrical Products (33)						
1970	0.889 (35.47)[b]	0.238 (7.71)[b]	0.8921[b]	1,372.88	335	0.127 (5.15)[b]
1979	0.928 (32.06)[b]	0.203 (5.33)[b]	0.8372[b]	774.17	304	0.131 (3.68)[b]
Non-Metallic Mineral Products (35)						
1970	1.038 (41.68)[b]	0.235 (5.32)[b]	0.8308[b]	1,362.09	558	0.273 (7.21)[b]
1979	0.965 (40.79)[b]	0.335 (7.51)[b]	0.8298[b]	1,264.93	522	0.300 (7.54)[b]

TABLE 4-1 (cont'd)

Major Group Title	L_2	$\ddot{K}_3$	R^2	F-Ratio	N	RTS
	(regression coefficients and t-values[a])					
Petroleum & Coal Products (36)						
1970	1.168	0.223	0.8851[b]	200.32	55	0.391
	(17.40)[b]	(1.48)				(2.86)[b]
1979	1.182	−0.076	0.8404[b]	128.97	52	0.105
	(15.59)[b]	(−0.49)				(0.69)
Chemicals & Chemical Products (37)						
1970	0.871	0.368	0.7966[b]	728.25	375	0.240
	(29.13)[b]	(9.88)[b]				(6.56)[b]
1979	0.799	0.447	0.6865[b]	379.93	350	0.246
	(22.22)[b]	(8.26)[b]				(4.52)[b]
Miscellaneous Manufacturing (39)						
1970	0.923	0.159	0.8781[b]	2,355.53	657	0.083
	(49.00)[b]	(4.93)[b]				(3.34)[b]
1979	0.920	0.122	0.8189[b]	881.82	393	0.042
	(30.05)[b]	(2.91)[b]				(1.31)
All Manufacturing Plants						
1970	1.021	0.133	0.8556[b]	34,316.96	11,583	0.155
	(218.64)[b]	(17.65)[b]				(23.31)[b]
1979	0.973	0.181	0.8015[b]	20,428.64	10,121	0.153
	(167.80)[b]	(21.03)[b]				(19.66)[b]

Source: Statistics Canada, special tabulations.

Note: The coefficients on L_2 and $\ddot{K}_3$ are derived from the equation (4.3). RTS is the coefficient on log L_2 in equation (4.5) and N is the number of observations used to estimate the regression equations. See text for further details.

a. t-values in parentheses; R^2 tested by F test; all t-tests are two-tailed.
b. Significant at 0.01 level.
c. Significant at 0.05 level.
d. Significant at 0.10 level.

industries, we test to see whether the degree of returns to scale changed significantly over the 1970s. In general they did not.

Of the industries experiencing constant returns to scale, half are in industry groups which might be characterized as areas where Canada is thought to be at a comparative disadvantage — Knitting Mills, Clothing and Leather. However, at least one industry group where Canada is not thought to do well, Textiles, exhibits increasing returns in both 1970 and 1979. In terms of those industries where Canada is thought to do well — Wood, Paper and Allied Industries, Transportation Equipment and Primary Metals — increasing returns to scale are experienced in both years, being particularly strong in Wood and in Paper and Allied Industries.[3]

One way to evaluate the reasonableness of these cross-section results is to compare them to the results of others. For Canada, Zohar (1982) has estimated economies of scale for the same two-digit major industry categories summarized in Table 4-1. His estimates differ in that he uses time series data for 1946–1977 rather than cross-sectional observations. His dependant variable is total activity value added and his explanatory variables are total manhours and net capital stock.

Time series estimates of economies of scale generally suffer from having to disentangle two highly collinear relationships — the effect of scale economies and the effect of productivity changes on the amount of output. Productivity increases are usually estimated from the coefficient attached to a time trend variable. When inputs and the time trend are highly correlated, as they tend to be in time series, it is difficult to separate their effects. Zohar reports two scale estimates — one without any allowance for smoothly changing productivity estimated via a time trend, and one with a time trend to allow for productivity improvements. The former probably overestimates the scale effect. The latter may more closely approximate the scale effect, though in cases where inputs are collinear with time, some of the productivity effects may still be embodied in the estimates of scale elasticity.

Table 4-2 compares the two Zohar time series scale elasticities with our cross-sectional estimates for 1970 and 1979. Generally, Zohar's two time series scale estimates either bracket or have one end of their range quite close to our cross-sectional scale estimates (13 of the 19 industries for which estimates are available). Three industries (Primary Metals, Metal Fabricating, and Transportation Equipment) have much higher time series scale elasticities. However, Zohar's time series estimate of productivity for the first two are negative, possibly indicating substantial collinearity problems. Zohar also estimates a version of the translog in a form that reduces the collinearity of the input terms and the time trend — the non-linear approximation to the CES. These results are reported in Table 4-3. Generally, economies of scale coefficients for this formulation, when productivity is accounted for by the time trend, are smaller than the Cobb-Douglas. And in the case of Primary Metals, Metal Fabrication and Transportation Equipment, these time series scale estimates bracket our cross-sectional ones.

Finally, in three industries (Leather, Knitting Mills, and Petroleum and Coal Products), Zohar's Cobb-Douglas time series estimates are both lower than our cross-sectional scale estimates. In the case of Petroleum, Zohar's Cobb-Douglas time series estimates are unreasonably low, but when re-estimated with the translog, bracket our cross-sectional estimates. Knitting Mills also moves to bracket our estimates when a translog approximation is used, but not when a Cobb-Douglas is used. However, both Zohar's estimates for Leather are below our estimates.[4]

The dangers of aggregation are clearly demonstrated by Zohar's total manufacturing sector scale estimates. These generally exceed his individual industry scale estimates and are very high.

TABLE 4-2 Comparison of Cross-Section and Time Series Estimates of Returns to Scale Derived from the Cobb-Douglas Production Function in Canadian Manufacturing Industries at the Industry Group Level

	Time Series[a]		Cross Section	
Major Group Title	No Productivity Term	With Productivity Term	1970	1979
Food & Beverages (10)	1.53	0.83	1.28	1.27
Tobacco Products (15)	1.98	0.90	1.18	1.45
Rubber & Plastics (16)	1.13	0.76	1.16	1.10
Leather (17)	1.04	1.00	1.10	1.10
Textiles (18)	0.88	1.16	1.13	1.10
Knitting Mills (23)	0.91	0.88	1.05	1.06
Clothing (24)	1.04	0.96	1.03	1.04
Wood (25)	1.30	1.25	1.27	1.26
Furniture & Fixtures (26)	1.40	1.17	1.14	1.15
Paper & Allied Products (27)	1.21	0.89	1.22	1.22
Printing & Publishing (28)	1.63	0.73	1.18	1.22
Primary Metals (29)	1.38	1.52[b]	1.18	1.13
Metal Fabricating (30)	1.62	1.70[b]	1.14	1.14
Machinery (31)	0.99	1.06	1.05	1.07
Transportation Equipment (32)	1.61	1.56	1.13	1.12
Electrical Products (33)	1.70	0.79	1.28	1.13
Non-Metallic Mineral Products (35)	1.39	0.81	1.27	1.30
Petroleum & Coal Products (36)	0.25	0.27	1.39	1.11
Chemical & Chemical Products (37)	1.45	0.18	1.24	1.25
Miscellaneous Manufacturing (39)	n.a.	n.a.	1.08	1.04
Total Manufacturing	1.75	1.67	1.16	1.15

Source: Zohar (1982, Volume 1, Appendix D, pp. 134–35) and Table 4-1.
Note: Table 3-3 of Zohar (1982, Volume 1, p. 48) contains a number of transcription errors from Appendix D. Hence the latter source is used here.
a. Over the period 1946–77, with some exceptions.
b. Zohar estimates negative productivity for these industries.

TABLE 4-3 Comparison of Time Series[a] Returns to Scale Estimated by Cobb-Douglas and Translog Production Function in Canadian Manufacturing Industries at the Industry Group Level

	Production Function			
	Cobb-Douglas		Translog	
Major Group Title	No Productivity Term	With Productivity Term	No Productivity Term	With Productivity Term
Food & Beverages (10)	1.53	0.83	1.41	0.56
Tobacco Products (15)	1.98	0.90	0.74	1.07
Rubber & Plastics (16)	1.13	0.76	1.06	0.32
Leather (17)	1.04	1.00	0.79	0.59
Textiles (18)	0.88	1.16	−0.36	−0.76
Knitting Mills (23)	0.91	0.88	1.14	0.82
Clothing (24)	1.04	0.96	1.33	1.24
Wood (25)	1.30	1.25	0.65	0.58
Furniture & Fixtures (26)	1.40	1.17	1.45	0.73
Paper & Allied Products (27)	1.21	0.89	1.50	1.18
Printing & Publishing (28)	1.63	0.73	1.34	−0.03
Primary Metals (29)	1.38	1.52	1.59	−0.82
Metal Fabricating (30)	1.62	1.70	1.73	1.13
Machinery (31)	0.99	1.06	1.46	0.63
Transportation Equipment (32)	1.61	1.56	1.92	0.91
Electrical Products (33)	1.70	0.79	1.60	0.62
Non-Metallic Mineral Products (35)	1.39	0.81	1.66	0.90
Petroleum & Coal Products (36)	0.25	0.27	1.94	0.48
Chemical & Chemical Products (37)	1.45	0.18	1.45	0.16
Miscellaneous Manufacturing (39)	n.a.	n.a.	n.a.	n.a.
Total Manufacturing	1.75	1.67	1.87	1.17

Source: Zohar (1982, Volume 1, Appendix D, Table D-1, pp. 134–35 and Table D-4, pp. 140–42).
Note: Table 3-3 of Zohar (1982, Volume 1, p. 48) contains a number of transcription errors from Appendix D. Hence the latter source is used here.
a. Over the period 1946–77, with some exceptions.

A second source of time series estimates is provided by Daly and Rao (1984), who used data from 1958 to 1979 and a translog cost function as opposed to a production function to estimate scale elasticity at what was essentially the 2-digit level. They also provide two such estimates — one from a regression with a time trend and a derived expression meant to incorporate all productivity growth in the scale term. Their estimates along with our own are presented in Table 4-4. As with the previous comparison, our cross-sectional estimates generally fall in the range provided by the two time series estimates and there are fewer aberrations than with Zohar's work.

On the whole then, our cross-sectional results can be said to be compatible with those previously estimated from time series data. Compatibility is all that is being claimed and generally all that is desired, for the two estimates should not be expected to be the same. The estimates derived from a cross-section are those that pertain to the micro-production function. The time series estimates are those that are relevant to the macro-production function — the production function written in terms of the sum of the individual establishment variables (outputs, labour, and capital). Sato (1975) has shown that in general the macro-function does not correspond to the micro-function. Thus we should not expect the time series estimates to correspond to our micro-estimates. The macro-estimates will depend not only on the true micro-production function but also on the distribution of plant sizes and on the changing nature of that distribution over time.

Our cross-section estimates are therefore conceptually superior to those derived from time series data. In addition, they do not suffer from collinearity problems arising from having to separate productivity changes from scale effects. There are, of course, other potential conceptual problems with cross-sectional estimates. In particular, it is sometimes argued that in a competitive industry, plants with a cost disadvantage due to scale should not be expected to survive. As such, it could be argued that the plant size distribution will generally be truncated above the minimum efficient sized (MES) plant. If so, then cross-sectional scale estimates will not reflect the true scale economies that exist only in below-MES plants, because such plants will not be observed. However, the empirical evidence does not suggest that this is a problem. Sub-optimal capacity has been found to exist across a wide range of Canadian industries (Gorecki, 1976a; Dickson, 1979; and Gupta, 1979).

There is still, of course, the argument that the scale elasticity estimated from a cross-section may pick up more than scale effects. Because of the nature of the data, it may reflect different prices charged by different plants for the same products,[5] or may reflect a different mix of products produced by large as opposed to small plants. Neither problem, however, should cause problems with our use of the estimated

TABLE 4-4 Comparison of Return to Scale Estimates from Translog Cost Function Estimated from Time Series 1958–79 to those Derived from Cobb-Douglas Production Function in Canadian Manufacturing Industries at the Industry Group Level, 1970 and 1979

	Time Series		Cross Section	
Major Group Title	No Productivity Term	With Productivity Term	1970	1979
Food & Beverages (10)	1.08	1.61	1.28	1.27
Tobacco Products (15)	1.29	1.38	1.18	1.45
Rubber & Plastics (16)	1.15	0.94	1.16	1.10
Leather (17)	1.87	0.80	1.10	1.10
Textiles (18)	1.40	1.04	1.13	1.10
Knitting Mills[a] (23)	1.42	1.19	1.05	1.06
Clothing (24)			1.03	1.04
Wood (25)	1.15	0.66	1.27	1.26
Furniture & Fixtures (26)	1.19	1.06	1.14	1.15
Paper & Allied Products (27)	1.24	1.02	1.22	1.22
Printing & Publishing (28)	1.28	1.20	1.18	1.22
Primary Metals[b] (29)	1.17–1.19	0.85–1.04	1.18	1.13
Metal Fabricating (30)	1.21	1.01	1.14	1.14
Machinery (31)	1.25	0.92	1.05	1.07
Transportation Equipment[c] (32)	1.08–1.15	0.98–1.43	1.13	1.12
Electrical Products (33)	1.34	1.03	1.28	1.13
Non-Metallic Mineral Products (35)	1.28	0.94	1.27	1.30
Petroleum & Coal Products (36)	1.02	1.16	1.39	1.11
Chemical & Chemical Products (37)	1.23	0.97	1.24	1.25
Miscellaneous Manufacturing (39)	1.15	0.92	1.08	1.04

Source: Daly and Rao (1984) & Table 4-1.

a. Daly and Rao combine Knitting Mills and Clothing.

b. Daly and Rao report separately Iron & Steel (1.19, 1.04) and Non-Ferrous Metals (1.17 and 0.85).

c. Daly and Rao report separately Motor Vehicles (1.15, 1.15), Motor Vehicle Parts (1.14, 1.43) and Non-Auto Transportation Equipment (1.08, 0.98).

scale elasticity to correct Canada/U.S. relative productivity for size effects — as long as the price or quality differences are relatively similar for similar industries for the two countries. It simply affects the interpretation of the reason for the scale correction. In either case the correction is still necessary if we are to interpret the relative Canada/U.S. productivity ratio as reflecting efficiency differences, corrected for the different average scale of plants in the two countries.

A third standard of comparison for our scale estimates is provided by the Fuss and Gupta (1981) scale elasticity estimates that arise from the estimation of the variable cost function:

$$\log Y_t = b + a\,Q + c/Q + \sum_{t=2}^{T} B_t\, D(t) + u_t \qquad (4.6)$$

where Y is variable costs (materials, energy, wages and salaries) divided by sales (Q). The B_t are time-specific dummy variables to allow for omitted factor prices. Fuss and Gupta estimated the coefficients for (4.6) from pooled cross-sectional industry size class averages for the years 1965–68. The scale elasticity varies with plant size and has been tabulated at the 2-digit industry level in Table 4-5 for plants one-half estimated MES. We also report our own estimates for the purposes of comparison. A comparison at a less aggregated level is presented in Appendix D, Table D-1.

Output elasticity estimates derived from cost functions may be biased upwards (the cost elasticity is biased downwards), if the regression fallacy is important (Borts, 1960). The regression fallacy occurs if actual output only approximates long-run or expected output because of a transitory component and thus the regression suffers from the problem of an error in an explanatory variable. Fuss and Gupta (1981) removed the potential bias arising from this problem by using size group averages. A potentially more serious problem with their estimates arises from the use of a variable rather than a total cost function. A variable cost function is expected to yield returns to scale when the production function is non-homothetic (p. 128). If most of what we think of as scale economies come from capital savings, use of a variable cost function will bias the cost elasticity upward. Finally, the Fuss and Gupta estimates omit wage rates from their specification of the dual cost function. Since wage rates and size class are generally positively correlated, this will bias upward their derived cost elasticity and bias downward the scale elasticity coefficient.

Much the same problem arises if the degree of capacity utilization varies in a systematic fashion with the size variable. The direction of the bias is not clear, since the systematic deviation could vary directly or inversely with size. Investigation of this matter requires data which are presently unavailable to us.

The results reported in Table 4-5 show the variable-cost-based scale

TABLE 4-5 **Comparison of Returns to Scale Estimates from Variable Cost Function with Cobb-Douglas Production Function in Canadian Manufacturing Industries at the Industry Group Level**

Major Group Title	Variable Cost Function 1965–68	Cobb-Douglas 1970	Cobb-Douglas 1979
Food & Beverages (10)	1.04	1.28	1.27
Tobacco Products (15)	1.02	1.18	1.45
Rubber & Plastics (16)	1.04	1.16	1.10
Leather (17)	1.01	1.10	1.10
Textiles (18)	1.01	1.13	1.10
Knitting Mills (23)	1.01	1.05	1.06
Clothing (24)	1.02	1.03	1.04
Wood (25)	1.06	1.27	1.26
Furniture & Fixtures (26)	1.01	1.14	1.15
Paper & Allied Products (27)	1.02	1.22	1.22
Printing & Publishing (28)	1.03	1.18	1.22
Primary Metals (29)	1.05	1.18	1.13
Metal Fabricating (30)	1.01	1.14	1.14
Machinery (31)	1.02	1.05	1.07
Transportation Equipment (32)	1.11	1.13	1.12
Electrical Products (33)	1.01	1.28	1.13
Non-Metallic Mineral Products (35)	1.12	1.27	1.30
Petroleum & Coal Products (36)	1.01	1.39	1.11
Chemical & Chemical Products (37)	1.02	1.24	1.25
Miscellaneous Manufacturing (39)	1.01	1.08	1.04
Total Manufacturing	n.a.	1.16	1.15

Source: Fuss and Gupta (1981) as reported in Harris with Cox (1984, Table B-3, pp. 186–87) and Table 4-1.

elasticity estimates are generally lower than our own. While the former show increasing returns to scale, they are generally not significantly different from 1 and average only 1.03, compared to the average we derive of approximately 1.17 when using the production function.

Returns to Scale: The 4-digit Industry Level

Having presented an overview of the estimated returns to scale using 2-digit industries, we turn to the results at the 4-digit level that we will use for the Canada/U.S. productivity comparisons.[6] Table 4-6 presents a summary of these results. It describes the extent to which our estimates suggest that Canadian manufacturing industries are characterized by increasing, decreasing, or constant returns to scale. For the purposes of Table 4-6 we categorize an industry as having increasing returns to scale (I) if the scale elasticity is greater than 1.0 and significant at the 0.10 probability level; as having decreasing returns (D) if the scale elasticity is

TABLE 4-6 The Significance of Returns to Scale in 167 4-Digit Canadian Manufacturing Industries, 1970 and 1979

	1970					1979				
	Scale Elasticity	Industries		Total Value Added	Number of Employees	Scale Elasticity	Industries		Total Value Added	Number of Employees
Category	Mean (1)	Number (2)	Percent (3)	Percent (4)	Percent (5)	Mean (6)	Number (7)	Percent (8)	Percent (9)	Percent (10)
I	1.260	108	64.7	78.3	80.8	1.322	83	49.7	64.4	66.1
D	0.856	3	1.8	0.7	0.6	0.729[d]	3	1.8	2.5	0.9
C	1.078[a]	54	32.3	20.5	18.1	1.035	73	43.7	31.9	31.6
M	n.a.	2	1.2	0.5	0.4	n.a.	8	4.8	1.3	1.4
All industries[b]	1.209[c]	167	100.0	100.0	100.0	1.159[c]	167	100.0	100.0	100.0

Source: Statistics Canada, special tabulations.

Note: The coefficients on L_2 and $\ddot{K}_3$ are derived from the equation 4.3. RTS is the coefficient on log L_2 in equation 4.5. See text for further details.

a. This is the mean for 52 of the industries with constant returns to scale. Excluded are 1082 ($a + b = 611.568$) and 1840 ($a + b = 8.943$). If these two are included the mean increases to 12.566.

b. Totals may not add to 100 because of rounding errors.

c. Excludes RTS = M for 1970 and 1979 and for 1970 SIC 1082 and 1840.

d. This is the mean for two of the three industries with decreasing returns to scale. Excluded is 3651 ($a + b = -2.45$). If this industry is included the mean falls to -0.331.

negative and significant at .10; and as constant (C) in all the remaining cases.

In 1970, 78 percent and in 1979, 64 percent of value added of the Canadian manufacturing sector was found in industries characterized by increasing returns to scale. Industries with decreasing returns to scale were of little significance in either 1970 or 1979. On the other hand, industries with constant returns to scale accounted for 20 percent in 1970 and 32 per cent in 1979 of sector value added. Finally, lack of observations prevented estimation of scale economies for two industries in 1970 and eight in 1979. A comparison of the percentage of industries in a category (columns 3 and 8 in Table 4-6) with the percentage value added and employment (columns 4, 5, 9, and 10) reveals that industries with increasing returns were the larger industries, while the converse applied to industries with decreasing returns. Finally, the mean scale elasticity for increasing returns industries is substantially above unity, that for constant returns industries is close to unity, and that for decreasing returns industries is substantially below unity. Furthermore, comparing 1970 with 1979, these deviations from unity have increased, on average, for increasing and decreasing returns to scale industries.

The distribution of the scale elasticities estimated at the 4-digit level are presented in Table 4-7. A priori, if much of the literature on Canada's scale disadvantage in manufacturing is to be believed, one would expect scale economies to exist — but not to be so large that it is difficult to explain how small Canadian plants can coexist beside their larger foreign counterparts. Table 4-7 indicates that the scale elasticities generally are above unity, with most concentrated in the range .80–1.50 (88 percent in 1970, 89 percent in 1979). There are some unreasonable outliers. The estimate for Cane and Beet Sugar Processors (1082) is 611.57 in 1970; for Petroleum Refining (3651) is −2.45 in 1979; for Cordage and Twine (1840), 8.94 in 1970 and 3.77 in 1979. However, these outliers are reasonably few in number — only five estimates are above 2 in both 1970 and 1979; only two are below .60 in 1970, three in 1979. Hence, the distribution of our estimates at least suggests that they are not unreasonable.

Table 4-7 indicates the reasons for the earlier results reported in Table 4-6 that show a greater percentage of industries with constant returns to scale in 1979 than 1970.[7] On the whole, there has been little shift in the distribution above and below the scale elasticity value of 1. In 1970, 91 percent of the industries had a scale elasticity above unity, 82 percent in 1979 (Table 4-7). The distribution around 1 has been relatively constant (24 percent between .90 and 1.10 in 1970 and 30 percent in 1979). However, the range from .90 to 1.00 has gained at the expense of the range 1.00 to 1.10. On the whole then, the distribution is relatively stable.

In much of our previous work (e.g., Baldwin and Gorecki, 1983a) we have excluded industries characterized as miscellaneous because of

TABLE 4-7 The Distribution of the Degree of Returns to Scale Across 167 Canadian 4-Digit Manufacturing Industries, 1970 and 1979

	Industries per Category			
	1970		1979	
Scale Elasticity Category[a]	Number	Percent	Number	Percent
Less than 0.00	1	0.606	2	1.258
0.01–0.49	—	—	—	—
0.50–0.59	—	—	1	0.629
0.60–0.69	1	0.606	—	—
0.70–0.79	1	0.606	3	1.887
0.80–0.89	6	3.636	4	2.516
0.90–0.949	1	0.606	6	3.774
0.95–0.99	5	3.030	12	7.547
1.00–1.049	4	2.424	11	6.918
1.05–1.09	29	17.576	19	11.950
1.10–1.19	50	30.303	46	28.931
1.20–1.29	26	15.758	28	17.610
1.30–1.39	17	10.303	8	5.031
1.40–1.49	8	4.848	8	5.031
1.50–1.749	4	2.424	5	3.145
1.75–1.99	7	4.242	1	0.629
2.00–2.99	3	1.818	4	2.516
3.00 and higher	2	1.212	1	0.629
Total	165[b]	100[c]	159[b]	100[c]

Source: Statistics Canada, special tabulations.

a. Estimated from equation 4.3.

b. The scale elasticity could not be estimated because of insufficient observations for two industries in 1970 and eight in 1979.

c. May not total to 100 because of rounding.

their heterogeneous nature. So far in this study we have used only criteria 1 to 7 or, in some instances, 1 to 11, to exclude establishments (see Chapter Three for details). This has not led to the omission of miscellaneous industries. In order to examine such industries, we prepared Table 4-8, analogous to Table 4-6 except that it covers only miscellaneous industries. A comparison of the two tables shows that in both 1970 and 1979 miscellaneous industries also generally were characterized by increasing returns to scale. The shift from increasing to decreasing returns to scale categories over the 1970s is similar in both tables. Furthermore, as with Table 4-6, we find that industries experiencing increasing returns to scale tend to be larger than the average and constant returns industries smaller than the average. Hence, we may infer that at least with respect to production function estimates, the miscellaneous industries bear considerable resemblance to the manufacturing universe as a whole.

It is useful to determine whether the application of a rule of thumb

TABLE 4-8 The Significance of Returns to Scale[b] in 25 Miscellaneous 4-Digit Canadian Manufacturing Industries,[a] 1970 and 1979

	1970					1979				
	Scale Elasticity[c]	Industries		Total Value Added	Number of Employees	Scale Elasticity[c]	Industries		Total Value Added	Number of Employees
Category	Mean (1)	Number (2)	Percent (3)	Percent (4)	Percent (5)	Mean (6)	Number (7)	Percent (8)	Percent (9)	Percent (10)
I	1.227	20	80.0	84.9	86.8	1.215	16	64.0	72.1	78.3
D	—	0	—	—	—	—	0	—	—	—
C	1.023[d]	5	20.0	15.1	13.2	1.090	8	32.0	27.2	21.0
M	—	0	—	—	—	—	1	4.0	0.7	0.7
All miscellaneous industries	1.192[e]	25	100.0	100.0	100.0	1.175	25	100.0	100.0	100.0

Source: Statistics Canada, special tabulations.

a. 1089, 1620, 1650, 1799, 1899, 2392, 2499, 2541, 2599, 2619, 2660, 2740, 2980, 3039, 3090, 3150, 3290, 3399, 3549, 3599, 3690, 3782, 3783, 3799, and 3999.

b. RTS is the coefficient on log L_2 in equation 4.5.

c. Estimated from the equation 4.3.

d. This mean is for four of the five industries with constant returns to scale. Excluded is 3690 ($a + b = -0.959$). If 3690 is included the mean becomes 0.623.

e. This mean is for 24 of the 25 miscellaneous industries (see Note d). The mean for all 25 is 1.107.

delimiting constant, increasing and decreasing returns to scale yields results similar to the significance tests used previously. It may be that a small number of observations in some industries yielded large standard errors for the estimates of scale elasticities and therefore tended to cause us previously to classify industries as having constant returns when, in effect, they probably possess increasing or decreasing returns to scale. To test whether this might be the case we select, somewhat arbitrarily, two rules of thumb:

	Returns to Scale		
	Decreasing	*Constant*	*Increasing*
Rule 1:	Less than 0.95	0.95–1.05	Greater than 1.05
Rule 2:	Less than 0.90	0.90–1.10	Greater than 1.10

The results of applying these rules are presented in Table 4-9. Column 1 presents the number of industries per category for the entire sample. Column 1(a) gives the results for only those industries that had 20 or more observations. The remaining columns, for a given row, reclassify the industries as to the degree of returns to scale using the statistical tests of significance outlined above. For example, the table shows that in 1970 there were nine industries with a + b between 0.95 and 1.05, all of whose estimated scale elasticities were not significantly different from 1.

The table shows that both rule 1 and rule 2 tend to overestimate the extent to which the statistical tests signify increasing or decreasing returns to scale. Rule 1 does very well at predicting constant returns to scale — better than rule 2 — while the converse applies to increasing returns to scale. This difference reflects the fact that for most industries with an estimated scale elasticity between 1.05 and 1.10, returns to scale were significantly greater than unity.

Both rules do poorly at predicting decreasing returns to scale relative to the significance tests used previously, in that the percentage error is high. One of the reasons why the results using these rules of thumb may not always coincide with the levels of significance tests is that the number of establishments for some industries may lead to a large standard error for the estimated scale elasticity. The figures in Table 4-9 in parenthesis attempt to test for this; they represent only those instances where the industry had 20 or more observations. In all instances (except rule 2 for constant returns) we see a marked improvement in the ability of the rules of thumb to predict industries where returns to scale are increasing, decreasing or constant. For example, rule 1 shows that of the 146 industries that had an estimated scale elasticity greater than 1.05, 108 (or 74 percent) had significant increasing returns to scale. If only industries with only 20 or more observations are considered, then the corresponding numbers are 111 and 95 (or 85.6 percent), respectively. Hence, rough rules of thumb, particularly when industries with small numbers of observations are excluded, provide fairly accurate guides as to where

TABLE 4-9 The Degree of Returns to Scale in 167 4-Digit Canadian Manufacturing Industries Using Different Criteria, 1970 and 1979

Rule of Thumb Returns to Scale	Number of Industries per category		Industries Classified According to Statistical Significance of Scale Elasticity[b]					
			Decreasing		Constant		Increasing	
Criteria[a]	1	1(a)	2	2(a)	3	3(a)	4	4(a)
Decreasing								
Rule 1: less than 0.95								
1970	10	(4)	3	(2)	7	(2)	0	(0)
1979	16	(6)	3	(2)	13	(4)	0	(0)
Rule 2: less than 0.90								
1970	9	(3)	3	(2)	6	(1)	0	(0)
1979	10	(3)	3	(2)	7	(1)	0	(0)
Constant								
Rule 1: 0.95–1.05								
1970	9	(6)	0	(0)	9	(6)	0	(0)
1979	23	(15)	0	(0)	23	(15)	0	(0)
Rule 2: 0.90–1.10								
1970	39	(31)	0	(0)	25	(17)	14	(14)
1979	48	(31)	0	(0)	44	(27)	4	(4)
Increasing								
Rule 1: greater than 1.05								
1970	146	(111)	0	(0)	38	(16)	108	(95)
1979	120	(88)	0	(0)	37	(18)	83	(70)
Rule 2: greater than 1.10								
1970	117	(87)	0	(0)	23	(6)	94	(81)
1979	101	(75)	0	(0)	22	(10)	79	(65)

Source: Statistics Canada, special tabulations.
Note: Figures in parentheses, Columns 1(a), 2(a), 3(a), and 4(a) report those results for those industries which had 20 or more observations.
a. Estimated as a + b from the equation 4.3.
b. RTS is the coefficient on log L_2 in equation 4.5.

returns to scale are significantly increasing, decreasing or constant. We will return to this point where we choose the scale elasticities that are used to create Canada/U.S. relative productivity estimates.

Nevertheless, some striking anomalies do still occur. In 1970, industry 1093 has an estimated scale elasticity of 1.76 and in 1979 industry 1094 has a scale elasticity of 1.74, yet both are not significantly different from unity at .10. Part of the explanation may be the number of observations — 25 for 1093 in 1970 and 22 for 1094 in 1979. This suggests that if Table 4-9 is re-estimated with a higher cut-off for the numbers in parenthesis, the rules of thumb will perform much better. This, indeed, is the case.[8]

Finally we examine the stability of the estimates of the parameter values over time. We use, as a first approximation, some fairly simple measures, defined as follows:

$$\text{PDIV} = (\text{a} + \text{b}, 1979 - \text{a} + \text{b}, 1970)/\text{a} + \text{b}, 1970;$$

$$\text{ADIV} = (\text{a}, 1979 - \text{a}, 1970)/\text{a}, 1970; \text{ and, finally,}$$

$$\text{BDIV} = (\text{b}, 1979 - \text{b}, 1970)/\text{b}, 1970,$$

with the results presented in Table 4-10. As with Table 4-9, the figures in parentheses refer to those instances where 20 or more observations are available to estimate the production function. In view of the substantial influence of industry 1082 in 1970, with a + b = 611.568 this has been excluded from all calculations in the main body of the table, for both 1970 and 1979. It might be noted that there were only nine observations with which to estimate 1082 in 1970 and eight in 1979. The table presents PDIV, ADIV, and BDIV for all industries, those for which the index is less than and greater than 0, and finally the absolute value of the index.

Overall, Table 4-10 shows that there is a small decline in returns to scale (PDIV), – 0.056. However, this conceals a considerable decline for 86 industries, averaging –0.230, and an increase for 71 industries, averaging 0.154. Hence, disregarding sign, PDIV shows, on average, a value of 0.196. Much of this variation seems due to industries with a small number of observations, as a comparison of the bracketed and non-bracketed terms reveals. The overall mean value of PDIV in the second case falls to –0.023 and the mean absolute change is now 0.134. Hence, more stability is obtained once these industries with a small number of observations are excluded.

Turning now to fluctuations in the estimated output elasticities of labour and capital, we see that these are much more volatile than overall returns to scale. These fluctuations are usually reduced considerably when industries with a small number of observations are omitted (the bracketed numbers). The fluctuations are much greater for BDIV than ADIV. These changes in output elasticities compared with overall returns to scale, which, is just the sum of a and b, suggests, that to a considerable degree, changes in the output elasticity of labour (a) offset

TABLE 4-10 Stability of Returns to Scale (a + b) and Output Elasticities for Labour (a) and Capital (b) for 167 4-Digit Canadian Manufacturing Industries,[a] 1970–1979

Variable and Sample[b]	Mean		Minimum		Maximum		Standard Deviation	
PDIV[c]								
All industries	−0.056	(−0.023)	−2.667	(−2.667)	1.351	(0.939)	0.404	(0.313)
PDIV less than 0	−0.230	(−0.163)	−2.667	(−2.667)	−0.003	(−0.003)	0.442	(0.372)
PDIV greater than 0	0.154	(0.115)	0.002	(0.002)	1.351	(0.939)	0.210	(0.147)
All industries, absolute value of PDIV	0.196	(0.134)	0.002	(0.002)	2.667	(2.667)	0.357	(0.281)
ADIV[d]								
All industries	0.027	(−0.041)	−2.881	(−0.583)	11.913	(0.796)	1.039	(0.244)
ADIV less than 0	−0.249	(−0.172)	−2.881	(−0.583)	−0.004	(−0.007)	0.347	(0.145)
ADIV greater than 0	0.474	(0.213)	0.001	(0.001)	11.913	(0.796)	1.527	(0.190)
All industries, absolute value of ADIV	0.335	(0.189)	0.001	(0.001)	11.913	(0.796)	0.984	(0.162)
BDIV[e]								
All industries	0.044	(0.181)	−8.654	(−8.654)	7.186	(6.501)	1.569	(1.395)
BDIV less than 0	−0.817	(−0.658)	−8.654	(−8.654)	−0.016	(−0.010)	1.418	(1.322)
BDIV greater than 0	0.853	(0.783)	0.003	(0.003)	7.186	(6.501)	1.242	(1.114)
All industries, absolute value of BDIV	0.836	(0.731)	0.003	(0.003)	8.654	(8.654)	1.327	(1.200)

Source: Statistics Canada, special tabulations.

Note: Figures in parentheses report those results where the industry had 20 or more observations.

a. The estimate of a + b, a, and b comes from equation (4.3).

b. The table excludes all those industries for which a production function could not be estimated and industry 1082 which in 1970 a + b = 611.568. The total is thus 157, not 167.

c. Reading down the rows the sample sizes are 157 (103), 86 (51), 71 (52) and 157 (103).

d. Reading down the rows the sample sizes are 157 (103), 97 (68), 60 (35) and 157 (103).

e. Reading down the rows the sample sizes are 157 (103), 76 (43), 81 (60) and 157 (103).

those of capital (b), thus leading to smaller fluctuations in overall returns to scale.

One of the difficulties with the discussion surrounding Table 4-10 is that one cannot specify whether the differences in returns to scale during the 1970s mark a structural change or a shift in the production function. In order to test for this possibility we pool the 1970 and 1979 observations and estimate the equation:

$$\begin{aligned} \log (Y/L_2) = {} & k + g_1 G + b \log (\ddot{K}_3/L_2) \\ & + b_1 [\log (\ddot{K}_3/L_2) \cdot G] + z \log L_2 \\ & + z_1 [\log L_2 \cdot G] \end{aligned} \qquad (4.7)$$

where G is a dummy variable set equal to 0 for 1970 and unity for 1979. Equation 4.7 is the same as 4.5 except that we have introduced a shift parameter. Hence, if the coefficient z_1 is statistically significant from zero, we can infer that a structural shift in returns to scale has taken place over the 1970 to 1979 period.

Table 4-11 presents details on whether a structural shift has taken place, using equation 4.7, with the results presented for various subsets of the 167 4-digit manufacturing industries. The table shows that 126 of the 167 industries, or 75.4 percent, show no structural shift. In other words, the returns to scale do not change significantly. If significance is not measured at .10 but at a stricter standard, .01, then the number of industries not experiencing structural change increases from 126 to 147, or 88.0 percent. The results are much the same for miscellaneous industries and those with 20 or more observations in both 1970 and 1979. The 4-digit industries where a structural shift took place seems to be fairly evenly spread across 2-digit industries, with particular concentrations occurring in Food and Beverages (5) and Wood Industries (4).

In view of the fact that for the vast majority of industries there is no structural change, we decided, for the purposes of estimating total factor productivity measures in Chapter Six, to use the pooled estimates except in those instances where a structural change took place. This procedure has the advantage of considerably increasing the degrees of freedom and hence the reliability of our estimates, especially in view of the non-trivial number of industries where sample size is quite small. In deciding which significance level to select as indicating structural change, we decided to use .01 because given the relatively short period 1970 to 1979 for which our estimates are made, we would not expect substantial change. Furthermore, since an earlier work on entry and exit (Baldwin and Gorecki, 1983c) shows that the vast majority of output in 1970 and 1979 came from plants in existence in both years — continuing plants — it seems likely that structural change is the exception rather than the rule. In Appendix D, Tables D-2 and D-3 present the scale economy estimates by industry, together with the number of observations per industry used to estimate the production function.

TABLE 4-11 Testing for a Structural Change in the Degree of Returns to Scale in 167 4-Digit Canadian Manufacturing Industries, 1970–1979[a]

	Number		Percent	
All industries				
No structural change	126	(73)	75.4	(70.9)
Structural change	37[b]	(30)[c]	22.2	(29.1)
Significant at .01	16	(15)		
Significant at .05	29	(25)		
Significant at .10	37	(30)		
Missing	4	(0)	2.4	(0)
Total[e]	167	(103)	100.0	(100.0)
Miscellaneous industries[d]				
No structural change	19		76.0	
Structural change	6		24.0	
Significant at .01	5			
Significant at .05	6			
Significant at .10	6			
Missing	0		0	
Total[e]	25		100	

Source: Statistics Canada, special tabulations.
Note: Figures in parentheses refer to industries in which there were 20 or more observations in both 1970 and 1979.
a. Using equation (4.7) and the significance of the coefficient on log $L_2 \cdot G$.
b. These were 1032, 1040, 1050, 1072, 1091, 1620, 1650, 1799, 1880, 1893, 2310, 2392, 2441, 2442, 2511, 2513, 2592, 2593, 2640, 2732, 2733, 2860, 2960, 2980, 3041, 3050, 3080, 3150, 3210, 3250, 3330, 3542, 3651, 3760, 3911, 3932, and 3996.
c. Those in footnote b except 1032, 1880, 1893, 2592, 2593, 3932, and 3996.
d. See footnote a of Table 4-8 for listing.
e. Totals may not add to 100 because of rounding errors.

Table 4-12 contains a summary of the extent of returns to scale using our preferred estimation method. The 2-digit average scale elasticities are the average of the scale elasticities estimated separately for each of 1970 and 1979 at the 2-digit level and reported in Table 4-1 above. The remaining columns summarize the distribution of individual 4-digit estimates when 1970 and 1979 observations are pooled. Two sets of 4-digit estimates are presented: those for 160 industries, which excludes those for which scale estimates could not be estimated or were clearly influenced by observation errors; and, in parenthesis, the distribution for the 107 industry sample used to estimate Canada/U.S. productivity differences in Chapter Six. While the 2-digit estimates are usually based on a relatively large number of establishments, they may be somewhat misleading if individual 4-digit industries are characterized by different production processes. The latter is felt to be unlikely since the Standard Industrial Classification system was devised generally on the basis of supply-side criteria. Indeed, the distribution of individual 4-digit industries is generally concentrated around the 2-digit average. Nevertheless,

TABLE 4-12 The Average Returns to Scale at the 2-Digit or Major Group SIC Industry Level and Its Distribution at the 4-digit SIC Level, Canada, 1970–1979

		Range of 1970 and 1979 Pooled 4-Digit Estimates of Returns to Scale[b]						
Major Group Title	2-Digit: Average of 1970 & 1979[a]	Less than 0.9	0.9–1.0	1.0–1.1	1.1–1.2	1.2–1.3	1.3–1.4	Greater than 1.4
Food & Beverages (10)	1.27			3(3)	8(8)	2(2)	1(0)	2(2)
Tobacco Products (15)[c]	1.31[c]					1(0)		1(1)
Rubber & Plastics (16)	1.13				2(0)			
Leather (17)	1.10		1(1)	3(2)		1(1)		
Textiles (18)	1.11	1(1)	3(3)	6(4)	2(1)	1(1)		1(1)
Knitting Mills (23)	1.05		1(1)	2(1)				
Clothing (24)	1.04		1(1)	3(1)	4(2)			2(1)
Wood (25)	1.26			2(1)	3(1)	2(1)		4(3)
Furniture & Fixtures (26)	1.14			2(0)	2(1)	1(1)		
Paper & Allied Products (27)	1.22				3(2)	2(2)		1(1)
Printing & Publishing (28)	1.20				1(1)	2(0)		
Primary Metals (29)	1.15		1(0)	3(2)	1(1)	1(0)	1(0)	
Metal Fabricating (30)	1.14			2(1)	7(5)	2(1)		
Machinery (31)	1.06			1(0)	2(1)	1(1)		
Transportation Equipment (32)	1.13		1(1)	3(3)	5(3)	1(1)		
Electrical Products (33)	1.13			7(6)	1(1)	1(0)		
Non-metallic Mineral Products (35)	1.29	1(1)	1(1)	1(1)	3(1)	2(2)	4(3)	1(0)
Petroleum & Coal Products (36)	1.25						1(0)	1(0)
Chemicals & Chemical Products (37)	1.24	1(0)		3(1)	3(2)	3(2)	1(1)	
Miscellaneous Manufacturing (39)	1.06		3(2)	4(3)	5(5)	2(2)	1(1)	1(0)
All Manufacturing Plants	1.15	3(2)	12(10)	45(29)	52(35)	25(17)	9(5)	14(9)

Source: Statistics Canada, special tabulations.

a. Returns to scale were estimated for all plants in each 2-digit industry in 1970 and 1979 separately. The mean of the two years is presented here. See Table 4-1 for further details.

b. Industries for which economies of scale could not be estimated or which were clearly influenced by observation errors were eliminated when compiling these ranges. Economies of scale estimates involved pooling plant data for 1970 and 1979. The numbers in parentheses refer to the sample of 107 industries used to estimate Canada/U.S. productivity in Chapter Six.

c. For this group, the estimates for 1970 and 1979 differed substantially. See Table 4-1 for further details.

there is enough variance in the 4-digit estimates, particularly for Chemicals and Chemical Products, Non-Metallic Mineral Products, and Food and Beverages, to warrant the use of the 4-digit estimates in the comparison of Canada/U.S. productivity developed in Chapter Six.

Plant Diversity and Output Levels

A familiar theme in the literature concerning the productivity is the effect of short production runs on Canadian plant efficiency. This literature argues that the disadvantage Canada experiences vis-à-vis the United States increases with N (the number of products produced by a plant), other things equal. In earlier work (Baldwin and Gorecki, 1983a) we examined the impact of trade, tariffs and domestic industry structure upon product diversity. This was mostly conducted at the inter-industry level with a limited analysis at the intra-industry level. Here we take the analysis a step further by examining the direct impact of plant output diversity upon output at an individual industry level.

In the previous sections we have ignored the effect of diversity upon our estimate of scale economies. We asked whether getting larger plant size allows greater per unit output per unit input. We let Canadian plants do so in the way that appears optimal to them — by increasing plant size without increasing length of production run, by diversifying into additional product lines, or by expanding the production run length of existing product lines.

Economies from plant size can arise from a number of sources. First, the plant may have certain fixed costs irrespective of the number of products produced. This gives rise to plant-specific economies as output is expanded. Second, each product line may have fixed costs — and longer production runs can give rise to product-specific economies. If larger plants have longer production runs, it may be this effect that the estimated scale parameter is catching. Third, the product-specific (or the plant-specific) fixed costs may not be independent of the number of products produced. The traditional literature has stressed the diseconomies arising from coordination problems if the number of product lines is increased (Caves et al., 1980). More recently, the scope economies literature has led to the suggestion that there may be agglomeration economies from expanding the number of products. If large plants are also more diversified, it may be that the scale parameter is catching the effect of agglomeration economies.

Expansion of plant scale without an increase in number of products produced will exploit both plant scale and product-specific economies. But where the elasticity of demand for existing products is much less than for new products, a firm may add product lines in order to take advantage of plant scale economies. If agglomeration economies are positive, this will decrease costs both from this effect and the plant scale effect. Even if agglomeration economies are negative, the plant scale effect may offset the former and lead to decreased unit costs as a result of the expansion of number of products produced.

In our work on plant size and diversity (Baldwin and Gorecki, 1983a), we found that plants get larger both by including more products and by increasing the length of the production run. In most industries, the rate at which the former occurs declines with size, suggesting that plant economies or agglomeration economies that would lead to greater diversity are eventually exhausted. Production run length also increases at a decreasing rate in many industries — but with less frequency than for diversity. In a number of industries, the relationship between production run length and plant size suggests that production run length does not reach a maximum but continues to increase across the entire plant size range. This suggests there are a number of industries where production run or plant scale economies outweigh agglomeration economies, since market growth opportunities have led to substantial increases in production run length — as opposed to increased diversity.

Nevertheless, the way in which expansion occurs as plants get larger may affect the estimate of scale economies. While expansion of production via the addition of product lines, as opposed to the expansion of product run length, is likely to have a different impact upon costs, very few attempts have been made to incorporate the effects of diversity on estimates of the production function. The failure to do so may affect the estimate of economies of scale obtained.

The effect of diversity on the estimates of economies of scale can be illustrated by the following simple example. Suppose that the production function per product line i is given by

$$Q_{1i} = A\,L_{1i}^{a} \tag{4.8}$$

where Q_{1i} is the output of firm 1, L_{1i} is the input of firm 1, and a is the scale coefficient. Now suppose a second firm (#2) exists which produces twice as much Q in two separate production lines, each of which is equal in length to the first firm, i.e.,

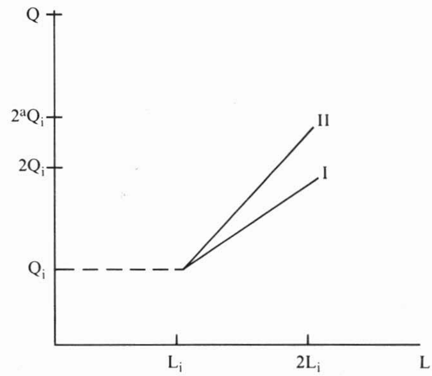
$$Q_{2i} = AL_{1i}^{a} + AL_{1i}^{a} = 2\,AL_{1i}^{a} = 2Q_{1i}. \tag{4.9}$$

Then if inputs and outputs were plotted as in Figure 4.1, it would appear that there are no economies of scale — a doubling of inputs just doubles output. Now suppose there is a third firm (#3) that uses twice as much labour as firm 1 but does so in the same product line — it expands by increasing length of product run and not by increasing diversity. Then

$$Q_{3i} = 2^{a}AL_{1i}^{a} = 2^{a}Q_{i} \tag{4.10}$$

If we plot inputs and outputs of firm 1 and 3 ($L_1,Q_1,2L_1,2^aQ_1$) the described production function will have a steeper slope (line II) —

FIGURE 4–1 The Relationship between Diversity and Scale Economies



higher scale economies — than for a situation with only firm 2 and 1 (L_1,Q_1,$2L_1$,$2Q_1$) (line I)–providing a in the above equation is greater than or equal to 1 (see Figure 4.1).

The issue then is the method that should be used to incorporate the diversity of plant output — the number of products per plant into the production function.

One way to handle the diversity (number of products) problem is to estimate a production function using average length of production run, i.e.,

$$\left(\frac{Q}{N}\right)^{b} = AN^{w}\left(\frac{K}{N}\right)^{a}\left(\frac{L}{N}\right)^{1-a} \tag{4.11}$$

where N = no. of products. A proxy for number of products N can be derived as the numbers equivalent from the Herfindahl index of product diversity at the plant level. The above production function relates average production run length to average factors used per product as a normal Cobb-Douglas would, but allows the function to shift either up or down with the number of products combined in the same plant.

Equation 4.11 can be rewritten as:

$$Q = A' N^{w'} K^{a'} L^{b'} \tag{4.12}$$

where $w' = (w - 1 + b)/b$; $a' = (a/b)$; and $b' = (1 - a)/b$.

From equation 4.12, it is apparent that the effect of holding N constant but expanding inputs proportionately and thus exploiting both plant scale (PLSCAL) and product-specific economies (PRODSCAL) is just $a' + b' = 1/b$. On the other hand, the effect of expanding capital, labour, and number of products proportionately and thus exploiting plant scale (PLSCAL) and agglomeration economies (AGGECON) is $(w/b) + 1$. Finally, the effect of holding capital and labour constant but increasing the number of products, and thus losing product-run economies (PRODSCAL) but gaining agglomeration economies (AGGECON), is $w' = (w - 1)/b + 1$. Thus the joint effects can be derived from:

$$\text{PLSCAL} + \text{PRODSCAL} = a' + b' = 1/b \equiv G_1 \quad (4.13)$$

$$\text{PLSCAL} + \text{AGGECON} = w' + a' + b' = (w/b) + 1 \equiv G_2 \quad (4.14)$$

$$\text{AGGECON} - \text{PRODSCAL} = w' = (w - 1)/b + 1 \equiv G_3 \quad (4.15)$$

$$G_2 - G_3 = G_1. \quad (4.16)$$

As is evident from equations 4.13, 4.14, 4.15 and 4.16, it is the joint effects of various combinations of plant, product and agglomeration economies that can be measured using this approach. This occurs because expansion of output (without product numbers) exploits both plant and product economies. Changing product numbers, other things constant, affects both product-run economies and agglomeration economies. It is, in effect, not possible to hold two of the scale effects constant at the same time.

If agglomeration economies are relatively unimportant, a large significant value of G_1 and an insignificant G_3 indicate that plant economies predominate over product economies. If we assume agglomeration economies to be negative, the same conclusion also applies. However, if agglomeration economies are large and positive, then no such conclusion can be drawn. A small value of G_3 indicates that the net effect of diversification (a gain in agglomeration economies but a loss in production-run-length economies) is small. A significant G_1 implies that together plant and product economies are significant.

We proxy N with the inverse of H4 — the Herfindahl index of plant diversity previously defined in Chapter Three. In other words:

$$N \equiv 1/H4 \quad (4.17)$$

where, in this context, N is defined as the number of products over which the plant would have to allocate its output equally in order to generate the observed value of H4. We therefore estimated

$$\log Y = k + a' \log L_2 + b' \log \ddot{K}_3 + w' \log N \quad (4.18)$$

where $\ddot{K}_3$ is estimated using equation 4.4.

Equation 4.18 is estimated for the test sample of eight industries used previously to examine the effect of alternate estimation techniques. The results, along with the returns to scale estimate derived from the same establishment sample but without the term log N (i.e., equation 4.3, column 2), are presented in Table 4-13. The standard scale estimate

TABLE 4-13 **Estimates of the Cobb-Douglas Production Function for Eight 4-Digit Canadian Manufacturing Industries with Diversity Included, 1979**

Industry SIC	Returns to Scale[a] (No Numbers Variable) Equation 4.3	PLSCAL + PRODSCAL[b] $(a'+b')$ G_1	PLSCAL + AGGECON[b] $(w'+a'+b')$ G_2	AGGECON − PRODSCAL[b] (w') G_3	w[c]
		Equation 4.11			
(1)	(2)	(3)	(4)	(5)	(6)
1072	1.261	1.161	1.157	−0.004	0.135
1081	1.166	1.214	1.129	−0.085	0.106
1832	0.910	0.790	1.485	0.695	0.614
2513	1.261	1.344	1.076	−0.269	0.057
2860	1.180	1.235	1.239	0.004	0.194
3042	1.236	1.257	1.097	−0.159	0.077
3320	1.087	1.403	1.334	−0.070	0.245
3360	1.078	1.192	1.208	0.016	0.174

Source: Statistics Canada, special tabulations.
a. Equation 4.18 without the term log (1/H4), i.e., equation 4.3.
b. See text for definition of joint scale effects.
c. Derived from equations 4.13 and 4.14 such that $w = (G_2 - 1)/G_1$.

generally increases, but not by much–the exception is SIC = 3320 — as a comparison of columns 2 and 3 reveals. G_1 is typically large relative to G_3, which suggests that if agglomeration economies are unimportant, plant scale predominates over production run length economies. The coefficient w', which catches the offsetting effects of production run economies and agglomeration economies, is generally not significantly different from zero. The implied coefficient on N in equation 4.11 is reported in column 6 and is generally small but positive. Indeed whenever $w' = 0$, then $w = (a' + b' - 1)/(a' + b')$ rather than $(w' + a' + b' - 1)/(a' + b')$. Since there are generally increasing returns to scale, an insignificant value for w' indicates that w will be positive. Positive values of w' and scale economies yield larger values of w, thereby suggesting small but positive agglomeration economies.[9]

Equation 4.18 was also estimated across all establishments in the manufacturing sector as a whole, all establishments within 2-digit industries, and finally for individual 4-digit industries. However, unlike earlier sections of the paper, we do not present detailed tabular findings here, since in the majority of cases, the coefficient attached to N is not statistically significant. The sample selection criteria employed all those presented in Tables 3-4 and 3-5, not just 1 to 7, as has been the case until now. The reasons for this were explained in Chapter Three.

At the level of the manufacturing sector, w' (the coefficient attached to N) was statistically insignificant in both 1970 and 1979. At the industry 2-

TABLE 4-14 **The Impact of Plant Diversity on Output for 167 4-Digit Canadian Manufacturing Industries, 1970 and 1979**

Coefficient on Log (1/H4)[a]	Number of Industries per Category	
	1970	1979
Negative	90	93
Positive	62	56
Missing[b]	15	18
Negative and Significant[c]	17[d]	14[f]
Positive and Significant[c]	8[e]	3[g]

Source: Statistics Canada, special tabulations.
a. In equation 4.18.
b. Insufficient observations or no product diversity data reported.
c. At .10 or higher using a one-tailed t-test.
d. The 4-digit SIC of these industries is as follows: 1040; 1050; 1094; 1860; 2310; 2450; 2513; 2660; 2680; 2710; 2860; 2890; 2940; 3060; 3541; 3914; and 3994.
e. The 4-digit SIC of these industries is as follows: 1020; 2980; 3041; 3180; 3730; 3782; 3920; and 3999.
f. The 4-digit SIC of these industries is as follows: 1060; 1620; 1650; 1720; 1860; 2513; 2710; 2980; 3020; 3150; 3542; 3562; 3799; and 3931.
g. The 4-digit SIC of these industries is as follows: 1011; 3391; and 3541.

digit group level, w′ was negative in all but five of the twenty industry groups, and was significant at 0.10 or better in seven of these cases.[10] In two of the five instances in which N had a positive impact, this was significant.[11] In 1979, N had a negative impact in all but six instances, and this was significant in five instances.[12] None of the positive coefficients were significant. In only two industries did N have a negative and significant impact in both 1970 and 1979 — Primary Metals and Machinery Industries. Hence it would appear that w′ is usually negative.

We now turn to the impact of product diversity on output at the level of the individual 4-digit industry. The results are summarized in Table 4-14. The results for 1979 are probably more meaningful than for 1970, since the diversity data used with the 1970 census data pertain to 1974 while the 1979 results use only 1979 data. In 15 industries in 1970 and 18 in 1979 it was not possible to estimate the impact of N on output, either because there were data on too few plants (see Chapter Three for details) or because the industry had no products classified as primary to it.[13] Of the remaining industries the sign attached to w′ was more often negative than positive (ratio of approximately 3:2). N had a significant and negative impact in 17 industries in 1970 and 14 in 1979. Positive and significant coefficients on N were fewer and decreased much more dramatically, 8 and 3 between 1970 and 1979, respectively. In only SIC 1860, Carpet, Mat and Rug Industry; 2513, Sawmills and Planing Mills; and 2710, Pulp and Paper Mills; did N have a negative and significant impact in both years. Somewhat surprisingly SIC 3541, Concrete Pipe Manufacturers, switched sign between 1970 (negative) and 1979 (positive), but still retained significance. Hence, despite a number of exceptions, the results in Table 4-14 suggest that, by and large, increasing product diversity (the net effect of product-run scale economies and agglomeration economies) tends to result in lower output.

Although the traditional literature would predict that increased product diversity should reduce output, other things equal, this result is not recorded universally across our sample. Several explanations may be put forward to explain this. First, in some industries the number of primary products may be so small that measured product diversity has little variation and hence is largely insignificant.[14] This would appear to be of consequence in at least some industries. For example, in the fourteen instances where N4D = 1 in 1979, the coefficient on N was significant in only one case, for N4D = 2 the corresponding numbers were eighteen and one for 1979.[15] This is much lower than the results overall, which were, for 1979, approximately one in 8.8.[16] Similar results were obtained for 1970, although the difference was not as dramatic.[17] Hence there is some evidence that the smaller the number of ICC products classified to an industry, the more likely it is that the coefficient attached to N will be insignificant.[18]

In order to see whether the results concerning the impact of product diversity on output are sensitive to the level of the industrial commodity classification used, equation 4.18 was re-estimated using N = (1/H5) rather the N = (1/H4). Earlier work showed that using the 5-digit ICC results in the typical 4-digit industry having two to three times as many commodities classified to it compared with the 4-digit ICC (Baldwin and Gorecki, 1983a, Table 1, p. 11). The coefficient on N = (1/H5) was negative and significant (at .10) in eleven[19] instances for 1970; and twelve[20] instances for 1979. The corresponding figures for a positive and significant coefficient were seven[21] and six[22], respectively. Once again, it should be noted that there are few industries in which the sign on N = (1/H5) was the same and significant in both 1970 and 1979. These results are similar to those recorded in Table 4-14, with many of the same industries experiencing significant relationships irrespective of the level of the ICC used to measure product diversity.[23] Hence, the effect of product diversity would not appear to be a function of the level of commodity classification used.

As indicated, an explanation of the positive signs of w' (the coefficient attached to N) can be found in the recent literature on economies of scope (Panzar and Willig, 1981), which sees additional products sharing some common fixed factor of production; thus with a given factor endowment, additional products use up excess capacity and result in increased output. Hence, the effect of agglomeration economies may offset the effect of shorter production runs when diversity is increased, and thus the coefficient on N would be positive. The industries for which a significant positive relationship emerged included such industries as 1011, Slaughtering and Meat Processors, and 1020, Fish Products Industry, where, with capital fixed and bumper crops, this might result in the addition of extra product lines. However, more knowledge will be needed to see whether such an explanation could be applied to industries such as 3391, Battery Manufacturers, and 3180, Office and Store Machinery Manufacturers.

In the end, we are led to conclude that while diversity matters somewhat, it is not so overwhelming to affect our "scale" estimates that are derived without its consideration. That is, the scale estimates that are the result of plant and product run extensions associated with larger plant size, but which exclude agglomeration effects, very closely approximate that which is derived from the simpler approach — which ignores what is happening to the number of products and the extent of agglomeration economies.

Output Valuation and Measured Output

As noted in Chapter Three, there is a problem in comparing Canadian output data with those published in the United States, as well as individual establishments within the same industry in Canada, because of valuation procedures. In the United States, all of the output of a plant is valued at its "selling" price. In the case of intra-firm transfers, the reporting procedure requires that such transfers be valued at "full economic or commercial value, i.e., including not only the direct costs of production but also a reasonable proportion of 'all other costs' (including company overhead) and profit" (United States, Department of Commerce, 1980, p. A-2). In Canada, on the other hand, output (i.e., shipments) is valued, as either:

- cost (D1);
- book transfer value (D2);
- other (D3); and
- final selling price (D4).

D1, D2, and D3 were the dummy variables defined earlier and D4, the omitted category, was the fourth. Thus, the Canadian Census does not insist that prices used for intra-firm transactions effectively include a return on capital. Maule (1969), in work for the Royal Commission on Farm Machinery, corrected for this and found that after correction, Canadian sales and productivity increased.

The actual bias that is caused by the different reporting procedures is difficult to judge a priori. If arm's-length prices were the only category reported in D4 (final selling price), then we might expect lower prices in D1, D2, and D3 if Canadian firms do not go to the trouble of adding in a percentage of "other costs," as is done in the United States. But given the apparent leeway available to them, Canadian firms probably do not even report all non-arm's-length transactions in categories 1 to 3. Some

TABLE 4-15 **The Significance of Various Valuation Reporting Procedures in the Canadian Manufacturing Sector, 1970 and 1979**[a]

	Reporting Procedure			
Variable	**D1 = 1 (Cost)**	**D2 = 1 (Book Transfer Value)**	**D3 = 1 (Other)**[b]	**D4 = 1 (Final Selling Price)**
Number of Plants				
1970[c]	1,492 (12.9%)	201 (1.7%)	4,123 (35.6%)	5,767 (49.8%)
1979	1,053 (10.4%)	166 (1.6%)	667 (6.6%)	8,235 (81.4%)
Percentage of production workers				
1970[c]	12.2	2.8	27.1	57.9
1979	9.8	3.2	8.2	78.8
Percentage of total value added				
1970[c]	12.6	3.2	25.5	58.7
1979	9.2	4.4	9.1	77.3

Source: Statistics Canada, special tabulations.
Note: Percentages total 100 across the rows.
a. Refers to plants which met criteria 1 to 7 in Chapter Three. Hence, since one of the criteria is that NW is greater than 4, the table uses as a percentage of production workers, rather L_1 = NS + NW.
b. Includes those plants reporting "other" on census forms and those plants for which data were not available. See text for details.
c. For 1970 valuation reporting procedures are proxied by those used in 1974.

may be reported in D4. Moreover, in those industries where non-arm's-length transactions prevail, firms that take the trouble to report D1 or D2 may also take pains to allocate part of other costs — if only because they may be a Canadian subsidiary of a multinational firm and be used to doing so in the United States. Or they may be those firms most sensitive to "transfer-pricing" issues for tax purposes and therefore most careful to include a return on capital. In these cases, prices may actually be higher in D1, D2, or D3 as compared to D4 if they reflect "costs" and not market transactions.

Table 4-15 details the number and relative importance of establishments classified by different valuation reporting procedures for the whole manufacturing sector. The distributions vary markedly between 1970 (these figures are actually derived from 1974 data) and 1979, with D4 increasing substantially in importance relative to D3. This reflects the fact that for 1970, reporting practices were proxied by those of 1974. If a plant did not exist in 1974 but did in 1970, then it is included in the category D3. Hence, if no drastic change in the underlying distribution of reporting procedures took place during the 1970s, the 1974 proxy for

1970 considerably understates the importance of D4 and overestimates D3.[24] The differences in the 1970 and 1979 distributions suggest that serious shortcomings exist with respect to the 1970 data because of the allocation procedure adopted.

Table 4-15 shows, and here we concentrate our attention on the 1979 results, that most establishments, approximately four out of five use the final selling price to report value of shipments. These establishments also account for the bulk of value added and production workers in the manufacturing sector. Turning now to D1 and D2, we see that one in ten establishments report on the basis of cost and one or two in one hundred on the basis of book transfer value. However, since the share of employment and value added accounted for by establishments with D2 = 1 is much larger than the percentage of establishments that they represent, we can infer that plants which report on the basis of book transfer value are generally substantially larger than the average. Finally, the category "other" accounts for 6.6 percent of establishments and 8 to 9 percent of employment and value added.

These findings suggest that *overall* differences in valuation reporting procedures between Canada and the United States are unlikely to be of major importance in accounting for the average U.S./Canada productivity differences for all industries. If, for example, value added per worker in Canada was 80 percent of that for the United States, then assuming D1 and D2 underreported by 10 percent and these categories accounted for 14 percent of value added, the U.S./Canada productivity ratio would increase by 1.12 to 81.12.[25] However, this does not mean that within individual industries, correcting for differences in valuation procedures could not substantially raise measured Canadian productivity vis-à-vis the United States.

In order to estimate the significance of the valuation procedures at the industry level, we re-estimated the production function with dummy variables as:

$$\log Y = k + a \log L_2 + b \log \ddot{K}_3 + d_1 D1 + d_2 D2 + d_3 D3. \tag{4.19}$$

If D1, D2, and D3 fail to include other costs and D4 includes just arm's-length transactions, then we would predict d_1, d_2, and d_3 would all be less than zero. For reasons stated above, we expect the 1979 results to be more reliable than those for 1970.

At the 2-digit level, the results are in accord with a priori expectations. In 1979, d_1 is correctly signed in fourteen of the twenty industry groups but significant on only one occasion, while d_2 is correctly signed in sixteen of the nineteen industry groups for which it was possible to estimate d_2, with significance being recorded in three instances.[26]

Table 4-16 presents a summary of the signs of the estimated coefficients for d_1, d_2, and d_3 for the individual 4-digit manufacturing industry production functions. In a number of instances, particularly for d_2 in

TABLE 4-16 The Impact of Plant Diversity on Output for 167 4-Digit Canadian Manufacturing Industries, 1970 and 1979[a]

Coefficient on Reporting Procedure[a]	Reporting Procedure: D1 = 1 (Cost)	D2 = 1 (Book Transfer Value)	D3 = 1 (Other)
	(number of industries per category)		
Positive			
1970	71	39	68
1979	64	29	60
Negative			
1970	86	41	97
1979	70	40	62
Missing[b]			
1970	10	87	2
1979	33	98	45
Positive and significant[c]			
1970	7[d]	4[e]	6[f]
1979	11[g]	5[h]	8[i]
Negative and significant[c]			
1970	17[j]	4[k]	20[l]
1979	6[m]	12[n]	15[o]

Source: Statistics Canada, special tabulations.

a. In equation 4.19.
b. Insufficient observations to estimate the complete regression equation (once in 1970, four times in 1979), or no establishments used a given reporting procedure in an industry (the remainder).
c. At .10 or higher using a one-tailed t-test.
d. 1020, 1089, 1094, 1510, 1650, 1880, and 1893.
e. 1040, 1620, 1720, and 3010.
f. 1092, 1510, 2599, 2890, 3380, and 3781.
g. 2480, 2520, 2560, 2619, 2980, 3020, 3110, 3230, 3380, 3580, and 3911.
h. 1072, 1831, 3110, 3549, and 3652.
i. 1072, 1091, 1799, 2480, 2541, 3080, 3110, and 3652.
j. 1091, 1530, 1872, 2391, 2450, 2619, 2720, 2860, 2980, 3010, 3020, 3060, 3270, 3541, 3561, 3760, and 3914.
k. 1020, 1050, 3740, and 3915.
l. 1011, 1530, 1820, 1880, 2310, 2392, 2431, 2432, 2441, 2513, 2580, 3020, 3060, 3241, 3260, 3550, 3740, 3760, 3913, and 3992.
m. 1071, 1092, 2599, 3399, 3511, and 3652.
n. 1020, 1050, 1060, 1071, 1650, 1832, 2460, 2541, 3031, 3042, 3782, and 3783.
o. 1060, 1094, 1740, 2392, 2441, 2442, 2450, 2619, 2731, 2733, 2860, 3010, 3090, 3250, and 3550.

1970 and 1979, but also for d_1, and d_3 in 1979, lack of plants using other than final selling price to report value of shipments resulted in no estimate. For those instances where estimates were made, for both 1970 and 1979, d_1, d_2, and d_3 are more usually negative rather than positive but the margin is not large. If only those coefficients that were significant are considered, we find that for d_2 in 1979 negative signs substantially outweigh positive signs. However, for d_1 in 1979 the positive coefficients are much more frequent than the negative ones. These results suggest that no a priori statement can be made about the direction of the valuation bias and the reporting technique adopted at this level of aggregation.

The incidence of plants reporting sales using D1, D2, and D3 varies considerably across the manufacturing sector. Thus, we more closely examined those instances where a significant percentage of industry value added was accounted for by plants reporting using D1, D2, or D3. If in these instances we find that the coefficients on D1 to D3 are generally not significant, there is less need to worry about using the estimated coefficients to correct value added. We choose a cut-off of 20 percent of industry value added as our criterion and report the results for 1979 only.

Table 4-17 shows that for twenty-eight industries, plants that used cost (D1) accounted for 20 percent or more of industry value added. The corresponding numbers for book transfer value (D2) and other (D3) were seven and twenty respectively. Hence, adjustments to value added because of reporting practices have the potential to affect a non-trivial proportion of the 167 4-digit manufacturing industries. However, Table 4-17 suggests that the impact of valuation technique, virtually without exception, is not significant. Furthermore in those instances where the coefficient d_1, d_2 or d_3 is significant it is usually *positive*, not negative. Hence, it was decided to omit from further consideration adjustments to measured value added on the basis of reporting practice. It would appear that the heterogeneity within a group is sufficient to obscure any measurable impact. Furthermore, it would appear that even in the United States there is some difficulty in getting respondents to apply uniformly the definitions of final selling price cited at the beginning of this section (U.S. Department of Commerce, 1981, p. xxii).

Summary and Conclusion

In this chapter we have estimated scale economies for 1970 and 1979 for a large number of the 167 4-digit industries into which the manufacturing sector is divided, as well as all of the 20 2-digit industries. The results suggest that for the 1970s Canadian industries in general experienced increasing returns to scale, a result consistent with previous estimates of returns to scale for Canada, and the separate finding, using a different approach, that much sub-optimal capacity exists in Canadian manufacturing industry. Since in the vast majority of 4-digit industries no structural change was indicated in returns to scale between 1970 and 1979, we pooled the data for these industries for these years in order to derive the estimates of return to scale used in Chapter Six in calculating Canada/U.S. relative efficiency.

TABLE 4-17 The Impact of Various Valuation Reporting Procedures for Those Industries Where Such Procedures Account for a Significant Proportion of Industry Value-Added,[a] 1979

Industry	Percent of Industry Value Added[a]	Establishments Number	Establishments Percent[a]	Coefficient (t-value)[b]
	For Plants D1 = 1 (Cost)			d_1
1510	67.7	2	40.0	−0.147 (−0.40)
1832	23.7	12	23.1	−0.105 (−0.35)
1860	22.2	5	20.0	−0.132 (−0.42)
2480	21.5	1	5.6	1.868 (4.78)[c]
2491	42.5	1	14.3	−0.167 (−0.36)
2680	22.4	4	13.8	0.282 (1.63)
2720	31.0	1	16.7	−0.222 (−1.31)
2940	26.0	12	26.1	−0.064 (−0.36)
2970	37.1	3	16.7	0.709 (1.66)
3020	35.9	13	18.3	0.259 (2.12)[d]
3031	20.7	30	26.3	−0.019 (−0.16)
3041	45.3	33	34.4	0.084 (1.21)
3042	22.6	44	28.6	0.039 (0.47)
3080	21.4	48	20.0	0.075 (1.52)
3110	65.3	16	27.6	0.287 (2.12)[d]
3180	53.6	3	20.0	0.188 (0.56)
3242	23.7	12	22.2	−0.283 (−0.99)
3280	28.0	13	21.3	0.029 (0.32)
3549	39.1	22	26.2	0.108 (1.26)
3550	23.1	37	18.3	0.074 (0.88)
3561	52.7	3	37.5	−0.032 (−0.15)
3562	47.7	8	32.0	0.238 (1.13)

TABLE 4-17 (cont'd)

Industry	Percent of Industry Value Added[a]	Establishments Number	Establishments Percent[a]	Coefficient (t-value)[b]
3570	31.5	3	37.5	−0.501 (−0.66)
3591	31.8	4	57.1	0.207 (0.46)
3781	43.3	3	27.3	0.544 (1.10)
3783	43.9	4	20.0	−0.350 (−1.20)
3799	21.0	13	17.6	−0.027 (−0.16)
3911	33.9	1	4.8	0.763 (2.45)[d]
	For Plants D2 = 1 (Book Transfer Value)			**d_2**
1792	28.0	2	9.5	0.425 (0.97)
3230	24.4	3	20.0	−0.104 (−0.43)
3243	27.1	1	17.4	−0.151 (−0.41)
3310	21.8	3	15.8	−0.369 (−1.27)
3570	20.8	1	12.5	−0.611 (−0.45)
3651	63.6	19	55.9	0.035 (0.11)
3652	47.8	1	14.3	1.415 (41.99)[d]
	For Plants D3 = 1 (Other)			**d_3**
1040	20.1	37	21.1	−0.075 (−0.64)
1082	31.8	1	12.5	0.093 (0.12)
1091	42.4	5	16.7	0.687 (1.98)[e]
1092	37.7	6	23.1	0.390 (1.54)
1094	22.5	6	27.3	−0.720 (−4.31)[c]
1792	24.4	4	19.0	0.139 (0.40)
1810	84.7	12	70.6	0.171 (0.29)
1832	27.0	9	17.3	0.084 (0.24)
1851	65.1	2	25.0	0.268 (0.68)

TABLE 4-17 (cont'd)

Industry	Percent of Industry Value Added[a]	Establishments Number	Establishments Percent[a]	Coefficient (t-value)[b]
2480	26.8	6	33.3	0.580 (2.16)[d]
2520	27.3	12	21.0	0.153 (0.85)
2543	30.9	8	15.4	0.218 (0.94)
2940	48.2	12	26.1	0.124 (0.71)
2960	35.7	5	20.8	0.282 (1.10)
3031	26.4	20	17.5	−0.172 (−1.30)
3380	42.8	12	32.4	−0.028 (−0.174)
3570	22.3	1	12.5	0.787 (0.74)
3599	23.0	9	19.1	0.036 (0.17)
3781	25.1	1	9.1	0.294 (0.34)
3791	23.9	1	6.3	0.025 (0.04)

Source: Statistics Canada, special tabulations.
a. Significant means 0.20 or greater. Industry value added and number of establishments refers to plants which remain after criteria 1 to 7 have been applied.
b. From equation 4.19. For plants D1 = 1, coefficient is d_1, for D2 = 1, d_2 and D3 = 1, d_3.
c. Significant at .01.
d. Significant at .05.
e. Significant at .10.

The chapter also attempted to advance our understanding of the way in which the number of products, or product diversity, per plant impacts on output. In this connection the important issue is whether as the plant increases the number of products it produces, other things equal, this will result in positive or negative agglomeration economies which offset or reinforce the impact of reduced product line economies, since output is held constant. Our results, although by no means conclusive, suggest that agglomeration economies are not large and are generally insufficient to offset the adverse effect on product line economies.

The final part of the chapter examined the effect of the method of the valuation of plant shipments in Canada vis-à-vis the United States. We were not able to detect any measurable bias in Canadian shipments because of valuation reporting procedures, and hence do not take the issue any further.

Chapter 5

Canada/U.S. Productivity: *Data and Measurement Problems*

Four separate data measurement problems need to be resolved before the indices of productivity discussed previously and elaborated in more detail in Chapter Six can be used. First, the U.S. method of valuing final output differs from the Canadian in a way that may bias U.S. value added upwards relative to Canadian value added. Second, to the extent that Canadian firms price up to the tariff, Canadian value added is biased upward and needs to be reduced vis-à-vis the United States. Third, U.S. firms tend to use outside services to a greater extent than Canadian firms, biasing measured or census value added upwards in the United States vis-à-vis Canada. Fourth, there is the question of the appropriate choice of a measure of capital stock, given the differing approaches in the United States and Canada. The first three problems relate to defining value added correctly; these are discussed in the second section of this chapter. The issue of the most appropriate capital stock is discussed at some length in the third section. The final section presents a brief summary and conclusion.

Defining Canada/U.S. Value Added

Introduction

In the introduction to this chapter three potentially serious problems in comparing Canadian and U.S. value added were outlined. The first, concerning differences in sales valuation procedures between the two countries, was addressed in Chapter Four. The results showed that our data do not reveal enough about valuation procedures to warrant corrections at this juncture. Hence, in this section we concentrate on correcting Canada/U.S. value added for differences in prices and purchased services and we show, on a 2-digit industry basis, the impact of the various corrections on Canada/U.S. value added.

Correcting Output Comparisons for Differences in Prices

In deriving the total factor productivity measure, we compare value added in Canada and the United States. The relative dollar values may differ because prices in the two countries are not the same. Therefore, a correction is required for different price levels. Three separate methods are available.

We can assume that Canadian firms essentially use the U.S. price expressed in Canadian dollars. In this case, the measure of relative labour productivity would be

$$\text{RELVA1} = \frac{V_c}{V_u} \bullet \frac{1}{E}, \tag{5.1}$$

where V_c = value added per manhour in the Canadian industry; V_u is value added per manhour in the corresponding U.S. industry; and E is the exchange rate.

RELVA1 can easily be estimated from available data and has an intuitive appeal as an indicator, on average, of the level of output and hence income at the command of individual Canadians compared with their U.S. counterparts. Unfortunately, RELVA1 implicitly assumes that U.S. and Canadian prices are the same for a given bundle of goods and services, given exchange rate adjustments. Previous investigators have not found the assumption of equal prices to be correct (e.g., Frank, 1977; West, 1971).

In order to allow for different price levels, it can be assumed that Canadian firms price just up to the U.S. price, expressed in Canadian dollars, plus the tariff. In a number of studies, including Caves et al. (1980) and Saunders (1980), it is assumed that because the Canadian market is relatively small compared to that of the United States, with conditions of oligopolistic interdependence fairly widespread and a weak competition law, Canadian producers price up to the tariff. This is also the tariff pricing model of Eastman and Stykolt (1967). Using this approach to pricing and following Saunders (1980) yields the following measure of relative labour productivity:

$$\text{RELVA2} = \frac{e_c}{e_u} = \frac{V_c}{V_u}(1 - \text{ERP})\frac{1}{E}, \tag{5.2}$$

where V_c, V_u and E are defined as above; e_c is physical net output per manhour in Canada; e_u is physical net output per manhour in the corresponding U.S. industry; and ERP = effective rate of protection.

RELVA2 is relative physical output or value added per manhour because of the use of the term (1 – ERP).[1] RELVA2, like RELVA1, can be estimated for a large sample of industries. However, RELVA2 does incorporate the strong assumption that firms price up to the tariff.

Instead, it may be more accurate to presume that firms follow no set pattern in their pricing strategies. Actual prices in the United States (P_u) and in Canada (P_c) could be collected and the resulting price relations used to deflate relative value added. This approach, because of the data problems involved in carefully matching inputs and outputs of an industry across two countries, has only been conducted for a few industries — West (1971) for the early 1960s for 30 industries and Frank (1977) for the early 1970s for 33 industries. The measure of relative productivity produced by this method is:

$$\text{RELVA3} = \frac{e_c}{e_u} = \frac{V_c^*}{V_u} \tag{5.3}$$

where V_c^* is $(VS_c.P_u/P_c - CMAT_c.P_u/P_c - CFE_c.P_u/P_c)/MHRS_c$; VS is industry total activity value of shipments; CMAT is industry total activity cost of materials; CFE is industry total cost of fuel and electricity; MHRS is industry manhours worked, expressed as production and related manhour equivalent, P_u/P_c = is the U.S./Canada price ratio relevant to VS_c, $CMAT_c$ and CFE_c; and the remaining variables are as discussed above. VS, CMAT and CFE each consist of a number of subcomponents, for which separate price ratios can be calculated. In aggregating to get a price ratio for each of these three categories, either U.S. or Canadian weights for these components can be used.[2]

The use of RELVA3 provides the most accurate relative productivity estimate but is only practicable if considerable resources are devoted to a careful comparison of the U.S. and Canadian census of manufacturers. This is reflected in the small number of industries for which the third approach has been utilized — 33 by Frank (1977) and 30 by West (1971). In the present study it was considered that such an exercise, using 167 4-digit industries, was not practicable. Instead, resort is made to RELVA2.

Although we cannot derive RELVA3 for our entire sample, it nevertheless is possible to compare, for Frank's (1977) sample of 33 industries, the results of using RELVA1 or RELVA2 rather than RELVA3 to estimate relative Canada/U.S. productivity. To the extent that the results are similar, we can place confidence in our findings based on RELVA2 across the entire 167-industry sample.

Table 5-1 presents the three measures of relative productivity for 29 of the 33 industries in Frank's sample. Several points should be noted in interpreting the table. First, based on our earlier work (Baldwin and Gorecki, 1983a), we did not think that the Canadian and U.S. industry definitions were comparable for four of Frank's industries.[3] Second, in several instances Frank combined several 4-digit Canadian manufactur-

TABLE 5-1 Alternative Measures of Relative Labour (Manhour) Productivity, Canada/U.S., for the Early 1970s for 29 Canadian Industries

	RELVA1[b]	RELVA2		RELVA3[e]		
Industry Name and Number[a]	(1)	Using Simple Effective Protection[c] (2)	Using More Comprehensive Measure of Protection[d] (3)	Canadian Weights (4)	U.S. Weights (5)	Average of U.S. & Canadian Weighted Measures (6)
1 Slaughtering & Meat Packing	0.9312	0.8183	0.8428	0.9321	1.1496	1.0408
2 Dairy Products	0.6128	0.4891	0.4457	0.3713	0.3842	0.3778
3 Fish Products	0.6522	0.5247	0.6127	0.9422	0.6227	0.7825
4 Fruit & Vegetable Processing	0.6554	0.5958	0.6091	0.6590	0.7267	0.6929
5 Biscuit Manufacturing	0.5005	0.4829	0.4887	0.5099	0.5003	0.5051
6 Baked Products	0.5229	0.4724	0.4785	0.6548	0.6719	0.6633
7 Soft Drinks	0.8096	0.8339	0.8426	0.7697	0.7717	0.7707
8 Breweries	0.8679	0.5918	0.5990	0.6505	0.6043	0.6274
9 Confectionary Products	0.5852	0.5516	0.5571	0.5157	0.4851	0.5004
10 Cotton Yarn & Cloth Mills	0.9130	0.7043	0.7276	0.3049	0.4091	0.3570
11 Woollen Textile Mills	0.6725	0.4731	0.4920	0.7801	0.7808	0.7804
13 Hosiery Mills	0.7456	0.5235	0.5303	0.7922	0.7560	0.7741
14 Other Knitting Mills	0.6405	0.3261	0.3386	0.6911	0.6942	0.6926
16 Pulp & Paper Mills	0.7475	0.6387	0.7260	0.7887	0.6540	0.7214
17 Paper Bag & Box Mfg	0.7400	0.5928	0.5986	0.5694	0.5418	0.5556
18 Other Paper Converters	0.6166	0.5249	0.5393	0.5234	0.5047	0.5141
19 Petroleum Refining	0.8776	0.4793	0.4930	0.3551	0.4690	0.4121
20 Paint & Varnish	0.7082	0.5580	0.5635	0.4950	0.4987	0.4968
21 Soap & Cleaning Products	0.5546	0.4630	0.4678	0.4467	0.5026	0.4746
22 Tobacco Products Mfg.	0.6360	0.0553	0.1259	−0.2959	−0.3993	−0.3476
24 Veneer & Plywood Mills	0.6232	0.4715	0.5200	0.7015	0.7057	0.7036
26 Iron & Steel Mills, Steel Pipe & Tube	0.8782	0.7819	0.8028	0.9660	1.0653	1.0156
27 Iron Foundries	0.7154	0.6454	0.6563	0.6320	0.6844	0.6582

28 Non-ferrous Metal Smelting, etc.	0.6092	0.5896	0.6056	0.7435	0.6457	0.6946
29 Fabricated Structural Metals	0.9760	0.8917	0.9038	0.5514	0.4940	0.5227
30 Motor Vehicle Parts & Accessories	0.6880	0.6990	0.7316	0.6072	0.6535	0.6303
31 Truck & Bus Bodies	0.7409	0.6164	0.6616	0.5223	0.3843	0.4533
32 Heating & Air Conditioning	0.6822	0.5651	0.5889	0.5876	0.5273	0.5574
33 Major Appliance Mfg.	0.5350	0.4632	0.4772	0.4982	0.5386	0.5184
			Average (Standard Deviation)			
All Industries	0.7047	0.5663	0.5871	0.5954	0.5871	0.5912
	(0.128)	(0.162)	(0.160)	(0.241)	(0.259)	(0.245)
28 Industry Set[f]	0.7072	0.5846	0.6036	0.6272	0.6493	0.6520
	(0.130)	(0.131)	(0.136)	(0.172)	(0.190)	(0.180)
27 Industry Set[g]	0.6996	0.5801	0.5990	0.6391	0.6303	0.6347
	(0.126)	(0.131)	(0.137)	(0.163)	(0.178)	(0.164)
25 Industry Set[h]	0.7053	0.5925	0.6118	0.6417	0.6327	0.6372
	(0.129)	(0.125)	(0.131)	(0.168)	(0.183)	(0.168)

Source: Statistics Canada, special tabulations and Frank (1977, Table 6, pp. 49–53).

a. The 4-digit Canadian SIC industries corresponding to each industry are as follows, with the industry number following, in parentheses, with the 4-digit SIC: 1 (1011); 2 (1040); 3 (1020); 4 (1031, 1032); 5 (1071); 6 (1072); 7 (1091); 8 (1093); 9 (1081); 10 (1810); 11 (1820); 13 (2310); 14 (2391, 2392); 16 (2710); 17 (2731, 2732, 2733); 18 (2740); 19 (3651, 3652); 20 (3750); 21 (3760); 22 (1510, 1530); 24 (2520); 26 (2910, 2920, 3050); 27 (2940); 28 (2950, 2960, 2970, 2980); 29 (3020); 30 (3230, 3250); 31 (3241, 3242, 3243); 32 (3070, 3160); and 33 (3320). We should like to thank P. Opryszez of the Conference Board in Canada for providing these matching industry definitions for Frank's (1977) industries.

b. RELVA1 = VMHRS70/(VMHRS72 * 0.9905) * PR70), where: VMHRS70 is value added per manhour in Canada for 1970; VMHRS72 is value added per manhour in the U.S., expressed in U.S. dollars, for 1972; 0.9905 is the exchange rate used to convert 1972 U.S. dollars to 1972 Canadian dollars; PR70 is a gross output price index used to convert value added in 1972 prices to 1970 prices.

c. RELVA2 = RELVA1(1-SERP) where SERP is a simple measure of effective protection.

d. RELVA2 = RELVA1(1-ERP) where ERP is measure of effective protection that allows for subsidies, indirect taxes and exports.

e. RELVA3 = [(VS70 • Pu/Pc − CMAT70 • Pu/Pc − CFE70 • Pu/Pc)/NWS72]/VMHRS72 where: VS70, CMAT70, and CFE70 are, respectively, value of shipments, cost of material, and cost of fuel and electricity for 1970 but expressed in 1972 dollars using a gross output price index for VS, and an input price index for CMAT and CFE; Pu/Pc is the price ratio derived from Frank (1977, Table 6, pp. 49–53) where Pu/Pc is a separate price index for VS, CMAT and CFE; NWS70 is the number of wage and salary earners in 1970; and VMHRS72 is as defined in b. RELVA3 is defined in three ways depending on whether the price ratios Pu/Pc are derived from Canadian or U.S. weights, as published in Frank (1977, Table 6, pp. 49–53).

f. Excludes Tobacco Products Mfg.

g. Excludes Tobacco Products Mfg. and Cotton Yarn & Cloth Mills.

h. Excludes Tobacco Products Mfg., Cotton Yarn & Cloth Mills, Other Knitting Mills and Other Paper Converters.

ing industries.[4] We followed this procedure. Each relative productivity index was estimated separately for the constituent 4-digit industries and then a weighted average was estimated using total industry employees as weights. Third, the Frank data on relative Canada/U.S. prices and the U.S. value added data are for 1972, while the Canadian value added data are for 1970. In order to ensure comparability, the 1972 U.S. data are converted to Canadian dollars for that year and then, using price indices, to 1970 Canadian dollars.[5] Fourth, RELVA2 is estimated using a simple effective tariff protection variable and a more comprehensive measure that allows for exports, indirect taxes and subsidies. Fifth and finally, RELVA3 is estimated in three ways, using Frank (1977, Table 6, pp. 49–53) with a relative Canada/U.S. price index estimated with Canadian quantity weights, U.S. quantity weights, and the average of the two.

Table 5-1 presents the estimated values of RELVA1, RELVA2, and RELVA3 for each of 29 industries, together with the mean level of each of these indices of relative Canada/U.S. productivity for the whole sample and three sub-samples. The sub-samples are selected as follows. For Tobacco Products, one of its two 4-digit constituent industries has an effective rate of protection greater than unity (using either of the effective tariff rates defined above), leading to the nonsensical conclusion that Canada's output per employee is negative when estimating RELVA2 for this industry component of Tobacco Products Mfg. Therefore we exclude this industry in the first subset (28 industries). Second, for RELVA3 we compared the results in column (4) of Table 5-1, which uses industry data collected for this study together with the price ratios from Frank, with Frank's own estimates of relative Canada/U.S. productivity (1977, Table 7, pp. 56–60). Some differences are to be expected because of different ways of combining sub-industries and different years for Canada (1970 vs. 1972). Nevertheless, if the estimate in Table 5-1, column 4 was outside a range of 0.50 plus or minus Frank's (1977, Table 7, using Canadian prices), then it was concluded that the Canada/U.S. price ratios generated by Frank could not be applied to the data available to us. This resulted in the exclusion of Cotton Yarn and Cloth Mills and Tobacco Products Mfg. for the second subset (27 industries). Finally, in our regression analysis in Chapter Six we do not consider industries of a miscellaneous nature, so we estimate the means excluding the industries mentioned above plus Other Knitting Mills and Other Paper Converters in the third subset (25 industries). Hence, at the bottom of Table 5.1 there are means, together with their respective standard deviations, for four different industry sets.

Table 5-1 shows that RELVA2 is less than RELVA1, which was to be expected since effective tariffs are usually positive and less than unity. In the case of Soft Drinks and Motor Vehicles, Parts and Accessories, effective tariffs are negative and RELVA2 exceeds RELVA1. The case of

Tobacco Products Mfg. has already been mentioned. The difference between RELVA1 and RELVA2 across the whole sample suggests that accounting for differences in U.S./Canada prices using the tariff mark-up assumption substantially reduces the estimates of Canada/U.S. productivity. Furthermore use of the simple effective tariff protection rate, which assumes somewhat unrealistically that firms are able to price up to the tariff on all of their exports, probably imparts an excessive downward bias compared to RELVA2 estimated using the more comprehensive effective protection measure, which does not make this assumption (column 2 vs. column 3). This difference is particularly dramatic for Fish Products and Pulp and Paper Mills. Hence the pricing issue is one that demands serious attention, and if RELVA2 is to be used it would appear that taking exports into account yields more sensible answers.

We now turn to a comparison of the results involving RELVA3 with the other measures of relative productivity in Table 5-1. Overall, the mean level of RELVA3 tends to be somewhat above RELVA2 but below RELVA1. This is not surprising since in not all instances will firms be able to price up to the tariff, so that RELVA2 somewhat underestimates Canada's productivity relative to the United States — by somewhere between 2 to 4 percentage points. However, RELVA3 is much closer to RELVA2 than RELVA1.

In order to see whether RELVA2 is a good predictor, on average, of RELVA3, the following equation was estimated:

$$\text{RELVA3} = \underset{(0.64)}{1.032}\ \text{RELVA2} \tag{5.4}$$

where RELVA3 is measured using Canadian weights and RELVA2 using the more comprehensive method of estimating effective tariffs. The equation is estimated without an intercept, and the t-value is that which tests to see whether the coefficient on RELVA2 is statistically significant from unity. The estimates are derived from the 25-industry sample used in Table 5-1. The analogous equation estimated for RELVA3 and RELVA1 reveals a different result:

$$\text{RELVA3} = \underset{(2.20)}{0.893}\ \text{RELVA1} \tag{5.5}$$

where all the terms are as before except RELVA1. Since the coefficient in equation (5.4) is not significantly different from unity, in contrast to equation (5.5) where the contrary result is found, and the correlation between RELVA3 and RELVA2 is significant, whereas this is not the case for the correlation between RELVA3 and RELVA1, we conclude RELVA2 is a much better proxy for RELVA3 than RELVA1; RELVA1 systematically overstates Canadian productivity relative to the United States.[6]

Examination of Table 5-1 shows that although RELVA2 and RELVA3

TABLE 5-2 Correlation Between Various Measures of Relative Labour (Manhour) Productivity, Canada/U.S., for 25 Canadian Industries, early 1970s

	RELVA2[a]		RELVA3[a]		
	Simple Protection (1)	Comprehensive Protection (2)	Canadian Weights (3)	U.S. Weights (4)	Average (5)
(1)	1.0000	0.9794 [a] (0.9408)[a]	0.4059[b] (0.3677)[c]	0.4602[b] (0.2562)	0.4529[b] (0.3092)
(2)		1.0000	0.4960[b] (0.5208)[a]	0.4802[b] (0.3515)[c]	0.5088[a] (0.4646)[b]
(3)			1.0000	0.8381[a] (0.8562)[a]	0.9549[a] (0.9754)[a]
(4)				1.0000	0.9623[a] (0.9185)[a]
(5)					1.0000

Source: Frank (1977) and Statistics Canada, special tabulations.

Notes: The correlation coefficients of RELVA1 with columns (1) to (5) are as follows: 0.7403[a] (0.7123)[a]; 0.7303[a] (0.7108)[a]; 0.2925 (0.3115); 0.3736[c] (0.2269); and 0.3492[c] (0.2677). Figures in parentheses refer to the Spearman Rank Correlation Coefficient.

a. Significant at .01 level.
b. Significant at .05 level.
c. Significant at .10 level.

are quite close overall, for individual industries some variance does exist, as for example for Petroleum Refining or Veneer and Plywood Mills. Table 5-2 shows the differences in the correlation amongst the various measures of RELVA2 and RELVA3 for the 25-industry sample.

It might be noted parenthetically that the correlations, both rank and simple, tend to be higher between RELVA2 and RELVA3 when the former is estimated using the more comprehensive measure of protection (column 3 of Table 5-1) and the latter is derived using Canadian weights (column 4 of Table 5-1). In view of this, from now on, unless otherwise stated, RELVA2 will be taken to be estimated using the comprehensive tariff measure and RELVA3 to be the Canadian weighted version.

While RELVA2 is a good proxy for RELVA3 with respect to both mean and variability, the difference between the two may be systematically related to certain industry characteristics. If so, any cross-sectional study that tries to explain the inter-industry variability in relative productivity with certain industry characteristics as regressors risks having these regressions pick up the error in the proxy being used rather than true determinants of Canadian productivity disadvantage. Since such a study is the focus of Chapter Seven, it is important to ask whether there are systematic differences between RELVA2 and RELVA3 that are related to industry characteristics.

One of the major reasons for possible differences between RELVA2 and RELVA3 is that the ability of firms to price up to the tariff may vary across industries. In regressions explaining the determinants of relative productivity, this can be approached in two ways. First, in our regression analysis of Canada/U.S. productivity differences, we could include explanatory variables that try to explain inter-industry differences in RELVA2 to take into account the mismeasurement. This has been the approach of Saunders (1980), Caves et al. (1980), and others who have tackled this subject. Second, we can adjust the dependent variable directly by finding out which explanatory variables determine the size of the discrepancy between RELVA2 and RELVA3 and using this information to adjust RELVA2 in our sample set. It is to this second approach that we now turn.

Based upon earlier work of Hazledine (1980) and Saunders (1980), the relationship between P_{max}, P_c, and P_u, where P_{max} is the U.S. price expressed in Canadian dollars plus the tariff, can be modelled as follows:

$$P_c = P_u + m(P_{max} - P_u) \qquad (5.6)$$

In this equation the U.S. price places a floor on the Canadian price, with P_{max} placing a ceiling on the Canadian price ($m = 1$). If $P_{max} = P_c$ (i.e., if $m = 1$), then we can conclude that RELVA2 = RELVA3 and no adjustment is necessary to the dependent variable when we come to estimate the inter-industry differences in Canada/U.S. productivity. The proportion of the difference between P_{max} and P_u (the value of m) that is passed on to Canadian consumers is assumed to be influenced by factors such as concentration, exports and imports. Thus

$$m = f(x). \qquad (5.7)$$

Rewriting 5.6 gives

$$P_c - P_u = m\,(P_{max} - P_u) \qquad (5.8)$$

$$\frac{P_c - P_u}{P_{max} - P_u} = m \qquad (5.9)$$

$$\frac{\dfrac{P_c}{P_u} - 1}{\dfrac{P_{max}}{P_u} - 1} = m \qquad (5.10)$$

Multiplying top and bottom by Canada/U.S. value added per manhour (RELVA) yields

$$\frac{\text{RELVA3}^{-1} - \text{RELVA}}{\text{RELVA2}^{-1} - \text{RELVA}} = \text{m}. \quad (5.11)$$

We estimate the following equation:

$$\frac{\text{RELVA3}^{-1} - \text{RELVA}}{\text{RELVA2}^{-1} - \text{RELVA}} = \text{f (EXP, IMP, INTER)} \quad (5.12)$$

where EXP is exports as a proportion of industry shipments, IMP is imports as a proportion of domestic disappearance, and INTER is an interaction term, CON/IMP, where CON is the proportion of industry shipments accounted for by the leading four firms.[7] We would expect EXP to be insignificant, since both RELVA2 and RELVA3 already incorporate the effect of pricing exports at world prices. However, if Canadian firms had some monopoly power on the world market then EXP would be positive. If lower export prices are not fully accounted for in the effective tariff calculations, EXP will have a negative sign. IMP should limit the availability of Canadian producers to raise prices and hence should be negatively signed. The final term, INTER, should be positively signed. For a given level of IMP, INTER tells us what the effect of increasing concentration is upon the dependent variable — since we assume that more highly concentrated industries will be able to take advantage of any tariff protection, INTER should be positively signed. The result of estimating the above regression for the 25-industry sample in Table 5-1 is as follows:

$$(\text{RELVA3}^{-1} - \text{RELVA})/(\text{RELVA2}^{-1} - \text{RELVA}) \quad (5.13)$$

$$\begin{aligned} = \underset{(0.32)}{1.29} + \underset{(0.04)}{2.097}\ \text{INTER} + \underset{(0.67)}{2.242}\ \text{EXP} - \underset{(-0.75)}{9.230}\ \text{IMP} \end{aligned}$$

$$\bar{R}^2 = 0.1147 \quad F = 0.91 \quad DFE = 21$$

where the t-tests are two-tailed for the null hypothesis that the parameter is zero except that on the constant, where the test is whether the coefficient is different from unity. The estimated equation agrees with our a priori expectations. Neither EXP, IMP, or INTER are significantly different from zero, while m (the constant) is not significantly different from unity. Hence, it would appear that RELVA2/RELVA3 = m = 1.

We also tried a different variant that considered the effect of concentration separately as well as interactively. The estimated regression is:

$$\frac{\text{RELVA3}^{-1} - \text{RELVA}}{\text{RELVA2}^{-1} - \text{RELVA}} = \underset{(-1.61)}{-2.14} - \underset{(-1.92)}{14.228}\ \text{INTER} \quad (5.14)$$

$$+ \underset{(0.59)}{1.711}\text{EXP} + \underset{(1.84)}{6.541}\text{CON}$$

$$\bar{R}^2 = 0.2343 \quad F = 2.14 \quad DFE = 21.$$

In this formulation, the effect of concentration is exhibited to be more significant, albeit at only the 10 percent level; moreover the coefficient on INTER indicates that the effect of concentration decreases as imports increase their penetration.

These results suggest that there is no overwhelming argument in favour of making further adjustments to the tariff-adjusted measure of relative productivity (RELVA2) to include the extent to which firms price up to the tariff. This result is consistent with Caves et al. (1980, pp. 265–269) and Saunders (1980), who both included variables on the right-hand side of a regression equation explaining relative productivity, to control for pricing up to the tariff, and found such variables insignificant. Hence, we conclude that pricing up to the tariff assumption is a good approximation of actual pricing behaviour.[8] It should, however, be remembered in the subsequent analysis that concentration may catch some of the error in using RELVA2 for RELVA3. We return to this in Chapter Seven.

Our findings on the relationship of U.S. and Canadian prices can thus be summarized as follows. Assuming that Canadian producers simply price by taking the U.S. price in Canadian dollars considerably overstates Canadian productivity vis-à-vis the United States. Assuming that Canadian firms price up to the tariff provides, on average, a pretty good approximation to the actual pricing policy of Canadian firms. Nevertheless, a difference exists between individual relative productivity based on the assumption that firms price to the tariff and actual prices. An attempt was therefore made to develop a rule relating actual relative productivity (RELVA3) to that generated by assuming that firms price to the tariff (RELVA2). This was unsuccessful. Hence, RELVA2 will be used as our approximation to RELVA3.[9]

This discussion of Canada/U.S. price differences is based upon the experience in the early 1970s. For the late 1970s we have no data comparable to Frank with which to test the assumption that U.S. and Canadian prices are essentially the same except for exchange rate and tariff corrections. Given the abrupt change in the exchange rate in the late 1970s and the fact that relative Canada/U.S. product prices moved quite differently than the ratio of the implicit GDP price indices — much more so than changes in the effective tariff would suggest — we decided not to use exchange rates and tariffs to correct relative value added for the late 1970s. Instead value added for both Canada and the United States for the late 1970s was expressed in 1972 Canadian and U.S. dollars, respectively, using each country's own price deflators. The double deflation method was used to derive constant value added. Then the 1972 effective tariff rate and exchange rate were used to correct for differences in the price levels between the two countries.

Correcting for Differences in the Service Components of Value Added

A second difficulty in comparing productivity using value added concerns the measurement of value added in Canada vis-à-vis the United States. As we noted in Chapter Three, for Canada census value added is not equivalent to true value added, the former being measured as the difference between total value of production (adjusted for inventory changes) less purchased inputs of materials and fuel and electricity. This is not true value added because of the omission of purchased services. The difference between true and census value added has been summarized as follows:

> Value added for the country as a whole is often described as its gross domestic product. (Though gross domestic product is a net ouput measure in the sense just described, it is termed "gross" in respect of its inclusion of capital cost allowances.) Such a concept is also sometimes mentioned with reference to an industry, a conceptually pure measurement of its value added being implied.
>
> However, in practice the Census of Manufactures cannot at present gather a measure of "pure value added", that is, a conceptually pure measure of the value added of the manufacturing industries. This is because it has not been found practicable to collect information on purchases of services as a regular part of the annual Census. As a result the value added figure produced is often referred to as "Census value added" by way of distinction from "pure value added". That is, the only inputs deducted from gross output in obtaining Census value added data are purchased commodities or products, including energy; value added is not measured net of most purchases of services or indirect taxes (such as property taxes). Duplication of measurement of goods output is thus avoided, but this is not true of services (except that the value of custom manufacturing services, included in material inputs, is subtracted from value added, also true of some specialized services used in SIC 288, Publishing only). (Canada, Statistics Canada, 1979b, p. 36)

Hence census value added will overstate "true" or "pure" value added to the extent that services are not deducted from total value of production or gross output.

The United States defines census value added in a similar way to Canada. The relevant passage is as follows:

> The first step in the calculation of value added is the conversion of the value of shipments (including resales and miscellaneous receipts) to value of production by adding the ending inventory of finished foods and work in process inventories and subtracting the beginning inventory. The cost of materials (including materials, supplies, fuel, electric energy, cost of resales, and cost of contract work) is then subtracted from this value of production to obtain value added.
>
> Value added avoids the duplication in the value of shipments figure which

> results from the inclusion of the shipments of establishments producing materials and components, along with the shipments of establishments producing finished products. It does not exclude the cost of services purchased from other business firms, as does the concept of value added, used in the national income accounts. Nevertheless, it is considered to be the best value measure available in census data for comparing the relative economic importance of manufacturing among industries and geographic areas. (U.S., Department of Commerce, 1981, p. xxiv)

Hence it would appear appropriate to compare U.S. and Canadian census value added, since both are defined in essentially the same manner.

Despite this similarity, we decided to take the analysis a step further. Although the definition of value added may be the same, the incidence of purchased services may differ between the United States and Canada, leading to systematic differences in measured productivity.

In order to see how important U.S./Canadian differences in purchased services are, we compare the ratio of GDP (and national income) to census value added at the level of the manufacturing sector. The ratio will be less than 1 to the extent that value added includes services. Furthermore, a comparison of GDP to value added for Canada and the United States will show the extent to which value added is overstated in one country vis-à-vis the other. If the ratio is the same for both countries, no systematic bias is imparted to comparing U.S. and Canadian value added; if the Canadian ratio is lower than that in the United States, then U.S. census value added will be systematically biased downward compared to Canada; and if the Canadian ratio is larger than the U.S. ratio, then the converse applies. By beginning our examination at the level of the manufacturing sector, we see if detailed adjustments at the level of the individual industry are necessary.

Table 5-3 presents the ratio of GDP (and national income) to value added for the Canadian and U.S. manufacturing sector for the 1960s and 1970s. GDP is defined net of indirect taxes and depreciation, while national income includes depreciation. Both national income and value added include depreciation, but GDP nevertheless may provide more stability because of the problems in assigning corporate depreciation figures to individual establishments.[10] Both measures are used here, but various adjustments were needed to make GDP and national income comparable between Canada and the United States. The published U.S. GDP figure is at market prices and includes excise and indirect taxes, while the Canadian figure is at factor cost and does not. Since value added is calculated net of such taxes on final product prices, the Canadian approach is followed. Fortunately, a U.S. figure comparable to the Canadian can be derived. National income is defined for Canada as the sum of wages and salaries, corporate profits and other investment income and net income from unincorporated businesses, while for the

TABLE 5-3 A Comparison of Canadian and U.S. Value Added Coverage Ratios for the Manufacturing Sector: 1960–1979

Year	Canada GDP[a]/V.A.[e] (1)	U.S. GDP[b]/V.A.[f] (2)	Canada Domestic Income[c]/V.A.[e] (3)	U.S. Domestic Income[d]/V.A.[f] (4)
1960	—	80.2	—	74.5
1961	83.4	80.2	77.4	74.0
1962	83.4	80.7	75.7	75.0
1963	83.7	79.8	75.8	74.0
1964	83.5	79.7	76.9	74.2
1965	80.7	80.3	75.6	74.7
1966	81.2	80.2	75.9	75.0
1967	81.2	78.9	72.9	73.3
1968	81.6	79.1	73.6	73.6
1969	80.6	78.3	75.3	72.2
1970	82.2	77.6	72.7	71.0
1971	82.1	78.3	73.8	70.8
1972	82.5	77.0	75.7	70.2
1973	82.4	75.2	74.3	68.7
1974	79.9	70.6	75.1	63.6
1975	80.8	76.0	75.6	67.3
1976	83.4	75.7	78.9	67.9
1977	83.2	74.8	77.0	66.9
1978	81.3	—	75.6	—
1979	80.4	—	80.5	—

Source: Various official U.S. and Canadian statistical publications.

a. Canadian GDP at factor cost is taken from Canada, Statistics Canada (1976) *National Income and Expenditure Accounts Volume 1, The Annual Estimates 1926–1974*, Cat. no. 13–531 (Ottawa: Information Canada) and Canada, Statistics Canada *National Income and Expenditure Accounts*, Cat. no. 13–201 (various issues).

b. U.S. GDP is defined here as published GDP originating in manufacturing less indirect taxes. The sources for indirect taxes are: *Survey of Current Business*, Vol. 56, July 1976 and Vol. 58, July 1978; U.S. Department of Commerce (1966) *The National Income and Product Accounts of the United States, 1929–1965, Statistical Tables*, A Supplement to the *Survey of Current Business*, and for GDP originating in manufacturing, U.S., Department of Commerce (1981) *General Summary*, 1977 Census of Manufacturers, Subset Series (Washington, D.C.: GPO).

c. Canadian domestic income is the sum of wages and salaries, corporate profits and investment income, net income from unincorporated businesses and inventory valuation change. The data sources are the same as those in footnote a above.

d. U.S. domestic income is taken from the same sources as cited in footnote b above.

e. Canadian value added is taken from Canada, Statistics Canada, *Manufacturing Industries of Canada: National and Provincial Areas*, Cat. no. 31–203, various issues. Note total activity value added is used so that U.S. and Canadian concepts of value added match.

f. U.S. value added is taken from the last source in footnote b.

United States the published national income figure is used. It should be noted that these national income figures refer to *domestic* income, since value added refers to domestic activity. We are now in a position to evaluate and discuss the table.

Table 5-3 shows that, using either the ratio of GDP or domestic income to value added, the U.S. value of this ratio declined over the 1960s and 1970s while the Canadian value of the ratio remained relatively unchanged. Over the period 1961–69, for example, the ratio of GDP to value added averaged 0.821 for Canada and 0.797 for the United States, while for the period 1970–77 the respective values of the ratio for the two countries were 0.82 and 0.757. A similar trend is recorded if the ratio of domestic income to value added is used. Even within the 1970s, we see a growing difference between the United States and Canada. The mean ratio of GDP to value added for 1970–1972 was 0.822 for Canada and 0.776 for the United States, while for the period 1975–1977 the corresponding means were 0.825 and 0.755, respectively. Hence, from Table 5-3 we can infer that U.S. census value added will be systematically biased upward compared to Canadian value added and that this difference has grown over time. In terms of productivity analysis using value added, this implies that U.S. productivity is biased upward compared to Canada.

In order to take into account the fact that census value added does not exclude purchased services, we construct a variable, CORR, for both Canada ($CORR_c$) and the United States ($CORR_u$) which attempts to measure the purchased services. This can then be deducted from census value added to obtain true value added. This is not, however, a straightforward exercise or else we would have made these adjustments in estimating individual industry production functions in Chapter Four. Problems arise because, for both Canada and the United States, the dollar quantity of purchased services is taken from financial statistics based upon company data while census value added is based upon establishment data. Furthermore, company and establishment data are based upon somewhat different classification systems, thus resulting in some prorating to reconcile the classification systems. Hence, our definition of true value added as the difference between census value added and purchased services should be regarded as a somewhat imperfect proxy: Appendix A provides further details of the definition of $CORR_c$ and $CORR_u$, while census value added for both the United States, CVA_c and Canada, CVA_c, is defined at the beginning of this section.

In this and the previous section, we discussed the adjustments necessary to compare Canadian and U.S. value added. It was necessary to take into account different price levels and the extent to which purchased services accounted for a different percentage of value added in each country. Corrections for price differences reduce Canadian value added relative to the United States; corrections for service differentials increase it. In deriving the final corrected value added measure used in this study, we first made the correction for services and then applied the correction for price differentials. This was done because the price differential correction relied upon the effective tariff rate — which is derived from an input/output table that excludes purchased services in the calculation of value added. Hence, we define U.S. and Canadian value added, using the notation introduced in this chapter, as follows:

$$V_c = (CVA_c - CORR_c)\ (1 - ERP) \tag{5.15}$$

$$V_u = (CVA_u - CORR_u)\ E. \tag{5.16}$$

This gives us

$$RELVA4 = V_c/V_u. \tag{5.17}$$

The Impact of Various Adjustments on Canada/U.S. Value Added

The sensitivity of Canada/U.S. value added to various adjustments is presented in Table 5-4 at the 2-digit or major industry group level for 1970 and 1979. Three adjustments are made to obtain relative Canada/U.S. value added: the exchange rate corrected version (RELVA1); the exchange rate and tariff corrected version (RELVA2); and, finally, the exchange rate, tariff, and purchased services corrected version (RELVA4). These adjustments are first made to each of the 107 4-digit industries for which total factor productivity estimates are presented in Chapter Six. The table presents the mean levels of Canada/U.S. value added for all such 4-digit industries classified to a given 2-digit industry. For example, for the 15 4-digit industries classified to Food and Beverages in 1970, RELVA1 averages 0.0920. The final row refers to means and, in parentheses, standard deviations across the whole 107 4-digit industries.

The results in Table 5-4 accord with expectations, since correcting for the impact of higher prices in Canada reduced Canadian value added relative to the United States. In both 1970 and 1979, the mean value of RELVA2 as a proportion of the mean value of RELVA1 is 0.85 across the 107-industry sample. In contrast, the impact of removing purchased services, which are more important in the United States, is to increase Canadian value added relative to the United States, but not sufficiently to offset the impact of higher Canadian prices, since in both 1970 and 1979 the ratio of the mean value of RELVA4 to the mean ratio of RELVA1 is 0.92. Hence, previous researchers who only adjusted Canadian value added by the exchange rate and tariff underestimated Canadian value added relative to U.S. value added.

Table 5-4 shows that there is a substantial variation in the Canada/U.S. value added ratio and its sensitivity to the various adjustments made. However, in general RELVA2 is less than RELVA1 and RELVA4 is greater than RELVA2 but less than RELVA1. Several conspicuous exceptions stand out, however, where RELVA4 is greater than RELVA1 — Printing and Publishing, Primary Metals, Machinery, and Transportation Equipment. The reason for the discrepancy is that tariff rates in these major groups are quite low compared with the rest of the manufacturing sector (Economic Council of Canada, 1983, Table 9-2, p. 112). Thus most of the adjustment is due to purchased services. This variability suggests that adjustments need to be on an industry by industry basis, rather than using the manufacturing sector average to apply to all industries.

Choice of Capital Stock

Capital stock estimates are available either from company balance sheets (book value) or as the sum of investment flows (gross fixed capital stock). Each has its difficulties. Book value, in that it comes from company balance sheets, cannot be readily defined in other than historic dollars. The time profile of investments may thus affect the relative book value reported for the same industry in two different countries, even though no real differences exist. In addition, book value of capital assigned to an industry, which comes from taxation statistics at the company level, may be inaccurate since the total book value of a company is assigned to the industry which accounts for the largest percentage of the company's sales. The greater the level of industry disaggregation (4-digit as opposed to 2-digit), the more likely is a company to span, in a significant fashion, several industries with its output and the less precise will be the resulting capital stock estimates.

In contrast, capital stock series constructed from investment flows potentially suffer from neither an aggregation nor a pricing problem. Since investment flows are measured at the establishment level and the secondary production of an establishment (that which belongs to an industry other than that to which the establishment has been classified) is relatively less than for the company, there may be less bias due to misclassification.[11] Second, since capital stock is constructed from investment flows, price indexes can be used to provide estimates in constant dollars or in reproduction costs at any point in time.

While the constructed capital stock estimate then has certain potential advantages compared to book value, it is not without its problems. The accuracy of constructed capital stock depends upon the assumptions as to service life, mortality functions, and depreciation rates that are used in its construction. The formula for gross capital stock requires an average service life and some assumption about the rate of asset discard (the mortality function). Net stock requires in addition the specification of a depreciation function.

More importantly, from our point of view, the greatest problem with the constructed capital stock series is that it is not available at the level of

TABLE 5-4 Canada/U.S. Value Added Subject to Various Adjustments at the Industry Group Level[a], 1970 and 1979

No. of Constituent 4-Digit Industries	Industry Group	1970 Nature of Adjustment: Exchange Rate[b]	1970: Exchange Rate and Tariff[c]	1970: Exchange Rate, Tariff & Purchased Services[d]	1979 Nature of Adjustment: Exchange Rate[b]	1979: Exchange Rate and Tariff[c]	1979: Exchange Rate, Tariff & Purchased Services[d]
15	Food & Beverages (10)	0.0920	0.0774	0.0825	0.1083	0.0875	0.0936
1	Tobacco (15)	0.0909	0.0405	0.0514	0.0963	0.0430	0.0517
0	Rubber & Plastics (16)	—	—	—	—	—	—
4	Leather (17)	0.1334	0.1043	0.1128	0.1164	0.0946	0.1031
11	Textiles (18)	0.0775	0.0631	0.0667	0.0742	0.0582	0.0623
2	Knitting Mills (23)	0.0615	0.0433	0.0465	0.0779	0.0547	0.0585
5	Clothing (24)	0.1380	0.1022	0.1094	0.1694	0.1255	0.1375
6	Wood Products (25)	0.0610	0.0528	0.0557	0.1026	0.0907	0.0961
2	Furniture & Fixtures (26)	0.0494	0.0423	0.0465	0.0597	0.0511	0.0535
5	Paper & Allied Products (27)	0.1041	0.0920	0.1007	0.1322	0.1167	0.1270
1	Printing & Publishing (28)	0.0594	0.0577	0.0654	0.0799	0.0777	0.0873
3	Primary Metals (29)	0.0913	0.0868	0.0994	0.1060	0.1006	0.1140
7	Metal Fabricating (30)	0.0800	0.0720	0.0789	0.1024	0.0916	0.1000
2	Machinery (31)	0.0240	0.0248	0.0293	0.0400	0.0407	0.0490
8	Transportation Equipment (32)	0.0574	0.0556	0.0602	0.0660	0.0631	0.0675
7	Electrical Products (33)	0.0770	0.0665	0.0752	0.0718	0.0620	0.0687
9	Non-Metallic Mineral Products (35)	0.0519	0.0490	0.0537	0.0758	0.0708	0.0777
0	Petroleum & Coal Products (36)	—	—	—	—	—	—
6	Chemicals & Chemical Products (37)	0.0642	0.0579	0.0595	0.0928	0.0843	0.0936
13	Miscellaneous Manufacturing (39)	0.0498	0.0432	0.0489	0.0560	0.0488	0.0559
107	Total Manufacturing	0.0756 (0.0531)[e]	0.0645 (0.0431)[e]	0.0701 (0.0701)[e]	0.0897 (0.0668)[e]	0.0762 (0.0528)[e]	0.0833 (0.0570)[e]

Source: Statistics Canada, special tabulations.

a. The various corrections to value added are first made to the 107 4-digit industry sample for which estimates of total factor productivity are presented in Chapter Six. Then for each industry group the Canada/U.S. value added is the mean of the 4-digit industries classified to each industry goup. The number of such industries is indicated in the first column.
b. This is RELVA1 in the text.
c. This is RELVA2 in the text.
d. This is RELVA4 in the text.
e. The standard deviation of the 107-industry sample.

disaggregation we are using — the 4-digit industry. Book value, however, is available at the 3-digit level and it is this that we use. Because book value has been much maligned, it is important to evaluate its deficiencies. As already indicated, book value may suffer from a matching problem since it is derived from company, not establishment, data. The extent of the mismatch between industry statistics generated by company data with that developed from establishment data was handled in the following manner. The capital generated by the company data at the 3-digit level was apportioned to 3-digit industry definitions in the same proportion that the values of wages, salaries and materials from the company statistics bore to the same variables, industry by industry, derived from establishment data.[12] In those cases where the apportioning factor so defined indicated a gross mismatch, in particular Petroleum Refining and Pulp and Paper, we excluded the industry altogether from our final comparison.

While this approach was intended to handle the "aggregation" problem, we still need to ask whether the use of book value introduces other major distortions. It is not a constant dollar measure. It may suffer from substantial differences in accounting conventions. On the other hand, to the extent that accounting conventions are not whimsical and reflect, on average, the real value of capital stock, ratios of book value of capital in Canada to those in the United States may be accurate measures of relative capital employed in the two countries. Ultimately the issue then is an empirical one which we address by asking how Canada/U.S. book value ratios for the manufacturing sector differ from ratios of capital stock constructed from investment flows.

In a cross-country comparison, it is essential that the assumptions leading to a capital stock estimate be the same. Unfortunately, the published fixed capital stock estimates for Canada[13] and for the United States[14] derived from investment flows do not use the same assumptions (see Blades, 1983). Therefore we had the Canadian estimates recalculated with a similar set of assumptions to those used in the United States.[15] For this purpose, we used Blades' information on the assumptions of capital stock estimates of the U.S. Bureau of Economic Analysis as to service lives. The mortality function used was a truncated bell-shape (normal) with the truncation occurring at 45 and 155 percent of average service lives (see Koumanakos, 1980). This is similar to the U.S. mortality function used by BEA, which is a Winfrey (a bell-shape) that truncates at 45 and 155 percent of the average service life (see U.S. Department of Commerce, Bureau of Economic Analysis, 1982, p. T-15).

In Table 5-5, we present the Canadian end-year gross capital stock estimates, using the aforementioned assumptions to ensure Canada/U.S. comparability, for machinery and equipment, for structures, and for the sum of these two. In Table 5-6 we present the ratio of Canada/U.S. gross fixed capital stock in each of these categories. During the

TABLE 5-5 End-of-Year Gross Capital Stock[a], Canada and U.S. Manufacturing Sector, 1961–1979

	Machinery & Equipment		Structures & Engineering Const.		Total	
	Canada	U.S.	Canada	U.S.	Canada	U.S.
			(expressed in $ 1972[b])			
1961	12,957.0	138,117	9,934.4	129,619	22,891.4	267,736
1962	13,442.9	140,610	10,258.9	131,674	23,701.8	272,284
1963	13,928.4	143,936	10,566.2	133,758	24,494.6	277,694
1964	14,699.2	149,208	10,980.7	135,524	25,679.9	284,731
1965	15,691.8	157,324	11,584.6	138,688	27,276.4	296,012
1966	16,984.5	168,035	12,370.6	143,314	29,355.1	311,349
1967	18,013.0	178,939	12,970.9	148,356	30,983.9	327,295
1968	18,678.2	187,590	13,540.3	152,073	32,218.5	339,663
1969	19,525.9	196,645	14,190.0	156,073	33,715.9	352,718
1970	20,648.7	204,447	15,035.6	159,141	35,684.3	363,588
1971	21,565.8	210,068	15,652.2	160,699	37,218.0	370,767
1972	22,378.3	218,190	16,164.8	161,917	38,543.1	380,108
1973	23,514.2	227,778	16,752.4	163,566	40,266.6	391,344
1974	24,919.2	241,452	17,545.3	166,233	42,464.5	407,685
1975	26,196.3	253,032	18,309.1	167,076	44,505.4	420,108
1976	27,301.2	265,400	18,873.7	168,189	46,174.9	433,590
1977	28,335.2	281,043	19,483.7	169,725	47,818.9	450,768
1978	29,158.9	298,034	19,944.7	171,309	49,103.6	469,343
1979	30,196.3	317,274	20,335.0	172,812	50,531.3	490,087

Source: Canada, Statistics Canada, special tabulations and U.S., Department of Commerce, Bureau of Economic Analysis (1982).

a. See text for assumptions made so that Canadian and U.S. capital stocks are comparable.

b. U.S. and Canadian capital stock numbers are expressed in 1972 dollars in their respective currencies. The units are in millions of dollars.

period 1961–1979, there has been a slow but inexorable growth of about two percentage points in the ratio of total Canada/U.S. capital stock. Much of this comes from the increase in the structures component. If capital equipment alone is compared, there is much less of an increase. The average Canada/U.S. ratio over the period 1961–69 is 9.83 percent; for 1970–79, it is only 10.13 percent, and the latter increase is probably really less than .40 percentage points. The federal excise tax of 12 percent was removed in 1967. The price index used to deflate the investment series does not appear to reflect this, while the investment series probably includes excise taxes.

In Table 5-7, we compare the Canada/U.S. ratios of book value of capital to the ratios of gross fixed capital investment built up from investment flows.[16] It is apparent that the book value ratio tracks the fixed capital ratios relatively well in the 1960s but it falls about a percentage point below the latter by the late 1970s. There may therefore be a downward bias to our TFP measures imparted by our use of book values.

TABLE 5-6 Ratio of Canada/U.S. Gross Fixed Capital Stock,[a] Manufacturing Sector, 1961–1979

	Machinery & Equipment	Structures & Engineering Construction	Total
1961	9.38	7.66	8.55
1962	9.56	7.79	8.70
1963	9.68	7.90	8.82
1964	9.85	8.10	9.02
1965	9.97	8.35	9.21
1966	10.11	8.63	9.43
1967	10.07	8.74	9.47
1968	9.96	8.90	9.49
1969	9.93	9.09	9.56
1970	10.10	9.45	9.81
1971	10.27	9.74	10.04
1972	10.26	9.98	10.14
1973	10.32	10.24	10.29
1974	10.32	10.55	10.42
1975	10.35	10.96	10.59
1976	10.29	11.22	10.65
1977	10.08	11.48	10.61
1978	9.78	11.64	10.46
1979	9.52	11.77	10.31

Source: See Table 5-5.
a. Since the Canada/U.S. exchange rate was essentially at par in 1972 (0.9997) these ratios use the raw numbers in Table 5-4, unadjusted, to estimate these ratios.

However, if we compared the book value ratio to the machinery and equipment fixed capital stock ratio, there is much less of a difference. Thus the extent of the bias from using book value depends upon the extent to which the trend in the structures component presented in Table 5-5 is correct. Since there is considerable leeway in allocating construction expenditure between new investment and repairs, it may be that there is a difference in the practice followed in the two countries that yields higher structures capital stock in Canada.

In order to evaluate the magnitude of the possible bias from using book value, we provide in Table 5-8 five-year averages of the relative capital stock measures, the relative employment in the manufacturing sector, and the relative capital/labour ratios using each of the two measures of capital. Since the relative gross fixed capital stock measure does not take into account the absolute price differences between the countries, we correct this measure by assuming that the imported and non-imported machinery and equipment prices reflected the average tariff in machinery and equipment of about 6 percent in the seventies[17] — an assumption whose applicability for a subset of industries was tested earlier in this chapter. The Canada/U.S. ratio of gross book capital value

TABLE 5-7 Comparison of Canada/U.S. Capital Stock Estimated from Gross Book Value and Gross Fixed Capital Stock, Manufacturing Sector, 1961–1979

Year (1)	Ratio of Gross Book Value Canada/U.S. (2)	Ratio of Gross Fixed Capital Canada/U.S. (3)
1961	8.78	8.55
1962	8.74	8.70
1963	8.90	8.82
1964	9.47	9.02
1965	9.78	9.21
1966	9.81	9.43
1967	10.25	9.47
1968	9.29	9.49
1969	8.94	9.56
1970	9.24	9.81
1971	9.25	10.04
1972	9.34	10.14
1973	9.24	10.29
1974	9.53	10.42
1975	9.70	10.59
1976	9.80	10.65
1977	9.62	10.61
1978	9.57	10.46
1979	9.33	10.31

Source: Canada, Statistics Canada, *Corporation Financial Statistics*, Cat. no. 61–201 various issues (1965–1979); Canada, Department of National Revenue, *Taxation Statistics* various issues (1961–1964); U.S., Department of the Treasury, Internal Revenue Service, Statistics of Income Division, *Corporation Source Book of Statistics of Income*, various issues.

in the manufacturing sector between 1971 and 1975 was 9.41 percent; the comparable estimated ratio for gross fixed capital was 9.68 percent. For the period 1976–79, the respective ratios were 9.58 percent and 9.88 percent respectively. If instead we had compared relative Canada/U.S. capital/labour ratios (using total employees for labour), the book-value capital/labour ratio would average 1.046 between 1971–75 and the gross fixed capital/labour ratio would average 1.075. For the period 1976–79, the two ratios averaged 1.079 and 1.113 respectively. We conclude that, at least for our purposes, the use of book-value rather than gross fixed capital stock will have little effect on our conclusions.[18]

Even though book values of capital from the Internal Revenue Service for the United States and Corporation Financial Statistics for Canada[19] are selected as the estimates of capital stock, other problems still remain unresolved. In particular, a decision has to be made as to whether gross or net capital stock is used. The capital concept selected should be

TABLE 5-8 Comparison of Canada/U.S. Capital Stock, Estimated from Gross Book Value and Gross Fixed Capital Stock, and Relative Capital Stock Employment Ratios (K/L), Manufacturing Sector, Five-Year Averages, 1961–1979

	Ratio of Book Value of Capital Canada/U.S.	Ratio of Gross Fixed Capital Canada/U.S.	Ratio of Total Employees Canada/U.S.	Relative K/L Ratios Using Book Value Canada/U.S.	Relative K/L Ratios Using Gross Fixed Capital Canada/U.S.
1961–65	9.13	8.86	8.46	1.079	1.047
1966–70	9.51	9.55	8.54	1.114	1.118
1971–75	9.41	10.30 (9.68)[a]	9.00	1.046	1.144 (1.075)[a]
1976–79	9.58	10.51 (9.88)[a]	8.88	1.079	1.184 (1.113)[a]

Source: Tables 5-5 to 5-7 and various U.S. and Canadian Census of Manufacturers publications to derive employment in manufacturing.

a. Corrected for Canada/U.S. price differences assuming a price difference equal to the average tariff rate of 6 percent on machinery and equipment in the early 1970s. (See Economic Council of Canada, 1983, Table 9-2, p. 112). Hence the figure in parentheses is 0.94 of the figure immediately to the left.

proportional to the flow of services yielded by the stock of machinery and buildings, etc., that is available to be drawn upon in the production of goods. In discussing whether the gross or net concept is most suitable for this purpose, West (1971, p. 77) has noted:

> The valuation of assets from taxation statistics is at original cost, i.e., all existing assets valued in terms of prices when they entered stock. The stock estimate was also left gross with no attempt made to subtract capital consumption allowances based on these original cost valuations. By avoiding these deductions, possible differences between the two countries in the tax treatment of depreciation do not affect the capital stock estimate.

In view of West's comments, we decided to use the gross rather than net capital stock estimates.

In our discussion of V_c and V_u, we went to considerable lengths to take into account the possibility that Canadian and U.S. prices might differ even after taking into account the exchange rate. This was solved by assuming that Canadian output is priced up to the tariff. In the case of capital stocks we have a problem, since the appropriate price adjustment should be a weighted average depending upon when the various pieces of equipment and machinery that make up the capital stock were purchased.[20] The evidence suggests that the size of such price adjustments has fallen over time.[21] In particular under the Machinery program introduced in 1968, machinery and equipment of a class and kind not made in Canada has entered duty free.[22] Daly et al. (1968, p. 33) claim that "The Canadian reductions of duty on machines were effective January 1, 1968, with an undertaking that the average level of Most Favoured Nations' duties (net of remissions) will not exceed 9 percent." This is consistent with the average nominal tariff paid for the 2-digit industry Machinery. For the years 1966, 1970, 1975 and 1978, the average tariff rate paid was 8.3, 6.9, 5.9, and 5.9, respectively.[23] Hence one option would be to apply these nominal tariff rates to our capital stock estimates for 1970 and 1979, in addition to the exchange rate adjustment.

Such an adjustment assumes that on average domestic production is priced up to the tariff. Domestic production cannot be ignored, since imports as a percentage of domestic machinery was 58.1 in 1970, 65.7 in 1975 and 68.0 in 1979.[24] While such a pricing assumption is reasonable in most industries, there is reason to believe it is particularly inappropriate in the machinery and equipment industry. Pricing up to the tariff behaviour must be predicated upon there being a well-defined foreign price to which a tariff can be added. In the case of made-to-order equipment, it is not clear that a Canadian manufacturer has the degree of certainty about the tender value of a foreign manufacturer that would allow him to adopt such behaviour.

Previous studies have largely ignored the capital valuation problem. Caves et al. (1980, p. 261) and Saunders (1980) have argued that the industry being studied is an exception (Connidis, 1978, p. 236), or have claimed that for trends over time such considerations are irrelevant (Frank, 1977, p. 69). Only in the case of West (1971, pp. 80–82) were adjustments made to the capital stock data to take price differences into account. West, however, was writing of the early 1960s and dealt with a small sample of industries. Nevertheless, his results assuming exchange rate, tariff and sales tax corrections are instructive.[25] They show that if Canadian equipment was priced up to the duty-paid cost on average, the price of capital would have been 8 percent higher in Canada than in the United States (West, 1971, p. 79).[26] However, West was unable to construct a weighted average but took current year rates of duties in the early 1960s on imports of machinery and equipment to a particular industry.

Because of the difficulties inherent in valuing price differentials in capital stock, we adopted a conservative approach. That is, we adopted a methodology which we believe biases the value of the Canadian capital stock upward. In the end, we chose to make only an exchange rate correction to place the U.S. capital stock in Canadian dollars. The exchange rate was 0.99 \$Can./U.S. in 1972. This is below the long run (twelve year) average which is about 1.04 \$Can./U.S., when exchange rates are weighted by the percentage of total investment in machinery and equipment made in that year. Since the TPF formula uses relative Canadian/U.S. capital/labour ratios multiplied by a negative coefficient, this biases our TFP measure downward.

Since we are comparing different years in Canada and the United States, we also require a correction for changes in the price level. We do so by using the input price index, INPINX (see Appendix A for further details). This presumes that gross book value is revalued over time to take account of rising prices. How accurate such an assumption might be has received little attention. Our mean Canada/U.S. capital/labour ratio for the early 1970s was 1.09; for the late 1970s it was 1.06. If gross book value per employee is calculated for Canada and the United States for each year in the 1970s from published data, the mean of these ratios is 1.06. We believe, therefore, that our correction yields sensible results on average.

The problem of defining the stock of capital is only the first of a two-part problem. The second concerns the estimation of the flow of services from such a stock. Unfortunately, flow of services data are not available on an industry-by-industry basis. Hence, resort to proxies is necessary. One obvious alternative is to use the rate of return to capital, which in the absence of rents and capital market distortions should equal the rental rate of capital. This approach has been used by Caves et al. (1980, p. 281) and Griliches and Ringstad (1971, pp. 24–27).

We do not follow this approach. Our total factor productivity measures all involve the capital/labour ratios of Canada relative to the

United States. We should like $(r_i K_c/L_c)/(r_j K_u/L_u)$ where r_i and r_j are the rates of return (or rate of flow) yielded by the gross capital stock in each of Canada and the United States respectively. While r_i and r_j probably differ industry by industry, in our view capital is sufficiently mobile (even when found with FIRA-type restrictions) that they should be similar for the same matched industries. As such they cancel out or nearly so, and the ratio of the gross stocks is all that needs to be included.

Summary and Conclusion

A comparison of U.S. and Canadian productivity is plagued by a number of important measurement difficulties that need to be addressed. In this chapter we have discussed several of these problems, including some which were recognized by previous researchers but also others which have been largely ignored. The problems of differing prices between the two countries was resolved by assuming that Canadian firms priced up to the tariff. Since census value added does not remove purchased services and their importance differs between Canada and the United States, such services were deducted from census value added. Finally, gross book value of capital stock was used as the indicator of capital stock. While we have made some progress in resolving the various problems, there is clearly room for more data development.

Chapter 6

Canada/U.S. Productivity: *Alternative Measures and Empirical Results*

Productivity ultimately is of interest because of its association with efficiency and the viability of the manufacturing sector. Various indices have been suggested to measure the concept of productivity. In this chapter, we discuss these indices and the one adopted here. We then apply the measures to Canadian and U.S. data for the early and late 1970s, after first considering the problems of matching Canadian and U.S. concepts and variable definitions. The chapter concludes with a brief summary and conclusion.

Measures of Canada/U.S. Productivity

In this section we consider two sets of measures of Canada/U.S. relative productivity. The first set is concerned with measures which use the aggregate production function. Hence the relative productivity indices are defined in terms of industry aggregates such as capital, labour and value added. However, if the production function is estimated from establishment data for individual industries, the appropriate total factor productivity measure must be derived from such a micro production function. Such an exercise is undertaken later in this chapter and the derived measure of relative Canada/U.S. productivity is compared with the indices presented below.

Total Factor Productivity Using an Aggregate Production Function

In this study, we use a total factor productivity measure that is associated with the Cobb-Douglas production function at the industry level. It is the same as the commonly used Tornqvist approximation of the translog TFP measure using Divisia input and output indices (see Cowing et al., 1981, p. 164), where the factor shares we use are those yielded by the factor elasticities derived from the Cobb-Douglas production function estimated for individual Canadian manufacturing industries.

We have chosen to use the Cobb-Douglas characterization of the production function to derive our total factor productivity index for reasons already discussed in Chapter Four. To briefly reiterate, this function would appear to capture the information provided by the data set on economies of scale. Moving to the more general translog function at the level of aggregation we are using is not justified. The individual coefficients of such functions tend to be highly unstable over time — partly because of the multicollinearity inherent in this function and partly because of the paucity of observations often present at the 4-digit level. Finally, it should be noted that Denny and Fuss (1983) find that an extension of the Tornqvist TFP measure to allow for different translog functions adds little or nothing for a comparison of efficiency levels between Ontario and British Columbia. The reasons that these two regions of North America are sufficiently similar to justify the use of the Tornqvist index are also likely to apply to Canada/U.S. comparisons — relatively free flow of capital and information, similar cultural backgrounds, similar educational systems, and work forces with similar work ethics.

While our TFP formulae resemble the often-used translog index (Gallop and Jorgenson, 1980), we chose to start by postulating a production function rather than by using the more general index number approach for several reasons. The index approach, it is claimed, is useful because it does not require knowledge of the underlying process with great precision. But for the index to be accurate, the production function must fall into one of a general class of functions. The translog index is exact for the class of production functions that can be represented by a translog function — a specific case being the Cobb-Douglas.[1] Thus there is little difference between our approach and the alternate index number framework in terms of prior assumptions that we have to make on the underlying production process. Admittedly, we chose the Cobb-Douglas, which is a restricted form of the translog production function, but only after we asked whether much was to be gained from going to the more complex function.

A second advantage claimed for the index number approach is that the underlying production function need not be estimated in order to derive the weights attached to the different factors. Factor shares, which are readily estimable, are the weights used. Unfortunately, they are the appropriate weights only in the case where constant returns to scale prevail. If scale economies exist, factors cannot all be paid their marginal product and just have the total product exhausted. Since the thrust of this paper is aimed at evaluating the effect of scale economies, it seems particularly inappropriate to use the standard index number approach, which implicitly assumes constant returns to scale.

Even if there were constant returns to scale, an index number approach that uses factor shares as weights has other problems. Obtaining accurate measures of factor shares is probably no less difficult than estimating the factor elasticities directly from the production function — at least when census data are used to obtain factor shares. In the census, wage payments can substantially underestimate labour compensation because they omit many fringe benefits — which often are one-third of actual wages reported. Moreover, reported value added overstates true value added because service payments are not deducted from gross sales in arriving at the reported value added. Service payments average between 10 and 15 percent of sales and a much higher percentage of value added. Thus wage shares taken from uncorrected census of manufacturers data are biased downward. Instead of just making somewhat ad hoc corrections to existing data, we approached the problem directly by estimating individual production functions at the industry level from establishment data.

We chose three related but different methods of measuring total factor productivity. Each assumes that technology in the two countries can be represented by a Cobb-Douglas production function with similar factor elasticities,[2] but each calculates these coefficients differently.

a) In the first case, we presume constant returns to scale and derive the labour coefficient using establishment data and not the simple labour share of industry output. The labour coefficient is estimated from the first-order side conditions that have the wage rate set equal to the marginal revenue product (Griliches and Ringstad, 1971, p. 73):[3]

$$\begin{aligned} \text{TFP1} &= \exp(\text{A1}) \text{ where} \\ \text{A1} &= \ln\,(\text{VA}_c/\text{VA}_u) - \tilde{a}\,\ln\,(\text{L}_c/\text{L}_u) - \tilde{b}\,\ln\,(\text{K}_c/\text{K}_u) \end{aligned} \tag{6.1}$$

where VA is value added,; L is labour measured in manhours; K is capital; c is Canada; u is U.S.; $\tilde{a}$ is labour elasticity; and $b = 1 - \tilde{a} =$ capital elasticity.

b) In the second case, we use a scale adjusted Tornqvist index (Cowling et al., p. 166) where the previously estimated a's and b's are adjusted by the economy of scale variable derived from our estimate of the Cobb-Douglas that uses the pooled 1970 and 1979 sample but uses our preferred estimation technique. Thus:

$$\begin{aligned} \text{TFP2} &= \exp(\text{A2}) \\ \text{A2} &= \ln(\text{VA}_c/\text{VA}_u) - \tilde{a}.\text{s}.\ln(\text{L}_c/\text{L}_u) - \tilde{b}.\text{s}.\ln(\text{K}_c/\text{K}_u) \end{aligned} \tag{6.2}$$

and $s = (a^* + b^*)$ from our pooled regression estimates. This TFP estimate avoids the constant returns to scale assumption imbedded in the standard TFP1 case. It does not, however, use the individual labour and capital elasticity estimates derived from our estimation of individual production functions, since they are somewhat less stable over time than the returns to scale estimate and therefore may be subject to greater measurement error.

c) Our third estimate of TFP does, however, employ these estimated elasticities. In this case, we used our regression estimates of the production function, a* and b*, to yield:

$$\begin{aligned} TFP3 &= \exp(A3) \qquad (6.3) \\ A3 &= \ln(VA_c/L_c)/(VA_u/L_u) - (a^* + b^* - 1)\ln(L_c/L_u) \\ &\quad - b^* \ln(K_c/L_c)/(K_u/L_u) \end{aligned}$$

TFP1 then is the measure that allows for no economies of scale and uses the factor share method to derive the coefficient on labour. TFP2 and TFP3 both use the same estimate of economies of scale. TFP3 is our preferred measure. The difference is that we place more weight in TFP3 on our estimates of both the factor elasticities and the economy of scale coefficient. In TFP2 we use only our estimate of economies of scale from the estimation of the production function and rely upon the factor share estimation procedure to determine the relative elasticities of the two factors.

We adopt the strategy of trying two different ways of incorporating the economies of scale estimate because, like Griliches and Ringstad (1971), we have more confidence in the sum of the input elasticities (the scale elasticity) than in the individual components. Therefore we consider the sensitivity of our results to alternate ways of apportioning the total scale effect between the two factors.

While these are all total factor productivity measures [as opposed to the partial labour productivity measure used by Saunders (1980)], it is not the additional contribution made by adding capital that we stress as our more important extension. Examination of the third measure (TFP3) shows that the inclusion of capital will only be important to the extent that the relative capital/labour ratios differ between Canada and the United States. If factor price ratios are the same and the production function is homothetic, we should expect these ratios to be about 1 and the last term to disappear or be very small. Indeed, the mean relative capital/labour ratio of Canada/U.S. is about 1. The second term, that of relative size, will not be zero if economies of scale exist and there are differences in industry size. Our scale estimates indicate that the former is generally the case where the U.S. industry is larger than the Canadian.

Our contribution is to provide correction factors for scale that differ industry by industry because of different scale elasticity estimates (a* + b*). Previous cross-sectional estimates of the determinants of relative Canada/U.S. productivity (Spence in Caves et al., 1980; Saunders, 1980) allowed for scale effects in only the roughest fashion by including as an explanatory variable a rough proxy for scale (the cost disadvantage ratio). Moreover Spence failed, though Saunders did attempt to interact this proxy with a relative size variable that might have been related to L_c/L_u. A comparison of our cross-sectional regressions that examine the determinants of TFP1 to TFP2 or TFP3 allows conclusions to be drawn about the effect of this omission.

It is important to reiterate a point made in Chapter Four — that the scale effects that are being allowed to vary industry by industry may not come from the same source. Scale effects may exist because of plant economies associated with larger size, because of longer production runs associated with larger plant size, or because of agglomeration economies that may be associated with increased plant diversity that accrues as plants get larger. Our intra-industry regressions of plant diversity and length of production run suggests that at least two effects, if not all three, are important. It is thus this general sense we give to the expression "scale" economies. We are interested in correcting relative Canada/U.S. productivity for the effects of size and we have therefore not divided the scale effect into its different components. We are essentially assuming that whatever leads to greater productivity within existing Canadian industry as size of plant increases would continue to apply if plants got even larger and approached the American mean plant size.[4]

Total Factor Productivity Assuming a Production Function at the Establishment Level

The TFP measure derived in the previous section assumes a Cobb-Douglas production function at the industry level — between aggregate outputs and inputs. If the production function is estimated from establishment data for individual industries, the appropriate total factor productivity measure must be derived from such a micro production function. Previous work has generally ignored the difference between micro and macro relationships — probably because micro data are so rarely used. Klein (1946, 1962) is an exception, but his suggestions have been all but forgotten.

The problem arises because micro and macro relationships are generally not the same (Sato, 1975). Even in the face of constant returns to scale, a Cobb-Douglas production function at the plant level does not generalize to a Cobb-Douglas production function at the industry level — except in circumstances which Sato (1975) has shown generally do not hold. The distribution of efficiency, defined as value added per worker, must follow a Pareto distribution for the generalization to hold, and few industries appear to follow this pattern.

Instead of asking what the conditions must be for a micro Cobb-

Douglas to generalize to a macro Cobb-Douglas (as Sato does), we can start by positing a micro Cobb-Douglas and ask what the total factor productivity measure in the aggregate variables should be. This is relatively straightforward if we posit that plant size variables (outputs, inputs) follow a log-normal distribution at the industry level. Prais (1976) has emphasized this distribution in his work on firm and plant sizes; Steindl (1965), Silberman (1967) and Clarke (1979) have tested the extent to which it fits the plant size distribution.

If we start with an industry Cobb-Douglas production function, at the establishment level, i=1, N; C=Canada; U=United States:

$$VA_{jc}/L_{jc} = A_{jc}L_{jc}^{a+b-1}(K_{jc}/L_{jc})^{b} \tag{6.4}$$

$$VA_{ju}/L_{ju} = A_{ju}\,L_{ju}^{a+b-1}(K_{ju}/L_{ju})^{b} \tag{6.5}$$

Then

$$\begin{aligned} M_c &= \Sigma \ln A_{jc}/N_{jc} \\ &= [\Sigma \ln (VA_{jc}/L_{jc}) - (a + b - 1)\,\Sigma \ln L_{jc} \\ &\quad - b\,\Sigma \ln (K_{jc}/L_{jc})]/N_{jc} \end{aligned} \tag{6.6}$$

$$\begin{aligned} M_u &= \Sigma \ln A_{ju}/N_{ju} \\ &= [\Sigma \ln (VA_{ju}/L_{ju}) - (a + b - 1)\,\Sigma \ln L_{ju} \\ &\quad - b\,\Sigma \ln (K_{ju}/L_{ju})]/N_{ju} \end{aligned} \tag{6.7}$$

Now M_c and M_u are the geometric means of the efficiency terms. While we could use the ratio of these geometric means to define the total factor productivity measure, it is the ratio of the arithmetic means that more closely approximates the usual measure of TFP.

However, for a variable y that has a log-normal distribution, the arithmetic mean (AM) is related to the geometric mean (GM) by the following formula:

$$AM = e^{GM}\,e^{\sigma^2/2} \tag{6.8}$$

where σ^2 is the variance of $x_i = \log y_i$; $AM = \Sigma y_i/N$; and $GM = (\prod_i y_i)^{1/N}$

$$\log \frac{\Sigma\, y_i}{N} = \frac{1}{N}\,\Sigma \log y_i + \sigma^2/2 \tag{6.9}$$

or

$$\Sigma \log y = N \log \bar{Y} - N\sigma^2/2. \tag{6.10}$$

Thus, using this relationship between the arithmetic and geometric means:

$$\bar{A}_c/\bar{A}_u = e^{\,M_c - M_u} e^{(\sigma^2_{Ac} - \sigma^2_{Au})/2} \tag{6.11}$$

where σ^2_{Au} = variance of $\ln A_{ic}$; σ^2_{Au} = variance of $\ln A_{iu}$.

Since both $\ln A_{ic}$ and $\ln A_{iu}$ are functions of outputs and inputs, the σ^2_A will be a function of the variances of Q, L and K. We tested whether these variances of Q, L, and our proxy for K differed for a sample of Canadian industries and found they did not. Assuming then the same variance for each size variable and a correlation coefficient of unity between any size variable (Q, L, M, K) within an industry, but differing between the two countries, yields:

$$\sigma^2_{Ac} = (a + b - 1)^2 \sigma^2_c \tag{6.12}$$

$$\sigma^2_{Au} = (a + b - 1)^2 \sigma^2_u \tag{6.13}$$

Now $M_c - M_u$ is written in terms of the sums of the logarithms of the input and output measures; but census data at the industry level is collected as the sum of the untransformed variables.

Then using the previous formula for log normally distributed variables and substituting for each of VA_{ic}, VA_{iu}, L_{ic}, L_{iu}, K_{ic}, K_{iu} in the formula for $M_c - M_u$, as well as assuming similar variances and a correlation coefficient of unity for the lognormal size variables within each industry in the two countries, gives

$$\begin{aligned} M_c - M_u = {} & \ln (\overline{VA}_c/\overline{L}_c)/(\overline{VA}_u/\overline{L}_u) - (a+b-1)\ln(\overline{L}_c/\overline{L}_u) \\ & - b\ln (\overline{K}_c/\overline{L}_c)/(\overline{K}_u/\overline{L}_u) + (a+b-1)(\sigma^2_c - \sigma^2_u)/2 \end{aligned} \tag{6.14}$$

where $\overline{VA}_c$, $\overline{VA}_u$, $\overline{L}_c$, $\overline{L}_u$, $\overline{K}_c$, $\overline{K}_u$ are just the arithmetic means of the variables.

Thus the total factor productivity can be defined as,

$$TFP4 = \exp(A4) \tag{6.15}$$

where

$$\begin{aligned} A4 = {} & M_c - M_u + [(a+b-1)^2 \bullet (\sigma^2_c - \sigma^2_u)]/2 \\ = {} & \ln (\overline{VA}_c/\overline{L}_c)/(\overline{VA}_u/\overline{L}_u) \\ & - (a+b-1)\ln(\overline{L}_c/\overline{L}_u) - b\ln(\overline{K}_c/\overline{L}_c)/(\overline{K}_u/\overline{L}_u) \\ & + [(\sigma^2_c - \sigma^2_u) \bullet ((a+b-1) + (a+b-1)^2)]/2. \end{aligned} \tag{6.16}$$

Hence there are two methods of estimating TFP using a production function at the establishment level, one of which relies on the summation of logarithms of the variables — equations 6.6, 6.7, and 6.11 — and the other which relies upon the means of the variables and their variances in logarithms — equation 6.14. We did not have information on the sum and variance of the logarithms of the variables. Hence, we define TFP4 by taking equation 6.16 and assuming the variances for Canada (σ^2_c) and the United States (σ^2_u) are identical for each industry. Hence:

$$\begin{aligned} \text{TFP4} = \exp\,[&\ln(\overline{VA}_c/\overline{L}_c)/(\overline{VA}_u/\overline{L}_u) \\ &-(a^*+b^*-1)\ln(\overline{L}_c/\overline{L}_u) \\ &-b^*\ln(\overline{K}_c/\overline{L}_c)/(\overline{K}_u/\overline{L}_u)] \end{aligned} \tag{6.17}$$

where a*, b* are our estimated micro production function elasticities.

In evaluating this measure, TFP4, we choose not to use average plant size in terms of average labour ($\overline{L}_c/\overline{L}_u$) but to use the ratio of the average size of larger plants in Canada to larger plants in the U.S. (EFF1T). We do so because of the different coverage of small establishments that the use of EFF1T avoids, a matter discussed at some length in Baldwin and Gorecki (1983b).

Matching U.S. and Canadian Concepts and Definitions to Estimate Relative Productivity

In order to estimate TFP1 to TFP4 we need to define VA_c, VA_u, L_c, L_u, K_u, K_c, EFF1T and the elasticity output with respect to labour and capital. In doing so we have two separate tasks: first, to match the underlying concept of labour or capital to the available data; and second, to make sure, as far as possible, that the Canadian and U.S. definitions are comparable. In most instances we have been able to match the definition fairly closely with the underlying concept and, furthermore, U.S. and Canadian sources usually employ comparable definitions. Hence, for most of the variables defined in Table 6-1 little elaboration is required here, given the discussion of value added and capital in Chapter Five and the definitions in Appendix A.

Nevertheless, there is one minor point which should be noted with respect to comparisons between Canada and the United States. In deriving productivity measures we use data based on both aggregate industry variables such as L_c and L_u and data derived from micro-establishment data, a* and b*. In Chapter Three we outlined a number of criteria to remove certain establishments so that individual industry production functions could be estimated. The effect of these criteria was the removal of head offices.[5] At the aggregate level, corrections are also required concerning head offices, not only to ensure consistent treatment between micro and macro variables but also because head offices are treated differently by Canadian and U.S. census authorities in aggregate variables. In the United States, head offices are not reported in 4-digit industry aggregates, and it is at the 4-digit level that TFP1 to TFP4 are estimated. In Canada, in contrast, head office data are assigned to the industry level on the basis of the primary activity of the enterprise to which the head office belongs. Therefore we removed all head office data from the normally reported Canadian aggregates such as L_c, and VA_c. We were not able to do so for the book value capital stock, but at least it is included in the figures for both countries.

TABLE 6-1 Concepts and Definitions of Variables Used to Measure Relative Canadian/U.S. Productivity

K_c, K_u	Gross depreciable assets: defined as buildings and machinery and equipment. See BV_c and BV_u in Appendix A for further details and the discussion in Chapter Five.
L_c, L_u	Total number of manhours worked: expressed as production and related manhour equivalent. See Appendix A under L_c and L_u for further details.
VA_c, VA_u	VA_c is Canadian census value added corrected for purchased services and Canada/U.S. differences in prices, while VA_u is U.S. value added corrected for purchased services. See Chapter Five for further details. VA_c and VA_u are defined in equations 5.14 and 5.15, respectively, as V_c and V_u.
EFF1T	The ratio of the average size of larger plants in Canada to larger plants in the United States. See Appendix A under EFF1T for details.
a*, b*	Elasticity of labour and capital, respectively; taken from industry production functions which in most instances pool 1970 and 1979 data. Where a structural change was indicated between 1970 and 1979, the individual year estimates were used. See Chapter Four for details.
$\tilde{a}$	Elasticity of labour derived from the first order side conditions that set the wage rate equal to the marginal revenue product. Estimated using individual establishment data. See Griliches and Ringstad (1971, p. 73) and Appendix C for details.

Source: Chapters Four and Five, Appendices A and C.

The Canadian manufacturing sector is divided into 167 4-digit manufacturing industries and it is at this level of industry classification that we define TFP1 to TFP4. However, 60 of these industries had to be excluded for a variety of reasons: the U.S. and Canadian industry definitions did not match; the industry was of a miscellaneous nature, consisting of several separate industries for which separate production functions and aggregate statistics should be, but could not be, presented; the industry match between the Canadian Corporation Financial Statistics and the Census of Manufacturers was so poor that a capital stock estimate could not be derived;[6] or the scale economy estimates a* and b* were subject to what appeared to be measurement problems.[7] The resulting sample of 107 industries accounted for 60.73 percent of the value added of the manufacturing sector in 1970 and 59.69 percent in 1979. The corresponding figures for total employees was 60.17 percent and 58.44 percent, respectively.

TFP estimates are available for the early and late 1970s. For the first period, we compare Canada 1970 to the U.S. census year 1972. For the second period, we compare Canada 1979 to the U.S. census year of 1977. These are referred to as TFP70 and TFP79. With any growth in productivity, this causes a downward bias to the 1970 estimate and an upward bias to the 1979 estimate. Since U.S. and Canadian GDP per worker grew by 13 and 11 percent, respectively, between 1970 and 1972, the 1970 TFP estimates will be downward biased. However, U.S. GDP per worker was only about 1 percent higher in 1979 than in 1977. Thus the 1979 TFP should be relatively unbiased.

Alternate Values of Canada/U.S. Productivity

Table 6-2 presents relative Canada/U.S. industry data for manhours worked, sales, and value added. The relative sales values were calculated using only an exchange rate correction (column 4), and using an exchange rate correction along with the assumption that Canadian prices exceed U.S. prices by the amount of the nominal tariff rate (column 5). Relative value added is calculated assuming the exchange rate, effective tariff rate, and purchased services corrections discussed in Chapter Five, with the results in column (6). The relative Canada/U.S. measures of industry size are calculated at the 2-digit or industry group level by considering only the 107 4-digit industries which are used subsequently in the analysis of Canada/U.S. relative productivity. The number of 4-digit industries in each industry group is listed in column (1).

If we compare the relative output to the relative labour values, it is evident that Canada is a relatively inefficient user of labour. We use relatively more labour than we produce in the way of output — whether the latter is measured in terms of gross sales or value added. But it is the total factor productivity measure corrected for scale economies that is the focus of our study, to which we now turn.

We report a number of statistics to summarize the distribution of the various TFP estimates. We calculate the median as well as the arithmetic mean, since the distributions are generally not symmetric, being skewed upward. Because the upper tail may contain observations that are incorrect, we also truncate the distribution by removing approximately the top and bottom 10 percent of the sample. The mean and median of the TFP estimates of this sample are also reported and, by comparison with those from the complete sample, permit an evaluation of the effect of large and probably erroneous outliers. Finally, we also calculate weighted averages of the TFP measures (using both value added (VA) and employment (E) weights) for both samples and for all the productivity measures. If Canada concentrates production in the least disadvantaged industries, the weighted average should be higher than the unweighted average.

The values of the three TFP measures that are derived from the aggregate production function (TFP1, TFP2, TFP3) are reported in

Table 6-2.[8] As expected, the 1979 measures are all above the 1970 measures. The increase ranges from 14 to 22 percent. The extent to which this increase is the result of the slight mismatch in the years chosen for comparison can be estimated quite readily. An aggregate measure of TFP3, using total real GDP, total employment, and gross fixed capital stock for the manufacturing sector as a whole, can be generated using Canadian data for 1970 and 1979 and U.S. data for 1972 and 1977. The increase in this TFP measure would have been around 12 percent. Choosing 1972 and 1977 for Canadian figures and reproducing the same comparison produces virtually no increase in relative Canada/U.S. productivity over this time period. Thus most of the increase in the mean of the disaggregated TFP measure is probably the result of our choice of years for comparison and little should be read into it at this point.

The estimate for 1979, for reasons indicated, is considered to be the better representative of the efficiency of the Canadian manufacturing sector relative to that of the United States. Looking at Table 6-3, the constant returns to scale variant (TFP1) has a mean or median for that year in the range of .71 to .73. On this basis, Canadian industry is only about 70 percent as efficient as American. The weighted averages are slightly higher, indicating that Canada does concentrate production a little more heavily in those industries where it has less of a disadvantage. In contrast, the two scale-corrected measures are centred above 1 — for both the complete and the truncated sample. In both cases, the median is below the mean but still around 1. The weighted means are equal to or slightly greater than the unweighted means.

On the basis of the difference between TFP2 or TFP3 and TFP1, we might conclude that scale accounted for most of the inefficiency in the Canadian manufacturing sector. However, both of these scale-corrected measures probably overestimate the effect of scale economies. The scale-correction term in these measures is applied to a size variable that consists of relative Canada/U.S. market size — a variable that on average is about 10 percent. As such, this formula continually corrects for scale until relative markets are equal in size. However, the benefits of scale are to be found at the plant level and it is doubtful that markets of equal size are required for Canadian plants to become large enough to exploit most of potential scale economies. During the 1970s, Canadian large plants were on average between 60 and 70 percent the size of the average of the top half of the U.S. size distribution — even though the relative market sizes were much smaller.

The TFP4 estimate that is constructed from the micro-production function data explicitly considers the scale effect by using relative plant size instead of relative market size. Moreover, it accords more with our preconceptions of how scale economies should be incorporated into the total factor productivity estimate. But of course the appropriateness of this formulation depends upon the assumptions made about plant size

TABLE 6-2 Relative Canada/U.S. Industry Size at the Industry Group Level[a], Canada, 1979[b]

Number of Constituent 4-Digit Industries (1)	Industry Group (2)	Relative Canada/U.S. Manhours[c] (3)	Relative Canada/U.S. Sales[d]: Exchange Rate Corrections (4)	Relative Canada/U.S. Sales[d]: Exchange Rate and Tariff Corrections (5)	Relative Canada/U.S. Value Added, Exchange Rate, Tariff and Purchased Services Corrections[e] (6)
15	Food & Beverages (10)	17.63	10.58	8.90	9.36
1	Tobacco (15)	11.36	10.40	7.15	5.17
0	Rubber & Plastics (16)	—	—	—	—
4	Leather (17)	15.75	9.77	8.63	10.31
11	Textiles (18)	9.65	7.46	7.34	6.23
12	Knitting Mills (23)	7.28	8.20	6.70	5.85
5	Clothing (24)	22.69	14.64	12.06	13.75
6	Wood Products (25)	15.96	11.41	10.47	9.61
2	Furniture & Fixtures (26)	11.27	7.48	6.58	5.35
5	Paper & Allied Products (27)	15.71	14.41	13.05	12.70
1	Printing & Publishing (28)	10.26	8.24	7.90	8.73
3	Primary Metals (29)	14.07	12.52	11.86	11.40
7	Metal Fabricating (30)	12.67	11.32	10.34	10.00
2	Machinery (31)	7.17	5.11	4.95	4.90
8	Transportation Equipment (32)	11.06	9.59	9.04	6.75
7	Electrical Products (33)	9.11	8.51	7.66	6.89
9	Non-Metallic Mineral Products (35)	8.86	8.06	7.57	7.77
0	Petroleum & Coal Products (36)	—	—	—	—
6	Chemicals & Chemical Products (37)	11.32	10.76	10.01	9.36
13	Miscellaneous Manufacturing (39)	8.05	6.61	5.96	5.59
107	Total Manufacturing	12.43 (9.75)[f]	9.63 (5.76)[f]	8.58 (4.88)[f]	8.33 (5.70)[f]

Source: Statistics Canada, special tabulations.

a. The various relative Canada/U.S. ratios are first estimated for the 107 4-digit industries for which estimates of total factor productivity are presented below. Then for each industry group the relative Canada/U.S. ratio is the mean of the ratio for the 4-digit industries classified to each industry group. The number of such industries is presented in column 1.

b. Canadian data are for 1979; U.S. data are for 1977.

c. Relative Canada/U.S. manhours refers to all employees, both production and non-production. Data are available only for production workers on manhours worked. In order to derive the manhours figure for all employees we used the approximation procedure adopted to define L_2 in Chapter Three.

d. Sales in Canada and the United States were expressed in 1972 dollars using a gross output price index (GPINX for Canada and IVS for the United States). Relative prices between the two countries for 1972 were taken into account either by the exchange rate or exchange rate plus nominal tariff (NRP) following our discussion in Chapter Five.

e. For details see Chapter Five and Table 5-4.

f. The standard deviation of the 107-industry sample.

TABLE 6-3 Average Canada/U.S. Total Factor Productivity in the Manufacturing Sector in 107 and 87 4-Digit Canadian Manufacturing Industries,[a] 1970 and 1979, using the Aggregate Production Function

	Statistic	Sample	Number of Industries	1970	1979
TFP1	Mean	Full Set	107	.63	.73
	Median	Full Set	107	.61	.71
	Mean	Reduced Set	87	.62	.72
	Median	Reduced Set	87	.61	.71
	Weighted Mean (VA)[b]	Reduced Set	87	.64	.77
	Weighted Mean (E)[c]	Reduced Set	87	.64	.76
TFP2	Mean	Full Set	107	.98	1.17
	Median	Full Set	107	.83	.99
	Mean	Reduced Set	87	.90	1.05
	Median	Reduced Set	87	.83	.99
	Weighted Mean (VA)[b]	Reduced Set	87	.95	1.11
	Weighted Mean (E)[c]	Reduced Set	87	.93	1.11
TFP3	Mean	Full Set	107	1.06	1.29
	Median	Full Set	107	.84	.99
	Mean	Reduced Set	87	.91	1.09
	Median	Reduced Set	87	.85	.99
	Weighted Mean (VA)[b]	Reduced Set	87	.94	1.10
	Weighted Mean (E)[c]	Reduced Set	87	.92	1.08

Source: Statistics Canada, special tabulations.

a. The 107-industry sample (i.e., full set) is the maximum number of industries for which TFP measures could be estimated. The smaller 87-industry sample (i.e., reduced set) excludes the top and bottom deciles.

b. Using industry value added as weights.

c. Using industry total employment as weights.

lognormality and similarity of variance between matched industry pairs. Nevertheless, the TFP4 estimate is our preferred measure of the disadvantage faced by Canadian industry.

In Table 6-4, we compare the disaggregated measure TFP4 to TFP1 and TFP3 for 1979. It falls between TFP1 and TFP3, as expected. In the full sample, the mean of TFP4 is .93, the median .76. This suggests that the distribution of TFP4 is skewed upwards. When the sample is truncated, the mean falls to .80, as compared to .72 for TFP1. Using the weighted versions with outliers excluded, scale accounts for one-third of the Canada/U.S. productivity difference that the uncorrected TFP1 measure indicates.

Figure 6-1 charts the frequency distribution of each of TFP1, TFP3,

TABLE 6-4 A Comparison of Canada/U.S. TFP Measures for 107 and 87[a] 4-Digit Canadian Manufacturing Industries in 1979, Using the Aggregate and the Canadian Micro-Production Function Approach

TFP1	TFP4	TFP3	Sample Size	Measure
.73	.93	1.29	107	Mean
.71	.76	.99	107	Median
.77	.84	1.10	87	Wt. Mean (VA)[b]
.76	.83	1.08	87	Wt. Mean (E)[c]
.72	.80	1.09	87	Mean
.71	.76	.99	87	Median

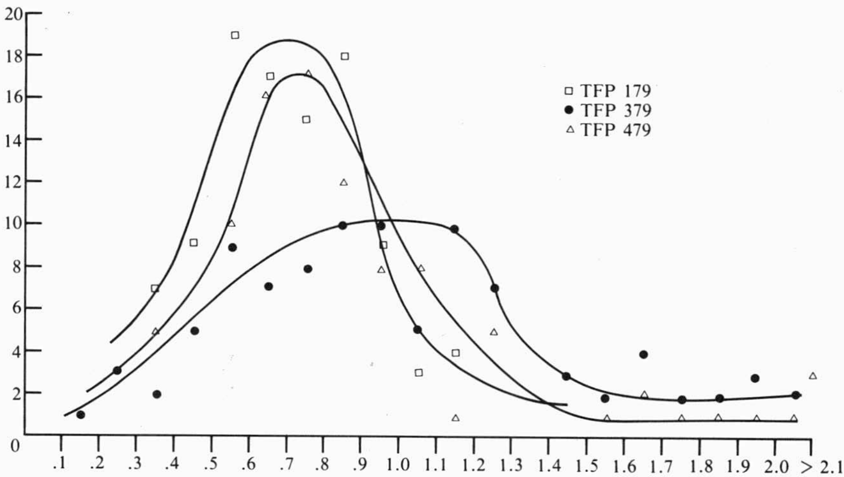
Source: Statistics Canada, special tabulations.

a. The 107-industry sample (i.e., full set) is the maximum number of industries for which TFP measures could be estimated. The smaller 87-industry sample (i.e., reduced set) excludes the top and bottom deciles.

b. Using industry value added as weights.

c. Using industry total employment as weights.

FIGURE 6–1 A Comparison of the Distribution of TFP1, TFP3, TFP4 for 1979



and TFP4 for 1979. In this figure, we have drawn freehand the continuous distribution that the point estimates seem to suggest. The reader should note that for ease of interpretation we have made the distribution unimodal even though the data suggest a bimodal distribution. It is apparent that the scale-corrected measures are both centred above the constant returns to scale variant (TFP1). However, TFP1 and our preferred scale-corrected measure (TFP4) have much smaller variance than TFP3. If we compare TFP1 and TFP4, we obtain the same general impression yielded by Table 6-4. Introducing scale corrections into the TFP measure increases the measure of relative efficiency but leaves the mode below 1.

Table 6-5 presents the mean level of TFP1, TFP3 and TFP4 for all 4-digit industries classified to each 2-digit industry or industry group. The table refers to the 107-industry sample discussed above and presents estimates for 1970 and 1979. However, in view of our discussion concerning choice of years, we rely only on 1979 in considering Table 6-5.

Although, like the results in Table 6-4, we find TFP4 is usually between TFP1 and TFP3, there is a considerable variation in the degree to which Canada/U.S. productivity differences are accounted for by scale. In some instances scale plays little or no role, but probably for differing reasons. In industries such as Paper and Allied Products and Primary Metals, Canada is often considered to have a comparative advantage and therefore scale is unlikely to be an important factor. However, even in some of the industries where Canada is considered to have a comparative disadvantage, such as Leather, Textiles and Knitting Mills, scale would also not appear to be the factor accounting for the disadvantage. Nevertheless, in Transportation Equipment, despite the U.S./Canada Autopact, scale economies are an important factor explaining productivity differences, while in Electrical Products, Furniture and Fixtures and Clothing scale would appear to be an important factor accounting for Canada's comparative disadvantage. In sum, there is a considerable variation in the importance of scale in explaining Canada/U.S. productivity differences at the aggregate 2-digit or industry-group level.

We therefore conclude that scale matters, but not as much as the aggregate TFP measures suggest. Moreover, there is a substantial efficiency gap with the United States that remains after the scale effect is included. Only about one-third of the gap between the Canadian and the U.S. manufacturing sectors disappears when scale is properly incorporated, but there is considerable variation across 2-digit industries.

It is apparent from these comparisons that the estimate of relative efficiency is sensitive to the method used to incorporate scale economies. In each of these comparisons, we only changed our assumption about the TFP formula. In particular, we held constant the assumption that relative value added was best measured by making the relative price corrections discussed in Chapter Five. In order to illustrate how sensitive our results are to alternate relative pricing assumptions, we present in Table 6-6 the TFP means in 1979 for each of the three alternate relative price assumptions we might have made. In column 2 it is assumed that price differences just reflect exchange rate differences; column 3 adjusts prices using the assumption that Canadian prices are U.S. prices adjusted for the exchange rate and tariffs; column 4 (our preferred method) makes the same adjustment as column 3 but also adjusts relative value added for the difference in the two countries' ratio

TABLE 6-5 Relative Canada/U.S. Productivity (TFP1, TFP3 and TFP4) at the Industry Group Level[a], Canada, 1970 and 1979

Number of Constituent 4-Digit Industries (1)	Industry Group (2)	1970 TFP1[b] (3)	1970 TFP3[b] (4)	1970 TFP4[b] (5)	1979 TFP1[b] (6)	1979 TFP3[b] (7)	1979 TFP4[b] (8)
15	Food & Beverages (10)	0.5280	1.1040	0.7055	0.5787	1.1988	0.7425
1	Tobacco (15)	0.4788	0.9423	0.8864	0.6031	1.2397	1.0829
0	Rubber & Plastics (16)	—	—	—	—	—	—
4	Leather (17)	0.6491	0.7750	0.6731	0.6583	0.7536	0.6661
11	Textiles (18)	0.6327	0.7553	0.5934	0.7138	0.9717	0.6902
12	Knitting Mills (23)	0.5953	0.5506	0.5615	0.7520	0.6322	0.6805
5	Clothing (24)	0.5260	0.8180	0.6298	0.6453	1.0355	0.7375
6	Wood Products (25)	0.4621	0.8382	0.5031	0.6495	1.5913	0.9955
2	Furniture & Fixtures (26)	0.5773	3.5436	2.6741	0.5500	3.2607	2.7209
5	Paper & Allied Products (27)	0.5850	1.0023	0.5658	0.7267	1.2334	0.6958
1	Printing & Publishing (28)	0.6696	0.9173	0.7307	0.8243	1.1625	0.9052
3	Primary Metals (29)	0.8279	1.0061	0.8302	0.8774	1.0417	0.8681
7	Metal Fabricating (30)	0.6791	0.9891	0.7438	0.8001	1.1439	0.8908
2	Machinery (31)	0.6395	1.5476	1.1952	0.7842	1.7276	1.2293
8	Transportation Equipment (32)	0.7180	0.9825	0.7656	0.6719	1.0159	0.7794
7	Electrical Products (33)	0.8726	1.2991	1.1299	0.9029	1.2814	1.1529
9	Non-Metallic Mineral Products (35)	0.6602	1.1560	0.6415	0.8629	1.4962	0.8340
0	Petroleum & Coal Products (36)	—	—	—	—	—	—
6	Chemicals & Chemical Products (37)	0.5656	0.9776	0.7468	0.8335	1.2480	0.9459
13	Miscellaneous Manufacturing (39)	0.6538	0.1159	0.8611	0.7910	1.7613	1.3057
107	Total Manufacturing	0.6309 (0.1872)[c]	1.0553 (0.8480)[c]	0.7706 (0.5208)[c]	0.7330 (0.2415)[c]	1.2912 (1.1865)[c]	0.9250 (0.7238)[c]

Source: Statistics Canada, special tabulations.

a. The various Canada/U.S. ratios were first estimated for the 107 4-digit industry sample. Then for each industry group the Canada/U.S. ratio is the mean of the ratio for the 4-digit industries classified to each industry group. The number of such industries is presented in column 1.

b. See text for definition of TFP1, TFP2 and TFP4.

c. The standard deviation of the 107-industry sample.

TABLE 6-6 The Sensitivity of the Average TFP Measure to Different Assumptions About Canada/U.S. Relative Prices Across 107[a] 4-Digit Canadian Manufacturing Industries, 1979

TFP Measure (1)	Price Adjusted Using Just Exchange Rate Adjustments (2)	Price Adjusted Using Exchange Rate and Effective Tariff Rate Adjustments (3)	Price Adjusted as in Column (3) with GDP/Value-Added Adjustment (4)
TFP1	.78	.67	.73
TFP2	1.24	1.05	1.17
TFP3	1.36	1.16	1.29
TFP4	.97	.83	.93

Source: Statistics Canada, special tabulations.

a. These averages were calculated across 107 4-digit matching Canadian and U.S. industries, the maximum number for which TFP measures could be estimated.

of GDP to value added. It is apparent that the estimated TFP is quite sensitive to the pricing assumption used. If we had not made the adjustment for the difference in the purchased service component of value added, Canada/U.S. relative productivity would have been underestimated by at least 10 percentage points. However, our conclusion as to the effect of scale would not have changed greatly. Comparing TFP1 and our preferred measure TFP4 indicates that the differences in the mean of these measures is about the same for each of columns 2, 3, and 4.

Summary and Conclusion

In this chapter we have designed measures of relative Canada/U.S. productivity that take into account scale and Canada/U.S. differences in plant size distributions. Our finding is that on average Canadian plants do suffer from technical inefficiency which is not completely explained by the disadvantage of suboptimal plant scale. Nevertheless, about one-third of the disadvantage is accounted for by suboptimal plant scale. Thus our work affirms that a good part of the Canadian "problem" is related to the scale effect — an effect whose importance has been downplayed more recently. Our finding is that scale is an important determinant of the disadvantage the Canadian manufacturing sector faces in terms of unit of output produced per unit of input. Thus it emphasizes the importance of understanding the determinants of relative plant scale. In associated studies (Baldwin and Gorecki, 1983a, 1983c), we addressed the relatively difficult and little studied problem of the determinants of plant size distribution. Our findings indicate that size of market is the primary determinant of relative Canada/U.S. plant scale.

However, this chapter should not be regarded as providing definitive statements on Canada/U.S. efficiency. Rather it is a first attempt to deal with some difficult though not intractable empirical problems. The results are important, if only because they suggest where the highest returns to further research might lie. Capital stock estimates have proved in the past to be a major stumbling block for inter-country comparisons. While additional work could provide more comparable estimates of gross fixed capital stock at a disaggregated industry level, our investigations suggest that they will not yield results that differ substantially from those using book value. Rather our results suggest that relative productivity comparisons need to correct for inter-country price differences, since the TFP estimates are quite sensitive to the assumptions used here. Moreover, in light of the lack of GDP estimates at the industry level, value added productivity comparisons need be concerned about differences between measured or census value added and real GDP. Finally, it is critical to evaluate the accuracy of the aggregation routine that has been used here to go from a micro-production function to a TFP measured in macro (aggregated) variables.[9] Our scale-adjusted TFP measures differ substantially depending upon the technique chosen. While aggregation problems have been discussed in the literature, their importance is made readily apparent here by the sensitivity of our results to the two alternate methods chosen.

Chapter 7

The Determinants of Relative Plant Scale, Industry Specialization and Relative Productivity

This chapter focuses on the determinants of relative productivity. However, since our relative productivity variable is corrected for relative plant size, a separate equation for relative plant size is also estimated. Together these two equations permit us to distinguish between those influences that affect productive "efficiency" directly, as opposed to indirectly though plant scale effects. We also examine the determinants of an industry's plant level product specialization (or its converse diversity), because of the importance some have attributed to this variable in explaining the Canadian manufacturing sector's productivity disadvantage.

Thus, we have three equations:

a. for relative Canada/U.S. plant size (EFF1T);
b. for a measure of a Canadian industry's product specialization at the plant level (HERF4D), and
c. for relative Canada/U.S. productivity (TFP).

a. Relative Plant Scale

EFF1T The ratio of larger plant size (measured in sales) in Canada to larger plant size in the United States. Larger plants are defined as those accounting for the top 50 percent of industry employment. This variable is discussed extensively in Chapter Two.

b. Diversity

HERF4D The industry level of plant specialization. This variable is inversely related to plant level diversity. The whole question of diversity and length of production run is discussed extensively in Chapter Two.

c. **Productivity**

TFP Canada/U.S. relative productivity in the manufacturing sector calculated using value added corrected for tariffs, exchange rate differences, and other expenses. For the regressions, we use three of the four measures defined in Chapter Five:

1. TFP1 — the constant returns to scale TFP variant using the aggregate production function;

2. TFP3 — the scale economies TFP variant using the aggregate production function;

3. TFP4 — the scale economies TFP variant using the micro-production function and the aggregation routine outlined in the previous chapter.

The second section of this chapter considers relative plant scale, the third section diversity, and the fourth section relative productivity. The chapter concludes with a brief summary and conclusion.

The regression results presented in the following three sections are not estimated across all of the 167 4-digit industries into which the Canadian manufacturing sector is divided, nor are all of the variables defined for 1970 and 1979, the two years which appear in the title of most of the tables. Some industries had to be excluded because of their miscellaneous or heterogeneous nature, lack of good match between the Canadian and U.S. industry definitions, or unavailability of a particular variable. Hence the sample size varied between 120 industries and 107 industries.[1] Furthermore, variables were not always available for 1970 and 1979; when this occurred, an adjacent year was used.[2] In these cases the assumption is made that the missing value of a particular variable for 1970 and 1979 is highly correlated with the actual value used.[3] Finally, in some instances the independent variables were defined at a more aggregate level of industry classification than the 4-digit, necessitating some prorating or spreading.[4] Appendix A contains more information concerning data sources and methods.

The Determinants of Relative Canada/U.S. Plant Scale

The Model

Specification of the determinants of relative plant scale needs to be based on a model of the process that generates the distribution of plant sizes. The traditional approach has been to stress the connection between market characteristics such as concentration and plant size distribution via a behavioural model which posits that oligopolies set prices above costs, thereby allowing a fringe of smaller, less efficient firms to enter (see Muller's 1982 review article). In markets where concentration is not high, alternative explanations of plant size distribution are proferred. The fact that optimal plant size depends upon transportation and distribution as well as production costs means that small plants can exist side by side where there are regional markets of different size (Scherer et al., 1975). It has also been argued that there are alternate but equally effective strategies — i.e., with respect to advertising or research and development — that permit different size firms/plants to exist side by side (Caves and Porter, 1977; Porter, 1979; Newman, 1978; Caves and Pugel, 1980).

The traditional set of explanatory variables therefore includes those factors that generally influence the size distribution of plants as well as those factors, both technological and behavioural, that in special circumstances could lead to sub-optimality. The latter set includes those factors that truncate the upper tail or extend the lower tail of the Canadian size distribution relative to the United States. A market size variable is generally included to capture the truncation of the upper tail of the distribution. The variables used to capture the extent to which the lower tail may be extended generally proxy those forces hypothesized to prevent competitive forces from producing the same distribution as in the United States — tariffs, trade variables, concentration, and foreign ownership variables that the miniature replica hypothesis emphasizes as among the primary determinants of both sub-optimal scale and excessive product differentiation in Canada. In addition to the above, the cost penalty of a plant not achieving MES is included because the power of this economy of scale variable to affect average plant size should be reduced where the cost penalty of operating a sub-MES plant is small.

Factors which are expected to increase or be related to the variance of the plant size distribution (as opposed to those that truncate a tail) are also generally included, because a large potential variance in plant size implies that large and small plants can subsist side by side. Variables used to capture these factors include the regional character of the industry, the extent of product differentiation, the variance of margins/sales ratios across firms, and the cost disadvantage ratio of small as opposed to large plants.[5]

The variables used in our model of relative plant scale are defined as follows (greater detail can be found in Appendix A), with the expected sign given in parenthesis:

ADVDM(−) the advertising sales ratio for consumer non-durable goods industries, zero otherwise;

CA(+) (exports minus imports divided by the sum of exports plus imports) + 1 — a variable often (Caves et al., 1980, pp. 78, 271) referred to as measuring comparative advantage;

CDR(−) the ratio of value added per manhour of the smallest plants accounting for 50 percent of industry employment divided by the value added per manhour of largest plants accounting for 50 percent of industry employment;

CDR1(−) where MESMSD (defined below) is less than its median, CDR1 is set equal to CDR, zero otherwise;

CDR2(+) where MESMSD is less than its median, CDR2 is set equal to CDR, zero otherwise;

CON(+) the proportion of industry shipments accounted for by the four largest enterprises;

EASTFV(+) HVTRCRF x MESMSD — the ratio of domestic disappearance to MES where concentration, tariffs and foreign ownership are greater than their respective means, zero otherwise;

EASTV(+) HVTRHCR x MESMSD — the ratio of domestic disappearance to MES where both concentration and effective tariff protection are greater than their respective means, zero otherwise;

ERP(−) effective tariff protection, defined to take into account export intensiveness and indirect taxes and subsidies, as suggested by Wilkinson and Norrie (1975, pp. 5–20);

FOR(+) the proportion of industry shipments accounted for by foreign-owned firms;

HVTRCRF(−) a dummy variable which takes the value of 1 when concentration, effective tariffs and foreign ownership are high, defined as greater than their respective means, zero otherwise;

HVTRHCR(−) a dummy variable that takes the value of 1 when both concentration and effective tariff protection are greater than their respective means, zero otherwise;

IMP(+) imports as a proportion of domestic disappearance, where the latter consists of domestic production minus exports plus imports;

MARCVA(−) the average of the coefficient of variation of the margin/sales ratio;

MESMSD(+) ratio of domestic disappearance (i.e., domestic production + imports − exports) to MES plant;

NRP(−) the nominal tariff protection;

NTD(−) non-tariff barrier dummy variable;

RD(−) the ratio of research and development personnel to all wage and salary earners;

REG(−) a regional dummy variable taking on the value of 1 when the industry is classified as regional, zero otherwise.

In most instances the variable definition and expected sign follows that of previous work summarized in Muller (1982) and hence requires little additional elaboration. However, this is not the case with respect to the variables designed to capture the impact of the Eastman/Stykolt hypothesis, the cost disadvantage ratio, concentration, and trade effects.

Tariffs, Concentration, Foreign Ownership and Market Size

The inefficiency of Canadian manufacturing industries is commonly attributed to the level of tariff protection — ERP.[6] Eastman and Stykolt (1967) and Bloch (1974) suggest that it may not be tariffs per se that result in inefficient scale; rather it may be only in industries with high tariffs and high concentration that tariffs have an impact on EFF1T. In such industries the protection afforded the firm, combined with oligopolistic interdependence (implied by high concentration) and the weak Canadian competition law, results in a competitive environment in which plant sizes are less than required to minimize unit costs. In order to capture the interdependence between tariffs and market structure, HVTRHCR and EASTV are introduced. We hypothesize that HVTRHCR would lower the level of EFF1T but that as market size (MESMSD) increases in such industries (EASTV), relative plant scale increases.

Previous work (Dickson, 1979; Gupta, 1979) has tended to ignore the assumption implicit in the Eastman/Stykolt proposition that the combination of protection and imperfect markets is a prerequisite for scale sub-optimality. In others (Caves et al, 1980), no test is made for an independent effect of both concentration and tariffs. The latter is of some importance because without some idea as to the sign generally associated with the tariff or concentration variables, it is difficult to evaluate the importance of the sign on the interaction term.

Our particular formation allows for two different types of non-linearities. First, it presumes that the effect of both tariffs and concentration is non-linear, by including a binary variable for high tariff/high concentration industries in addition to both tariff and concentration variables. Secondly, it allows the Eastman/Stykolt effect to be diminished within this set as market size and therefore the forces of competition increase.[7]

It has also been argued that high foreign ownership may exacerbate the problem of inefficient scale because of the miniature replica effect — with foreign ownership, the Canadian industry becomes a smaller version of the U.S. industry and most of the leading U.S. firms are present (English, 1964; Eastman and Stykolt, 1967, pp. 88 and 93). This effect is likely to be particularly important in those industries that are characterized by high concentration and high tariffs. Hence the terms HVTRCRF and EASTFV are included. These are likely to effect EFF1T, mutatis mutandis, in the same way as HVTRHCR and EASTV.

The variables FOR, CON, and ERP are included to see whether they have an impact independent of the high tariff/high concentration or high tariff/high concentration/high foreign ownership terms. In this respect, previous work has suggested that FOR and CON should have a positive impact on EFF1T and ERP a negative one. However, often there is a degree of ambiguity as to the expected impact of these variables because of the Eastman/Stykolt effect. By specifically modelling that effect, it should be easier to examine the separate influence of CON, FOR, and ERP.

Cost Disadvantage Ratio

When considering whether to build a plant at or below MES, the firm should be influenced by the cost of operating at less than MES compared to at MES. The steeper the cost curve the greater the pressure on the firm to build a plant of MES, other things being equal (Gorecki, 1976a, Table 5-6, p. 56; and Scherer et al., 1975, pp. 103–111). We use a proxy for the cost disadvantage of small firms, CDR, which is a variant of the approximation first suggested by Caves et al. (1975).[8]

A potentially serious measurement problem exists in CDR, since it depends not just on the cost disadvantage incurred by small firms from operating sub-MES plants but also on the firm size distribution around MES.[9] In markets where MESMSD is large and thus competition stronger, firms are more likely to have plants of MES or larger. In these markets, CDR is relatively meaningless as an estimate of the slope of the cost curve below MES. Moreover, since relative plant scale will be high when most plants are greater than MES, CDR should be positively related to the efficiency measure in large markets — exactly the opposite of the relationship hypothesized to exist between the slope of the cost curve below MES and the relative plant scale efficiency measure.

When markets are relatively small compared to MES, CDR will better reflect the steepness of the cost curve to the left of MES plant. The concentrated nature of these markets reduces competition and possibly leaves price above the long run average cost of MES plant, thereby providing an umbrella under which smaller plants can survive. Therefore CDR1 was included to take this into account.

Concentration

Concentration has been interpreted as a proxy for collusion — essentially catching the umbrella effect that stimulates entry by inefficiently small plants (Muller, 1982). But it also has been suggested that concentration reduces sub-optimal capacity by increasing the likelihood that efficient-sized plants are built (Gorecki, 1976a).

The concentration measure and the inverse of MESMSD are closely related, and failure to recognize this can lead to interpretation problems.[10] The effect of plant scale has already been captured in the latter. Thus inclusion of the concentration variable catches those factors of the leading firms other than large plant size that determine concentration — whatever encourages relative multiplant operations by the leading firms (see Caves et al., 1980, chapter 3). We follow Scherer et al. (1975, pp. 112–115) and adopt the view that the direction of causality flows from these factors to relative plant size and not vice versa.

Trade Variables

While we report the coefficients attached to import intensity (IMP) and comparative advantage (CA), we also experimented with export intensity (EXP) — exports divided by shipments — and a conventional measure of intra-industry trade [(EXP + IMP) – (absolute value of (EXP – IMP))/(EXP + IMP)]. Each of these four variables is included to capture a separate aspect of the manner in which trade may affect relative plant scale. The use of import and export intensity implicitly assumes that the importance of each does not depend upon the magnitude of the other. The use of comparative advantage tests whether it is the extent to which an industry specializes in one or the other that is important. Finally, the intra-industry trade measure was included to capture the extent to which trade is of a two-way nature. The latter two provided no additional information and were discarded.

The Regression Results

The regression results for the determinants of relative Canada/U.S. plant scale for 120 4-digit Canadian manufacturing industries for the years 1970 and 1979 are presented in Table 7-1. Ordinary least squares was used to produce the estimated coefficients. An application of a Chow test examined whether there was a structural change in the relationship over the decade. This test indicated that no structural change took place.

The regression results are generally consistent with our expectations and the results of previous researchers (Muller, 1982, Table 1, pp. 761–62). Market size (MESMSD) has the expected positive impact upon EFF1T in both 1970 and 1979, with a coefficient that changes very little in size and is highly significant. Regional industries often have lower, but not significantly lower, values of EFF1T than national industries, thereby confirming what others have found — that tariffs rather than transportation costs or their proxy, regional dispersion of production, are the main factors in limiting market size (Muller, 1982). Greater concentration (CON) significantly reduces scale inefficiency, thereby suggesting that those factors other than plant size that lead to concentration (i.e., the multiplant activity of large firms) have a positive feedback effect on plant size. ADVDM and RD generally have no significant

TABLE 7-1 The Determinants of Canada/U.S. Relative Plant Scale: Regression Results Across 120 4-Digit Canadian Manufacturing Industries, 1970 and 1979

	EFF1T70		EFF1T79	
	Coeff	Sign	Coeff	Sign
Constant	−0.117	.62	−0.510	.05
IMP	−0.413	.16	−0.431	.10
CA	0.058	.51	0.189	.03
NRP	0.392	.25	0.640	.25
ERP	−0.444	.26	0.076	.62
MESMSD	0.009	.01	0.014	.0000
ADVDM	−1.518	.51	−4.486	.12
RD	2.723	.42	−1.760	.54
CON	1.231	.0001	1.515	.0000
CDR1	−0.407	.001	−0.179	.10
EASTV	0.058	.03	0.043	.08
HVTRHCR	−0.424	.11	−0.652	.01
REG	−0.036	.75	0.017	.88
FOR	−0.073	.71	0.138	.46
MARCVA	0.221	.14	0.200	.17
$\bar{R}^2$	0.3067	.0000	0.4555	.0000
F-RATIO	4.76[a]		8.11[a]	

Source: Statistics Canada, special tabulations.
Note: For each variable the table presents its estimated regression coefficient (Coeff) and level of statistical significance (Sign) for a two-tailed test that t is significantly different from zero.
a. Significant at the .01 level.

impact although ADVDM is consistently correctly signed. CA has the predicted positive impact and is statistically significant at the 3 percent level but only in 1979 — industries in which Canada has a comparative advantage would normally be expected to be of efficient scale.

Previous work had detected no relationship between import intensity and scale inefficiency. However, our results show that imports have a negative impact that is statistically insignificant in 1970 but significant at the 10 percent level in 1979. This is inconsistent with the predicted positive relationship which was posited on the premise that imports provided competition and hence eliminated inefficient scale. This negative relationship is consistent with an adaptation process that results in much smaller scale plants assembling and finishing semi-finished imported products or, alternatively, small specialist firms filling particular niches in the market that cater to Canadian tastes. It also accords with our work on the entry/exit process (Baldwin and Gorecki, 1983c) that found number of firms and number of entrants in an industry to be a positive function of import share, and number of exits to be negatively related to import share.

The impact of MESMSD on EFF1T suggests that free trade with the United States would eliminate any scale disadvantage. A quadrupling of market size would, other things held constant,[11] raise the mean level of EFF1T in both 1970 and 1979 to unity — i.e., on average, Canadian plant sizes would be equal to MES. This is the magnitude of increasing market size that Ontario and Quebec plants would gain access to if Canada had a free trade agreement with the United States (Wonnacott and Wonnacott, 1982, p. 416).

The Eastman/Stykolt hypothesis that the effect of tariffs should be felt particularly in concentrated industries is confirmed by the signs and significance of the HVTRHCR and EASTV variables. While tariffs per se [effective (ERP) or nominal (NRP)] have no significant impact, EFF1T is smaller in high tariff/high concentration industries, due to the negative coefficient on HVTRHCR, but this is offset as market size increases within such industries (the positive coefficient on EASTV). For 68.4 percent in 1970 and 95.5 percent in 1979 of the high tariff/high concentration industries, the value of EASTV is not sufficient to offset the negative impact of HVTRHCR. The higher percentage in 1979 may reflect a government policy of reducing tariffs during the Kennedy Round in a way that makes it easier to detect the plant scale problem by 1979.

Foreign ownership had little impact across all industries (FOR). Caves et al. (1980) showed a significant positive relationship between EFF1T or a similar measure of plant scale inefficiency and FOR; therefore, the results presented here contrast sharply with previous studies, perhaps reflecting the use of more recent data in this study. Finally, where the cost disadvantage of small plants is large relative to large plants (CDR1), EFF1T is larger — clearly suggesting that where scale economies are important, Canadian industry tends to build larger plants.

We took our analysis of the determinants of relative plant scale a step further by examining the determinants of changes in EFF1T between 1970 and 1979. This serves two purposes. First, one of the problems that besets any applied research in a cross-sectional analysis such as this is that if the coefficients differ by industry, the estimated coefficients are weighted averages of the "micro" coefficients — whose weights depend upon the distribution of the explanatory variables. A first difference form will also produce weighted averages — but the weights depend upon the distribution of changes in the explanatory variables. The latter will generally differ from the former and a comparison of the two may reveal anomalies in the underlying micro-efficients. Second, the form of the interaction term previously employed does not allow the researcher to determine whether it is tariffs or concentration that is the primary cause of scale inefficiency — since both are treated equally.

The results are reported in Table 7-2 for first differences. Only variables that were significant in either 1970 or 1979 and exhibited a change over the period were included in the regression analysis.[12] In terms of

TABLE 7-2 The Determinants of Changes[a] in Canada/U.S. Relative Plant Scale: Regression Results Across 120 4-Digit Canadian Manufacturing Industries, 1970–1979

	Equation 1		Equation 2		Equation 3	
	Coeff	t-value	Coeff	t-value	Coeff	t-value
Constant	0.080	1.65	0.056	1.30	0.057	1.32
IMPDIF	−1.797	−3.93[b]	−1.713	−3.84[b]	−1.710	−3.84[b]
CADIF	0.260	2.05[c]	0.261	2.13[c]	0.266	2.14[c]
MESMSDF	0.023	4.94[b]	0.024	5.33[b]	0.024	5.35[b]
ADVDMDIF	2.753	0.38	—	—	—	—
CONDIF	2.236	4.77[b]	2.260	5.22[b]	2.236	4.88[b]
CDR1DIF	−0.080	−0.64	—	—	—	—
EASTVDIF	0.027	0.65	0.010	0.28	—	—
CONHCVDF	0.180	0.15	—	—	0.211	0.18
EHCDF	−0.325	−3.57[b]	−0.342	−3.92[b]	−0.349	−4.18[b]
HVTRHCRO	−0.095	−0.89	—	—	—	—
$\bar{R}^2$	.4475		.4595		.4593	
F-RATIO	10.64[b]		17.86[b]		17.85[b]	

Source: Statistics Canada, special tabulations.

Note: For each variable the table presents its estimated regression coefficient (Coeff) and t-value. The tests of significance are two-tailed and the $\bar{R}^2$ tested by an F-test.

a. Defined as first differences.

b. Significant at .01 level.
m07.09Significantat.01level.

c. Significant at .05 level.

notation, the suffix DIF or DF indicates a first difference. Nonlinearities were included by considering differences in market size (EASTVDIF), effective tariff rates (EHCDF), and concentration (CONHCVDF) in high concentration/high effective tariff rate industries, respectively.[13] HVTRHCR for 1970 is the dummy variable for the high tariff/high concentration category.

The findings corroborate our earlier results.[14] Increases in market size and concentration across the whole sample lead to significant increases in relative plant scale. In high concentration/high tariff industries, only decreases in effective tariff protection significantly improved relative plant scale efficiency. Changes in concentration or market size in such industries had negative and positive effects, as expected, but they were not significant. Changes in the level of imports and changes in comparative advantage had the expected impact (based on our cross-section results) and were statistically significant at the 5 percent level or better — increases in imports result in a fall in relative plant scale while the converse applies to comparative advantage.[15] These results generally serve to strengthen the cross-section results. They also yield the interesting finding that tariff reductions in high concentration/high tariff industries led to increases in relative plant scale in such industries. This suggests that tariff policy may offer an efficacious method of overcoming sub-optimal scale problems in concentrated industries.

Conclusion

Our investigations have demonstrated that plant scale is a general problem in Canada and that tariffs exacerbate the problem. We have shed light on some of the apparently puzzling results of earlier researchers. Tariffs do matter, but primarily when concentration is also high. Under these conditions plant scale inefficiency is likely to obtain. Furthermore, falling tariffs in such industries during the 1970s led to increases in relative plant scale. Across the whole sample of industries, concentration has a positive impact on relative plant scale; but in industries characterized by high tariffs, high concentration has served to lower relative plant scale. Hence concentration has a complex two-way effect.

In terms of policy conclusions, two inferences can be drawn. First, in high concentration/high tariff industries, tariff reduction would appear to increase plant scale. While scope exists in Canada's competition policy legislation for tariff reduction to increase competition, this has rarely been done despite recommendations by a government-appointed advisory body to the government of the day.[16] Second, since trade liberalization leads to greater import and export penetration[17] the evidence suggests that these forces have offsetting effects on relative plant scale: imports decrease plant scale and exports are associated with larger relative plant scale. Further analysis of the offsetting benefits and costs of these opposite effects is required.

The Determinants of Industry Plant Specialization (HERF4D)

The Model

The factors that determine the degree of product diversity and length of production run can be divided into several categories. The first category includes those factors that shield the industry from competitive forces and permit "excessive" diversity. Such influences include tariffs, concentration and the level of impacts. The second category includes those technological factors that limit or raise the level of product diversity. In this context, the number of products per industry is likely to be particularly significant. The final category includes those factors that determine how the firm distributes its output among the plants it owns such that costs are minimized.

Production run length per plant and size of plant are endogenous to a complex profit maximization decision by firms in heterogeneous goods markets. In differentiated product markets, firms face potential trade-offs between satisfying a variety of different tastes at higher unit costs if they cannot fully exploit production run length economies, and producing longer production runs of fewer varieties at lower unit costs. The variety of goods chosen and the average length of production run depend on the elasticity of demand for each product and the nature of the cost curve — which in turn depends upon the extent to which multi-product economies are available at the plant level by product packing even though average production run length may be short. Thus the decisions on plant scale and product diversity are part of a simultaneous product decision.

In Chapter Two, our intra-industry regressions using establishment data indicated that plant diversity increases with plant size but at a decreasing rate. Thus we include both average plant size variables (AVPLSZ and AVPLSQ). In the intra-industry regressions, the multi-plant status of the owning firm was also found to be important. Therefore the multiplant activity of an industry (MPLNT) is also included as a control variable. Previous work by Caves (1975) and Caves et al. (1980) on inter-industry variability of diversity finds both control variables to be significant — albeit in multiplicative form.

Plant scale is included because of its relationship to successful product packing. Caves et al. (1980, p. 207), after examining the plant size decision process, suggested that "large plants will typically be more diversified than small ones because some plants turn out diverse outputs as a result of this optimization process." This view has larger firms somehow managing to sell more products, combining them together in one plant to exploit plant scale economies and grow even larger because of the cost advantage so created. There is, however, an offsetting effect even in this view of the world. For if a large firm is larger because it is more successful in selling more of each product, there is no presumption that its plants will be less specialized unless plant economies of scale are so important that they are not exhausted until the largest scale plants. Indeed, it seems reasonable to suggest that large firms have sufficiently long production runs that they can afford to begin "unbundling" their plants and decreasing the average diversity of their plants. However, all this simply suggests that diversity is likely to increase at first as plant size gets larger but that beyond a certain point it will again decline. In our paper on the effect of diversity on plant size (Baldwin and Gorecki, 1985), we found evidence that product packing occurs across the entire plant size distribution. Therefore we postulate a negative coefficient on AVPLSZ.

There is another reason that average size of plant and the number of plants per firm are likely to be related to diversity. They are both likely to be correlates of the degree of diversity chosen by the firm. If a firm with a given number of products and given size should decide to produce in only a small number of plants, and therefore in plants of larger average size, it is making a decision as to the plant diversity given the number of products being produced. Average size of plant should have a negative effect on diversity since, at the limit, a plant that is as large as the entire industry must necessarily produce the industry's entire range of products.

If average plant size is included as an independent variable in a regression equation explaining diversity, then the addition of a variable capturing the number of plants per firm (MPLNT) essentially captures firm size effects. This is because the greater the number of plants per firm for a given plant size, the larger will be the average firm size. The larger the firm for a given size of plant, the more likely it is that every plant will be more specialized. In effect, the decision to build more plants is one that will depend, among other things, on the cost of having a diversified as opposed to a specialist plant. And when more plants are built, it is likely that the advantages of specialization outweigh the disadvantages of smaller plant size. Therefore, ceteris paribus, the multiplant variable should be positively correlated with specialization.[18] This argument must be tempered with the recognition that the multiplant nature of some industries will be severely affected by transportation cost considerations. In this case, multiple plants are constructed not to take advantage of specialization but because of the regional nature of the Canadian market. Hopefully, however, inclusion of a binary variable characterizing the industry as regional or otherwise (REG) will correct for this influence.

There is, of course, a danger in using such correlates of diversity as average plant size and number of plants per firm. If there are a number of factors that jointly determine average plant size, number of plants per firm, and diversity, it would be desirable to use these variables to specify a set of equations that jointly determine each of the variables of interest. However to the extent that we are unsure of the specification of the complete model or data on these other variables is unavailable, inclusion of such correlates offers a convenient way of proxying the missing variables. This is our reason for including both.

Such proxies do present a potential problem. If the proxy is closely related not just to missing variables but also to included ones, it may decrease the significance of individual parameter estimates because of multicollinearity. In particular, to the extent that trade-related variables determine average plant size, inclusion of the plant size variables may mask the effect of the trade variables. To test for this possibility, we estimated the relations with and without average plant size and the number of plants per firm. The sign and significance of other variables did not vary much in either case, while both average plant size and number of plants per firm were highly significant, when included. Therefore we reported results including both average plant size and number of plants per firm.

The measure of plant level diversification should also depend on the potential number of products that might be produced. That is, if every product produced in the industry (N) is produced in each plant and no products from other industries are produced, the Herfindahl will be bounded below by 1/N (R4D). To the extent that plant economies do not require such crowding, plant diversity will be reduced — that is, will take on a value above 1/N. The intra-industry regressions suggested that there are substantial non-linearity effects of R4D on product diversity. Therefore we entered R4D in logarithmic form.

It should be noted that the product count variable does not measure the complete universe of products that might be produced in all countries (something akin to the Standard International Trade Classification). Instead it is derived from the number of products actually being produced in Canada. Thus the variable standardizes for the factors that determine whether more or less products are being produced in the industry. Inclusion of this opportunity to diversify the variable has implications for the way in which we approach the interpretation of the other explanatory variables. With the number of products produced in the industry included in the regression, part of the effect normally posited for some independent variables may already be captured.

For instance, it is often claimed that as markets get larger, the less popular product lines can be produced and therefore industry diversity is increased. The effect of tariffs is usually couched in somewhat similar terms. Higher tariffs permit the production of a product line that would otherwise be imported from abroad. In both situations this effect could potentially be caught by R4D. Thus the variables introduced to normalize for the number of product lines in an industry may capture some of the effect of market size or other variables that is usually posited to occur through total number of products produced. More importantly, to the extent that this is so, other independent variables should measure the specialization effect that does not depend upon industry level diversity.

We feel this is unlikely to be the case. In discussions with officials at Statistics Canada, it was emphasized that the number of ICC products was likely to be related primarily to the factors outlined previously. While it was possible, they felt, to argue that N might be higher relative to similar numbers for U.S. industries where the relative Canadian market size was higher, or where tariffs were higher, their opinion was that this effect would be small in comparison to others.[19]

The trade position of an industry is likely to influence the length of production run and product diversity. Where an industry has a high export intensity (EXP) or a comparative advantage (CA), it might be expected that production runs will be longer and plants more specialized. Turning to the other side of the trade balance, import intensity (IMP) is likely to have two different impacts, making it difficult to specify the a priori direction. On the one hand, imports may spur Canadian firms to concentrate on longer production runs to meet or beat the competition. On the other hand, high imports may affect average plant size detrimentally — a result suggested by Baldwin and Gorecki (1983c) — and lead to "product packing" in order to offset the cost disadvantage of small plants. While average plant size already is included separately as an independent variable, imports may measure the size of the incentive facing domestic firms to minimize costs.[20]

Another important attribute of Canadian manufacturing industries that is postulated to affect diversity is the level of tariff protection. An extensive literature following Eastman and Stykolt (1967) has postulated the existence of inefficient plant scale and excessive product differentiation in response to tariff protection. Although the impact of foreign competition should be caught with the previously discussed trade variables, there may be a residual effect caught by the tariff variables.

The effect of tariffs on diversity depends upon the extent to which unexploited scale or scope economies exist. Higher tariffs facilitate the production of more products in Canada. To the extent that costs can be reduced by adding the new product lines to existing plants, plant diversity will increase and the tariff rate (ERP) will be negatively signed. However, if tariffs expand demand for all products sufficiently that plant size gets large enough to exhaust economies, product unbundling may occur. In this case plants become more specialized and the tariff rate will have a negative sign.

The above discussion presumes that the number of 4- and 5-digit ICC products per industry represent not just the technological product opportunities but the number of products chosen to be produced in Canada. If, however, they represent just technological opportunities, the plant diversity index will be affected by changes in two variables brought about by higher tariffs. The first is the change in the number of products produced per firm. The second is the change in the number of products produced per plant. The latter has already been covered in the above discussion. The former should respond positively to higher tariffs and therefore lead to greater diversity. In this case, the first effect may be sufficient to cause a negative coefficient on the tariff variable — especially if unexploited economies lead to product packing. Related work (Baldwin and Gorecki, 1985) suggests that product packing is an important phenomenon. Therefore we posit a negative coefficient on the tariff rate variable (ERP) used here.

Eastman and Stykolt (1967) and Bloch (1974) suggest that the performance of an industry may not be inversely related to tariffs alone. Rather it may be that tariffs have an adverse impact only in industries with high tariffs and high concentration. In such industries the protection afforded the firm, combined with oligopolistic interdependence (implied by high concentration) and the weak Canadian competition law, result in a competitive environment that is not sufficient to force firms to adopt the optimal trade-off between size and product diversity. The consequence of this may either be higher profits or higher costs. The profit evidence presented by Bloch (1974, Table 3, p. 607), albeit based on a small sample of industries, is consistent with this line of reasoning in that it suggests that the joint effect of tariffs and concentration is what leads to higher profits. Thus ERP may have a greater effect on plant diversity in concentrated industries.

In order to capture the interdependence between tariffs and market structure, we include a dummy variable (HVTRHCR) which takes the value 1 when both concentration and effective tariff protection are greater than their respective means, zero otherwise, and an interactive term (PLESTV = HVTRHCR · AVPLSZ), which is the average size of plant where both concentration and effective tariff protection are greater than their respective means. If tariffs actually increase diversity in high concentration industries, HVTRHCR should have a negative sign. The term PLESTV is introduced to capture certain non-linearities in the tariff effect. If tariffs influence plant level diversity by affecting the rate at which products are added (or not substracted) as plant size gets larger, then the coefficient on average plant size in high tariff/high concentration industries should differ from that attached to AVPLSZ. Since the coefficient on average plant size is hypothesized to be negative, our hypothesis is that it should be negative for the interaction term PLESTV if the effect of tariffs is to increase diversity, as suggested above.

Advertising may be regarded as the means by which firms obtain sufficient product line depth to combine products at the plant level to take advantage of plant level economies. Thus, for a given plant size, the firm has more likely reached that size through combining a large number of products if advertising is high. We therefore include an advertising intensity variable (ADVDM). This should be positively related to product diversity and therefore should have a negative coefficient in the regression equation.

Foreign ownership (FOR) is postulated to have two opposing effects on plant level diversity. On the one hand, there may be reason to suppose that foreign ownership will result in longer production runs and greater specialization. It is sometimes argued that foreign-owned plants will attain minimum efficient size at a smaller size than domestic firms because the foreign-owned firms can rely on some services provided by the parent corporation on a variable cost basis that would otherwise be fixed costs. If this is the case, the foreign firms will not be forced to add products at the same rate to take advantage of scale economies. In addition, it may be that a foreign firm, without the tariff but with plant(s) in Canada, will have the choice of importing some items and manufacturing others. The domestic firm that hopes to attain the same scale economies in distribution and therefore needs the same range of products may have to produce all products in Canada — if there is some impediment to its purchasing part of its product line from abroad. Both of the above reasons suggest that foreign ownership should increase plant specialization. High foreign ownership would be positively related to our diversity variable.

On the other hand, it has been argued that the ease of adding products may be greater for foreign firms. In the parlance adopted earlier, the product agglomeration costs are lower. In this case, foreign firms may find it easier to add products to obtain plant scale economies, and industries where foreign ownership is high may have more diversified plants. If so, the coefficient on foreign ownership would be negative.

There are a number of reasons to postulate that the length of production run and diversity may be affected by whether the industry is regional or national. Regional industries offer smaller markets and the imperatives of plant economies will be greater. We should therefore expect greater plant diversity and a negative sign in our regression. Thus a regional dummy variable (REG) is included whose sign is posited to be negative.

The variables used are briefly summarized as follows (greater detail may be found in Appendix A), with the expected sign given in parentheses:

ADVDM(−) the advertising-sales ratio for consumer non-durable goods industries, zero otherwise;

AVPLSZ(−) average plant size measured in terms of shipments, defined in 1971 constant dollars of plants classified to the industry (size measured in $000,000s);

AVPLSQ(+) average plant size (AVPLSZ) squared;

CA(+) (exports minus imports divided by the sum of exports plus imports) + 1 — a variable often (Caves et al., 1980, pp. 78, 271) referred to as measuring comparative advantage;

ERP(?) effective tariff protection, defined to take into account export intensiveness and indirect taxes and subsidies as suggested by Wilkinson and Norrie (1975, pp. 5–20);

FOR (?) the proportion of industry shipments accounted for by foreign-owned firms;

HVTRHCR(−) a dummy variable which takes the value of 1 when both concentration and effective tariff protection are greater than their respective means, zero otherwise;

IMP(?) imports as a proportion of domestic disappearance, where the latter consists of domestic production minus exports plus imports;

MPLNT(+) a dummy variable which takes on the value of 1 when the average number of plants per unconsolidated enterprise is greater than the mean across 141 of 167 manufacturing industries (i.e., all 4-digit industries excluding the miscellaneous set), zero otherwise;

PLESTV(−) HVTRHCR · AVPLSZ;

R4D(+) the reciprocal of the number of 4-digit ICC products classified to the industry (N4D);

REG(−) a regional dummy taking on the value of 1 when the industry was classified as regional, zero otherwise.

The Regression Results

The results are reported in Table 7-3.[21] As expected, industries with larger average plant size (ASVPLSZ) are characterized by greater product diversity at the plant level. In addition, the rate of increase in product diversity slows as average plant size increases, as indicated by the positive coefficient attached to AVPLSQ (AVPLSZ squared). Plants are more specialized in industries where multiplant operations are prevalent (MPLNT = 1). The opportunity to diversify, measured by log R4D, is, as expected, positively related to product diversity.

Comparison of the results of equations 1 and 3 to 2 and 4 in Table 7-3 permit an evaluation of the Eastman/Stykolt effect. In equations 2 and 4, only AVPLSZ and PLESTV (AVPLSZ in high tariff/high concentration industries) are included and the corresponding squared term to APLSZ is omitted because of its high collinearity with PLESTV. The coefficient on PLESTV is always negative and is statistically significant at the 5 percent level. Thus for a given plant size in high tariff/high concentration industries, product diversity will be substantially higher compared to similar sized plants elsewhere in the manufacturing sector.[22]

No conclusion about tariff protection emerge because while the coefficient is positive in 1970 it is negative in 1979 and its significance changes in alternate specifications. The trade variables are not significant; while trade may have no direct impact upon product diversity, indirect effects via average plant size do exist, as the previous section demonstrates.

Neither the regional character of an industry (REG) nor the percentage of foreign ownership (FOR) had a significant effect. Advertising intensity (ADVDM) had, as expected, a negative relationship with product diversity in both 1970 and 1979, but it was significant only in the latter year.

We also tested for the determinants of changes in product diversity and of average production run length between 1970 and 1979.[23] We had no success with the former because of the relatively small changes in diversity. However, changes in production run length (using average plant size (AVPLSZ) divided by the numbers equivalent of the diversity index (1/HERF4D)) provided more interesting results. The change in plant size was the most significant determinant; moreover in high tariff/high concentration industries, an increase in plant size had less of an effect on production run length. A decline in tariffs results in an increase in length of production run irrespective of whether the industry was in the high tariff/high concentration category.

TABLE 7-3 The Determinants of Product Diversity at the 4-Digit ICC: Regression Results Across 119 4-Digit Canadian Manufacturing Industries, 1970 and 1979

	1970				1979			
	Equation 1		Equation 2		Equation 3		Equation 4	
	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign
Constant	0.858	.0000	0.842	.0000	0.902	.0000	0.895	.0000
Trade and Tariffs								
ERP	0.094	.23	0.224	.01	−0.059	.09	−0.024	.55
CA	0.035	.15	0.029	.22	0.027	.26	0.024	.32
IMP	0.070	.37	0.086	.27	0.011	.87	0.013	.85
Plant Size and Multiplant								
AVPLSZ	−0.008	.0009	−0.001	.05	−0.005	.003	−0.001	.10
AVPLSQ	0.00004	.007	—	—	0.00001	.007	—	—
MPLNT	0.040	.011	0.046	.004	0.030	.05	0.027	.08
Eastman/Stykolt								
PLESTV	—	—	−0.007	.04	—	—	−0.005	.02
HVTRHCR	—	—	−0.076	.10	—	—	−0.013	.74
Other								
ADVDM	−0.964	.11	−0.571	.34	−1.820	.02	−1.658	.03
LOG R4D	0.088	.0000	0.097	.0000	0.092	.0000	0.097	.0000
REG	−0.020	.50	−0.007	.81	0.004	.89	0.012	.68
FOR	−0.015	.74	−0.016	.73	0.037	.43	0.035	.46
$\bar{R}^2$	0.4461	.0000	0.4601	.0000	0.4643	.0000	0.4578	.0000

Source: Statistics Canada, special tabulations.
Note: For each variable the table presents its estimated regression coefficient (Coeff) and level of statistical significance (Sign). The levels of significance are for two-tailed tests that t is statistically significant from zero.

Changes in comparative advantage had a positive but insignificant impact upon length of production run changes, but changes in imports were positive and significant. Hence, increasing imports decreased diversity and increased the length of production run. In the previous section, we reported that increases in tariffs resulted in a decline in larger Canadian plants relative to the size of larger U.S. plants. The results taken together suggest that Canadian plants, when facing import competition, become smaller and carve specialist niches in the marketplace that lead to longer average production run length, rather than adding even more products to offset the loss in plant scale economies resulting from declining sales in their primary product lines.

We also experimented with an interaction term between foreign ownership and the high tariff/high concentration variables for both the 1970 and 1979, and decadal change regressions. In general, these terms indicate that high foreign ownership tended to ameliorate the impact of high tariffs and high concentration. Thus foreign ownership had a beneficial rather than negative effect — at least insofar as increases in the length of production run for a given increase in average plant size was concerned.

Conclusion

It may, therefore, be concluded that much of the earlier concern with plant scale as opposed to diversity was not misplaced, as the diversity decision is closely related to the plant scale decision. The scale variables are the primary determinant of diversity. Trade and tariff variables are felt indirectly through the scale variables.

The Determinants of Relative Productivity (TFP1, TFP3, TFP4)

Previous researchers who have compared Canadian partial labour productivity measures to those of the United States have not been unaware of the need to take into account the effect of scale economies. But they have done so in a manner that has at least one of two defects. These studies have included measures of capital intensity, or the importance of scale economies, as explanatory variables in their analyses of inter-industry differences in labour productivity. Such a procedure essentially can be justified in the following way.

Consider the case where the production process can be represented by a Cobb-Douglas production function, $Q = AL^aK^b$, in both countries, but where only A differs for Canada and the United States. Then the relative labour productivity Canada/U.S. is given by:

$$\ln(VA_c/L_c)/(VA_u/L_u) \tag{7.1}$$
$$= \ln(A_c/A_u) - (a+b-1)\ln(L_c/L_u) - b\ln(K_c/L_c)/(K_u/L_u).$$

Then a cross-sectional regression of the form

$$\begin{aligned} & \ln(VA_c/L_c)/(VA_u/L_u) \qquad (7.2) \\ & = f\,(L_c/L_u,\ (K_c/L_c)/(K_u/L_u),X) \\ & = g_0 \ln(L_c/L_u) + g_1 \ln[(K_c/L_c)/(K_u/L_u)] + g_2 X \end{aligned}$$

where X is a vector of industry characteristics, essentially allows X to explain the relative total factor productivity differences, while the relative labour and the relative capital labour terms capture effects on labour productivity that can be defined as technological — i.e., resulting from being at different points on the production function.

Any cross-sectional analysis suffers from a potential problem in that coefficients may not be constant across the sample. The Eastman-Stykolt hypothesis, for instance, posits an interaction effect of tariffs and concentration. There may also be threshold effects that require non-linearities. However, judicious use of interaction and shift terms based on a priori hypotheses can deal with this problem when the above relationship, equation 7.2, is estimated — except for the relative size and relative capital-labour intensity variables. Here, outside information is required that allows the coefficients that should be attached to these two terms to differ by industry.

By separately estimating the parameters of the production function industry by industry, we allow the coefficients in equation 7.2, (g_0, g_1), that should vary in a cross-sectional industry study, to do so. In effect, we constrain the coefficients in equation 7.2 to take specific values by moving them and their associated variables to the left-hand side of the regression. Our dependent variable then is simply a partial labour factor productivity measure corrected for the curvature of the production function — or a scale-corrected total factor productivity measure.

Of our three measures of relative productivity, two (TFP3 and TFP4) correct for scale economies and therefore need not include proxies of relative plant scale or market size as explanatory variables to allow for scale effects. In contrast, TFP1 does not make such a correction and should include the appropriate control variable. Since our analysis has suggested that the appropriate variable for this purpose is relative plant scale, we include EFF1T for this purpose. The remaining explanatory variables for all three TFP measures should catch non-optimization tendencies that have come to be broadly subsumed under the X-efficiency rubric — since this is what we postulate determines the extent to which Canadian industry is as efficient as U.S. industry once scale economies have been incorporated into the analysis.

While there is a paucity of literature to guide us in our choice of variables that are most likely to be related to industry inefficiency, De Alessi (1983) has tried to place some order in what is a rather eclectic area by arguing that the attentuation of property rights or an increase in transactions costs will lead to "shirking" or X-inefficiency. In particular, he argues that monopolists will face higher transactions costs and less optimization pressure and that X-inefficiency will be higher in less competitive markets. While De Alessi's propositions have been challenged (Liebenstein, 1983), they provide the null hypothesis that we choose to test.

If this hypothesis is true, we would expect variables such as concentration (CON), the size of the market normalized by efficient plant size (MESMSD), and the degree of regional fragmentation (REG) all to affect relative Canadian/U.S. efficiency because they represent, in different ways, the intensity of competition. We might also expect a variable (MPLNT) representing the multiplant nature of the industry to be important. In the De Alessi framework, the greater the number of plants the greater the opportunity for experimentation with new production techniques and the higher should be relative efficiency. Product differentiation (ADVDM) may attenuate competition by providing firms with secure local market niches. Similarly, trade variables such as the effective tariff rate (ERP), import intensity (IMP), and export intensity (EXP) might be expected to affect relative efficiency because they too represent the degree of competitive pressure that attenuates natural tendencies, leading to inefficiency.

In addition to the above-mentioned variables, we include interactive terms (HVTRHCR and EASTV) between imperfectly structured markets and the level of tariffs to test the Eastman/Stykolt hypothesis that the joint barriers to optimization provided by each of the above reinforce one another. We hypothesize that where concentration and tariffs are both high (HVTRHCR), efficiency will be lower, but in such industries an increase in normalized market size (EASTV) will improve efficiency. These interaction terms or variants thereof were found to be particularly significant in explaining relative Canada/U.S. plant scale.

We also include a measure of scale effects, the cost disadvantage of small plants relative to large plants (CDR1). Since scale economies and relative plant size have already been incorporated directly into the analysis, the traditional justification for such a variable — that it catches differences in labour productivity that arise because of smaller Canadian plants and the existence of scale economies — is lacking here. It is nevertheless included, but for a different reason. It measures the extent to which small plants can coexist side by side with larger, more efficient plants. As such it should be inversely correlated with the pressures leading to optimization.

The percentage of engineers and other scientists in the labour force (RD) is included to capture a labour quality variable not directly measured in the production function. Its inclusion tests for bias in the productivity measure that might have been caused by its omission from the production function.

Foreign ownership (FOR) has been included, mostly because of the controversy that has surrounded its effect on the Canadian economy. Some of the ill effects associated with the miniature replica hypothesis that are attributed to foreign investment are probably associated with the tariff per se and not with foreign investment (Safarian, 1966). In this case, they may already have been captured by the tariff and concentration variables. However, Saunders (1980) did find a negative effect of foreign ownership. On the other hand, foreign firms, in that they are outsiders, can act as a catalyst for competition (Gorecki, 1976b). Globerman (1979) finds that foreign firms have a positive spillover effect on the productivity of domestic firms, although Corbo and Havrylyshyn (1982) find no evidence for this in a sample of seven industries. The presence of foreign firms may provide the most efficient agent for the international transmission of technology — though whether their presence indicates that the transmission has successfully occurred or that Canadian techniques were inefficient and the industry is still in the process of catching up cannot be specified a priori.

Finally, we include a plant level product diversity variable corrected for potential diversity (RELDIV5D, see Chapter Two) to test whether there are any residual effects of diversity. RELDIV5D, rather than HERF5D (actual diversity), is used because we wanted to correct for the potential level of diversity arising from different numbers of products.[24] Because our attempts to include diversity in the industry production functions were not generally successful, there may be a residual effect for this variable at the industry level.

The regression results for TFP1 are included in Table 7-4, along with the predicted signs of the variables. The variables have already been defined. Greater detail on each variable can be found in Appendix A. The estimated coefficients, their t-values, and the level of significance of the coefficients that would allow rejection of the null hypothesis that each coefficient is different from zero, are reported for the subset of variables that consistently appear to be important in the complete sample, where a stepwise regression procedure was followed.

Four variables are significant in both years. Greater import penetration (IMP) leads to higher relative efficiency. The scale correction variable (relative plant size, EFF1T) has a positive coefficient of around .15 in 1970 and .09 in 1979. The former corresponds to our average scale economic estimate and the latter is below it. The export variable (EXP) has a negative coefficient. This suggests that our assumption that Canadian domestic prices are marked up to the tariff is probably inappropriate for export industries. In export industries, prices would more likely reflect world prices. Foreign ownership (FOR) has a positive coefficient — indicating that investment flows, like trade in goods, have a beneficial effect on the Canadian manufacturing sector. Finally, higher effective tariffs (ERP) have a negative impact on efficiency but the variable is only significant in 1970.

TABLE 7-4 The Determinants of TFP1 Across 102 4-Digit Canadian Manufacturing Industries: 1970 and 1979

	1970	1979
IMP coeff	0.251	0.399
t	(2.37)	(3.23)
P(|t| ≥ 0)	(0.019)	(0.002)
ERP	−0.384	—
	(−2.472)	
	(0.015)	
EFF1T	0.151	0.097
	(4.49)	(2.59)
	(0.000)	(0.010)
RELDIV5D	—	−0.445
		(−3.43)
		(0.080)
FOR	0.1233	0.150
	(2.08)	(1.77)
	(0.040)	(0.080)
EXP	−0.1703	−0.245
	(−1.620)	(−1.846)
	(0.108)	(0.068)
ADVDM	−1.808	—
	(−2.429)	
	(0.017)	
CDR1	—	−0.108
		(−2.143)
		(0.035)
$\bar{R}^2$	0.192	0.268
F	7.82	5.84
P ≥ F	0.0001	0.0001

Source: Statistics Canada, special tabulations.
Note: For each variable, the coefficient is followed by its t statistic and the probability that it is significantly different from zero using a two-tailed test.

We also estimated a regression for each year with a complete set of explanatory variables included, but do not report the results. They were basically the same, although multicollinearity reduced the significance of exports and foreign ownership somewhat in 1979. Advertising was significant in 1970 but not in 1979; CDR1 was negative and significant in 1979 but not in 1970. Finally, we treated relative plant scale and diversity as endogenous since it might be argued that relative efficiency should determine the extent to which firms are successful in meeting imports and thus will affect relative scale and the pressures to diversify so as to exploit scale economies. The results of this variant were broadly similar to the ordinary least squares estimates that used the complete set of explanatory variables — except that now diversity has a negative and significant effect in 1970 but a slightly weaker effect in 1979. The net effect of these experiments was to suggest that apart from perhaps diversity, no variables among our set significantly affected relative efficiency when measured by TFP1.

We report the results for the aggregate scale-corrected measure TFP3 in Table 7-5. We believe this measure to be the less precise of our two scale-corrected estimates. Column 1 presents the results for each year for the few variables that were at all significant. Virtually nothing is significant. We also truncate our sample to exclude some of the largest outliers (see notes to the table) and report our results for the complete set of explanatory variables in columns 2 and 3 for each year. A few more variables appear to be significant when this is done, but only foreign ownership appears in both years with a significance level of less than 5 percent.

Table 7-6 presents the regression results for our preferred scale-corrected measure TFP4. Again we report in column 1 the results using a step-wise routine for a reduced variable set across the entire industry example and, in columns 2 and 3, the results for the entire variable set for a truncated sample of observations that excluded outliers.[25] The entire sample yields little of interest. The truncated sample yields consistently significant estimates only for imports. There is weak evidence to suggest that the negative effect of exports, reported for TFP1, may also be present.

In conclusion, the most consistent finding is the negative influence of tariff barriers and the positive effect of imports. While Saunders (1980) found that tariffs had a negative effect, the coefficient on his import term, while positive, was not significant. Perhaps more important, we find that foreign ownership has a positive coefficient that is significant in the TFP1 formulation: Saunders reports a negative significant effect.

The difference in the results of the TFP1 and TFP4 regressions illustrate the difficult trade-off that faces an applied econometric study in this area. Using TFP1 and including EFF1T as an explanatory variable will bias the results to the extent that the coefficient attached to EFF1T measures only average scale effects. Other explanatory variables may be picking up the unmeasured deviation of the actual scale effect from the estimated mean. Using TFP4 potentially corrects for this problem — except that the scale effect is undoubtedly measured with error in a number of cases. This, of course, increases the residual variance and makes the coefficients less precise — perhaps accounting for the smaller number of significant coefficients in the latter case.

Nevertheless, there are some conclusions that are robust with respect to the approach chosen. The openness of the Canadian economy positively affects relative Canada/U.S. efficiency in the manufacturing

TABLE 7-5 The Determinants of TFP3 Across 102 4-Digit Canadian Manufacturing Industries, 1970 and 1979

	1970			1979		
	1[a]	2[b]	3[c]	1[a]	2[b]	3[c]
IMP coeff	—	0.769	0.443	1.010	0.262	−0.129
t		(2.239)	(1.552)	(1.912)	(1.613)	(−0.415)
$P(\lvert t \rvert \geq 0)$		(0.028)	(0.125)	(0.059)	(0.111)	(0.679)
ERP	—	−0.392	−0.199	—	−0.198	−0.112
		(−0.763)	(−0.470)		(−0.230)	(−0.210)
		(0.448)	(0.640)		(0.780)	(0.834)
MPLNT	—	−0.0003	0.008	—	−0.015	−0.088
		(−0.005)	(0.157)		(−0.183)	(−1.400)
		(0.996)	(0.876)		(0.854)	(0.166)
FOR	—	−0.489	0.254	—	0.604	0.425
		(−2.512)	(1.547)		(2.562)	(2.291)
		(0.014)	(0.126)		(0.012)	(0.025)
EXP	—	−0.697	−0.413	—	−0.542	0.274
		(−2.141)	(−1.521)		(−1.366)	(0.861)
		(0.035)	(0.132)		(0.176)	(0.392)
RELDIV5D	—	−0.292	−0.090	—	−0.609	−0.510
		(−0.971)	(−0.363)		(−1.728)	(−1.822)
		(0.334)	(0.718)		(0.088)	(0.073)
ADVDM	—	0.302	0.408	—	−0.314	2.248
		(0.132)	(0.217)		(−0.087)	(0.805)
		(0.896)	(0.829)		(0.931)	(0.424)
CDR1	—	−0.118	−0.023	—	−0.142	−0.109
		(−0.968)	(−0.226)		(−0.897)	(−0.869)
		(0.336)	(0.821)		(0.372)	(0.388)

MESMSD	—	0.0004	0.001	—	0.002	0.003
		(0.127)	(0.510)		(0.572)	(1.220)
		(0.899)	(0.612)		(0.569)	(0.227)
RD	—	−3.046	−1.219	—	−3.904	−1.540
		(−0.839)	(−0.408)		(−1.067)	(−0.559)
		(0.404)	(0.684)		(0.289)	(0.578)
HVTRHCR	—	−0.021	-0.3×10^{-4}	—	−0.248	−0.191
		(−0.083)	(−0.000)		(−0.778)	(−0.722)
		(0.934)	(0.999)		(0.439)	(0.473)
EASTV	—	−0.019	0.018	—	−0.010	0.033
		(−0.679)	(0.744)		(−0.322)	(1.305)
		(0.489)	(0.459)		(0.748)	(0.196)
REG	−0.275	−0.015	0.015	—	−0.001	−0.002
	(−1.492)	(−0.126)	(0.164)		(−0.007)	(−0.017)
	(0.138)	(0.900)	(0.870)		(0.994)	(0.986)
$\bar{R}^2$	0.021	0.185	0.086	0.034	0.17	0.17
F	2.23	1.48	0.59	3.66	1.30	1.16
$P \geq F$	0.14	0.14	0.86	0.06	0.23	0.33

Source: Statistics Canada, special tabulations.
Note: For each variable, the coefficient is followed by its t statistic and the probability that it is significantly different from zero using a two-tailed test.
a. Column 1 covers the entire 102 4-digit sample. Only variables which are significant are included in this column.
b. Column 2 excludes all TFP estimates ≤.33 and ≥3.0. Its sample size was 99 in 1970 and 95 in 1979.
c. Column 3 excludes all TFP estimates ≤.33 and ≥2.0. Its sample size was 95 in 1970 and 95 in 1979.

TABLE 7-6 The Determinants of TFP4 Across 102 4-Digit Canadian Manufacturing Industries, 1970 and 1979

	1970			1979		
	1[a]	2[b]	3[c]	1[a]	2[b]	3[c]
IMP coeff	—	0.719	0.393	0.845	0.648	0.585
t		(3.130)	(1.920)	(2.669)	(2.269)	(2.531)
$P(\|t\| \geq 0)$		(0.002)	(0.059)	(0.009)	(0.023)	(0.013)
ERP	—	−0.119	−0.113	—	−0.071	−0.103
		(−0.321)	(−0.369)		(−0.131)	(−0.234)
		(0.749)	(0.713)		(0.896)	(0.815)
MPLNT	—	0.024	0.017	—	0.006	0.019
		(0.554)	(0.468)		(0.096)	(0.381)
		(0.581)	(0.641)		(0.924)	(0.704)
FOR	—	0.193	0.162	—	0.043	0.145
		(1.401)	(1.398)		(0.239)	(0.990)
		(0.165)	(0.166)		(0.812)	(0.325)
EXP	—	−0.477	−0.278	—	−0.483	−0.332
		(−2.108)	(−1.444)		(−1.656)	(−1.398)
		(0.038)	(0.152)		(0.101)	(0.166)
RELDIV5D	—	0.120	0.126	—	−0.356	−0.127
		(0.568)	(0.713)		(−1.335)	(−0.583)
		(0.572)	(0.478)		(0.186)	(0.561)
ADVDM	—	1.498	1.243	—	1.946	2.092
		(0.905)	(0.900)		(0.701)	(0.931)
		(0.368)	(0.371)		(0.485)	(0.356)
CDR1	—	−0.013	0.036	—	−0.025	−0.069
		(−0.150)	(0.497)		(−0.212)	(−0.701)
		(0.881)	(0.621)		(0.833)	(0.486)

MESMSD	—	0.003	0.003	—	0.0009	0.003
		(1.479)	(1.773)		(0.317)	(1.273)
		(0.143)	(0.080)		(0.752)	(0.207)
RD	—	−1.920	−1.334	—	−2.789	−2.340
		(−0.747)	(−0.622)		(−0.994)	(−1.028)
		(0.457)	(0.536)		(0.323)	(0.307)
HVTRHCR	−0.217	−0.142	−0.130	—	0.086	0.153
	(−1.551)	(−0.780)	(−0.857)		(0.352)	(0.769)
	(0.12)	(0.438)	(0.393)		(0.725)	(0.444)
EASTV	—	0.005	0.007	—	−0.030	−0.031
		(0.225)	(0.372)		(−1.211)	(−1.559)
		(0.823)	(0.711)		(0.229)	(0.123)
REG	−0.259	−0.151	−0.144	—	−0.067	−0.134
	(−2.320)	(−1.836)	(−2.089)		(−0.615)	(−1.489)
	(0.022)	(0.070)	(0.040)		(0.541)	(0.140)
$\bar{R}^2$	0.067	0.024	0.196	0.066	0.137	0.184
F	3.58	2.07	1.56	7.12	1.03	1.43
P ≥ F	0.032	0.025	0.11	0.009	0.433	0.165

Source: Statistics Canada, special tabulations.
Note: For each variable, the coefficient is followed by its t statistic and the probability that it is significantly different from zero using a two-tailed test.
a. Column 1 covers the entire 102 4-digit sample. Only variables which are significant are included in this column.
b. Column 2 excludes all TFP estimates ≤.33 and ≥3.0. Its sample size was 99 in 1970 and 95 in 1979.
c. Column 3 excludes all TFP estimates ≤.33 and ≥2.0. Its sample size was 95 in 1970 and 95 in 1979.

sector. In particular, the greater the import penetration ratio, the higher is relative efficiency. Moreover, foreign ownership does not have a negative effect on relative efficiency — if anything it has a positive effect.

While the importance of trade therefore comes through strongly, virtually nothing else does. In particular, market imperfections as measured by concentration, size of market, and the regional nature of the industry do not consistently enter with a significant sign. The null hypothesis that the lack of competition is an important determinant of X-inefficiency is therefore not borne out — except with respect to the trade variables. That, of course, does not mean it is not important. It may be that there is a much more complex interaction among the various factors that shelter a market from competition. Or it may be that X-inefficiency is essentially random — as the regression results for TFP4 suggest.

Summary and Conclusion

In Chapter Six we found that, on average, Canadian plants do suffer from technical inefficiency which is not completely explained by the disadvantage of sub-optimal plant scale. Nevertheless, about one-third of the disadvantage is accounted for by sub-optimal plant scale. Thus, it is important to emphasize the understanding of the determinants of relative plant scale. In associated studies, we addressed the relatively difficult and little studied problem of the determinants of plant size distribution. Our findings, summarized here, are that size of market is the primary determinant of relative Canada/U.S. plant scale.

We also find that tariffs, combined with imperfect market structure, detrimentally affect relative plant scale. Here the policy implications are clear. Improvements in productivity can result from decreasing tariffs in markets which are relatively concentrated. Trade liberalization can help in this area.

We also find that product diversity leads to technical inefficiency, in addition to the scale effect — at least for our TFP1 measure. The concern of previous researchers with product diversity is justified. However, the policy implications are not as clear, because diversity and scale of plan are positively correlated and thus the efficiency effects work in opposite directions and cancel each other out to some extent. Our results are not precise enough at this stage to permit calculation of the net effect.

While the average level of relative Canada/U.S. inefficiency is of interest in its own right, its inter-industry variability is equally important if we are to evaluate the prescriptions for improvement that are to be found in the literature on industrial policy. Previous studies that did not correct for plant scale in the appropriate fashion, or that used restricted samples, reported that Canadian inefficiency was related to such variables as foreign ownership, research intensity, or the percentage of management personnel. The implications of such findings are that the position of Canadian industry can be affected by specific policies aimed at each of these variables: FIRA restrictions on foreign investment; government subsidy programs for R&D; and management programs to economize on resources in the white-collar field.

In contrast to earlier work, our regressions of inter-industry variability of relative Canada/U.S. efficiency indicate that it is the openness of the Canadian industry to both goods and investment flows that has a beneficial effect. While several other variables enter occasionally, their significance does not stand up to slight changes in model specification or sample choice and as such they cannot be said to be robust. We do not deny the relevance of such variables as R&D spending to the efficiency of individual industries — just that they do not have a strong cross-industry correlation to success as we measure it. Instead, we find that trade matters, both directly and indirectly. Indirectly, it affects relative plant scale, which in turn affects relative productivity. But barriers to trade (whether they be high tariffs, low import levels, or low foreign investment) also negatively affect the scale-corrected relative productivity measures studied here. As such, a strong argument can be made that the trade liberalization process over the postwar period has improved the competitiveness of Canadian industry and that continued emphasis on a reduction of trade barriers or their maintenance at present low levels is in Canada's best interests.

Appendix A
Data Base: Sources and Definitions

The study of Canada/U.S. productivity draws upon two basic data sources: Statistics Canada and various agencies of the U.S. government including the Bureau of the Census and the Internal Revenue Service (IRS). Statistics Canada assembled a special data base which drew together many series from different parts of that organization. Several features of the resultant data base should be noted. First, several of the series are unpublished and/or available for only a limited number of years. Second, the data base consisted of *all* observations for a given variable, no matter whether the particular observation is confidential within the meaning of the Statistics Act or not. For example, if there were only two firms in an industry, Statistics Canada would *not* publish concentration ratios for such industries. (However, as noted in the text, although the authors had access to such a data base, all the material presented in this study was vetted carefully for confidentiality disclosure.) The U.S. data were largely supplied by R. Caves of Harvard University, but were supplemented by reference to published and unpublished data from various U.S. statistical agencies.

In comparing U.S. and Canadian variables, industry definitions had to be made comparable. The Canadian classification system used was at the 4-digit level based on the 1970 Standard Industrial Classification. The U.S. system of classification was somewhat finer than the Canadian. Hence in a number of instances several U.S. industries had to be combined to form the corresponding Canadian industry. An important source in this exercise was Canada, Department of Industry, Trade and Commerce (1971, 1975). Table A-1 provides the concordance between the Canadian and U.S. classification system, as well as alternative sets of weights that can be applied to generate U.S. industry variables for the Canadian definition. Four different weights are shown — sales, assets, employment and value added. The size dimension selected was sales. Casual inspection of the different weights suggests that they are, on the whole, very similar. For example, Canadian industry 1011, Slaughtering and Meat Processors, consisted of three U.S. industries, 2011, 2013 and 2077, of which 2011, Meat Packing Plants, was by far the most significant. Finally, it should be noted that for IRS-generated variables such as $CORR_u$ and BV_u the Minor Industry Classification system (Table A-4) was used. This is somewhat more aggregative than the U.S. and Canadian 4-digit SIC. Hence prorating or assuming ratios were constant across all 4-digit industries within an IRS Minor Industry was necessary.

Although the Statistics Canada data are based upon the 1970 4-digit SIC, in a number of instances, series were provided at a more aggregative level of classification. Two systems were used. First, data series derived from input-output tables used a classification system that divided the manufacturing sector into 122 industries. Second, in a number of instances, such as the R&D statistics, the 3-digit level of classification was used which divides the manufacturing sector into 112 industries. Typically all the 4-digit constituent industries of a given input/output or 3-digit industry are assumed to have an equal value for the data series provided, which are typically ratios. Exceptions are noted in the text. Table A-2 provides the three levels of industry classification and a concordance. However, in the case of BV_c and $CORR_c$ the 1960 3-digit SIC was used. Table A-3 provides a concordance between the 1960 and 1970 3-digit SIC.

Definitions of Variables

The remainder of the appendix consists of a detailed description and definition of the variables used in the monograph. Since in many instances the series are not published, we refer to the unit or division within Statistics Canada from which the data were derived. Unless otherwise stated the variable is defined at the Canadian 4-digit level of classification and is available for 1970 and 1979 for Canada; while for the United States the classification system is the U.S. 4-digit SIC level but the data are for 1972 and 1979. In some instances it was necessary to adjust the data to make comparisons between Canada and the United States — for example, because of differences in prices. Such adjustments are described in the text of the paper.

All the variable definitions presented below, with a couple of exceptions (i.e., PHERF4D and PHERF5D), are at the industry level. The estimation of individual industry production functions required definitions of variables at the level of the establishment. These were all presented in Chapter Three and need not be repeated here.

Definitions of Variables: Canada

ADVDM is the advertising/sales ratio for consumer non-durable goods industries, zero otherwise. The advertising/sales ratio was provided by the Structural Analysis Division of Statistics Canada, from the Input/Output tables (i.e., the industry classification used in col. 3 in Table A-2). The underlying data for the ratio on advertising have been collected at the company[1] level by a 1974 Survey. If the company produced output in only one industry, then the advertising expenditures were attributed to that industry. Otherwise, they were split among the various industries in which the company produced. Modification of this ratio, from information provided by CALURA *(Corporation and Labour Union Returns Act)* and

Business Finance Data, were applied to other years. Data were available for ADVDM for 1975 rather than 1970.

AVPLSZ average plant size, defined in 1971 constant dollars, is value of industry shipments divided by the number of plants classified to the industry. Industry shipments are measured for total activity (see VS) and the price index is gross output (See GPINX). Industry shipments and number of plants per industry are taken from the Manufacturing and Primary Industries Division.

AVPLSQ is simply AVPLSZ squared. See AVPLSZ for details.

AVSZT is average size (measured in total activity value shipments) of the smallest number of the largest plants accounting for 50 percent of industry employment. Data are provided by Manufacturing and Primary Industries Division. See VS for further details.

BV_c is book value of capital. In order to generate estimates of BV_c, Corporation Financial Statistics must be used since the Census of Manufactures does not report capital. Two problems arise when doing so. First, the industry categories in the Financial Statistics and in the Census are not identical. However, the two can be matched (see Table A-3 for the concordance). Secondly, data that are reported in the Census (Canada, Statistics Canada, 1979b) and in the Financial Statistics (Canada, Statistics Canada, 1981b) are generated in different ways. The Census builds up industry totals from plant data. A plant's entire output is assigned to the industry for which the majority of its output is primary. Industry level data are relatively accurate except where plants produce a large percentage of secondary output — that is, output properly belonging to another industry but not classified there. Specialization ratios (the ratio of primary product to total product) indicate few misclassification problems in the Census (Baldwin, Gorecki, McVey, 1984, p. 5). In contrast, the Financial Statistics are generated from tax returns and whole companies are assigned to the industry for which the majority of all their output is primary. Thus the output of an entire plant can be misclassified, leading to potentially large distortions. There is, however, a method that can be used to check the degree of misclassification. Both the Census and the Financial Statistics report sales (S), salary and wage costs (W), and materials expenses (M). By comparing the relative size of each of these variables from the two sources, the potential distortion in using data generated by the Financial Statistics along with Census data can be estimated. In making these comparisons, using the appropriate concordance referred to above (i.e., Table A-3), we used the Census of Manufactures data based on total activity rather than manufacturing activity since the former corresponds more closely with the definitions used in the Corporation Financial Statistics. These ratios are used to generate a subset of industries that can be regarded as comparable.

Book value of capital for the Census of Manufactures was calculated in the following way. First, S, M, and W from the Financial Statistics were divided by the same variable taken from the comparable Census category.

These three ratios were averaged for each industry. In two industries, one of the three ratios was rejected as being very different from the other two and therefore probably incorrect. This average ratio, referred to as COVER70, COVER79 for 1970 and 1979 respectively, was then divided by the Financial Statistics capital value to give a capital value for the Census of Manufactures corresponding category. Since the Financial Statistics are collected at the SIC 3-digit level, these estimates are then spread to the 4-digit level. In spreading capital values from the 3- to the 4-digit level, the spreading factors that were used come from those provided by Statistics Canada to spread capital stock and were based on net investment figures. Separate weights were used for 1970 and 1979.

Three different measures of book value are created. These are:

1. gross depreciable assets — from line 14, Table 2A of the Corporation Financial Statistics for 1979 (Canada, Statistics Canada, 1981b).

2. net fixed assets — from line 18, Table 2A.

3. total assets less current liabilities — from lines 26 and 34 of Table 2A.

Corporation Financial Statistics is an annual Statistics Canada Publication, No. 61-207. As noted in Chapter Five, BV_c was defined as gross depreciable assets.

CA is 1 plus (exports minus imports divided by the sum of exports plus imports). The import and export data were provided by the External Trade Division, Trade of Canada, Statistics Canada. The import data are collected by Canadian Customs. The Custom's values are identical to the selling prices for most transactions, with exceptions occurring for transactions among company affiliates where adjustments are made such that the Custom's value may exceed company transfer prices. Imports are measured free on board (f.o.b.), which is the price as exported from the home base and does not include transportation costs. Some imports from the United States, however, are purchased on a delivered basis and their prices will reflect an allowance for transportation. Exports are recorded at the values declared on export documents, which reflect the actual selling price (and, in the case of non-arms length transactions, the transfer price used for company accounting purposes). Most exports are valued at the place in Canada where they are loaded onto a carrier for export.

The trade data are collected at the commodity level and were aggregated to the 4-digit SIC (industry) classification by the External Trade Division. Typically a commodity is allocated completely to the industry to which it is primary.

A number of approximations or adjustments had to be made to the data supplied by External Trade. First, in a number of cases, the data for a given 4-digit SIC were not presented in the raw data supplied. This required different sorts of approximations, depending on the nature of the "missing" data. For the 21 industries concerned the details are as follows:

SIC	Approximation	SIC	Approximation
1831	A	3241	C
1832	A	3242	C
1871	B	3243	C
1872	B	3511	C
1880	B	3512	C
2391	A	3541	B
2392	A	3542	B
2611	B	3549	B
2619	B	3791	C
3031	C	3799	C
3039	C		

A = Prorating 3-digit trade data to 4-digit level on basis of 4-digit industry sales (e.g., data supplied for 1830, which then were used to generate observations for 1831 and 1832).

B = Data provided at 3-digit level and for some of constituent 4-digit industries. The 3-digit trade is prorated in the same way as A (e.g., data were provided for 1870 and 1871. The 1870 data were then prorated to 1871 and 1872).

C = Same as B except data were provided for *all* of constituent 4-digit industries within a 3-digit industry. In other words, the residual that could not be allocated to particular 4-digit industries is prorated from the 3-digit industry as in A.

In the case of approximation C (9 of 21), the prorating was often minor because it is only the unallocated residual at the 3-digit level which is a problem. In other words, apart from 4 type A approximations and 8 type B, which may be somewhat crude, the data set should be a close match at the 4-digit.

Second, for one industry exports exceeded domestic production by such a margin (180 percent in 1971) as to suggest that the classification of export commodities to that 4-digit industry was incorrect. Further investigation suggested that one commodity should be relocated. This was confirmed in conversations with specialists within Statistics Canada.

The import and export data were available for 1971 rather than 1970. In estimating IMP and EXP the 1971 data were converted to 1970 dollars using the gross output price index. See GPINX for further details.

CDR is the ratio of value-added per manhour of the smallest plants accounting for 50 percent of industry employment divided by the value added per manhour for the largest plants accounting for 50 percent of industry employment. It was derived directly from data supplied on the size distribution of plants by the Manufacturing and Primary Industries Division.

CDR1 is set equal to CDR where MESMSD is less than its median, zero otherwise. See MESMSD and CDR for further details.

CDR2 is set equal to CDR where MESMSD is greater than its median, zero otherwise. See CDR and MESMSD for further details.

CDR3 is set equal to CDR where the industry is national (REG = 0) and MESMSD is greater than its median, zero otherwise. See CDR, MESMSD and REG for further details.

CDR4 is set equal to CDR where the level of imports (IMP) is less than its mean and MESMSD is greater than its median, zero otherwise. See CDR, IMP and MESMSD for further details.

CON is the proportion of industry shipments accounted for by the four largest enterprises. This was provided by the Manufacturing and Primary Industries Division.

$\mathbf{CORR_c}$ is the ratio of other expenses to sales. Both numerator and denominator are taken from the Corporation Financial Statistics. Other expenses are defined as the sum of:

14. repair and maintenance
15. rent (real estate)
16. rent (other)
21. taxes other than direct taxes
24. other expenses

where the number against each entry is taken from Table 2B of the 1979 Corporation Financial Statistics (Canada, Statistics Canada, 1981b). Sales is line 41 of the table. It should be noted that "other" expenses include office supplies, provisions for bad debt, charitable and political donations, management fees, advertising, travelling expenses, workman's compensation, pensions, unemployment insurance, and group insurance. To the extent that some of these are employee benefits, they probably should be left in as part of labour's remuneration, and therefore part of value-added. However, the error created by deducting all "other" expenses including these wage components is relatively minor compared to leaving it out. While we do not have an exact breakdown of the components for Canada, we do for the United States. The wage component for 1977 is less than 10 percent of the total "other" category — the "other" plus these wage components.
The Corporation Financial Statistics are measured at the 1960 3-digit SIC. Table A-3 shows the concordance between the 1970 and 1960 SIC at the 3-digit level. It was assumed that all 4-digit industries within a given 3-digit industry had the same value of $CORR_c$. See also BV_c.

COVER see BV_c.

$\mathbf{CVA_c}$ Canadian census value added. See Chapter Five for further discussion and definition.

EASTFV HVTRCRF • MESMSD. See HVTRCRF and MESMSD for further details.

EASTV HVTRHCR • MESMSD. See HVTRHCR and MESMSD for further details.

EFF1T AVSZT/USMES. See AVSZT and USMES for further details. EFF1T was measured using employment rather than sales because employment was the only metric for which U.S. data were available.

ERP is the effective tariff in an industry. The variable was estimated by the Structural Analysis Division from input/output data (i.e., industry classification used in col. 3 in Table A-2) and 1978 is the latest year for which the variable is available. The variable is calculated to take into account exports, indirect taxes and subsidies in an industry. It was estimated using the Wilkinson and Norrie (1975) definition of effective tariff protection. More specifically the basic equation is:

$$G_j = \frac{V_j' - V_j}{V_j'}$$

where V_j' is the value added/unit of output under protection and V_j is the value added/unit of output after protection has been removed.
The equation estimated was:

$$\frac{\left(1 - \sum_{i=1}^{n} a_{ij}\right) - \left(\frac{1 + b_j t_j}{1 + t_j}\right) - \left(\sum_{i=1}^{n-2} \frac{a_{ij}}{1 + t_i}\right)}{1 - \sum_{i=1}^{n} a_{ij}}$$

where: a_{ij} (the input coefficient) is the value of the ith input into the jth industry as a proportion of the value of the jth industry's output, at protected prices; t_i is the nominal tariff rate of the commodity; t_j is the nominal tariff rate of the jth industry; and b_j is the proportion of industry output exported.

To account for the impact of indirect taxes and subsidies the input coefficients from the input/output tables are summed from 1 to n-2. In the Wilkinson and Norrie study the tobacco and alcohol industries were excluded because import duties and excise taxes could not be separated. The data used here excluded all excise taxes and hence these industries are included.

In the input/output tables imports are defined to be the producers' values which excludes costs, insurance, freight and import duties at the Canadian border. Because imports are measured f.o.b. it was necessary for the effective rate of protection to calculate estimates of transportation and insurance charges. Exports are valued at producer prices and all values in the input/output tables are measured at current prices. The producer price is the selling price at the boundary of the producing establishment excluding taxes.

EXP is the proportion of domestic production (i.e., VS) that is exported. See CA for further details.

FOR is the proportion of industry shipments (i.e., VS) accounted for by foreign-owned enterprises. An enterprise is defined as foreign controlled if there is effective foreign control, although the percentage of stock owned by a foreign corporation may be less than 50 percent. The data were supplied by Multinational Enterprise Division.

GPINX is the Gross Output Price Index for an industry as provided by the Industry Product Division of Statistics Canada and estimated from the data provided in the Census of Manufacturers from shipments of commodities from an industry and from the industry selling price index that is available for most commodities. Commodities without a selling price index are grouped with "similar" commodities to provide an estimated price index. The Gross Output Price Index is computed for the majority of the industries at the 4-digit level.

HERF4D The Herfindahl index of *plant* diversity can be defined as

$$\text{PHERF4D} = \sum_{i=1}^{N} S_i^2$$

where S_i is the proportion of the plant's shipments classified to the Nth 4-digit ICC commodity. For the *industry*, HERF4D, consists of

$$\text{HERF4D} = \sum_{j=1}^{m} Rj, \ \text{PHERF4D}_j,$$

where m is the number of plants in the industry and Rj is the jth plant's share of total industry shipments. In other words, HERF4D is simply the weighted average of plant diversity using shipments as weights. In the text, however, HERF4D is sometimes used to refer to PHERF4D. The context makes it clear when this is the case. HERF4D and PHERF4D are available for 1974 in a machine readable form, but not for 1970. Although machine readable product data are available for 1972 and 1973, Statistics Canada personnel stated that 1974 was the first year that the data could be considered dependable. (In Economic Council of Canada, 1983, p. 123, it is incorrectly stated that 1973, not 1974, data were used in measuring product diversity).

HERF (and PHERF) are available for only "long-form" establishments, i.e., those that account for about 96 percent of shipments in the manufacturing sector (Canada, Statistics Canada, 1979b, p. 10), and those industries which have ICC products classified to them (those industries which have no ICC products classified to them are, to a large extent, finishing operations or primarily custom work, thus making specification of standard well-defined products difficult). This led to the exclusion of six industries. Data were derived in the Manufacturing and Primary Industry Division. See N4D for further details. A discussion of the usefulness of the Herfindahl index as a measure of product diversity can be found in Baldwin and Gorecki (1983a, Appendix B, pp. 135–45).

HERF5D is defined as analogously to HERF4D except for the 5-digit ICC. See N5D for further details.

HVTRCRF is a dummy variable that is equal to 1 when concentration (CON), effective tariff protection (ERP) and foreign ownership (FOR) are high (where these variables are greater than their respective means), zero otherwise. See CON and ERP for further details.

HVTRHCR is a dummy variable which is equal to 1 when both concentration (CON) and effective tariff protection (ERP) are greater than their respective means and zero otherwise (see CON and ERP).

IMP is imports as a proportion of domestic disappearance, where the latter is domestic production (i.e., VS) minus exports plus imports. See CA for discussion of source of export and import data.

INPINX is an intermediate input price index. Intermediate inputs include not only purchases of goods used in production, but also include an allowance for such items, repair and maintenance of capital stock and research and development. It is estimated by Industry Product Division using a similar methodology to that employed for the gross output price index GPINX.

INTRA [(XT + IM) – absolute value (XT – IM)]/(XT + IM), where XT = dollar value of exports and IM = the dollar value of imports. See CA for discussion of source of XT and IM.

K_c is book value of capital stock. For details see BV_c and Chapter Five.

L_c is industry manhours worked for all employees expressed in production and related worker manhours equivalent. More formally,

$$L_c = M + S. (M/W)$$

where M is manhours worked by production and related worker, S is gross earnings of administrative office and other non-manufacturing employees, and W is gross earnings of production and related workers.

The data were supplied by the Manufacturing and Primary Industries Division of Statistics Canada.

MARCVA is the average of the coefficient of variation of the margin/sales ratio for all firms in the industry. That is $\frac{TVA-VWS}{VS}$ where TVA is defined as total-activity value added, VWS is the total activity value of wages and salaries and VS is the total activity value of shipments. Total activity refers to both manufacturing and non-manufacturing activity, and value added is a measure of gross output less those purchased inputs which have been embodied in the value of the product. Value added is census value added which does not measure net purchases of services or indirect taxes, and subtracts the costs of materials and supplies used in manufacturing activity and the cost of purchased fuel and electricity used. The data were supplied by the Manufacturing and Primary Industries Division.

MESMSD is the ratio of domestic disappearance to USMES. Domestic disappearance is calculated as the total activity value of shipments (i.e., VS) plus total imports minus total exports. Canada, Statistics Canada (1979b, pp. 38–39) suggests total activity is most appropriate when comparing Canada (the numerator) with the U.S. (the denominator) census data. Note that the denominator is defined for 1972 and 1977, rather than 1970 and 1979. See USMES and VS for further details.

MPLNT is a dummy variable which takes on the value 1 when the average number of plants per unconsolidated enterprise (PLNT) is greater than the mean across 141 of the 167 manufacturing industries (i.e., excluding the miscellaneous industries), zero otherwise. Data are from the Manufacturing and Primary Industries Division. See PLNT for further details.

N* see N4D and N5D.

N4D is the number of 4-digit ICC (Industrial Commodity Classification) commodities per 4-digit SIC (Standard Industrial Classification) industry. Note than N* is also used to represent N4D. Five industries had no 4-digit ICC commodities classified to them. As noted under HERF4D, this is a reflection of the particular type of industry concerned — finishing operations and custom work. Chapter Two discusses the ICC in further detail. See Canada, Statistics Canada (1973) for further details.

N5D The same discussion applies as that above concerning N4D except that N5D is at the 5-digit ICC level.

NRP is nominal tariff protection, which is defined as the actual duties collected divided by the value of total imports less duties. The data were provided by the Structural Analysis Division, Statistics Canada at the input/output level of aggregation (i.e., column 2 of Table A-2) and for 1978 rather than 1979.

NTD is a dummy variable which takes the value 1 when non-tariff barriers are important and zero elsewhere. Information on non-tariff barriers came from a number of sources including Hazledine (1981).

PHERF4D is defined in HERF4D. The regression results concerning the determinants of PHERF4D are presented in Table 2-11 and the corresponding set of independent variables are defined in the notes to the table and will not be repeated here. TSH, TSHSQ and NOEST are from the Manufacturing and Primary Industries Division while OCON and USCON are from the Multinational Enterprise Division.

PHERF5D is defined in HERF5D. The same comments made under PHERF4D, mutatis mutandis, apply to PHERF5D.

PLESTFV HVTRCRF • AVPLSZ. See HVTRCRF and AVPLSZ for further details.

PLESTV HVTRHCR • AVPLSZ. See HVTRHCR and AVPLSZ for further details.

PLNT is the total number of unconsolidated enterprises classified to an industry divided by the number of plants classified to an industry. Data from Manufacturing and Primary Industries Division.

PPR4D is plant shipments (TSH) divided by PHERF4D. Like PHERF4D, PPR4D is a variable defined for the plant rather than the industry. See PHERF4D for details.

PPR5D is plant shipments (TSH) divided by PHERF5D. Like

PHERF5D, PPR5D is a variable defined for the plant rather than the industry. See PHERF5D for details.

PR4D AVPLSZ • HERF4D. See AVPLSZ and HERF4D for details.

PR5D AVPLSZ • HERF5D. See AVPLSZ and HERF5D for details.

R4D 1/N4D. See N4D for details.

R5D 1/N5D. See N5D for details.

RD is the ratio of research and development personnel to all wage and salary earners. Data are collected at the company level[2] and aggregated to the 3-digit SIC levels by attributing 100 percent of the expenditure to the industry of the company's principle product. It was provided by the Science Statistics Division, Statistics Canada. Data were available for RD for 1975 rather than 1970.

REG is a regional dummy taking on a value of 1 when the industry was classified regional and zero otherwise. The industries were classified as regional using Canada, Department of Consumer and Corporate Affairs (1971) concentration study with a small number of additions.

RELDIV4D (1–HERF4D)/(1–(1/N4D)). See HERF4D and N4D for details.

RELDIV5D (1–HERF5D)/(1–(1/N5D)). See HERF5D and N5D for details.

SERP is simple effective protection. This is defined in a similar way to ERP except that no account of exports, indirect taxes and subsidies is taken. For details see ERP and Wilkinson and Norrie (1975, p. 16).

TFP1 is total factor productivity measure 1. Defined in equation 6.1 and Table 6-1.

TFP2 is total factor productivity measure 2. Defined in equation 6.2 and Table 6-1.

TFP3 is total factor productivity measure 3. Defined in equation 6.3 and Table 6-1.

TFP4 is total factor productivity measure 4. Defined in equation 6.17 and Table 6-1.

VS is total activity value of shipments, which encompasses manufacturing and non-manufacturing activities. It is the net selling values at the reporting establishments and excludes discounts, returns, allowances, sales taxes, excise duties and transportation charges by common carriers. The unsold portion at year end of consignment shipments in Canada is treated as inventory and not as shipments, but all shipments to foreign countries for which the form B13 "Customs Export Entry" has been completed are treated as shipments. Resale is included in the total value of shipments and is classified as non-manufacturing activity. The data are taken from the Manufacturing and Primary Industries Division.

Definitions of Variables: United States

BV_u is the book value of gross depreciable assets. This is derived from the IRS Corporation Source Book and corresponds to "depreciable assets" (line 13 as taken from United States, Department of Treasury, 1983, p. 5). The IRS Minor Industry Classification system, detailed in Table A-4, is somewhat more aggregated than the 4-digit SIC, necessitating some prorating. Unlike other U.S. variables, BV_u was collected for 1972 and 1976, rather than 1972 and 1977.

$CORR_u$ is the ratio of other expenses to sales. The IRS publishes income statements for corporation tax returns that permit the same components as were used for Canada to estimate $CORR_c$ to be separated out. The U.S. categories are:

49. repairs
50. bad debts
51. rent paid on business property
52. taxes paid
53. contributions or gifts
58. advertising
59. pension, profit-sharing, stock bonus, and annuity plans
60. employee benefit programs
62. other deductions

Categories 59 and 60 are here because the same categories are imbedded in the "other" category in Canada (line 24, see $CORR_c$) and cannot be separated from it. The sum of these expense categories are then divided by "business" plus "other" receipts from the IRS Income Statements (lines 34 and 45, respectively). Together these two categories closely approximate the U.S. Census sales figures. All line numbers are taken from United States, Department of Treasury (1983, p. 5).

Once these correction factors are calculated, they are linked to the categories that have been used to compare Canada and U.S. industries. These categories are aggregations of U.S. 4-digit industries to match Canadian 4-digit industries — the latter being somewhat more aggregated than the 4-digit level. The application of these ratios to the categories used in this study was accomplished in the following way. Generally the IRS category is broader (see Table A-4) than the 4-digit U.S. industry levels (see Table A-1) that are aggregated to match Canadian industries. When all 4-digit Census industries fall within the same IRS Minor Industry, the above-described IRS ratio is used. When more than one IRS Minor Industry is involved because the 4-digit Census industries came from different IRS industries, the IRS ratios will be aggregated, using as weights the sales of the different 4-digit Census industries that make up the category. Finally, the correction ratios so created will be multiplied by the value of sales derived from the U.S. Census to give the absolute dollar value by which Census value added figures are reduced. $CORR_u$ was estimated for 1973 only.

CVA_u is U.S. census value added. See Chapter Five for further discussion and definition.

IPD is a value added price index with 1972 = 100. It is an unpublished series supplied to the authors by the Bureau of Economic Analysis, Department of Commerce. The Bureau uses a number of different sources in compiling IPD, including the monthly publication of the Bureau of Labor Statistics, Department of Labor, *Producer Prices and Price Indexes*. The level of industry aggregation is slightly less than the Canadian 2-digit or industry group level: the price data divide the manufacturing sector into 23 industries, whereas there are 20 2-digit industries in the Canadian SIC. Hence it was assumed all 4-digit industries within each of the 23 industries experience the same changes in the value of the value added price index.

ICM is the materials price index with 1972 = 100. See IPD for details.

IVS is the gross output price index with 1972 = 100. See IPD for details.

K_u is book value of capital stock adjusted for Canada/U.S. price differences. For details, see BV_u and Chapter V, section 5.3 above.

L_u is industry manhours worked for all employees expressed in production and related worker manhours equivalent. This variable is defined using the same approach as L_c except, of course, that U.S. variables are used.

N5DUS is the number of 5-digit products per industry using the product counts from the corresponding U.S. industry or industries. The Canada/U.S. industry concordance is presented in Table A-1 below, while U.S. Department of Commerce (1978) provides details of the U.S. system of product classification.

N7DUS The same discussion applies as that above concerning N5DUS except that N7DUS is at the 7-digit level of classification.

R5DUS 1/N5DUS. See N5DUS for details.

R7DUS 1/N7DUS. See N7DUS for details.

USCDR is the U.S. value added per worker in the smallest establishments accounting for half the employment in the industry divided by the U.S. value added per worker in the larger plants accounting for the balance. It is based on U.S. Bureau of Census data supplied by R. Caves of Harvard University and is available for 1972 and 1977.

USMES is the average shipments of the largest U.S. plants which account for the top 50 percent of industry shipments. It is based upon U.S. census data for 1972 and 1977, supplied by R. Caves of Harvard University. Conversion to Canadian currency was via the average noon spot rates for 1972 and 1977 as published by the Bank of Canada, while the price index used to convert these data to 1970 and 1979 respectively was GPINX. See GPINX for further details.

TABLE A-1 Concordance Between 4-Digit Standard Industrial Classification for 1972 and Canadian Standard Industrial Classification System for 1970[a]

Industry		Percentages of			
Code	Name	Sales	Assets	Emplmt	Val Add
2011	Meat packing plants	81.00	63.58	69.32	68.00
2013	Sausages & other prepared meat products	16.31	25.14	25.57	25.20
2077	Animal & marine fats & oils	2.69	11.28	5.11	6.80
1011	Slaughtering & Meat Processors	100.00	100.00	100.00	100.00
2016	Poultry dressing plants	84.69	82.47	84.16	81.13
2017	Poultry & egg processing	15.31	17.53	15.84	18.87
1012	Poultry Processors	100.00	100.00	100.00	100.00
2091	Canned & cured fish & seafoods	42.75	45.62	39.02	44.59
2092	Fresh or frozen packaged fish & seafoods	57.25	54.38	60.98	55.41
102	Fish Products	100.00	100.00	100.00	100.00
2032	Canned specialties	24.39	23.67	19.13	26.25
2033	Canned fruits, vegetables, preserves	52.56	55.35	59.04	52.37
2034	Dried fruits, vegetables, & soup mixes	7.89	8.87	8.15	7.59
2035	Pickled fruits & vegetables, sauces, salad dressing	15.16	12.11	13.68	13.79
1031	Fruit & Vegetable Canners & Preservers	100.00	100.00	100.00	100.00
2037	Frozen fruits, juices, vegetables	100.00	100.00	100.00	100.00
1032	Frozen Fruit & Vegetable Processors	100.00	100.00	100.00	100.00
2021	Creamery butter	4.96	2.93	2.12	2.03
2022	Cheese, natural & processed	19.59	14.64	13.35	12.14
2023	Condensed & evaporated milk	10.22	10.66	6.52	11.53
2024	Ice cream & frozen desserts	7.63	14.12	11.18	11.34
2026	Fluid milk	57.60	57.65	66.83	62.96
104	Dairy Products	100.00	100.00	100.00	100.00

TABLE A-1 (cont'd)

Industry		Percentages of			
Code	Name	Sales	Assets	Emplmt	Val Add
2041	Flour & other grain mill products	56.53	47.82	43.63	33.87
2043	Cereal breakfast foods	26.73	36.04	34.96	45.74
2045	Blended & prepared flour	16.74	16.14	21.41	20.39
105	Flour & Breakfast Cereal Products	100.00	100.00	100.00	100.00
2047	Dog, cat & other pet food	21.77	28.98	24.53	35.80
2048	Prepared animal & fowl feed, NEC	78.23	71.02	75.47	64.20
106	Feed Industry	100.00	100.00	100.00	100.00
2052	Cookies & crackers	100.00	100.00	100.00	100.00
1071	Biscuit Manufacturers	100.00	100.00	100.00	100.00
2051	Bread & other bakery products	100.00	100.00	100.00	100.00
1072	Bakeries	100.00	100.00	100.00	100.00
2065	Candy & other confectionary products	68.86	64.16	78.22	68.59
2066	Chocolate & cocoa products	20.48	21.89	12.89	17.37
2067	Chewing gum	10.66	13.95	8.89	14.04
1081	Confectionery	100.00	100.00	100.00	100.00
2061	Cane sugar, except refining only	13.42	31.41	24.07	17.93
2062	Cane sugar refining	57.52	33.02	36.95	45.37
2063	Beet sugar	29.06	35.57	38.98	36.70
1082	Cane & Beet Sugar	100.00	100.00	100.00	100.00
2075	Soybean oil mills	93.01	93.41	89.22	89.06
2076	Other vegetable oil mills, except corn	6.99	6.59	10.78	10.94
1083	Vegetable Oil Mills	100.00	100.00	100.00	100.00

2038	Frozen specialties	14.29	13.03	23.14	13.21
2044	Rice milling	5.03	2.96	2.42	2.74
2046	Wet corn milling	6.15	21.62	7.31	6.11
2079	Other edible fats & oils, NEC	15.27	12.50	7.79	9.45
2083	Malt	1.67	2.78	1.03	1.01
2087	Flavoring extracts & sirups, NEC	10.87	6.65	6.10	16.08
2095	Roasted coffee	17.20	11.31	7.79	15.23
2098	Macaroni, spaghetti, vermicelli, noodles	2.57	2.67	4.41	2.87
2099	Food preparations, NEC	26.95	26.48	40.01	33.30
1089	Miscellaneous Food Processors, NES	100.00	100.00	100.00	100.00
2086	Bottled & canned soft drinks & carb. waters	100.00	100.00	100.00	100.00
1091	Soft Drinks	100.00	100.00	100.00	100.00
2085	Distilled, rectified & blended liquors	100.00	100.00	100.00	100.00
1092	Distilleries	100.00	100.00	100.00	100.00
2082	Malt beverages	100.00	100.00	100.00	100.00
1093	Breweries	100.00	100.00	100.00	100.00
2084	Wines, brandy, brandy spirits	100.00	100.00	100.00	100.00
1094	Wineries	100.00	100.00	100.00	100.00
2141	Tobacco stemming & redrying	100.00	100.00	100.00	100.00
151	Leaf Tobacco Processors	100.00	100.00	100.00	100.00
2111	Cigarettes	87.83	82.53	69.40	88.11
2121	Cigars	7.94	10.94	24.59	7.73
2131	Tobacco (chewing & smoking) & snuff	4.23	6.53	6.01	4.16
153	Tobacco Products	100.00	100.00	100.00	100.00

TABLE A-1 (cont'd)

Industry		Percentages of			
Code	**Name**	**Sales**	**Assets**	**Emplmt**	**Val Add**
3011	Tires and inner tubes	56.19	63.66	39.69	54.36
3021	Rubber & plastics footwear	5.87	3.81	11.66	6.56
3031	Reclaimed rubber	0.29	0.52	0.33	0.28
3041	Rubber & plastics hose & belting	9.97	10.50	11.78	10.95
3069	Fabricated rubber products, NEC	27.68	21.51	36.54	27.85
162	Rubber Products	100.00	100.00	100.00	100.00
3079	Miscellaneous plastics products	100.00	100.00	100.00	100.00
165	Plastics Fabricating, NES	100.00	100.00	100.00	100.00
3111	Leather tanning & finishing	100.00	100.00	100.00	100.00
172	Leather Tanneries	100.00	100.00	100.00	100.00
3142	House slippers	4.63	5.57	4.83	4.77
3143	Men's footwear, except athletic	39.39	33.45	34.92	37.55
3144	Women's footwear, except athletic	41.13	41.50	43.95	42.51
3149	Footwear, except rubber, NEC	14.85	19.48	16.30	15.17
174	Shoe Factories	100.00	100.00	100.00	100.00
3151	Leather gloves & mittens	100.00	100.00	100.00	100.00
175	Leather Glove Factories	100.00	100.00	100.00	100.00
3131	Boot & shoe cut stock & findings	100.00	100.00	100.00	100.00
1792	Boot & Shoe Findings	100.00	100.00	100.00	100.00

3161	Luggage	32.17	40.58	29.48	31.13
3171	Women's handbags & purses	32.21	24.29	38.28	32.31
3172	Other personal leather goods	21.38	21.12	19.83	23.04
3199	Leather goods, NEC	14.24	14.01	12.41	13.52
1799	Luggage, Handbag & Miscellaneous Leather Products	100.00	100.00	100.00	100.00
2211	Broad woven fabric mills, cotton	26.10	27.65	30.43	28.34
2221	Broad woven fabric, manmade fiber & silk	37.83	38.21	37.56	41.32
2281	Yarn spinning mills: cotton, silk, fiber	22.06	22.59	22.48	19.56
2282	Yarn texturizing, throwing, twisting	14.01	11.55	9.53	10.78
181	Cotton & Spun Yarn, Throwsters & Cloth Mills	100.00	100.00	100.00	100.00
2231	Broad woven fabric, wool (including finish)	67.03	73.24	70.04	72.09
2283	Wool yarn mills, including carpet & rug	32.97	26.76	29.96	27.91
182	Wool Yarn & Cloth Mills	100.00	100.00	100.00	100.00
2296	Tire cord & fabric	13.94	4.00	9.50	6.00
2823	Cellulosic man-made fibers	12.00	12.30	16.24	10.02
2824	Synthetic organic fibers, except cellulosic	74.06	83.70	74.26	83.98
1831	Fibre & Filament Yarn Manufacturers	100.00	100.00	100.00	100.00
2298	Cordage & twine	100.00	100.00	100.00	100.00
184	Cordage & Twine	100.00	100.00	100.00	100.00
2293	Paddings & upholstery filling	50.15	56.12	55.00	55.89
2294	Processed waste & recovered fibers	49.85	43.88	45.00	44.11
1851	Fibre Processing Mills	100.00	100.00	100.00	100.00
2291	Felt goods, except woven felts & hats	100.00	100.00	100.00	100.00
1852	Pressed & Punched Felt Mills	100.00	100.00	100.00	100.00

TABLE A-1 (cont'd)

Industry		Percentages of			
Code	**Name**	**Sales**	**Assets**	**Emplmt**	**Val Add**
2271	Woven carpets & rugs	6.75	11.15	10.87	8.66
2272	Tufted carpets & rugs	88.23	83.23	83.78	86.14
2279	Carpets & rugs, NEC	5.02	5.62	5.35	5.20
186	Carpet, Mat & Rug	100.00	100.00	100.00	100.00
2393	Textile bags	100.00	100.00	100.00	100.00
1871	Cotton & Jute Bags	100.00	100.00	100.00	100.00
2394	Canvas & related products	100.00	100.00	100.00	100.00
1872	Canvas Products	100.00	100.00	100.00	100.00
2284	Thread mills	100.00	100.00	100.00	100.00
1891	Thread Mills	100.00	100.00	100.00	100.00
2241	Narrow fabrics & other smallwares mills	100.00	100.00	100.00	100.00
1892	Narrow Fabric Mills	100.00	100.00	100.00	100.00
2395	Pleating, novelty stitching, tucking	71.89	47.17	75.23	69.96
2397	Schiffli machine embroideries	28.11	52.83	24.77	30.04
1893	Embroidery, Pleating & Hemstitching	100.00	100.00	100.00	100.00
2261	Finishers of cotton broad woven fabric	23.74	30.01	32.37	28.91
2262	Finishers of manmade fiber & silk fabric	51.99	51.32	44.33	46.81
2269	Finishers of textiles, NEC	24.27	18.67	23.30	24.28
1894	Textile Dyeing & Finishing Plants	100.00	100.00	100.00	100.00

2292	Lace goods	0.98	2.03	1.76	1.43
2297	Nonwoven fabrics	8.29	17.96	6.54	9.30
2299	Textile goods, NEC	4.42	12.87	5.02	5.22
2391	Curtains & draperies	15.74	8.78	20.52	14.66
2392	Other house furnishings	31.84	26.02	30.44	28.36
2396	Automotive trimmings, apparel findings	23.62	18.67	16.71	25.73
2399	Fabricated textile products, NEC	15.11	13.67	19.01	15.30
1899	Miscellaneous Textile Industries, NES	100.00	100.00	100.00	100.00
2251	Women's full & knee length hosiery	62.11	67.57	60.29	59.78
2252	Other hosiery	37.89	32.43	39.71	40.22
231	Hosiery Mills	100.00	100.00	100.00	100.00
2257	Circular knit fabric mills	73.98	77.15	75.58	76.53
2258	Warp knit fabric mills	26.02	22.85	24.42	23.47
2391	Knitted Fabric Manufacturers	100.00	100.00	100.00	100.00
2253	Knit outerwear mills	73.39	75.00	71.33	73.16
2254	Knit underwear mills	23.46	21.10	24.93	23.01
2259	Knitting mills, NEC	3.15	3.90	3.74	3.83
2392	Other Knitting Mills	100.00	100.00	100.00	100.00
2311	Men's & boys' suits, coats & overcoats	12.22	11.28	12.11	13.79
2321	Men's & boys' shirts & nightwear	10.73	12.13	11.00	10.32
2322	Men's, youths' & boys' underwear	1.22	1.28	1.55	1.34
2323	Men's, youths' & boys' neckwear	1.50	1.55	1.08	1.47
2327	Men's, youths' & boys' separate trousers	8.89	11.33	8.86	8.06
2328	Men's, youths' & boys' work clothing	8.86	7.97	8.69	8.06
2329	Men's, youths' & boys' clothing, NEC	3.99	3.55	4.07	4.04
2331	Women's & juniors' blouses, waists & shirts	6.40	4.82	6.11	6.08
2335	Women's, misses' & juniors' dresses	18.25	19.48	20.54	19.40

TABLE A-1 (cont'd)

Industry		Percentages of			
Code	**Name**	**Sales**	**Assets**	**Emplmt**	**Val Add**
2337	Women's & juniors' suits, skirts & coats	9.20	8.54	7.36	8.62
2339	Women's & juniors' outerwear, NEC	8.35	6.81	7.97	8.02
2341	Women's & children's underwear & nightwear	6.79	8.08	7.52	7.28
2384	Robes & dressing gowns	1.03	0.94	0.97	0.95
2385	Raincoats & other waterproof garments	1.69	1.77	1.49	1.73
2386	Leather & sheep lined clothing	0.88	0.47	0.68	0.84
243+4	Men's & Women's Clothing	100.00	100.00	100.00	100.00
2361	Girls' dresses, blouses, waists & shirts	46.08	57.37	47.39	47.35
2363	Girls' & infants' coats and suits	13.26	6.60	12.32	12.75
2369	Girls' & infants' outerwear, NEC	40.66	36.03	40.29	39.90
245	Children's Clothing	100.00	100.00	100.00	100.00
2371	Fur goods	100.00	100.00	100.00	100.00
246	Fur Goods	100.00	100.00	100.00	100.00
2342	Brassieres, girdles & allied garments	100.00	100.00	100.00	100.00
248	Foundation Garments	100.00	100.00	100.00	100.00
2381	Dress & work gloves, except knit & leather	100.00	100.00	100.00	100.00
2491	Fabric Glove Manufacturers	100.00	100.00	100.00	100.00
2351	Millinery	25.36	11.64	22.07	24.89
2352	Hats & caps, except millinery	74.64	88.36	77.93	75.11
2492	Hat & Cap Industry	100.00	100.00	100.00	100.00

2387	Apparel belts	68.80	63.41	58.52	68.94
2389	Apparel & accessories, NEC	31.20	36.59	41.48	31.06
2499	Miscellaneous Clothing Industries	100.00	100.00	100.00	100.00
2421	Sawmills & planing mills, general	97.29	97.89	96.30	97.31
2429	Special product sawmills, NEC	2.71	2.11	3.70	2.69
251	Sawmills, Planing Mills & Shingle Mills	100.00	100.00	100.00	100.00
2435	Hardwood veneer & plywood	31.19	9.75	36.48	26.70
2436	Softwood veneer & plywood	68.81	90.25	63.52	73.30
252	Veneer & Plywood Mills	100.00	100.00	100.00	100.00
2426	Hardwood dimension & flooring mills	19.26	31.69	30.88	22.04
2431	Millwork	80.74	68.31	69.12	77.96
2541	Sash, Door, Millwork, Hardwood Flooring	100.00	100.00	100.00	100.00
2439	Structural wood members, NEC	30.36	31.76	33.33	28.57
2452	Pre-fabricated wood buildings & components	69.64	68.24	66.67	71.43
2543	Pre-Fabricated Buildings (Woodframe)	100.00	100.00	100.00	100.00
2434	Wood kitchen cabinets	100.00	100.00	100.00	100.00
2544	Wooden Kitchen Cabinets	100.00	100.00	100.00	100.00
2441	Nailed & lock corner wood boxes	30.76	27.02	29.00	28.93
2448	Wood pallets & skids	38.19	38.35	38.75	39.27
2449	Wood containers, NEC	31.05	34.63	32.25	31.80
256	Wooden Box Factories	100.00	100.00	100.00	100.00
3995	Burial caskets	100.00	100.00	100.00	100.00
258	Coffin & Casket	100.00	100.00	100.00	100.00

TABLE A-1 (cont'd)

Industry		Percentages of			
Code	**Name**	**Sales**	**Assets**	**Emplmt**	**Val Add**
2491	Wood preserving	100.00	100.00	100.00	100.00
2591	Wood Preservation Industry	100.00	100.00	100.00	100.00
2492	Particle board	100.00	100.00	100.00	100.00
2593	Manufacturers of Particle Board	100.00	100.00	100.00	100.00
2499	Wood products, NEC	100.00	100.00	100.00	100.00
2599	Miscellaneous Wood Industries	100.00	100.00	100.00	100.00
2511	Wood household furniture not upholstered	45.07	55.44	46.78	46.05
2512	Wood household furniture, upholstered	33.05	23.35	32.17	32.66
2514	Metal household furniture	13.98	12.03	12.03	13.23
2517	Wood TV, radio, phonograph, sew cabinets	5.19	5.87	6.61	5.23
2519	Household furniture, NEC	2.71	3.31	2.41	2.83
2619	Household Furniture	100.00	100.00	100.00	100.00
2521	Wood office furniture	22.47	19.83	29.26	22.23
2522	Metal office furniture	77.53	80.17	70.74	77.77
264	Office Furniture	100.00	100.00	100.00	100.00
2515	Mattresses & bed springs	27.12	23.86	22.95	23.33
2531	Public building & related furniture	13.94	15.81	15.64	14.39
2541	Wood partitions, shelving, fixtures	20.65	16.91	22.81	22.30
2542	Metal partitions, shelving, fixtures	19.12	26.16	19.15	20.05
2591	Drapery hardware, window blinds, shades	9.49	9.27	8.85	9.64
2599	Furniture & fixtures, NEC	9.68	7.99	10.60	10.29
266	Miscellaneous Furniture & Fixtures	100.00	100.00	100.00	100.00

3645	Residential electric lighting fixtures	100.00	100.00	100.00	100.00
268	Electric Lamp & Shade	100.00	100.00	100.00	100.00
2611	Pulp mills	6.07	8.23	4.81	5.62
2621	Paper mills, except building paper mills	54.54	54.35	58.88	53.31
2631	Paperboard mills	35.49	35.03	31.05	36.55
2661	Building paper & building board mills	3.90	2.39	5.26	4.52
271	Pulp & Paper Mills	100.00	100.00	100.00	100.00
2952	Asphalt felts & coatings	100.00	100.00	100.00	100.00
272	Asphalt Roofing	100.00	100.00	100.00	100.00
2651	Folding paperboard boxes	82.23	83.27	71.45	79.06
2652	Set-up paperboard boxes	17.77	16.73	28.55	20.94
2731	Folding Carton & Set-Up Boxes	100.00	100.00	100.00	100.00
2653	Corrugated & solid fiber boxes	100.00	100.00	100.00	100.00
2732	Corrugated Boxes	100.00	100.00	100.00	100.00
2643	Bags, except textile bags	100.00	100.00	100.00	100.00
2733	Paper & Plastic Bags	100.00	100.00	100.00	100.00
2641	Paper coating & glazing	22.84	25.13	19.29	24.04
2642	Envelopes	7.26	6.67	11.87	8.48
2645	Die-cut paper, paperboard & cardboard	7.91	5.84	7.88	7.37
2646	Pressed & molded pulp goods	1.90	5.55	3.16	2.46
2647	Sanitary paper products	24.21	20.38	13.63	21.56
2648	Stationery, tablets & related products	5.27	4.12	7.62	5.51
2649	Converted paper, paperboard products, NEC	7.37	6.17	9.38	7.95
2654	Sanitary food containers	16.60	19.90	18.20	16.12
2655	Fiber cans, tubes, drums, similar products	6.64	6.24	8.97	6.51
274	Other Paper Converters	100.00	100.00	100.00	100.00

TABLE A-1 (cont'd)

Industry		Percentages of			
Code	**Name**	**Sales**	**Assets**	**Emplmt**	**Val Add**
2732	Book printing	7.64	9.20	9.35	8.06
2751	Commercial printing, letterpress & screen	26.94	27.57	29.83	26.88
2752	Commercial printing, lithographic	41.77	39.41	42.06	42.09
2754	Commercial printing, gravure	5.69	8.27	4.57	4.96
2761	Manifold business forms	11.65	10.27	8.82	10.98
2771	Greeting card publishing	6.31	5.28	5.37	7.03
286	Commercial Printing	100.00	100.00	100.00	100.00
2753	Engraving & plate printing	12.72	1.23	11.82	11.91
2789	Bookbinding & related work	23.80	93.42	30.91	23.14
2791	Typesetting	30.46	2.58	32.03	33.28
2793	Photo-engraving	14.49	1.30	12.19	14.98
2794	Electrotyping & stereotyping	2.32	0.23	2.09	2.23
2795	Lithographic platemaking & related services	16.21	1.24	10.96	14.46
287	Platemaking, Typesetting, Trade Bindery	100.00	100.00	100.00	100.00
2711	Newspapers: publishing & printing	52.62	73.36	68.21	56.33
2721	Periodicals: publishing & printing	22.36	11.85	13.02	19.11
2731	Books: publishing & printing	18.20	10.32	11.18	17.53
2741	Miscellaneous printing	6.82	4.47	7.59	7.03
288+9	Publishing Only + Publishing & Printing	100.00	100.00	100.00	100.00
3312	Blast furnaces, steel works, rolling mills	87.20	93.08	84.28	86.54
3313	Electrometallurgical products	2.00	1.95	1.71	1.82
3316	Cold rolled steel sheet, strip, & bars	5.96	2.16	3.61	4.24
3324	Steel investment foundries	0.95	0.43	2.01	1.47
3325	Steel foundries, NEC	3.89	2.38	8.39	5.93
291	Iron & Steel Mills	100.00	100.00	100.00	100.00

3317	Steel pipe & tubes	100.00	100.00	100.00	100.00
292	Steel Pipe & Tube Mills	100.00	100.00	100.00	100.00
3321	Gray iron foundries	88.42	88.64	86.02	86.82
3322	Malleable iron foundries	11.58	11.36	13.98	13.18
294	Iron Foundries	100.00	100.00	100.00	100.00
3331	Primary smelting & refining of copper	46.46	19.61	29.35	28.60
3332	Primary smelting & refining of lead	7.73	3.11	4.78	7.55
3333	Primary smelting & refining of zinc	6.31	5.91	10.75	7.13
3334	Primary production of aluminum	32.86	63.07	43.69	47.84
3339	Nonferrous metals primary refining, NEC	6.64	8.30	11.43	8.88
295	Smelting & Refining	100.00	100.00	100.00	100.00
3353	Aluminum sheet, plate, & foil	49.94	61.83	28.64	36.52
3354	Aluminum extruded products	20.05	15.87	25.34	22.56
3355	Aluminum rolling & drawing, NEC	6.39	5.17	4.21	3.02
3361	Aluminum foundries (castings)	23.62	17.13	41.81	37.90
296	Aluminum Rolling, Casting & Extruding	100.00	100.00	100.00	100.00
3351	Rolling, drawing & extruding of copper	86.94	86.31	71.05	77.16
3362	Brass, bronze, copper, copper-base alloy	13.06	13.69	28.95	22.84
297	Copper & Alloy Rolling, Casting, Extruding	100.00	100.00	100.00	100.00
3341	Secondary smelting & refining nonferrous metals	49.79	31.89	28.90	33.53
3356	Other nonferrous rolling, drawing, extruding	29.55	45.28	29.38	30.53
3369	Nonferrous foundries (castings), NEC	13.97	14.98	32.95	25.62
3497	Metal foil & leaf	6.69	7.85	8.77	10.32
298	Metal Rolling, Casting & Extruding, NES	100.00	100.00	100.00	100.00
3443	Fabricated plate work (boiler shops)	100.00	100.00	100.00	100.00
301	Boiler & Plate Works	100.00	100.00	100.00	100.00

TABLE A-1 (cont'd)

Industry		Percentages of			
Code	**Name**	**Sales**	**Assets**	**Emplmt**	**Val Add**
3441	Fabricated structural metal	100.00	100.00	100.00	100.00
302	Fabricated Structural Metal	100.00	100.00	100.00	100.00
3442	Metal doors, sash, frames, moulding, trim	100.00	100.00	100.00	100.00
3031	Metal Door & Window	100.00	100.00	100.00	100.00
3446	Architectural & ornamental metal work	48.51	57.00	62.57	53.05
3448	Prefabricated metal building & components	51.49	43.00	37.43	46.95
3041	Ornamental & Architectural Metal, NES	100.00	100.00	100.00	100.00
3471	Electroplating, polishing, anodizing, color	59.58	64.38	66.42	66.15
3479	Coating, engraving, allied services, NEC	40.42	35.62	33.58	33.85
3041	Metal Coating	100.00	100.00	100.00	100.00
3411	Metal cans	42.22	48.87	27.10	36.81
3412	Metal shipping barrels, drums, kegs, pails	4.32	4.71	4.03	3.83
3444	Sheet metal work	25.08	15.97	29.27	26.36
3466	Crowns & closures	3.21	3.78	3.20	3.38
3469	Metal stampings, NEC	25.17	26.67	36.40	29.62
3042	Metal Stamping & Pressing	100.00	100.00	100.00	100.00
3315	Steel wire drawing, steel nails & spikes	20.84	20.03	16.27	17.82
3451	Screw machine products	18.06	19.06	21.53	19.81
3452	Bolts, nuts, screws, rivets, & washers	34.42	38.37	31.95	36.55
3495	Wire springs	10.39	7.97	12.60	10.41
3496	Miscellaneous fabricated wire products	16.29	14.57	17.65	15.41
305	Wire & Wire Products	100.00	100.00	100.00	100.00

3421	Cutlery	8.39	9.50	8.42	9.91
3423	Hand & edge tools, except mach tools, hand saws	24.21	19.94	24.69	23.97
3425	Hand saws & saw blades	3.82	4.01	4.15	3.92
3429	Hardware, NEC	63.58	66.55	62.74	62.20
306	Hardware, Tool and Cutlery	100.00	100.00	100.00	100.00
3433	Heating equipment except electric & air furnaces	100.00	100.00	100.00	100.00
307	Heating Equipment	100.00	100.00	100.00	100.00
3398	Metal heat treating	4.26	7.84	5.22	5.23
3431	Enameled iron & metal sanitary ware	3.38	4.07	3.40	3.50
3432	Plumbing fixture fittings & trim (brass)	6.46	4.65	5.65	6.09
3449	Miscellaneous metal work	8.94	5.52	5.92	6.09
3462	Iron & steel forgings	12.91	15.03	10.41	11.14
3463	Nonferrous forgings	2.03	3.17	1.76	1.75
3484	Small arms	3.59	3.84	4.89	4.69
3489	Ordnance & accessories, NEC	4.36	4.10	7.47	5.80
3493	Steel springs, except wire	3.02	2.59	2.58	2.52
3494	Valves & pipe fittings, except plumbers' brass	26.95	28.29	28.63	29.46
3498	Fabricated pipe & pipe fittings	6.42	4.54	5.31	6.11
3499	Fabricated metal products, NEC	17.68	16.36	18.76	17.62
309	Miscellaneous Metal Fabricating	100.00	100.00	100.00	100.00
3523	Farm machinery & equipment	81.06	84.97	83.48	83.22
3524	Garden tractors, lawn & garden equipment	18.94	15.03	16.52	16.78
311	Agricultural Implements	100.00	100.00	100.00	100.00
3585	Air conditioning, air heating, refrigeration	100.00	100.00	100.00	100.00
316	Commercial Refrigeration & Air Conditioning	100.00	100.00	100.00	100.00

TABLE A-1 (cont'd)

Industry		Percentages of			
Code	**Name**	**Sales**	**Assets**	**Emplmt**	**Val Add**
3573	Typewriters, electronic computing equipment	72.48	70.11	66.13	68.75
3574	Other calculating & accounting machines	7.13	7.58	10.27	8.00
3576	Scales & balances, except laboratory	2.24	1.77	3.06	2.55
3579	Office machines, NEC	14.52	17.25	15.75	17.10
3581	Automatic merchandising machines	3.63	3.29	4.79	3.60
318	Office & Store Machinery	100.00	100.00	100.00	100.00
3721	Aircraft	56.82	45.69	52.83	55.71
3724	Aircraft engines & engine parts	23.56	32.17	23.87	21.83
3728	Aircraft parts & auxiliary equipment, NEC	19.62	22.14	23.30	22.46
321	Aircraft & Aircraft Parts	100.00	100.00	100.00	100.00
3711	Motor vehicles & passenger car bodies	100.00	100.00	100.00	100.00
323	Motor Vehicles	100.00	100.00	100.00	100.00
3713	Truck & bus bodies	100.00	100.00	100.00	100.00
3241	Truck Body Manufacturers	100.00	100.00	100.00	100.00
2451	Mobile homes	70.73	64.69	65.96	68.30
3792	Travel trailers & campers	29.27	35.31	34.04	31.70
3242	Non-Commercial Trailer Manufacturers	100.00	100.00	100.00	100.00
3715	Truck trailers	100.00	100.00	100.00	100.00
3243	Commercial Trailer Manufacturers	100.00	100.00	100.00	100.00

3465	Automotive stampings	19.65	22.60	19.81	19.25
3592	Carburetors, pistons, rings, valves	2.77	2.46	4.29	3.61
3647	Vehicular lighting equipment	1.86	1.63	2.19	2.17
3694	Electrical equipment for engines	7.57	5.31	9.30	8.76
3714	Motor vehicle parts & accessories	68.15	68.00	64.41	66.21
325	Motor Vehicle Parts & Accessories	100.00	100.00	100.00	100.00
3743	Railroad equipment	100.00	100.00	100.00	100.00
326	Railway Rolling Stock	100.00	100.00	100.00	100.00
3731	Ship building & repairing	100.00	100.00	100.00	100.00
327	Ship Building & Repair	100.00	100.00	100.00	100.00
3732	Boat building & repairing	100.00	100.00	100.00	100.00
328	Boat Building & Repair	100.00	100.00	100.00	100.00
3799	Transportation equipment, NEC	100.00	100.00	100.00	100.00
329	Miscellaneous Vehicles	100.00	100.00	100.00	100.00
3634	Electric housewares & fans	77.54	73.96	82.14	75.24
3635	Household vacuum cleaners	22.46	26.04	17.86	24.76
331	Small Electrical Appliances	100.00	100.00	100.00	100.00
3631	Household cooking equipment	22.51	25.95	27.00	20.48
3632	House refrigerators, home & farm freezers	41.18	30.96	39.51	39.30
3633	Household laundry equipment	32.49	34.24	27.35	34.03
3636	Sewing machines	3.82	8.85	6.14	6.19
332	Major Applicances (Electric & Non-Electric)	100.00	100.00	100.00	100.00
3646	Commercial, industrial lighting fixtures	60.64	49.23	59.68	57.95
3648	Lighting equipment, NEC	39.36	50.77	40.32	42.05
333	Lighting Fixtures	100.00	100.00	100.00	100.00

TABLE A-1 (cont'd)

Industry		Percentages of			
Code	**Name**	**Sales**	**Assets**	**Emplmt**	**Val Add**
3651	Radio & T.V. receiving sets	100.00	100.00	100.00	100.00
334	Household Radio & T.V. Receivers	100.00	100.00	100.00	100.00
3661	Telephone & telegraph apparatus	18.86	20.45	15.95	17.93
3662	Radio & T.V. transmit, signaling, detection	38.10	30.97	37.90	39.26
3671	Radio & T.V. receiving electron tubes	0.96	1.26	1.35	1.18
3672	Cathode ray T.V. picture tubes	2.90	3.16	1.80	2.34
3673	Transmit, industrial, special electron tubes	2.00	2.99	2.43	2.32
3674	Semiconductors & related devices	11.28	17.19	11.58	11.74
3675	Electronic capacitors	1.86	1.80	3.28	2.02
3676	Resistors for electronic applications	1.55	1.65	2.43	1.78
3677	Electronic coils, transformers, inductors	1.48	1.23	2.84	1.45
3678	Connectors for electronic applications	2.02	1.80	2.15	2.34
3679	Electronic components, NEC	12.76	12.30	12.01	10.74
3825	Electrical signal testing instruments	6.23	5.20	6.28	6.90
335	Communication Equipment	100.00	100.00	100.00	100.00
3612	Power, distribution, specialty transformers	16.98	18.68	15.98	14.96
3613	Switchgear & switchboard apparatus	24.66	18.90	23.63	25.75
3621	Motors & generators	29.22	33.45	30.95	29.30
3622	Industrial controls	16.26	17.60	17.25	17.67
3623	Welding apparatus, electric	7.66	6.46	5.29	6.98
3629	Electrical industrial apparatus, NEC	5.22	4.91	6.90	5.34
336	Electrical Industrial Equipment	100.00	100.00	100.00	100.00

3357	Drawing & insulating of nonferrous wire	100.00	100.00	100.00	100.00
338	Electric Wire & Cable	100.00	100.00	100.00	100.00
3691	Storage batteries	73.56	72.56	72.46	68.32
3692	Primary batteries, dry & wet	26.44	27.44	27.54	31.68
3391	Battery Manufacturers	100.00	100.00	100.00	100.00
3624	Carbon & graphite products	8.31	20.36	7.60	7.81
3641	Electric lamps	24.14	25.44	21.18	26.01
3643	Current-carrying wiring devices	26.81	20.03	32.48	27.53
3644	Noncurrent-carrying wiring devices	19.53	15.38	17.28	17.62
3693	X-Ray, electromedical, therapeutic apparatus	9.77	10.09	8.14	11.18
3699	Electrical machinery, equipment, supplies, NEC	11.44	8.70	13.32	9.85
3399	Miscellaneous Electrical Products, NES	100.00	100.00	100.00	100.00
3251	Brick & structural clay tile	59.01	61.03	59.36	59.18
3253	Ceramic wall & floor tile	20.20	18.48	20.44	19.75
3259	Structural clay products, NEC	20.79	20.49	20.20	21.07
3511	Clay Product Manufacturers (Domestic Clays)	100.00	100.00	100.00	100.00
3261	Vitreous china plumbing fixtures	32.34	29.49	21.43	31.10
3262	Vitreous china table & kitchen articles	9.81	7.01	13.17	11.22
3263	Fine earthenware table & kitchen articles	8.90	8.89	15.18	9.36
3264	Porcelain electrical supplies	32.90	43.38	29.91	31.69
3269	Pottery products, NEC	16.05	11.23	20.31	16.63
3512	Clay Product Manufacturers (Imported Clays)	100.00	100.00	100.00	100.00
3241	Cement, hydraulic	100.00	100.00	100.00	100.00
352	Cement Manufacturers	100.00	100.00	100.00	100.00
3281	Cut stone & stone products	100.00	100.00	100.00	100.00
353	Stone Products	100.00	100.00	100.00	100.00

TABLE A-1 (cont'd)

Industry		Percentages of			
Code	**Name**	**Sales**	**Assets**	**Emplmt**	**Val Add**
3271	Concrete block & brick	100.00	100.00	100.00	100.00
3542	Manufacturers of Structural Concrete Products	100.00	100.00	100.00	100.00
3272	Concrete products except block & brick	100.00	100.00	100.00	100.00
3549	Concrete Products Manufacturers, NES	100.00	100.00	100.00	100.00
3273	Ready-mixed concrete	100.00	100.00	100.00	100.00
355	Ready-Mix Concrete	100.00	100.00	100.00	100.00
3211	Flat glass	30.59	42.18	22.28	32.11
3221	Glass containers	69.41	57.82	77.72	67.89
3561	Glass Manufacturers	100.00	100.00	100.00	100.00
3229	Pressed & blown glass & glassware, NEC	48.79	65.64	57.66	58.46
3231	Glass products made of purchased glass	51.21	34.36	42.34	41.54
3562	Glass Products	100.00	100.00	100.00	100.00
3291	Abrasive products	100.00	100.00	100.00	100.00
357	Abrasives	100.00	100.00	100.00	100.00
3274	Lime	100.00	100.00	100.00	100.00
358	Lime Manufacturers	100.00	100.00	100.00	100.00
3255	Clay refractories	49.44	49.03	58.03	51.40
3297	Nonclay refractories	50.56	50.97	41.97	48.60
3591	Refractories	100.00	100.00	100.00	100.00

3275	Gypsum products	18.82	24.52	11.95	16.56
3292	Asbestos products	22.43	19.91	22.41	21.71
3293	Gaskets, packing, & sealing devices	19.55	12.45	29.57	21.83
3295	Minerals & earths, ground & treated	12.11	15.92	10.14	12.08
3296	Mineral wool	22.20	23.00	19.21	22.49
3299	Nonmetallic mineral products, NEC	4.89	4.20	6.72	5.33
3599	Miscellaneous Non-Metallic Mineral Products	100.00	100.00	100.00	100.00
2911	Petroleum refining	100.00	100.00	100.00	100.00
3651	Petroleum Refining	100.00	100.00	100.00	100.00
2992	Lubricating oils & greases	100.00	100.00	100.00	100.00
3652	Lubricating Oils & Greases	100.00	100.00	100.00	100.00
2951	Paving mixtures & blocks	87.02	86.01	92.67	87.74
2999	Products of petroleum & coal, NEC	12.98	13.99	7.33	12.26
369	Miscellaneous Petroleum & Coal Products	100.00	100.00	100.00	100.00
2875	Fertilizers, mixing only	100.00	100.00	100.00	100.00
372	Mixed Fertilizers	100.00	100.00	100.00	100.00
2821	Plastics materials, synthetic resins	100.00	100.00	100.00	100.00
373	Plastics & Synthetic Resins	100.00	100.00	100.00	100.00
2831	Biological products	4.49	5.92	7.78	3.77
2833	Medicinal chemicals & botanical products	6.35	12.26	6.00	4.24
2834	Pharmaceutical preparations	89.16	81.82	86.22	91.99
374	Pharmaceuticals & Medicines	100.00	100.00	100.00	100.00
2851	Paints, varnishes, lacquers, enamels	100.00	100.00	100.00	100.00
375	Paint & Varnish	100.00	100.00	100.00	100.00

TABLE A-1 (cont'd)

Industry		Percentages of			
Code	**Name**	**Sales**	**Assets**	**Emplmt**	**Val Add**
2841	Soap & other detergents, except specialty	59.30	62.85	49.60	60.57
2842	Specialty cleaning, polishing preparations	32.62	23.37	39.53	33.21
2843	Surface active agents, sulfonated oils	8.08	13.78	10.87	6.22
376	Soap & Cleaning Compounds	100.00	100.00	100.00	100.00
2844	Perfumes, cosmetics, toilet preparations	100.00	100.00	100.00	100.00
377	Toilet Preparations	100.00	100.00	100.00	100.00
2816	Inorganic pigments	28.00	22.18	31.22	29.15
2865	Cyclic crudes, intermediates, dyes	72.00	77.82	68.78	70.85
3781	Manufacturers of Pigments & Dry Colors	100.00	100.00	100.00	100.00
2812	Alkalies & chlorine	10.92	17.36	11.68	11.47
2813	Industrial gases	9.01	15.93	8.43	11.75
2819	Industrial inorganic chemicals, NEC	50.83	34.18	56.01	51.32
2873	Nitrogenous fertilizers	10.60	18.71	8.25	11.27
2874	Phosphatic fertilizers	15.63	10.29	13.08	10.73
2895	Carbon black	3.01	3.53	2.55	3.46
3782	Industrial Chemicals (Inorganic, NES)	100.00	100.00	100.00	100.00
2822	Synthetic rubber (vulcanizable elastomers)	10.23	7.18	9.83	8.73
2861	Gum & wood chemicals	3.12	1.83	4.91	2.76
2869	Industrial organic chemicals, NEC	86.65	90.99	85.26	88.51
3783	Industrial Chemicals (Organic, NES)	100.00	100.00	100.00	100.00
2893	Printing ink	100.00	100.00	100.00	100.00
3791	Manufacturers of Printing Inks	100.00	100.00	100.00	100.00

2879	Pesticides & agricultural chemicals, NEC	17.44	20.13	8.05	18.06
2891	Adhesives & sealants	14.06	14.06	9.83	12.86
2892	Explosives	6.10	5.98	12.27	8.50
2899	Chemicals & chemical preparations, NEC	33.37	36.53	24.47	33.92
3482	Small arms ammunition	6.64	11.81	9.17	6.89
3483	Ammunition, except for small arms, NEC	22.39	11.49	36.21	19.77
3799	Miscellaneous Chemicals Industries, NES	100.00	100.00	100.00	100.00
3811	Scientific instruments & equipment	9.77	7.12	13.05	9.09
3822	Automatic controls, environ & appliances	6.83	5.10	10.71	6.84
3823	Process control instruments & related instruments	8.50	8.21	13.54	8.44
3824	Totalizing fluid meters & counting devices	2.68	2.67	3.07	2.42
3829	Measuring & controlling devices, NEC	5.42	4.11	7.54	5.07
3832	Optical instruments & lenses	5.05	5.97	6.56	5.13
3841	Surgical & medical instruments & apparatus	9.02	8.29	12.04	8.41
3861	Photographic equipment & supplies	52.73	59.43	33.49	54.60
3911	Instruments & Related Products	100.00	100.00	100.00	100.00
3873	Watches, clocks, clockwork devices & parts	100.00	100.00	100.00	100.00
3912	Clock & Watch	100.00	100.00	100.00	100.00
3842	Orthopedic, prosthetic, surgical appliance	100.00	100.00	100.00	100.00
3913	Orthopedic & Surgical Appliances	100.00	100.00	100.00	100.00
3851	Ophthalmic goods	100.00	100.00	100.00	100.00
3914	Ophthalmic Goods	100.00	100.00	100.00	100.00
3843	Dental equipment & supplies	100.00	100.00	100.00	100.00
3915	Dental Laboratories	100.00	100.00	100.00	100.00

TABLE A-1 (cont'd)

Industry		Percentages of			
Code	**Name**	**Sales**	**Assets**	**Emplmt**	**Val Add**
3911	Jewellery, precious metal	49.23	34.37	43.70	47.58
3914	Silverware, plated ware, stainless ware	15.97	28.62	16.89	17.62
3915	Jewellers' findings & materials, lapidary	14.15	15.30	10.72	10.33
3961	Costume jewellery & novelties, nonprecious	20.65	21.71	28.69	24.47
392	Jewellery & Silverware	100.00	100.00	100.00	100.00
3949	Sporting & athletic goods, NEC	100.00	100.00	100.00	100.00
3931	Sporting Goods	100.00	100.00	100.00	100.00
3942	Dolls	10.30	6.72	14.23	9.11
3944	Games, toys, children's vehicles	89.70	93.28	85.77	90.89
3932	Toys & Games	100.00	100.00	100.00	100.00
3993	Signs & advertising displays	100.00	100.00	100.00	100.00
397	Signs & Displays	100.00	100.00	100.00	100.00
3991	Brooms & brushes	100.00	100.00	100.00	100.00
3991	Broom, Brush & Mop	100.00	100.00	100.00	100.00
3963	Buttons	14.02	11.71	16.53	13.41
3964	Needles, pins, hooks & eyes, similar notions	85.98	88.29	83.47	86.59
3992	Button, Buckle & Fastener	100.00	100.00	100.00	100.00
2295	Coated fabrics, not rubberized	71.67	62.22	75.63	64.33
3996	Linoleum, other hard floor coverings, NEC	28.33	37.78	24.37	35.67
3993	Floor Tile, Linoleum & Coated Fabrics	100.00	100.00	100.00	100.00

3652	Phonograph records & prerecorded tape	47.90	52.68	45.31	52.54
3931	Musical instruments	52.10	47.32	54.69	47.46
3994	Sound Recording & Musical Instruments	100.00	100.00	100.00	100.00
3951	Pens, mechanical pencils, & parts	60.97	59.34	60.56	66.39
3952	Lead pencils, crayons & artists' materials	39.03	40.66	39.44	33.61
3996	Pens & Pencils	100.00	100.00	100.00	100.00
3953	Marking devices	8.73	10.71	9.68	10.21
3955	Carbon paper & inked ribbons	11.52	8.41	6.81	9.53
3962	Feathers, plumes, artificial trees & flowers	5.27	5.00	5.73	4.83
3999	Manufacturing industries, NEC	74.48	75.88	77.78	75.43
3999	Fur Dressing & Dyeing + Other Misc Manufactures	100.00	100.00	100.00	100.00

Source: Statistics Canada and U.S. Bureau of Census.

a. The table should be read as follows: for each Canadian 4-digit industry (represented by the last row of any grouping) the corresponding U.S. industry (or industries) are listed directly above. The SIC code and name are those used in the respective U.S. and Canadian classification systems in 1972 and 1970, respectively.

NEC = not elsewhere classified (United States).

NES = not elsewhere specified (Canada).

TABLE A-2 Concordance Between 4-Digit Standard Industrial Classification, 3-Digit SIC and Input/Output Classification

4-Digit SIC Code (1970)	Manufacturing Industries	Input/ Output	3-Digit SIC
	1 — Food & Beverage Industries		
1011	Slaughtering & meat processors	016	101
1012	Poultry processors	017	101
1020	Fish Products industry	019	102
1031	Fruit & Vegetable canners & preservers	020	103
1032	Frozen fruit & vegetable processors	020	103
104	Dairy products industry	018	104
105	Flour & breakfast cereal products industry	022	105
106	Feed industry	021	106
1071	Biscuit manufacturers	023	107
1072	Bakery Products	024	107
1081	Confectionary manufacturers	025	108
1082	Cane & beet sugar processors	026	108
1083	Vegetable oil mills	027	108
1089	Miscellaneous food processors, NES	028	108
1091	Soft drink manufacturers	029	109
1092	Distilleries	030	109
1093	Breweries	031	109
1094	Wineries	032	109
	2 — Tobacco Products Industries		
151	Leaf tobacco processors	033	151
153	Tobacco products manufacturers	034	153
	3 — Rubber & Plastics Products Industries		
162	Rubber products industries	036	162
1623[a]	Tire & tube manufacturers	036	162
1624[a]	Rubber footwear manufacturers	035	162
1629[a]	Miscellaneous rubber products manufacturers	037	162
165	Plastics fabricating industry, NES	038	165
	4 — Leather Industries		
172	Leather tanneries	039	172
174	Shoe factories	040	174
175	Leather glove factories	041	175
1792	Boot & shoe findings manufacturers	042	179
1799	Miscellaneous leather products manufacturers	042	179
	5 — Textile Industries		
181	Cotton yarn & cloth mills	043	181
182	Wool yarn & cloth mills	044	182
1831	Fibre & filament yarn manufacturers	045	183

TABLE A-2 (cont'd)

4-Digit SIC Code (1970)	Manufacturing Industries	Input/ Output	3-Digit SIC
1832	Throwster, spun yarn & cloth mills	045	183
184	Cordage & twine industry	048	184
1851	Fibre processing mills	046	185
1852	Pressed & punched felt mills	050	185
186	Carpet, mat & rug industry	051	186
1871	Cotton & jute bags manufacturers	054	187
1872	Canvas products manufacturers	053	187
188	Automobile fabric accessories industry	055	188
1891	Thread mills	047	189
1892	Narrow fabric mills	049	189
1893	Embroidery, pleating & hemstitching manufacturers	055	189
1894	Textile dyeing & finishing plants	052	189
1899	Miscellaneous textile industries, NES	055	189
	6 — Knitting Mills		
231	Hosiery mills	056	231
2391	Knitted fabric manufacturers	057	239
2392	Other knitting mills	057	239
	7 — Clothing Industries		
2431	Men's clothing factories	058	243
2432	Men's clothing contractors	058	243
2441	Women's clothing factories	058	244
2442	Women's clothing contractors	058	244
245	Children's clothing industry	058	245
246	Fur goods industry	058	246
248	Foundation garment industry	058	248
2491	Fabric glove manufacturers	058	249
2492	Hat & cap industry	058	249
2499	Miscellaneous clothing industries, NES	058	249
	8 — Wood Industries		
2511	Shingle mills	059	251
2513	Sawmills & planing mills	059	251
252	Veneer & plywood mills	060	252
2541	Sash, door & other millwork plants, NES	061	254
2542[b]	Hardwood flooring plants	061	254
2543	Manufacturers of pre-fabricated buildings (woodframe construction)	061	254
256	Wooden box factories	062	256
258	Coffin & casket industry	063	258
2591	Wood preservation industry	064	259
2592	Wood handles & turning industry	064	259

TABLE A-2 (cont'd)

4-Digit SIC Code (1970)	Manufacturing Industries	Input/ Output	3-Digit SIC
2593	Manufacturers of particle board	064	259
2599	Miscellaneous wood industries, NES	064	259
	9 — Furniture & Fixture Industries		
2611	Furniture re-upholstery & repair shops	065	261
2619	Household furniture manufacturers, NES	065	261
264	Office furniture manufacturers	066	264
266	Miscellaneous furniture & fixtures manufacturers	067	266
268	Electric lamp & shade manufacturers	068	268
	10 — Paper & Allied Industries		
271	Pulp & paper mills	069	271
272	Asphalt roofing manufacturers	070	272
2731	Folding carton & set-up box manufacturers	071	273
2732	Corrugated box manufacturers	071	273
2733	Paper & plastic bag manufacturers	071	273
274	Miscellaneous paper converters	072	274
	11 — Printing, Publishing & Allied Industries		
286	Commercial printing	073	286
287	Platemaking, typesetting & trade bindery industry	074	287
288	Publishing only	073	288
289	Publishing & printing	073	289
	12 — Primary Metal Industries		
291	Iron & steel mills	075	291
292	Steel pipe & tube mills	076	292
294	Iron foundries	077	294
295	Smelting & refining	078	295
296	Aluminum rolling, casting & extruding	080	296
297	Copper & copper alloy rolling, casting & extruding	081	297
298	Metal rolling, casting & extruding, NES	082	298
	13 — Metal Fabricating Industries (except Machinery & Transportation Equipment Industries)		
301	Boiler & plate works	083	301
302	Fabricated structural metal industry	084	302
3031	Metal door & window manufacturers	085	303

TABLE A-2 (cont'd)

4-Digit SIC Code (1970)	Manufacturing Industries	Input/ Output	3-Digit SIC
3039	Ornamental & architectural metal industry, NES	085	303
3041	Metal coating industry	086	304
3042	Metal stamping & pressing industry	086	304
305	Wire & wire products manufacturers	087	305
306	Hardware, tool & cutlery manufacturers	088	306
307	Heating equipment manufacturers	089	307
308	Machine shops	090	308
309	Miscellaneous metal fabricating industries	091	309
	14 — Machinery Industries (except Electrical Machinery)		
311	Agricultural implement industry	092	311
315	Miscellaneous machinery & equipment manufacturers	093	315
316	Commercial refrigeration & air conditioning equipment manufacturers	094	316
318	Office & store machinery manufacturers	095	318
	15 — Transportation Equipment Industries		
321	Aircraft & aircraft parts manufacturers	096	321
323	Motor vehicle manufacturers	097	323
3241	Truck body manufacturers	098	324
3242	Non-commercial trailer manufacturers	098	324
3243	Commercial trailer manufacturers	098	324
325	Motor vehicle parts & accessories manufacturers	099	325
326	Railroad rolling stock industry	100	326
327	Shipbuilding & repair	101	327
328	Boatbuilding & repair	102	328
329	Miscellaneous vehicle manufacturers	102	329
	16 — Electrical Products Industries		
331	Manufacturers of small electrical appliances	103	331
332	Manufacturers of major appliances (electric & non-electric)	104	332
333	Manufacturers of lighting fixtures	110	333
334	Manufacturers of household radio & television receivers	105	334
335	Communications equipment manufacturers	106	335

TABLE A-2 (cont'd)

4-Digit SIC Code (1970)	Manufacturing Industries	Input/ Output	3-Digit SIC
336	Manufacturers of electrical industrial equipment	107	336
338	Manufacturers of electric wire & cable	108	338
3391	Battery manufacturers	109	339
3399	Manufacturers of miscellaneous electrical products, NES	110	339
	17 — Non-Metallic Mineral Products Industries		
3511	Clay products manufacturers (from domestic clays)	115	351
3512	Clay products manufacturers (from imported clays)	115	351
352	Cement manufacturers	111	352
353	Stone products manufacturers	117	353
3541	Concrete pipe manufacturers	113	354
3542	Manufacturers of structural concrete products	113	354
3549	Concrete products, NES	113	354
355	Ready-mix concrete manufacturers	114	355
3561	Glass manufacturers	119	356
3562	Glass products manufacturers	119	356
357	Abrasives manufacturers	120	357
358	Lime manufacturers	112	358
3591	Refractories manufacturers	116	359
3599	Miscellaneous non-metallic mineral products industries, NES	118	359
	18 — Petroleum & Coal Products Industries		
3651	Petroleum refining	121	365
3652	Manufacturers of lubricating oils & greases	121	365
369	Miscellaneous petroleum & coal products industries	122	369
	19 — Chemical & Chemical Products Industries		
372	Manufacturers of mixed fertilizers	123	372
373	Manufacturers of plastics & synthetic resins	124	373
374	Manufacturers of pharmaceuticals & medicines	125	374
375	Paint & varnish manufacturers	126	375
376	Manufacturers of soap & cleaning compounds	127	376
377	Manufacturers of toilet preparations	128	377

TABLE A-2 (cont'd)

4-Digit SIC Code (1970)	Manufacturing Industries	Input/ Output	3-Digit SIC
3781	Manufacturers of pigments & dry colours	129	378
3782	Manufacturers of industrial chemicals (inorganic), NES	129	378
3783	Manufacturers of industrial chemicals (organic), NES	129	378
3791	Manufacturers of printing inks	130	379
3799	Miscellaneous chemical industries, NES	130	379
	20 — Miscellaneous Manufacturing Industries		
3911	Instrument & related products manufacturers	131	391
3912	Clock & watch manufacturers	131	391
3913	Orthopaedic & surgical appliance manufacturers	131	391
3914	Ophthalmic goods manufacturers	131	391
3915	Dental laboratories	131	391
392	Jewellery & silverware industry	132	392
3931	Sporting goods manufacturers	134	393
3932	Toys & games manufacturers	134	393
397	Signs & display industry	136	397
3991	Broom, brush & mop manufacturers	133	399
3992	Button, buckle & fastener manufacturers	137	399
3993	Floor tile, linoleum & coated fabrics manufacturers	135	399
3994	Sound recording & musical instrument manufacturers	137	399
3995[c]	Stamp & stencil (rubber & metal) manufacturers	137	399
3996	Pen & pencil manufacturers	137	399
3997[c]	Typewriter supplies manufacturers	137	399
3998	Fur dressing & dyeing	137	399
3999	Other miscellaneous manufacturing industries	137	399
167	Totals[d,e]	122	112

Source: Statistics Canada.
a. These three 4-digit industries are grouped into 162.
b. Included with 2541.
c. Included with 3999.
d. Net of duplicated codes.
e. Takes into account footnotes a to c.
NES = not elsewhere specified.

TABLE A-3 Concordance Between the 1960 and 1970 Standard Industrial Classification and the Corporation Financial Statistics Classification System[a]

Financial Stats 1–80 (1)	1960 SIC (2)	1970 SIC (3)
1.	**Meat Products**	
	101 Slaughtering & Meat Proc.	101 Meat & Poultry Proc.
	103 Poultry Proc.	1011 Slaughtering & Meat Proc.
		1012 Poultry Proc.
2.	**Dairy Products**	
	105 Dairy Factories	104 Dairy Products Ind.
	107 Process Cheese Mnf.	
3.	**Fish Products**	
	111 Fish Products	102 Fish Products
4.	**Fruit & Vegetable Canners**	
	112 Fruit & Veg. Canners & Preservers	103 Fruit & Veg. Proc. Ind.
		1031 Fruit & Veg. Canners
		1032 Frozen Fruit & Veg. Proc.
5.	**Grain Mills**	
	123 Feed Mnf.	105 Flour & Breakfast Cereal Prod.
	124 Flour Mills	106 Feed Ind.
	125 Breakfast Cereal Mnf.	
6.	**Bakery Products**	
	128 Biscuit Mnf.	107 Bakery Products Ind.
	129 Bakeries	1071 Biscuit Mnf.
		1072 Bakeries
7.	**Other Food Products**	
	131 Confectionary Mnf.	108 Misc. Food Ind.
	133 Sugar Refineries	1081 Confectionary Mnf.
	135 Vegetable Oil Mills	1082 Cane & Beet Sugar Refineries
	139 Miscellaneous Food Ind.	1083 Vegetable Oil Mills
		1089 Miscellaneous Food Proc.
8.	**Soft Drinks**	
	141 Soft Drink Mnf.	109 Beverage Ind.
		1091 Soft Drink Mnf.

TABLE A-3 (cont'd)

Financial Stats 1–80 (1)	1960 SIC (2)	1970 SIC (3)
9.	**Distilleries**	
	143 Distilleries	1092 Distilleries
10.	**Breweries**	
	145 Breweries	1093 Breweries
11.	**Wineries**	
	147 Wineries	1094 Wineries
12.	**Tobacco Products**	
	151 Leaf Tobacco Proc. 153 Tobacco Prod. Mnf.	151 Leaf Tobacco Proc. 153 Tobacco Prod. Mnf.
13.	**Rubber Products**	
	161 Rubber Footwear Mnf. 163 Rubber Tire & Tube Mnf. 169 Other Rubber Ind.	162 Rubber Products Ind. 1623 Tire & Tube Mnf. 1624 Rubber Footwear Mnf. 1629 Miscellaneous Rubber Prod. Mnf.
14.	**Leather Products**	
	172 Leather Tanneries 174 Shoe Factories 175 Leather Glove Factories 179 Luggage, Handbag & Small Leather Goods Mnf.	172 Leather Tanneries 174 Shoe Factories 175 Leather Glove Factories 179 Luggage, Handbag & Small Leather Goods Mnf. 1792 Boot & Shoe Findings Mnf. 1799 Misc. Leather Prod. Mnf.
15.	**Cotton & Woolen Mills**	
	183 Cotton Yarn & Cloth Mills 193 Wool Yarn Mills 197 Wool Cloth Mills	181 Cotton Yarn & Cloth Mills 182 Wool Yarn & Cloth Mills
16.	**Synthetic Textiles**	
	201 Synthetic Textile Mills	183 Man-Made Fibre, Yarn & Cloth Mills

TABLE A-3 (cont'd)

Financial Stats 1–80 (1)	1960 SIC (2)	1970 SIC (3)
17.	**Other Primary Textiles**	
	211 Fibre Preparing Mills 212 Thread Mills 213 Cordage & Twine Ind. 214 Narrow Fabric Mills 215 Pressed & Punched Felt Mills 216 Carpet, Mat & Rug Ind. 218 Textile Dyeing & Finishing 219 Linoleum & Coated Fabrics Ind.	184 Cordage & Twine Ind. 185 Felt & Fibre Proc. Mills 1851 Fibre Proc. Mills 1852 Pressed & Punched Felt Mills 186 Carpet, Mat & Rug Ind. 189 Misc. Textile Ind. (Some 4-digit are in gr. 18) 1891 Thread Mills 1892 Narrow Fabric Mills 1894 Textile Dyeing & Finishing 3993 Floor Tile, Linoleum & Coated Fabrics Mnf.
18.	**Other Textile Products**	
	221 Canvas Prod. Ind. 223 Cotton & Jute Bag. Ind. 229 Misc. Textile Ind.	187 Canvas Prod. & Cotton & Jute Bags Ind. 1871 Cotton & Jute Bags Mnf. 1872 Canvas Products Mnf. 188 Auto Fabric Accessories Ind. 189 Misc. Textile Ind. (Some 4-digit are in gr. 17) 1893 Embroidery, Pleating & Hemstitching 1899 Misc. Textile Ind.
19.	**Hosiery Mills**	
	231 Hosiery Mills	231 Hosiery Mills
20.	**Other Knitting Mills**	
	239 Other Knitting Mills	239 Knitting Mills (except Hosiery)
21.	**Men's Clothing**	
	243 Men's Clothing Ind.	243 Men's Clothing Ind. 2431 Men's Clothing Factories 2432 Men's Clothing Contractors

TABLE A-3 (cont'd)

Financial Stats 1–80 (1)	1960 SIC (2)	1970 SIC (3)
22.	**Women's Clothing**	
	244 Women's Clothing Ind.	244 Women's Clothing Ind. 2441 Women's Clothing Factories 2442 Women's Clothing Contractors
23.	**Fur Goods**	
	246 Fur Goods Ind.	246 Fur Goods Ind.
24.	**Foundation Garments**	
	248 Foundation Garment Ind.	248 Foundation Garment Ind.
25.	**Other Clothing**	
	245 Children's Clothing Ind. 247 Hat & Cap Ind. 249 Other Clothing Ind.	245 Children's Clothing Ind. 249 Misc. Clothing Ind. 2491 Fabric Glove Mnf. 2492 Hat & Cap Ind. 2499 Misc. Clothing Ind. NES
26.	**Sawmills & Planing Mills**	
	251 Sawmills	251 Sawmills, Planing Mills & Shingle Mills 2511 Shingle Mills 2513 Sawmills & Planing Mills
27.	**Veneer & Plywood**	
	252 Veneer & Plywood	252 Veneer & Plywood
28.	**Sash, Door & Millwork Plants**	
	254 Sash & Door & Planing Mills	254 Sash, Door & Other Millwork Plants 2541 Sash, Door & Other Millwork Plants NES 2542 Hardwood Flooring Plants 2543 Mnf. of Prefabricated Bldg.
29.	**Wooden Boxes**	
	256 Wooden Box Factories	256 Wooden Box Factories
30.	**Coffins & Caskets**	
	258 Coffin & Casket Ind.	258 Coffin & Casket Ind.

TABLE A-3 (cont'd)

Financial Stats 1–80 (1)	1960 SIC (2)	1970 SIC (3)
31.	**Misc. Wood Products**	
	259 Misc. Wood Ind.	259 Misc. Wood Ind. 2591 Wood Preservation Ind. 2592 Wood Handles & Turning Ind. 2593 Mnf. of Particle Board 2599 Misc. Wood Ind. NES
32.	**Household Furniture**	
	261 Household Furniture Ind. 268 Elec. Lamp & Shade Ind.	261 Household Furniture Mnf. 2611 Furniture Re-upholstery & Repair Shops 2619 Household Furniture Mnf. NES 268 Elec. Lamp & Shade Mnf.
33.	**Office Furniture**	
	264 Office Furniture Ind.	264 Office Furniture Mnf.
34.	**Other Furniture**	
	266 Other Furniture Ind.	266 Misc. Furniture & Fixtures Mnf.
35.	**Pulp & Paper Mills**	
	271 Pulp & Paper Mills	271 Pulp & Paper Mills
36.	**Paper Boxes & Bags**	
	273 Paper Box & Bag Mnf.	273 Paper Box & Bag Mnf. 2731 Folding Carton & Set-up Box Mnf. 2732 Corrugated Box Mnf. 2733 Paper & Plastic Bag Mnf.
37.	**Other Paper Products**	
	272 Asphalt Roofing Mnf. 274 Other Paper Converters	272 Asphalt Roofing Mnf. 274 Misc. Paper Converters
38.	**Commercial Printing**	
	286 Commercial Printing	286 Commercial Printing
39.	**Engraving & Allied Ind.**	
	287 Engraving, Stereotyping & Allied Ind.	287 Platemaking, Typesetting & Trade Bindery Ind.

TABLE A-3 (cont'd)

Financial Stats 1–80 (1)	1960 SIC (2)	1970 SIC (3)
40.	**Publishing Only**	
	288 Publishing Only	288 Publishing Only
41.	**Publishing & Printing**	
	289 Publishing & Printing	289 Publishing & Printing
42.	**Iron & Steel Mills**	
	291 Iron & Steel Mills 292 Steel Pipe & Tube Mills	291 Iron & Steel Mills 292 Steel Pipe & Tube Mills
43.	**Iron Foundries**	
	294 Iron Foundries	294 Iron Foundries
44.	**Smelting & Refining**	
	295 Smelting & Refining 296 Alum. Rolling, Casting & Extruding 297 Copper & Alloy Rolling, Casting & Extruding 298 Metal Rolling, Casting & Extruding NES	295 Smelting & Refining 296 Alum. Rolling, Casting & Extruding 297 Copper & Alloy Rolling, Casting & Extruding 298 Metal Rolling, Casting & Extruding NES
45.	**Boiler & Plate Works**	
	301 Boiler & Plate Works	301 Boiler & Plate Works
46.	**Structural Steel**	
	302 Fabricated Structural Metal Ind.	302 Fabricated Structural Metal Ind.
47.	**Ornamental Iron Works**	
	303 Ornamental & Architectural Metal Ind.	303 Ornamental & Architectural Metal Ind. 3031 Metal Door & Window Mnf. 3039 Ornamental & Architectural Metal Ind. NES
48.	**Metal Stamping**	
	304 Metal Stamping, Coating & Pressing Ind.	304 Metal Stamping, Pressing & Coating Ind. 3041 Metal Coating Ind. 3042 Metal Stamping & Pressing Ind.
49.	**Wire & Wire Products**	
	305 Wire & Wire Prod. Mnf.	305 Wire & Wire Prod. Mnf.

TABLE A-3 (cont'd)

Financial Stats 1–80 (1)	1960 SIC (2)	1970 SIC (3)
50.	**Hardware & Tools**	
	306 Hardware, Tool & Cutlery Mnf.	306 Hardware, Tool & Cutlery Mnf.
51.	**Heating Equipment**	
	307 Heating Equipment Mnf.	307 Heating Equipment Mnf.
52.	**Machine Shops**	
	308 Machine Shops	308 Machine Shops
53.	**Misc. & Metal Products**	
	309 Misc. Metal Fabricating Ind.	309 Misc. Metal Fabricating Ind.
54.	**Agricultural Implements**	
	311 Agricultural Implement Ind.	311 Agricultural Implement Ind.
55.	**Commercial Refrigeration**	
	316 Commercial Refrigeration & Air Conditioning Equip. Manf.	316 Commercial Refrigeration & Air Conditioning Equip. Mnf.
56.	**Other Machinery**	
	315 Misc. Machinery & Equip. Mnf. 318 Office & Store Machinery Mnf.	315 Misc. Machinery & Equip. Mnf. 318 Office & Store Machinery Mnf.
57.	**Aircraft & Parts**	
	321 Aircraft & Parts Mnf.	321 Aircraft & Parts Mnf.
58.	**Motor Vehicles & Parts**	
	323 Motor Vehicle Mnf. 325 Motor Vehicle Parts & Accessories	323 Motor Vehicle Mnf. 325 Motor Vehicle Parts & Accessories
59.	**Truck Bodies**	
	324 Truck Body & Trailer Mnf.	324 Truck Body & Trailer Mnf. 3241 Truck Body Mnf. 3242 Non-Commercial Trailer Mnf. 3243 Commercial Trailer Mnf.
60.	**Misc. Transportation**	
	326 Railroad Rolling Stock Ind. 327 Shipbuilding & Repair 328 Boatbuilding & Repair 329 Misc. Vehicle Mnf.	326 Railroad Rolling Stock Ind. 327 Shipbuilding & Repair 328 Boatbuilding & Repair 329 Misc. Vehicle Mnf.

TABLE A-3 (cont'd)

Financial Stats 1–80 (1)	1960 SIC (2)	1970 SIC (3)
61.	**Small Appliances**	
	331 Mnf. of Small Electrical Applicances	331 Mnf. of Small Electrical Applicances
62.	**Major Appliances**	
	332 Mnf. of Major Appliances (elec. & non-elec.)	332 Mnf. of Major Appliances (elec. & non elec.)
63.	**Radio & Television Receivers**	
	334 Mnf. of Household Radio & Television Receivers	334 Mnf. of Household Radio & Television Receivers
64.	**Communications Equip.**	
	335 Communications Equip. Mnf.	335 Communications Equip. Mnf.
65.	**Industrial Electrical Equip.**	
	336 Mnf. of Elec. Ind. Equip.	336 Mnf. of Elec. Ind. Equip.
66.	**Battery Mnf.**	
	337 Battery Mnf.	339 Mnf. of Misc. Elec. Products 3391 Battery Mnf.
67.	**Misc. Electrical Equip.**	
	338 Mnf. of Electric Wire 339 Mnf. of Misc. Electrical Prod.	333 Mnf. of Lighting Fixtures 338 Mnf. of Elec. Wire & Cable 399 Mnf. of Misc. Electrical Prod. 3399 Mnf. of Misc. Elec. Prod. NES
68.	**Cement Manufacturing**	
	341 Cement Mnf.	352 Cement Mnf.
69.	**Concrete Manufacturing**	
	347 Concrete Prod. Mnf.	354 Concrete Prod. Mnf. 3541 Concrete Pipe Mnf. 3542 Mnf. of Structural Concrete Prod. 3549 Concrete Prod. Mnf. NES
70.	**Ready-mix Concrete**	
	348 Ready-mix Concrete Mnf.	355 Ready-mix Concrete Mnf.

TABLE A-3 (cont'd)

Financial Stats 1–80 (1)	1960 SIC (2)	1970 SIC (3)
71.	**Clay Products**	
	351 Clay Prod. Mnf.	351 Clay Prod. Mnf. 3511 Clay Prod. Mnf. (from domestic clays) 3512 Clay Prod. Mnf. (from imported clays)
72.	**Glass & Glass Products**	
	356 Glass & Glass Prod. Mnf.	356 Glass & Glass Prod. Mnf. 3561 Glass Mnf. 3562 Glass Prod. Mnf.
73.	**Other Non-Metallic Mineral Products**	
	343 Lime Mnf. 345 Gypsum Mnf. 352 Refractories Mnf. 353 Stone Products Mnf. 354 Mineral Wool Mnf. 355 Asbestos Prod. Mnf. 357 Abrasives Mnf. 359 Other Non-Metallic Min. Prod. Ind.	353 Stone Prod. Mnf. 357 Abrasives Mnf. 358 Lime Mnf. 359 Misc. Non-Metallic Mineral Prod. Ind. 3591 Refractories Mnf. 3599 Misc. Non-Metallic Mineral Prod. Mnf. NES
74.	**Petroleum Refineries**	
	365 Petroleum Refineries	365 Petroleum Refineries
75.	**Other Petroleum & Coal Products**	
	369 Other Petroleum & Coal Prod. Ind.	369 Misc. Petroleum & Coal Prod. Ind.
76.	**Fertilizers**	
	372 Mnf. of Mixed Fertilizers	372 Mnf. of Mixed Fertilizers
77.	**Pharmaceuticals**	
	374 Mnf. of Pharmaceuticals & Medicines	374 Mnf. of Pharmaceuticals & Medicines

TABLE A-3 (cont'd)

Financial Stats 1–80 (1)	1960 SIC (2)	1970 SIC (3)
78.	**Paint & Varnish**	
	375 Paint & Varnish Mnf.	375 Paint & Varnish Mnf.
79.	**Soap & Cleaning Compounds**	
	376 Mnf. of Soap & Cleaning Compounds	376 Mnf. of Soap & Cleaning Compounds
80.	**Toilet Preparations**	
	377 Mnf. of Toilet Preparations	377 Mnf. of Toilet Preparations
81.	**Industrial Chemicals**	
	378 Mnf. of Industrial Chemicals	378 Mnf. of Industrial Chemicals 3781 Mnf. of Pigments & Dry Colours 3782 Mnf. of Ind. Chemicals (inorganic) NES 3783 Mnf. of Ind. Chemicals (organic) NES
82.	**Other Chemicals**	
	371 Explosives & Ammunition Mnf. 373 Mnf. of Plastics & Synthetic Resins 379 Other Chemical Industries	373 Mnf. of Plastics Synthetic Resins 379 Misc. Chemicals Ind. 3791 Mnf. of Printing Inks 3799 Misc. Chemical Ind. NES
83.	**Scientific & Professional Equipment**	
	381 Scientific & Professional Equip. Mnf.	391 Scientific & Professional Equip. Ind. 3911 Instrument & Related Prod. Mnf. 3912 Clock & Watch Mnf. 3913 Orthopaedic & Surgical Appliance Mnf. 3914 Opthalmic Goods Mnf. 3915 Dental Laboratories
84.	**Jewellery & Silverware**	
	382 Jewellery & Silverware Mnf.	392 Jewellery & Silverware Mnf.

TABLE A-3 (cont'd)

Financial Stats 1–80 (1)	1960 SIC (2)	1970 SIC (3)
85.	**Broom, Brush & Mop Ind.**	
	383 Broom, Brush & Mop Ind.	3991 Broom, Brush & Mop Mnf.
86.	**Sporting Goods & Toys**	
	393 Sporting Goods & Toy Ind.	393 Sporting Goods & Toy Ind. 3931 Sporting Goods Mnf. 3932 Toys & Games Mnf.
87.	**Other Misc. Manufacturing**	
	384 Venetian Blind Mnf. 385 Plastic Fabricators NES 395 Fur Dressing & Dyeing Ind. 397 Signs & Displays Ind. 399 Misc. Mnf. Ind. NES	165 Plastics Fabricating Ind. NES 397 Signs & Displays Ind. 399 Misc. Mnf. Ind. NES (some 4-digit are in other groups) 3992 Button, Buckle & Fastener Mnf. 3994 Sound Recording & Musical Instrument Mnf. 3995 Stamp & Stencil Mnf. 3996 Pen & Pencil Mnf. 3997 Typewriter Supplies Mnf. 3998 Fur Dressing & Dyeing 3999 Other Misc. Mnf. Ind.

Source: Statistics Canada.

a. The left-hand column numbered 1–80 refers to the Corporation Financial Statistics Industry Categories. The second column contains the 1960 3-digit SIC categories that each of the Corporation Financial Statistics categories covers. On the right-hand side of the page, column (3), are the 1970 3-digit categories which correspond to these 1960 3-digit categories. It is in effect these aggregations that must be made in the Census of Manufactures if industries comparable to those in the Corporation Financial Statistics are to be created.

NES = not elsewhere specified.

TABLE A-4 U.S. Internal Revenue Service Minor Industries

Number	Industry Name
2010	Meat Products
2020	Dairy Products
2030	Preserved Fruits & Vegetables
2040	Grain Mill Products
2050	Bakery Products
2060	Sugar & Confectionary Products
2081	Malt Liquors & Malt
2088	Alcoholic Beverages, except Malt Liquors & Malt
2089	Bottled Soft Drinks & Flavourings
2096	Other Food & Kindred Products
2100	Tobacco Manufactures
2228	Weaving Mills & Textile Finishing
2250	Knitting Mills
2298	Other Textile Mill Products
2315	Men's & Boys' Clothing
2345	Women's & Children's Clothing
2388	Other Apparel & Accessories
2390	Miscellaneous Fabricated Textile Products; Textile Products NEC
2415	Logging, Sawmills & Planing Mills
2430	Millwork, Plywood & Related Products
2498	Other Wood Products, including Wood Buildings & Mobile Homes
2500	Furniture & Fixtures
2625	Pulp, Paper & Board Mills
2699	Other Paper Products
2710	Newspaper
2720	Periodicals
2735	Books, Greeting Cards & miscellaneous Publishing
2799	Commercial and other Printing & Printing Trade Services
2815	Industrial Chemicals, Plastics Materials & Synthetics
2830	Drugs
2840	Soap, Cleaners & Toilet Goods
2850	Paints & Allied Products
2898	Agricultural & other Chemical Products
2910	Petroleum Refining (including those Integrated with Extraction)
2998	Petroleum & Coal Products, NEC
3050	Rubber Products; Plastics Footwear, Hose & Belting
3070	Miscellaneous Plastics Products
3140	Footwear, except Rubber
3198	Leather & Leather Products, NEC
3225	Glass Products
3240	Cement, Hydraulic
3270	Concrete, Gypsum & Plaster Products
3298	Other Non-Metallic Mineral Products
3370	Ferrous Metal Industries; miscellaneous Primary Metal Products
3380	Non-Ferrous Metal Industries
3410	Metal Cans & Shipping Containers
3428	Cutlery, Hand Tools & Hardware; Screw Machine Products, Bolts & Similar Products
3430	Plumbing & Heating, except Electric & Warm Air
3440	Fabricated Structural Metal Products
3460	Metal Forgings & Stampings

TABLE A-4 (cont'd)

Number	Industry Name
3470	Coating, Engraving & Allied Services
3480	Ordnance & Accessories, except Vehicles & Guided Missiles
3490	Miscellaneous
3520	Farm Machinery
3530	Construction & Related Machinery
3540	Metal-working Machinery
3550	Special Industry Machinery
3560	General Industrial Machinery
3570	Office, Computing & Accounting Machines
3598	Engines & Turbines, Service Industry Machinery & other Machinery, except Electrical
3630	Household Appliances
3665	Radio, Television & Communication Equipment
3670	Electronic Components & Accessories
3698	Other Electrical Equipment
3710	Motor Vehicles & Equipment
3725	Aircraft, Guided Missiles & Parts
3730	Ship & Boat Building & Repairing
3798	Other Transportation Equipment, except Motor Vehicles
3815	Scientific Instruments & Measuring Devices; Watches & Clocks
3845	Optical, Medical & Ophthalmic Goods
3860	Photographic Equipment & Supplies
3998	Miscellaneous Manufacturing & Manufacturing Not Allocable

Source: U.S., Department of the Treasury, Internal Revenue Service, Statistics of Income Division (1983, pp. 9–17).

NEC = not elsewhere classified.

TABLE A-5 Concordance of Canadian Standard Industrial Classification System for 1970 with U.S. Census 4-Digit Standard Industrial Classification for 1972 and U.S. Internal Revenue Service Classification of Minor Industries for 1973

Canadian SIC (1970)	U.S. Census SIC (1972)	IRS Minor Industries (1973)
1011 Slaughtering & Meat Processors	2011 Meat Packing Plants	2010 Meat Products
	2013 Sausages & Other Prepared Meat Pr.	2010 Meat Products
	2077 Animal & Marine Fats & Oils	2096 Other Food & Kindred Products
1012 Poultry Processors	2016 Poultry Dressing Plants	2010 Meat Products
	2017 Poultry & Egg Processing	
102 Fish Products	2091 Canned & Cured Fish & Seafood	2096 Other Food & Kindred Products
	2092 Fresh or Frozen Packaged Fish & Seafood	
1031 Fruit & Vegetable Canners & Preservers	2032 Canned Specialties	2030 Preserved Fruits & Vegetables
	2033 Canned Fruits, Vegetables & Preserves	
	2034 Dried Fruits, Vegetables & Soup Mixes	
	2035 Pickled Fruits & Vegetables, Sauces, Salad Dressing	
1032 Frozen Fruit & Vegetable Processors	2037 Frozen Fruits, Juices & Vegetables	2030 Preserved Fruits & Vegetables
104 Dairy Products	2021 Creamery Butter	2020 Dairy Products
	2022 Cheese, Natural & Processed	
	2023 Condensed & Evaporated Milk	
	2024 Ice Cream & Frozen Desserts	
	2026 Fluid Milk	

TABLE A-5 (cont'd)

Canadian SIC (1970)	U.S. Census SIC (1972)	IRS Minor Industries (1973)
105 Flour & Breakfast Cereal Products	2041 Flour & Other Grain Mill Products	2040 Grain Mill Products
	2043 Cereal Breakfast Foods	
	2045 Blended & Prepared Flour	
106 Feed Industry	2047 Dog, Cat & Other Pet Food	2040 Grain Mill Products
	2048 Prepared Animal & Fowl Feed NEC	
1071 Biscuit Manufacturers	2052 Cookies & Crackers	2050 Bakery Products
1072 Bakeries	2051 Bread & Other Bakery Products	2050 Bakery Products
1081 Confectionery	2065 Candy & Other Confectionery Products	2060 Sugar & Confectionery Products
	2066 Chocolate & Cocoa Products	
	2067 Chewing Gum	
1082 Cane & Beet Sugar	2061 Cane Sugar, except Refining	2060 Sugar & Confectionery Products
	2062 Cane Sugar Refining	
	2063 Beet Sugar	
1083 Vegetable Oil Mills	2075 Soybean Oil Mills	2096 Other Food & Kindred Products
	2076 Other Vegetable Oil Mills, except Corn	
1089 Miscellaneous Food Processors, NES	2038 Frozen Specialties	2030 Preserved Fruits & Vegetables
	2044 Rice Milling	2040 Grain Mill Products
	2046 Wet Corn Milling	2040 Grain Mill Products
	2079 Other Edible Fats & Oils, NEC	2096 Other Food & Kindred Products
	2083 Malt	2081 Malt Liquors & Malt
	2087 Flavoring Extracts & Syrups, NEC	2089 Bottled Soft Drinks & Flavourings
	2095 Roasted Coffee	2096 Other Food & Kindred Products
	2098 Macaroni, Spaghetti, Vermicelli, Noodles	2096 Other Food & Kindred Products
	2099 Food Preparations, NEC	2096 Other Food & Kindred Products

1091 Soft Drinks	2086 Bottled & Canned Soft Drinks & Carb. Waters	2089 Bottled Soft Drinks & Flavourings
1092 Distilleries	2085 Distilled, Rectified & Blended Liquors	2088 Alcoholic Beverages, Except Malt Liquors
1093 Breweries	2082 Malt Beverages	2081 Malt Liquors & Malt
1094 Wineries	2084 Wines, Brandy, Brandy Spirits	2088 Alcoholic Beverages, Except Malt Liquors
151 Leaf Tobacco Processors	2141 Tobacco Stemming & Redrying	2100 Tobacco Manufacturers
153 Tobacco Products	2111 Cigarettes 2121 Cigars 2131 Tobacco (Chewing, Smoking & Snuff)	2100 Tobacco Manufacturers
162 Rubber Products	3011 Tires & Inner Tubes 3021 Rubber & Plastics, Footwear 3031 Reclaimed Rubber 3041 Rubber & Plastic Hose & Belting 3069 Fabricated Rubber Products, NEC	3050 Rubber Products, Plastics, Footwear, Hose
165 Plastics Fabricating, NES	3079 Miscellaneous Plastics Products	3070 Miscellaneous Plastics Products
172 Leather Tanneries	3111 Leather Tanning & Finishing	3198 Other Leather & Leather Products
174 Shoe Factories	3142 House Slippers 3143 Men's Footwear, Except Athletic 3144 Women's Footwear, Except Athletic 3149 Footwear, Except Rubber, NEC	3140 Footwear, Except Rubber
175 Leather Glove Factories	3151 Leather Gloves & Mittens	3198 Other Leather & Leather Products
1792 Boot & Shoe Findings	3131 Boot & Shoe Cut Stock & Findings	3198 Other Leather & Leather Products

TABLE A-5 (cont'd)

Canadian SIC (1970)	U.S. Census SIC (1972)	IRS Minor Industries (1973)
1799 Luggage, Handbag & Misc. Leather Products	3161 Luggage 3171 Women's Handbags & Purses 3172 Other Personal Leather Goods 3199 Leather Goods, NEC	3198 Other Leather & Leather Products
181 Cotton & Spun Yarn, Throwsters & Cloth Mills	2211 Broad Woven Fabric Mills, Cotton 2221 Broad Woven Fabric, Manmade Fiber & Silk 2281 Yarn Spinning Mills; Cotton, Silk Fiber 2282 Yarn Texturizing, Throwing, Twisting	2228 Weaving Mills & Textile Finishing 2228 Weaving Mills & Textile Finishing 2298 Other Textile Mill Products 2298 Other Textile Mill Products
182 Wool Yarn & Cloth Mills	2231 Broad Woven Fabric, Wool (Incl. Finish) 2283 Wool Yarn Mills, Including Carpet & Rug	2228 Weaving Mills & Textile Finishing 2298 Other Textile Mill Products
1831 Fibre & Filament Yarn Manufacturers	2296 Tire Cord & Fabric 2823 Cellulosic Man-made Fibers 2824 Synthetic Organic Fibers, Except Cellulosic	2298 Other Textile Mill Products 2815 Industrial Chemicals, Plastics Cellulosic 2815 Industrial Chemicals, Plastics Materials
184 Cordage & Twine	2298 Cordage & Twine	2298 Other Textile Mill Products
1851 Fibre Processing Mills	2293 Paddings & Upholstery Filling 2294 Processed Waste & Recovered Fibers	2298 Other Textile Mill Products
1852 Pressed & Punched Felt Mills	2291 Felt Goods, Except Woven Felts & Hats	2298 Other Textile Mill Products

186 Carpet Mat & Rug	2271 Woven Carpets & Rugs 2272 Tufted Carpets & Rugs 2279 Carpets & Rugs, NEC	2298 Other Textile Mill Products
1871 Cotton & Jute Bags	2393 Textile Bags	2390 Miscellaneous Fabricated Textile Products
1872 Canvas Products	2394 Canvas & Related Products	2390 Miscellaneous Fabricated Textile Products
1891 Thread Mills	2284 Thread Mills	2298 Other Textile Mill Products
1892 Narrow Fabric Mills	2241 Narrow Fabrics & Other Smallwares Mills	2298 Other Textile Mill Products
1893 Embroidery, Pleating & Hemstitching	2395 Pleating, Novelty Stitching, Tucking 2397 Schiffli Machine Embroideries	2390 Miscellaneous Fabricated Textile Products
1894 Textile Dyeing & Finishing Plants	2261 Finishers of Cotton Broad Woven Fabric 2262 Finishers of Man-Made Fiber & Silk Fabric 2269 Finishers of Textiles, NEC	2228 Weaving Mills & Textile Finishing
1899 Miscellaneous Textile Industries, NES	2292 Lace Goods 2297 Nonwoven Fabrics 2299 Textile Goods, NEC 2391 Curtains & Draperies 2392 Other House Furnishings 2396 Automotive Trimmings, Apparel Findings 2399 Fabricated Textile Products, NEC	2298 Other Textile Mill Products 2298 Other Textile Mill Products 2298 Other Textile Mill Products 2390 Miscellaneous Fabricated Textile Products 2390 Miscellaneous Fabricated Textile Products 2390 Miscellaneous Fabricated Textile Products
231 Hosiery Mills	2251 Women's Full & Knee Length Hosiery 2252 Other Hosiery	2250 Knitting Mills
2391 Knitted Fabric Manufacturers	2257 Circular Knit Fabric Mills 2258 Warp Knit Fabric Mills	2250 Knitting Mills

Table A-5 (cont'd)

Canadian SIC (1970)	U.S. Census SIC (1972)	IRS Minor Industries (1973)
2392 Other Knitted Mills	2253 Knit Outerwear Mills	2250 Knitting Mills
	2254 Knit Underwear Mills	
	2259 Knitting Mills, NEC	
243 Men's Clothing	2311 Men's & Boys' Suits, Coats & Overcoats	2315 Men's & Boys' Clothing
244 Women's Clothing	2321 Men's & Boys' Shirts & Nightwear	2315 Men's & Boys' Clothing
	2322 Men's, Youths' & Boys' Underwear	2315 Men's & Boys' Clothing
	2323 Men's, Youths' & Boys' Neckwear	2315 Men's & Boys' Clothing
	2327 Men's, Youths' & Boys' Separate Trousers	2315 Men's & Boys' Clothing
	2328 Men's, Youths' & Boys' Work Clothing	2315 Men's & Boys' Clothing
	2329 Men's, Youths' & Boys' Clothing, NEC	2315 Men's & Boys' Clothing
	2331 Women's & Juniors' Blouses, Waists & Shirts	2345 Women's & Children's Clothing
	2335 Women's, Misses' & Juniors' Dresses	2345 Women's & Children's Clothing
	2337 Women's & Juniors' Suits, Shirts & Coats	2345 Women's & Children's Clothing
	2339 Women's & Juniors' Outerwear, NEC	2345 Women's & Children's Clothing
	2341 Women's & Children's Underwear & Nightwear	2345 Women's & Children's Clothing
	2384 Robes & Dressing Gowns	2388 Hats, Caps, Fur Goods, Other Apparel
	2385 Raincoats & Other Waterproof Garments	2388 Hats, Caps, Fur Goods, Other Apparel
	2386 Leather & Sheeplined Clothing	2388 Hats, Caps, Fur Goods, Other Apparel
245 Children's Clothing	2361 Girls' Dresses, Blouses, Waists & Shirts	2345 Women's & Children's Clothing
	2363 Girls' & Infants' Coats & Suits	
	2369 Girls' & Infants' Outerwear, NEC	

246 Fur Goods	2371 Fur Goods	2388 Hats, Caps, Fur Goods, Other Apparel
248 Foundation Garments	2242 Brassieres, Girdles & Allied Garments	2345 Women's & Children's Clothing
2491 Fabric Glove Manufacturers	2381 Dress & Work Gloves, Except Knit & Leather	2388 Hats, Caps, Fur Goods, Other Apparel
2492 Hat & Cap Industry	2351 Millinery 2352 Hats & Caps, Except Millinery	2388 Hats, Caps, Fur Goods, Other Apparel
2499 Miscellaneous Clothing Industries	2387 Apparel Belts 2389 Apparel & Accessories, NEC	2388 Hats, Caps, Fur Goods, Other Apparel
251 Sawmills, Planing Mills & Shingle Mills	2421 Sawmills & Planing Mills, General 2429 Special Product Sawmills, NEC	2415 Logging, Sawmills, Planing Mills
252 Veneer & Plywood Mills	2435 Hardwood Veneer & Plywood 2436 Softwood Veneer & Plywood	2430 Millwork, Plywood & Related Products
2541 Sash, Door, Millwork, Hardwood Flooring	2426 Hardwood Dimension & Flooring Mills 2431 Millwork	2415 Logging, Sawmills, Planing Mills 2430 Millwork, Plywood & Related Products
2543 Pre-Fabricated Buildings (Woodframe)	2439 Structural Wood Members, NEC 2452 Prefab Wood Buildings & Components	2430 Millwork, Plywood & Related Products 2498 Other Wood Products, Including Buildings
2544 Wooden Kitchen Cabinets	2434 Wood Kitchen Cabinets	2430 Millwork, Plywood & Related Products
256 Wooden Box Factories	2441 Nailed & Lock Corner Wood Boxes 2448 Wood Pallets & Skids 2449 Wood Containers, NEC	2498 Other Wood Products, Including Buildings
258 Coffin & Casket	3995 Burial Caskets	3998 Other Manufacturing Products

TABLE A-5 (cont'd)

Canadian SIC (1970)	U.S. Census SIC (1972)	IRS Minor Industries (1973)
2591 Wood Preservation Industry	2491 Wood Preserving	2498 Other Wood Products, Including Buildings
2593 Manufactures of Particle Board	2492 Particleboard	2498 Other Wood Products, Including Buildings
2599 Miscellaneous Wood Industries	2499 Wood Products, NEC	2498 Other Wood Products, Including Buildings
2619 Household Furniture	2511 Wood Household Furniture not Upholstered 2512 Wood Household Furniture Upholstered 2514 Metal Household Furniture 2517 Wood TV, Radio, Phonograph, Sew Cabinets 2519 Household Furniture, NEC	2500 Furniture & Fixtures
264 Office Furniture	2521 Wood Office Furniture 2522 Metal Office Furniture	2500 Furniture & Fixtures
266 Miscellaneous Furniture & Fixtures	2515 Mattresses & Bedsprings 2531 Public Building & Related Furniture 2541 Wood Partitions, Shelving, Fixtures 2542 Metal Partitions, Shelving, Fixtures 2591 Drapery Hardware, Window Blinds, Shades 2599 Furniture & Fixtures, NEC	2500 Furniture & Fixtures
268 Electric Lamp & Shade	3645 Residential Electric Lighting Fixtures	3698 Other Electric Equipment

271 Pulp & Paper Mills	2611 Pulp Mills 2621 Paper Mills, Except Building Paper Mills 2631 Paperboard Mills 2661 Building Paper & Building Board Mills	2625 Pulp, Paper & Board Mills
272 Asphalt Roofing	2952 Asphalt Felts & Coatings	2998 Other Petroleum & Coal Products
2731 Folding Carton & Set-Up Box	2651 Folding Paperboard Boxes 2652 Set-Up Paperboard Boxes	2699 Other Paper Products
2732 Corrugated Boxes	2653 Corrugated & Solid Fiber Boxes	2699 Other Paper Products
2733 Paper & Plastic Bags	2643 Bags, Except Textile Bags	2699 Other Paper Products
274 Other Paper Converters	2641 Paper Coating & Glazing 2642 Envelopes 2645 Die-cut Paper, Paperboard & Cardboard 2646 Pressed & Molded Pulp Goods 2647 Sanitary Paper Products 2648 Stationery, Tablets & Related Products 2649 Converted Paper, Paperboard Products, NEC 2654 Sanitary Food Containers 2655 Fiber Cans, Tubes, Drums, Similar Products	2699 Other Paper Products

TABLE A-5 (cont'd)

Canadian SIC (1970)	U.S. Census SIC (1972)	IRS Minor Industries (1973)
286 Commercial Printing	2732 Book Printing	2735 Books, Greeting Cards & Misc. Publishing
	2751 Commercial Printing, Letter Press & Screen	2799 Commercial & Other Printing, Trade Services
	2752 Commercial Printing, Lithographic	2799 Commercial & Other Printing, Trade Services
	2754 Commercial Printing, Gravure	2799 Commercial & Other Printing, Trade Services
	2761 Manifold Business Forms	2799 Commercial & Other Printing, Trade Services
	2771 Greeting Card Publishing	2735 Books, Greeting Cards & Misc. Publishing
287 Platemaking, Typesetting, Trade Bindery	2753 Engraving & Plate Printing	2799 Commercial & Other Printing, Trade Services
	2789 Bookbinding & Related Work	
	2791 Typesetting	
	2793 Photoengraving	
	2794 Electrotyping & Stereotyping	
	2795 Lithographic Platemaking & Related Services	
288 Publishing Only	2711 Newspapers: Publishing & Printing	2710 Newspapers
289 Publishing & Printing	2721 Periodicals: Publishing & Printing	2720 Periodicals
	2731 Books: Publishing & Printing	2735 Books, Greeting Cards & Misc. Publishing
	2741 Miscellaneous Printing	2735 Books, Greeting Cards & Misc. Publishing

291	Iron & Steel Mills	3312 Blast Furnaces, Steel Works, Rolling Mills	3370 Ferrous Metal Industries, Primary
		3313 Electrometallurgical Products	
		3316 Cold Rolled Steel Sheet, Strip & Bars	
		3324 Steel Investment Foundries	
		3325 Steel Foundries, NEC	
292	Steel Pipe & Tube Mills	3317 Steel Pipe & Tubes	3370 Ferrous Metal Industries, Primary
294	Iron Foundries	3321 Gray Iron Foundries	3370 Ferrous Metal Industries, Primary
		3322 Malleable Iron Foundries	
295	Smelting & Refining	3331 Primary Smelting & Refinishing of Copper	3380 Nonferrous Metal Industries
		3332 Primary Smelting & Refining of Lead	
		3333 Primary Smelting & Refining of Zinc	
		3334 Primary Production of Aluminum	
		3339 Nonferrous Metals Primary Refining, NEC	
296	Aluminum Rolling, Casting & Extruding	3353 Aluminum Sheet, Plate & Foil	3380 Nonferrous Metal Industries
		3354 Aluminum Extruded Products	
		3355 Aluminum Rolling & Drawing, NEC	
		3361 Aluminum Foundries (Castings)	
297	Copper & Alloy Rolling, Casting, Extruding	3351 Rolling, Drawing & Extruding of Copper	3380 Nonferrous Metal Industries
		3362 Brass, Bronze, Copper, Copper-Base Alloy	
298	Metal Rolling Casting & Extruding, NES	3341 Secondary Smelting & Refining Nonferrous Metals	3380 Nonferrous Metal Industries
		3356 Other Nonferrous Rolling, Drawing Extruding	3380 Nonferrous Metal Industries
		3369 Nonferrous Foundries (Castings), NEC	3380 Nonferrous Metal Industries
		3497 Metal Foil & Leaf	3490 Miscellaneous Fabricated Metal Products
301	Boiler & Plate Works	3443 Fabricated Plate Work (Boiler Shops)	3440 Fabricated Structural Metal Products

TABLE A-5 (cont'd)

Canadian SIC (1970)	U.S. Census SIC (1972)	IRS Minor Industries (1973)
302 Fabricated Structural Metal	3441 Fabricated Structural Metal	3440 Fabricated Structural Metal Products
3031 Metal Door & Window	3442 Metal Doors, Sash, Frames, Molding, Trim	3440 Fabricated Structural Metal Products
3039 Ornamental & Architectural Metal, NES	3446 Architectural & Ornamental Metal Work	3440 Fabricated Structural Metal Products
	3448 Prefabricated Metal Buildings & Components	
3041 Metal Coating	3471 Electroplating, Polishing, Anodizing, Color	3470 Coating, Engraving & Allied Services
	3479 Coating, Engraving, Allied Services, NEC	
3042 Metal Stamping & Pressing	3411 Metal Cans	3410 Metal Cans & Shipping Containers
	3412 Metal Shipping Barrels, Drums, Kegs, Pails	3410 Metal Cans & Shipping Containers
	3444 Sheet Metal Work	3440 Fabricated Structural Metal Products
	3466 Crowns & Closures	3460 Metal Forgings & Stampings
	3469 Metal Stampings, NEC	3460 Metal Forgings & Stampings
305 Wire & Wire Products	3315 Steel Wire Drawing, Steel Nails & Spikes	3370 Ferrous Metal Industries, Primary
	3451 Screw Machine Products	3428 Cutlery, Hand Tools, Screw Machine Products
	3452 Bolts, Nuts, Screws, Rivets & Washers	3428 Cutlery, Hand Tools, Screw Machine Products
	3495 Wire Springs	3490 Miscellaneous Fabricated Metal Products
	3496 Miscellaneous Fabricated Wire Products	3490 Miscellaneous Fabricated Metal Products

306	Hardware, Tool & Cutlery	3421 Cutlery	3428 Cutlery, Hand Tools, Screw Machine Products
		3423 Hand & Edge Tools, Except Machine Tools, Handsaws	
		3425 Handsaws & Saw Blades	
		3429 Hardware, NEC	
307	Heating Equipment	3433 Heating Equipment, Except Electric & Air Furnaces	3430 Plumbing & Heating, Except Electric & Warm Air
309	Miscellaneous Metal Fabricating	3398 Metal Heat Treating	3380 Nonferrous Metal Industries
		3431 Enameled Iron & Metal Sanitary Ware	3430 Plumbing & Heating, Except Electric & Warm Air
		3432 Plumbing Fixture Fittings & Trim (Brass)	3430 Plumbing & Heating, Except Electric & Warm Air
		3449 Miscellaneous Metal Work	3440 Fabricated Structural Metal Products
		3462 Iron & Steel Forgings	3460 Metal Forgings & Stampings
		3463 Nonferrous Forgings	3460 Metal Forgings & Stampings
		3484 Small Arms	3480 Ordnance & Accessories, Except Vehicles & Missiles
		3489 Ordnance & Accessories, NEC	3480 Ordnance & Accessories, Except Vehicles & Missiles
		3493 Steel Springs, Except Wire	3490 Miscellaneous Fabricated Metal Products
		3494 Valves & Pipe Fittings, Except Plumbers' Brass	3490 Miscellaneous Fabricated Metal Products
		3498 Fabricated Pipe & Pipe Fittings	3490 Miscellaneous Fabricated Metal Products
		3499 Fabricated Metal Products, NEC	3490 Miscellaneous Fabricated Metal Products
311	Agricultural Implements	3523 Farm Machinery & Equipment	3520 Farm Machinery
		3524 Garden Tractors, Lawn & Garden Equipment	

TABLE A-5 (cont'd)

Canadian SIC (1970)	U.S. Census SIC (1972)	IRS Minor Industries (1973)
316 Commercial Refrigeration & Air Conditioning	3585 Air Conditioning, Air Heating, Refrigeration	3598 Engines, Turbines, Service Industry Machines
318 Office & Store Machinery	3573 Typewriters, Electronic Computing Equipment	3570 Office, Computing, Accounting Machines
	3574 Other Calculating & Accounting Machines	3570 Office, Computing, Accounting Machines
	3576 Scales & Balances, Except Laboratory	3570 Office, Computing, Accounting Machines
	3579 Office Machines, NEC	3570 Office, Computing, Accounting Machines
	3581 Automatic Merchandising Machines	3598 Engines, Turbines, Service Industry Machines
321 Aircraft & Aircraft Parts	3721 Aircraft 3724 Aircraft Engines & Engine Parts 3728 Aircraft Parts & Auxiliary Equipment, NEC	3725 Aircraft, Guided Missiles & Parts
323 Motor Vehicles	3711 Motor Vehicles & Passenger Car Bodies	3710 Motor Vehicles & Equipment
3241 Truck Body Manufacturers	3713 Truck & Bus Bodies	3710 Motor Vehicles & Equipment
3242 Non-Commercial Trailer Manufacturers	2451 Mobile Homes 3792 Travel Trailers & Campers	3798 Other Transportation Equipment
3243 Commercial Trailer Manufacturers	3715 Truck Trailers	3710 Motor Vehicles & Equipment

325 Motor Vehicle Parts & Accessories	3465 Automotive Stampings 3592 Carburetors, Pistons, Rings, Valves 3647 Vehicular Lighting Equipment 3694 Electrical Equipment for Engines 3714 Motor Vehicle Parts & Accessories	3460 Metal Forgings & Stampings 3598 Engines, Turbines, Service Industry Machines 3698 Other Electrical Equipment 3698 Other Electrical Equipment 3710 Motor Vehicles & Equipment
326 Railway Rolling Stock	3743 Railroad Equipment	3798 Other Transportation Equipment
327 Shipbuilding & Repair	3731 Shipbuilding & Repairing	3730 Ship & Boat Building & Repair
328 Boatbuilding & Repair	3732 Boat Building & Repairing	3730 Ship & Boat Building & Repair
329 Miscellaneous Vehicles	3799 Transportation Equipment, NEC	3798 Other Transportation Equipment
331 Small Electrical Appliances	3634 Electric Housewares & Fans 3635 Household Vacuum Cleaners	3630 Household Appliances
332 Major Appliances (Electric & Non-Electric)	3631 Household Cooking Equipment 3632 House Refrigerators, Home & Farm Freezers 3633 Household Laundry Equipment 3636 Sewing Machines	3630 Household Appliances
333 Lighting Fixtures	3646 Commercial Industrial Lighting Fixtures 3648 Lighting Equipment, NEC	3698 Other Electric Equipment
334 Household Radio & T.V. Receivers	3651 Radio & Television Receiving Sets	3665 Radio, Television, Communication Equipment

TABLE A-5 (cont'd)

Canadian SIC (1970)	U.S. Census SIC (1972)	IRS Minor Industries (1973)
335 Communication Equipment	3661 Telephone & Telegraph Apparatus	3665 Radio, Television, Communication Equipment
	3662 Radio & Television Transmitting, Signalling, Detection Equipment	3665 Radio, Television, Communication Equipment
	3671 Radio & Television Receiving Electron Tubes	3670 Electronic Components & Accessories
	3672 Cathode Ray Television Picture Tubes	3670 Electronic Components & Accessories
	3673 Transmitting, Industrial, Special Electron Tubes	3670 Electronic Components & Accessories
	3674 Semi-Conductors & Related Devices	3670 Electronic Components & Accessories
	3675 Electronic Capacitors	3670 Electronic Components & Accessories
	3676 Resistors for Electronic Applications	3670 Electronic Components & Accessories
	3677 Electronic Coils, Transformers, Inductors	3670 Electronic Components & Accessories
	3678 Connectors for Electronic Applications	3670 Electronic Components & Accessories
	3679 Electronic Components, NEC	3670 Electronic Components & Accessories
	3825 Electrical Signal Testing Instruments	3815 Scientific Instruments, Watches

336 Electrical Industrial Equipment	3612 Power, Distribution, Specialty Transformers 3613 Switchgear & Switchboard Apparatus 3621 Motors & Generators 3622 Industrial Controls 3623 Welding Apparatus, Electric 3629 Electrical Industrial Apparatus, NEC	3698 Other Electric Equipment
338 Electric Wire & Cable	3357 Drawing & Insulating of Nonferrous Wire	3380 Nonferrous Metal Industries
3391 Battery Manufacturers	3691 Storage Batteries 3692 Primary Batteries, Dry & Wet	3698 Other Electric Equipment
3399 Miscellaneous Electrical Products, NES	3624 Carbon & Graphite Products 3641 Electric Lamps 3643 Current-Carrying Wiring Devices 3644 Noncurrent-Carrying Wiring Devices 3693 X-Ray, Electromedical Therapeutic Apparatus 3699 Electrical Machinery, Equipment Supplies, NEC	3698 Other Electric Equipment
3511 Clay Product Manufacturers, (Domestic Clays)	3251 Brick & Structural Clay Tile 3253 Ceramic Wall & Floor Tile 3259 Structural Clay Products, NEC	3298 Other Nonmetallic Mineral Products
3512 Clay Product Manufacturers, (Imported Clay)	3261 Vitreous China Plumbing Fixtures 3262 Vitreous China Table & Kitchen Articles 3263 Fine Earthenware Table & Kitchen Articles 3264 Porcelain Electrical Supplies 3269 Pottery Products, NEC	3298 Other Nonmetallic Mineral Products
352 Cement Manufacturers	3241 Cement, Hydraulic	3240 Cement, Hydraulic
353 Stone Products	3281 Cut Stone & Stone Products	3298 Other Nonmetallic Mineral Products

TABLE A-5 (cont'd)

Canadian SIC (1970)	U.S. Census SIC (1972)	IRS Minor Industries (1973)
3542 Manufacturers of Structural Concrete Products	3271 Concrete Block & Brick	3270 Concrete, Gypsum & Plaster Products
3549 Concrete Products Manufacturers, NES	3272 Concrete Products Except Block & Brick	3270 Concrete, Gypsum & Plaster Products
355 Ready-Mix Concrete	3273 Ready-Mixed Concrete	3270 Concrete, Gypsum & Plaster Products
3561 Glass Manufacturers	3211 Flat Glass 3221 Glass Containers	3225 Glass Products
3562 Glass Products	3229 Pressed & Blown Glass & Glassware, NEC 3231 Glass Products Made of Purchased Glass	3225 Glass Products
357 Abrasives	3291 Abrasive Products	3298 Other Nonmetallic Mineral Products
358 Lime Manufacturers	3274 Lime	3270 Concrete, Gypsum & Plaster Products
3591 Refractories	3255 Clay Refractories 3297 Non-Clay Refractories	3298 Other Nonmetallic Mineral Products

3599 Misc. Non-Metallic Mineral Products	3275 Gypsum Products	3270 Concrete, Gypsum & Plaster Products
	3292 Asbestos Products	3298 Other Nonmetallic Mineral Products
	3293 Gaskets, Packing & Sealing Devices	3298 Other Nonmetallic Mineral Products
	3295 Minerals & Earths, Ground & Treated	3298 Other Nonmetallic Mineral Products
	3296 Mineral Wool	3298 Other Nonmetallic Mineral Products
	3299 Nonmetallic Mineral Products, NES	3298 Other Nonmetallic Mineral Products
3651 Petroleum Refining	2911 Petroleum Refining	2910 Petroleum Refining, Incl. Integrated
3652 Lubricating Oils & Greases	2992 Lubricating Oils & Greases	2998 Other Petroleum & Coal Products
369 Miscellaneous Petroleum & Coal Products	2951 Paving Mixtures & Blocks	2998 Other Petroleum & Coal Products
	2999 Products of Petroleum & Coal, NEC	
372 Mixed Fertilizers	2875 Fertilizers, Mixing Only	2898 Agricultural & Other Chemical Products
373 Plastics & Synthetic Resins	2821 Plastics Materials, Synthetic Resins	2815 Industrial Chemicals, Plastics Materials
374 Pharmaceuticals & Medicines	2831 Biological Products	2830 Drugs
	2833 Medicinal Chemicals & Botanical Products	
	2834 Pharmaceutical Preparations	
375 Paint & Varnish	2851 Paints, Varnishes, Lacquers, Enamels	2850 Paints & Allied Products

TABLE A-5 (cont'd)

Canadian SIC (1970)	U.S. Census SIC (1972)	IRS Minor Industries (1973)
376 Soap & Cleaning Compounds	2841 Soap & Other Detergents, Except Specialty	2840 Soap, Cleaners & Toilet Goods
	2842 Specialty Cleaning, Polishing Preps	
	2843 Surface Active Agents, Sulfonated Oils	
377 Toilet Preparations	2844 Perfumes, Cosmetics, Toilet Preparations	2840 Soap, Cleaners & Toilet Goods
3781 Manufacturers of Pigments & Dye Colours	2816 Inorganic Pigments	2815 Industrial Chemicals, Plastics Materials
	2865 Cyclic Crudes, Intermediates, Dyes	2898 Agricultural & Other Chemicals, Plastics
3782 Industrial Chemicals (Inorganic, NES)	2812 Alkalies & Chlorine	2815 Industrial Chemicals, Plastics Materials
	2813 Industrial Gases	2815 Industrial Chemicals, Plastics Materials
	2819 Industrial Inorganic Chemicals, NEC	2815 Industrial Chemicals, Plastics Materials
	2873 Nitrogenous Fertilizers	2898 Agricultural & Other Chemical Products
	2874 Phosphatic Fertilizers	2898 Agricultural & Other Chemical Products
	2895 Carbon Black	2898 Agricultural & Other Chemical Products
3783 Industrial Chemicals (Organic, NES)	2822 Synthetic Rubber (Vulcanizable Elastomers)	2815 Industrial Chemicals, Plastics Materials
	2861 Gum & Wood Products, NEC	2898 Agricultural & Other Chemical Products
	2869 Industrial Organic Chemicals, NEC	2898 Agricultural & Other Chemical Products

3791 Manufacturers of Printing Inks	2893 Printing Ink	2898 Agricultural & Other Chemical Products
3799 Miscellaneous Chemicals Industries, NES	2879 Pesticides & Agricultural Chemicals, NEC	2898 Agricultural & Other Chemical Products
	2891 Adhesives & Sealants	2898 Agricultural & Other Chemical Products
	2892 Explosives	2898 Agricultural & Other Chemical Products
	2899 Chemicals & Chemical Preparations	2898 Agricultural & Other Chemical Products
	3482 Small Arms Ammunition	3480 Ordnance & Accessories, Except Vehicles & Missiles
	3483 Ammunition, Except for Small Arms, NEC	3480 Ordnance & Accessories, Except Vehicles & Missiles
3911 Instruments & Related Products	3811 Scientific Instruments & Equipment	3815 Scientific Instruments, Watches
	3822 Automatic Controls, Environ & Appliances	3815 Scientific Instruments, Watches
	3823 Process Control Instruments & Related Products	3815 Scientific Instruments, Watches
	3824 Totalizing Fluid Meters & Counting Devices	3815 Scientific Instruments, Watches
	3829 Measuring & Controlling Devices, NEC	3815 Scientific Instruments, Watches
	3832 Optical Instruments & Lenses	3845 Optical, Medical, Opthalmic Goods
	3841 Surgical & Medical Instruments	3845 Optical, Medical, Opthalmic Goods
	3861 Photographic Equipment & Supplies & Apparatus	3860 Photographic Equipment & Supplies
3912 Clock & Watch	3873 Watches, Clocks, Clockwork Devices & Parts	3815 Scientific Instruments, Watches
3913 Orthopaedic & Surgical Appliances	3842 Orthopaedic, Prosthetic, Surgical appliances	3845 Optical, Medical, Opthalmic Goods

TABLE A-5 (cont'd)

Canadian SIC (1970)	U.S. Census SIC (1972)	IRS Minor Industries (1973)
3914 Opthalmic Goods	3851 Opthalmic Goods	3845 Optical, Medical, Opthalmic Goods
3915 Dental Laboratories	3843 Dental Equipment & Supplies	3845 Optical, Medical, Opthalmic Goods
392 Jewellery & Silverware	3911 Jewellery, Precious Metal 3914 Silverware, Plated Ware, Stainless Ware 3915 Jewellers' Findings & Materials, Lapidary 3961 Costume Jewellery & Novelties, Nonprecious	3998 Other Manufacturing Products
3931 Sporting Goods	3949 Sporting & Athletic Goods, NEC	3998 Other Manufacturing Products
3932 Toys & Games	3942 Dolls 3944 Games, Toys, Childrens' Vehicles	3998 Other Manufacturing Products
397 Signs & Displays	3993 Signs & Advertising Displays	3998 Other Manufacturing Products
3991 Broom, Brush & Mop	3991 Brooms & Brushes	3998 Other Manufacturing Products
3992 Button, Buckle & Fastener	3963 Buttons 3964 Needles, Pins, Hooks & Eyes, Similar Notions	3998 Other Manufacturing Products
3993 Floor Tile, Linoleum & Coated Fabrics	2295 Coated Fabrics, Not Rubberized	2298 Other Textile Mill Products
	3996 Linoleum, Other Hard Floor Coverings, NEC	3990 Other Manufacturing Products
3994 Sound Recording & Musical Instruments	3652 Phonograph Records, & Prerecorded Tape 3931 Musical Instruments	3665 Radio, Television, Communication Equipment
3996 Pens & Pencils	3951 Pens, Mechanical Pencils & Parts 3952 Lead Pencils, Crayons & Artists' Materials	3998 Other Manufacturing Products

3999 Fur Dressing & Dyeing & Other Miscellaneous Manufacturers	3953 Marking Devices 3955 Carbon Paper & Inked Ribbons 3962 Feathers, Plumes, Artificial Trees & Flowers 3999 Manufacturing Industries, NEC	3998 Other Manufacturing Products

Sources: Canada, Department of Industry, Trade & Commerce (1975), and Pugel (1978, Appendix Table A-3, pp. 121–23).
NEC = not elsewhere classified (United States).
NES = not elsewhere specified (Canada).

Appendix B
Sensitivity of Industry Production Function Estimates to Plant Sample Selection Criteria and Variable Definitions

This appendix addresses two issues raised in Chapter Three: the effect of changing the plant selection criteria and of using different proxies for labour and capital. In Chapter Three, eleven plant selection criteria were formulated. When all eleven are applied to the plants extant in individual 4-digit industries, in a non-trivial number of instances sample size was reduced to such an extent as to call into question the usefulness of estimating individual industry production functions. It is therefore important to ask whether all eleven criteria are necessary. This would only be the case if the proxies for labour and capital that use all eleven provide significantly different or better estimates of scale elasticity compared to the use of fewer criteria. Hence, the questions of sample selections, data quality and appropriate proxies for labour and capital are interrelated.

To investigate these issues we selected a sub-sample of eight industries from our 167 4-digit sample. These are drawn from a number of different 2-digit industry groups and, as presented in Table B-1, have varying numbers of establishments which are sensitive to the plant selection criteria. Since we chose to estimate a Cobb-Douglas production function using OLS (see Appendix C), it is this function we adopt here.

The remainder of the appendix addresses the following issues: the choice of capital variable; the choice of labour input; the effect of product heterogeneity; the effect of valuation technique; the sensitivity of the scale elasticity estimates to the selection criteria; and a summary and conclusion.

Capital and Fuel and Electricity

In Chapter Three, several possible proxies for capital were suggested and defined:

- K_1 gross capital expenditure on new construction and new machinery and equipment over the period 1970–1979, expressed in constant (1971) dollars;
- K_2 repair expenditures on construction and machinery and equipment over the period 1970–1979, expressed in constant (1971) dollars;
- K_3 cost of fuel and electricity, available for 1970 and 1979; and
- K_4 cost of materials and supplies, available for 1970 and 1979.

TABLE B-1 Sample of Eight 4-Digit Canadian Manufacturing Industries and Number of Plants Left after Application of Various Plant Sample Selection Criteria: 1970 and 1979

		Number of Establishments Left after Application of Various Criteria[a]							
		None		1–7		1–9[b]		1–11[b]	
SIC	Industry Name	1970	1979	1970	1979	1970	1979	1970	1979
1072	Bakeries	533	441	319	247	319	87	180	85
1081	Confectionery Manufacturers	58	50	46	29	46	26	30	26
1832	Throwsters, Spun Yarn & Cloth Mills	79	62	66	52	66	41	51	39
2513	Sawmills and Planing Mills	720	580	561	471	561	296	348	292
2860	Commercial Printing	974	892	689	611	689	307	537	307
3042	Metal Stamping and Pressing Ind.	315	287	213	154	213	101	157	101
3320	Manufacturers of Major Appliances	27	28	16	24	16	16	12	16
3360	Mfrs. Electrical Industrial Equip.	120	136	75	74	75	43	47	41

Source: Statistics Canada, special tabulations.
a. See Table 3-2 for sample selection criteria.
b. Criteria 8 and 9 are only relevant to 1979.

TABLE B-2 Correlation Between Various Proxy Measures of Capital for Eight 4-Digit Canadian Manufacturing Industries, 1979

	Correlation					
SIC	K_1K_2	K_3K_4	K_1K_3	K_1K_4	K_2K_3	K_2K_4
1072	0.8053	0.8878	0.7724	0.8266	0.8347	0.8278
1081	0.8005	0.8030	0.7421	0.7594	0.8399	0.7952
1832	0.7459	0.7160	0.7195	0.4835	0.7598	0.6664
2513	0.8073	0.7524	0.7112	0.6289	0.6949	0.6556
2860	0.7972	0.8385	0.6665	0.7104	0.7567	0.7644
3042	0.7420	0.8695	0.7364	0.6472	0.8309	0.7608
3320	0.7648	0.6865	0.6024	0.5763	0.8313	0.7750
3360	0.7841	0.8346	0.8314	0.7607	0.8117	0.7784

Source: Statistics Canada, special tabulations.
Note: All variables are in natural logs; criteria 1 to 9 were applied to select the sample of establishments (see Table 3-2 for details); and all the correlations are significant at .01 except K_1K_3, K_1K_4 for 3320 (both significant at .05).

The problem can be characterised as follows: K_1 and K_2 are only available for 1979, not 1970, while K_3 and K_4 are available for both years; and K_1 and K_2 are collected for a substantially smaller set of establishments than K_3 and K_4. Hence, if K_3 and K_4 yield much the same results as K_1 and K_2, then the former pair would appear to be more suited as proxies for capital in that they yield greater degrees of freedom. In order to make the task manageable we decided to compare the use of K_2 and K_3, since both are flows that should be highly correlated with the service of capital consumed. K_3 was preferred to K_4 because the former is much less likely to be plagued by any valuation problems because of inventory changes and was felt to be more closely associated with the flow of capital services. Furthermore, the pattern of correlations amongst K_1, K_2, K_3 and K_4 suggested that while K_1 and K_2 as well as K_3 and K_4 were significantly correlated with each other, K_2 and K_3 were more closely related than any other combination of K_1, K_2 with K_3, K_4. Full details of these correlations may be found in Table B-2.

We estimate two equations to see how close the results are between K_2 and K_3:

$$\log Y = k + a \log L_2 + b \log K_2 \quad \text{(B.1)}$$

$$\log Y = k + a \log L_2 + b \log K_3 \quad \text{(B.2)}$$

for the eight industries in Table B-1, where L_2 expresses the labour input in production and related worker manhour equivalents. The equations are estimated using criteria 1 to 9 (see Table 3-2 for details), the minimum number of selection criteria given the variables being considered. The regression results for equations B.1 and B.2 are presented in Table B-3.[1]

TABLE B-3 Estimation of Regression Equations of Value-Added (Y) on Manhours (L_2) and Fuel and Electricity (K_3) or Manhours (L_2) and Repair Expenditure on Construction, Machinery and Equipment (K_2) for Eight 4-Digit Canadian Manufacturing Industries, 1979

Industry Number	Equation B.1					Equation B.2				
	Constant	L_2	K_2	R^2	F-Ratio	Constant	L_2	K_3	R^2	F-Ratio
	(Regression Coefficients and t-values[a])									
1072	1.983	1.016	0.046	0.9270[b]	533.29	1.550	0.989	0.088	0.9272[b]	534.55
	(3.74)[b]	(18.16)[b]	(1.32)			(4.05)[b]	(13.93)[b]	(1.39)		
1081	1.816	1.027	0.101	0.8760[b]	81.25	1.283	0.893	0.242	0.8890[b]	92.08
	(1.15)	(6.29)[b]	(0.94)			(1.16)	(5.54)[b]	(1.92)[d]		
1832	3.689	0.894	−0.015	0.2775[b]	7.30	2.512	1.426	−0.465	0.3219[b]	9.02
	(1.07)	(2.66)[c]	(−0.08)			(0.86)	(3.45)[b]	(−1.58)		
2513	0.774	1.135	0.068	0.8667[b]	952.27	0.184	1.081	0.139	0.8659[b]	946.26
	(1.81)[d]	(26.52)[b]	(3.00)[b]			(0.52)	(17.33)[b]	(2.71)[b]		
2860	3.167	0.912	0.122	0.8787[b]	1,101.36	2.217	0.856	0.215	0.8774[b]	1,087.75
	(9.39)[b]	(26.26)[b]	(6.02)[b]			(8.19)[b]	(19.52)[b]	(5.70)[b]		
3042	5.498	0.685	0.225	0.8333[b]	244.99	3.962	0.525	0.423	0.8284[b]	236.60
	(8.39)[b]	(10.77)[b]	(6.62)[b]			(6.87)[b]	(6.15)[b]	(6.31)[b]		
3320	0.287	1.179	−0.007	0.8515[b]	37.28	0.461	1.256	−0.100	0.8535[b]	37.85
	(0.114)	(5.02)[b]	(−0.06)			(0.25)	(5.00)[b]	(−0.42)		
3360	3.777	0.893	0.051	0.7613[b]	63.79	3.218	0.674	0.322	0.7918[b]	76.06
	(2.46)[c]	(6.04)[b]	(0.65)			(3.19)[b]	(4.72)[b]	(2.52)[c]		

Source: Statistics Canada, special tabulations.
Note: Criteria 1–9 were applied to select the sample of establishments. See Tables 3-2 and B-1 for details.
a. t-values in parentheses; R^2 tested by F test; all t-tests are two-tailed.
b. significant at .01 level.
c. significant at .05 level.
d. significant at .10 level.

Overall, the scale elasticity is much the same whether equation B.1 or B.2 is used to estimate the production function:

SIC	Scale Elasticity	
	EQ B.1	EQ B.2
1072	1.062	1.077
1081	1.128	1.135
1832	0.879	0.961
2513	1.203	1.220
2860	1.034	1.071
3042	0.910	0.948
3320	1.177	1.156
3300	0.944	0.996

Use of equation B.2 with K_3 rather than K_2, however, does result in the scale elasticity being somewhat higher in all instances except SIC 3320, than equation B.1. The significance of the coefficients, the R^2 and F value, are much the same for both equation B.1 and B.2.

There are, however, some differences between the estimated parameters for equations B.1 and B.2. The coefficient on K_2 is usually smaller in absolute value than those on K_3, even where they are both significant (i.e., industries 2513, 2860, 3042). In contrast, the coefficients on L_2 are higher in equation B.1. This is probably the result of an errors-in-variable problem[2] — K_2 is probably not as good a proxy for capital services as K_3 and is thus biased towards zero (K_3 is significant in five out of the eight industries, K_2 in only three cases). As a result, some of the returns to capital is being picked up by L_2 in equation B.1, inflating it upwards. Further experimentation did not materially alter these results.[3]

Hence, we can conclude that in selecting a proxy for capital services the choice has little impact on the overall scale elasticity, but fuel and 17electricity seems to be less plagued by an errors-in-variable problem than a proxy derived from investment survey data for the 1970s.

In view of the importance attached to the use of K_3 as a proxy for capital, we undertook some non-linear estimation which involved estimating an equation with a linear combination of both K_3 and K_2 to see whether the results yielded a marked change over the coefficient attached to K_3 in equation B.2.[4] In general, we found that a term involving both K_2 and K_3 performed no better than one with K_3.

Manhours, Production and Non-Production Workers, and Labour

The labour input can be represented by a number of variables:

L_1 — the total number of employees in the plant, including both production and related workers (NW) and administrative, office and other non-manufacturing employees (NS); and

L_2 — MHRSWR + VS • MHRSWR/VW, where VS is gross earnings of NS, VW is the gross earnings NW, and MHRSWR is manhours worked by NW.

In Chapter Three we discussed the relative merits of the above measures of the labour input and selected L_2. Here we examine the sensitivity of our scale elasticity estimate to the specification of labour, by using not only L_1 and L_2 but also NW and NS separately. As will be apparent, the results are not very sensitive to the specification of the labour variable. In Table B-4 three estimates equations are presented: equation B.2 (previously defined) and

$$\log Y = k + a \log L_1 + b \log K_3 \qquad (B.3)$$

$$\log Y = k + a_1 \log NW + a_2 \log NS + b \log K_3 \qquad (B.4)$$

for the eight industries in Table B-1. The equations are estimated for criteria 1 to 7 (see Table 3-2 for details), the minimum number of selection criteria given the variables being considered. The table refers to 1979.[5]

TABLE B-4 Estimation of Regression Equations of Value-Added (Y) on Fuel and Electricity (K_3) and Manhours (L_2) or Total Employees (L_1) or Production (NW) and Office (NS) Employees, for Eight 4-Digit Canadian Manufacturing Industries, 1979

Industry Number	Equation B.2				
	Constant	L_2	K_3	R^2	F-Ratio
	(Regression Coefficients and t-values[a])				
1072	1.511	0.859	0.227	0.8992[b]	1,088.04
	(5.94)[b]	(21.32)[b]	(6.73)[b]		
1081	1.744	0.940	0.148	0.8541[b]	76.10
	(1.51)	(5.17)[b]	(1.01)		
1832	2.513	1.297	−0.330	0.3984[b]	16.22
	(1.16)	(4.03)[b]	(−1.43)		
2513	0.549	1.055	0.132	0.8897[b]	1,887.12
	(2.32)[c]	(24.43)[b]	(3.79)[b]		
2860	2.408	0.859	0.188	0.8697[b]	2,029.35
	(12.39)[b]	(28.14)[b]	(7.84)[b]		
3042	3.434	0.635	0.347	0.8289[b]	365.67
	(7.57)[b]	(9.65)[b]	(6.79)[b]		
3320	1.776	1.162	−0.099	0.9601[b]	252.55
	(2.67)[c]	(7.09)[b]	(−0.68)		
3360	4.293	0.667	0.236	0.8387[b]	184.59
	(7.16)[b]	(6.11)[b]	(2.40)[c]		

TABLE B-4 (cont'd)

Industry Number	Equation B.3				
	Constant	L_1	K_3	R^2	F-Ratio
		(Regression Coefficients and t-values[a])			
1072	7.938	0.866	0.235	0.9079[b]	1,202.47
	(34.50)[b]	(22.81)[b]	(7.46)[b]		
1081	9.520	1.040	0.057	0.8617[b]	81.00
	(9.17)[b]	(5.44)[b]	(0.37)		
1832	12.725	1.301	−0.356	0.4011[b]	16.41
	(7.79)[b]	(4.06)[b]	(−1.52)		
2513	8.900	1.058	0.106	0.8979	2,057.90
	(35.07)[b]	(26.12)[b]	(3.13)[b]		
2860	9.086	0.913	0.148	0.8817	2,265.19
	(64.23)[b]	(30.55)[b]	(6.33)[b]		
3042	8.318	0.664	0.331	0.8349	381.91
	(23.44)[b]	(10.10)[b]	(6.56)[b]		
3320	10.712	1.192	−0.124	0.9612[b]	259.89
	(11.43)[b]	(7.23)[b]	(−0.85)		
3360	9.464	0.697	0.214	0.8477[b]	197.59
	(15.90)[b]	(6.61)[b]	(2.32)[c]		

Industry Number	Equation B.4					
	Constant	NW	NS	K_3	R^2	F-Ratio
		(Regression Coefficients and t-values[a])				
1072	8.551	0.666	0.230	0.221	0.9093[b]	812.46
	(34.72)[b]	(18.04)[b]	(9.01)[b]	(6.97)[b]		
1081	10.429	0.948	0.106	0.014	0.8278[b]	40.05
	(7.34)[b]	(3.68)[b]	(1.14)	(0.07)		
1832	14.146	0.617	0.724	−0.356	0.4730[b]	14.36
	(8.59)[b]	(1.92)[d]	(3.27)[b]	(−1.64)		
2513	9.193	0.888	0.149	0.129	0.8967[b]	1,351.37
	(34.30)[b]	(22.53)[b]	(6.21)[b]	(3.87)[b]		
2860	9.711	0.627	0.306	0.142	0.8841[b]	1,542.92
	(63.79)[b]	(21.11)[b]	(12.76)[b]	(6.09)[b]		
3042	8.655	0.521	0.130	0.338	0.8330[b]	249.43
	(22.69)[b]	(7.21)[b]	(2.47)[c]	(6.67)[b]		
3320	11.319	1.149	0.052	−0.149	0.9596[b]	158.19
	(10.64)[b]	(5.55)[b]	(0.41)	(−0.95)		
3360	9.642	0.423	0.184	0.274	0.8326[b]	116.06
	(13.86)[b]	(3.83)[b]	(2.78)[b]	(2.76)[b]		

Source: Statistics Canada, special tabulations.

Note: Criteria 1–7 were applied to select the sample of establishments. See Tables 3-2 and B-1 for further details.

a. t-values in parentheses; R^2 tested by F test; all t-tests are two-tailed.
b. significant at .01 level.
c. significant at .05 level.
d. significant at .10 level.

Overall, the scale elasticity is much the same whether equation B.2, B.3 or B.4 is used to estimate the production function:

SIC	Scale Elasticity		
	EQ B.2	EQ B.3	EQ B.4
1072	1.086	1.101	1.117
1081	1.088	1.097	1.068
1832	0.967	0.945	0.985
2513	1.187	1.164	1.166
2860	1.047	1.061	1.075
3042	0.982	0.995	0.989
3320	1.063	1.068	1.052
3300	0.903	0.911	0.881

Typically, equation B.2 results in a scale elasticity less than that yielded by equation B.3 — except for SIC 1832 and 2513 — but B.2 has an equal chance of yielding a greater (SIC 1081, 2513, 3320 and 3360) or smaller (SIC 1072, 1832, 2860 and 3042) elasticity compared with that derived from equation B.4.

Turning now to the output elasticities for labour (L_1, L_2, NW + NS) and capital (K_3) we see, not surprisingly, considerable similarity in parameter estimates.[6] The labour elasticity is usually smaller for equation B.2 than for either B.3 or B.4. The capital elasticity is always significant for the same five industries (SIC 1072, 2513, 2860, 3042 and 3360) and for these industries the coefficient on K_3 is reasonably stable across equations B.2 to B.4, perhaps with the exception of SIC 2860.

In our discussion of the labour variable in Chapter Three we selected, on a priori grounds, L_2 over either L_1 or NS and NW entered separately. The analysis here suggests that, empirically at least, the results are quite similar whether L_2, L_1 or NS and NW are used. Hence our results can probably be compared with other studies that may have had to rely on L_1.

Product Diversity and Scale Elasticity

In this section we discuss the influence of the inclusion of product diversity on scale elasticity. The one relevant variable not defined above is: H4 = the Herfindahl index of product diversity at the 4-digit ICC level.

The equation corresponding to that estimated in Chapter Four is:

$$\log Y = k + a \log L_2 + b \log K_3 + d \log H4. \qquad \text{(B.5)}$$

This equation plus equation B.2 is presented in Table B-5 for the eight industries in Table B-1. All eleven selection criteria were employed (see

TABLE B-5 Estimation of Regression Equations of Value-Added (Y) on Fuel and Electricity (K_3), Manhours (L_2) and Product Diversity (H4) for Eight 4-Digit Canadian Manufacturing Industries, 1979

Industry	Equation B.2					Equation B.5					
Number	Constant	L_2	K_3	R^2	F-Ratio	Constant	L_2	K_3	H4	R^2	F-Ratio
	(Regression Coefficients and t-values[a])										
1072	1.569	0.994	0.080	0.9294[b]	539.42	1.576	0.994	0.080	0.006	0.9294[b]	355.25
	(4.14)[b]	(14.10)[b]	(1.26)			(3.99)[b]	(14.02)[b]	(1.24)	(0.06)		
1081	1.283	0.893	0.242	0.8890[b]	92.08	1.288	0.894	0.242	0.025	0.8890[b]	58.75
	(1.16)	(5.54)[b]	(1.92)[d]			(1.14)	(5.42)[b]	(1.88)[d]	(0.09)		
1832	2.690	1.397	−0.451	0.3084[b]	8.03	3.552	1.232	−0.364	−0.504	0.3244[b]	5.60
	(0.89)	(3.25)[b]	(−1.49)			(1.12)	(2.64)[c]	(−1.14)	(−0.91)		
2513	0.176	1.082	0.139	0.8645[b]	921.80	0.375	1.080	0.133	0.324	0.8689[b]	636.51
	(0.50)	(17.25)[b]	(2.68)[b]			(1.05)	(17.48)[b]	(2.60)[b]	(3.13)[b]		
2860	2.217	0.856	0.215	0.8774[b]	1,087.75	2.258	0.852	0.216	0.026	0.8776[b]	724.01
	(8.19)[b]	(19.52)[b]	(5.70)[b]			(8.14)[b]	(19.29)[b]	(5.73)[b]	(0.67)		
3042	3.962	0.525	0.423	0.8284[b]	236.60	3.932	0.537	0.414	0.071	0.8292[b]	156.93
	(6.87)[b]	(6.15)[b]	(6.31)[b]			(6.77)[b]	(6.13)[b]	(6.06)[b]	(0.64)		
3320	0.461	1.256	−0.100	0.8535[b]	37.85	−0.752	1.325	−0.069	0.263	0.8678[b]	26.25
	(0.25)	(5.00)[b]	(−0.42)			(−0.36)	(5.18)[b]	(−0.29)	(1.14)		
3360	3.236	0.682	0.313	0.7905[b]	71.67	3.165	0.681	0.316	−0.077	0.7921[b]	46.99
	(3.13)[b]	(4.63)[b]	(2.35)[c]			(3.01)[b]	(4.57)[b]	(2.35)[c]	(−0.54)		

Source: Statistics Canada, special tabulations.
Note: Criteria 1–11 were applied to select the sample of establishments. See Tables 3-2 and B-1 for further details.
a. t-values in parentheses; R^2 tested by F test; all t-tests are two-tailed.
b. significant at .01 level.
c. significant at .05 level.
d. significant at .10 level.

Table 3-2 for full details). Results are only presented and discussed for 1979, in view of the missing value problem for 1970 for a significant number of plants with respect to product diversity.

Table B-5 shows that the inclusion of H4 in the production function — equation B.2 compared with B.5 — does not in any material way affect the scale elasticity or the sign and significance of the coefficients attached to labour (L_2) and capital (K_3).[7] This is perhaps not surprising in view of the lack of significance of H4 for most industries in the table, but this conclusion holds for SIC 2513, where the product diversity variable is significant. Hence, we feel reasonably confident in not discussing the impact of including H4 on the scale elasticity in Chapter Four.

Output Valuation and Scale Elasticity

We also checked to see whether the introduction of terms representing output valuation had an impact upon scale elasticity. The relevant variables are defined as follows: D1 = 1, where shipments are valued at cost, zero otherwise; D2 = 1, where shipments are valued at book transfer value, zero otherwise; and D3 = 1, where shipments are valued at other, zero otherwise.

The equation corresponding to that estimated in Chapter Four is as follows:

$$\log Y = k + c \log L_2 + b \log K_3 + d_1 D1 + d_2 D2 + d_3 D3. \tag{B.6}$$

This equation, which is estimated for the eight industries in Table B-1 and for criteria 1-7 (see Table 3-2 for details), is presented in Table B-6. Results are only presented for 1979, in view of the missing value problem discussed in Chapter Four for 1970. Equation B.2, which excludes the output valuation dummy variables, is presented in Table B-4 for criteria 1 to 7.

In terms of scale elasticity, we see considerable stability as between equations B.2 and B.6:

	Scale Elasticity	
SIC	**EQ B.2**	**EQ B.6**
1072	1.086	1.081
1089	1.088	1.079
1832	0.967	0.810
2513	1.187	1.184
2860	1.047	1.048
3042	0.982	0.990
3320	1.063	1.078
3300	0.903	0.902

TABLE B-6 Estimation of Regression Equations of Value-Added (Y) on Fuel and Electricity (K_3), Manhours (L_2) and Output Valuation (D1, D2, D3) for Eight Canadian Manufacturing Industries, 1979

Industry Number	Equation B.6							
	Constant	L_2	K_3	D1	D2	D3	R^2	F-Ratio
	(Regression Coefficients and t-values[a])							
1072	1.549	0.855	0.226	0.097	0.261	0.213	0.9012[b]	439.60
	(5.91)[b]	(21.18)[b]	(6.67)[b]	(1.08)	(1.03)	(1.71)[d]		
1081	1.844	0.938	0.141	−0.168	0.693	n.a.	0.8646[b]	38.32
	(1.58)	(4.94)[b]	(0.91)	(−0.48)	(1.22)			
1832	4.792	0.855	−0.045	−0.123	−2.322	0.122	0.5695[b]	12.17
	(2.40)[c]	(2.84)[b]	(−0.21)	(−0.42)	(−4.18)[b]	(0.36)		
2513	0.598	1.054	0.130	−0.148	0.057	0.016	0.8904[b]	755.48
	(2.50)[c]	(24.39)[b]	(3.37)[b]	(−1.67)[d]	(0.34)	(0.16)		
2860	2.393	0.862	0.186	−0.097	−0.031	0.156	0.8701[b]	810.22
	(12.23)[b]	(28.10)[b]	(7.75)[b]	(−0.85)	(−0.12)	(0.92)		
3042	3.325	0.633	0.357	0.072	−0.562	0.184	0.8361[b]	150.95
	(7.23)[b]	(9.69)[b]	(7.04)[b]	(0.78)	(−1.93)[d]	(1.40)		
3320	1.558	1.191	−0.113	−0.081	n.a.	0.165	0.9608[b]	116.32
	(1.97)[d]	(6.68)[b]	(−0.74)	(−0.21)		(0.54)		
3360	4.298	0.674	0.228	−0.479	−0.111	0.001	0.8434[b]	73.25
	(7.00)[b]	(6.07)[b]	(2.36)[c]	(−1.41)	(−0.23)	(0.005)		

Source: Statistics Canada, special tabulations.
Note: Criteria 1–7 were applied to select the sample of establishments. See Tables 3-2 and B-1 for further details.
a. t-values in parentheses; R^2 tested by F test; all t-tests are two-tailed.
b. significant at .01 level.
c. significant at .05 level.
d. significant at .10 level.
n.a. = not applicable.

The most notable difference is for SIC 1832, where the scale elasticity declines by 16.2 percent. Nevertheless, these results suggest that our discussion in Chapter Four of output valuation was correct in not proceeding to include valuation variables when calculating the scale elasticity.

Turning to the sign, size and significance of L_2 and K_3 in equations B.2 (Table B-4) and B.6 (Table B-6), we again see considerable stability. The level of significance and sign on L_2 and K_3 do not change between equation B.2 and B.6 for any of the eight industries; the coefficients on L_2 and K_3 in equation B.6 usually lie within 0.90–1.10 those of equation B.2, for matched industries. The only exceptions are the coefficient on K_3 for SIC 3320, which declines by 12.4 percent between B.2 and B.6, and SIC 1832,where the corresponding changes for L_2 and K_3 are a decline of 34.1 percent and increase of 86.4 percent, respectively.[8] However, despite these rather dramatic changes, particularly for K_3 for SIC 1832, it was decided not to change our conclusion that there was little need to discuss scale elasticity in the output valuation section of Chapter Four, particularly in view of the general insignificance of d_1, d_2, and d_3 in the 167-industry sample.

Sensitivity of Scale Elasticity to Selection Criteria

Table B-1 shows that the number of observations per industry is very sensitive to the selection criteria employed to define the set of establishments for the purposes of production function estimation. As noted in Chapter Three, in a non-trivial number of instances, application of all eleven criteria in Table 3-2 reduces the sample size to such an extent as to throw doubt upon the usefulness of the estimated production function. If, however, the estimated scale elasticity is relatively stable across the various selection criteria, the less rigid criteria can be used with no loss of the quality of the estimated parameters.

Equation B.2 has been estimated for 1979 for criteria 1 to 7 (Table B-4), criteria 1 to 9 (Table B-3), and criteria 1 to 11 (Table B-5). The scale elasticity changes very little across these three samples:

	Scale Elasticity from EQ B.2		
SIC	1–7	1–9	1–11
1072	1.086	1.077	1.074
1081	1.088	1.135	1.135
1832	0.967	0.961	0.946
2513	1.187	1.220	1.221
2860	1.047	1.071	1.071
3042	0.982	0.948	0.948
3320	1.063	1.156	1.156
3360	0.903	0.996	0.995

Perhaps the most conspicuous exception is SIC 3360, which increases from 0.903 to 0.995, a rise of 10.2 percent. This and other increases in scale elasticity are not consistent with our discussion in Chapter Three, which suggested that application of criteria 8 and 9 might decrease the estimated scale elasticity. Indeed, in only three of the eight industries does the scale elasticity fall between criteria 1 to 7 and 1 to 9 (SIC 1072, 1832, and 3042). Hence, scale elasticity does not seem to be affected by sample selection criteria, nor does the successive application of the criteria cause a marked decline in the scale estimates, as was hypothesized in the main body of the study.

Turning now to the coefficients on L_2 and K_3, there is considerable stability, particularly with respect to L_2. On only two occasions does the coefficient on L_2 in equation B.2 estimated for criteria 1 to 11 fall outside the range 0.90–1.10 of the corresponding coefficient estimated for criteria 1 to 7. The two exceptions are SIC 1072, where the parameter estimate on L_2 shows an increase of 15.7 percent (0.859 to 0.994), and 3042, where a decrease of 17.3 percent (0.635 to 0.525) is recorded. In addition, the coefficient in L_2 in equation B.2 is always significant at .01 irrespective of the criteria applied.

The coefficient on K_3 is much more sensitive to the criteria employed:

SIC	Absolute Percentage Change Criteria 1 – 7 Compared to 1 – 11, for Coefficient K_3	# of Observations Criteria 1 – 7	1 – 11	Percentage Decline in the Number of Establishments Comparing Criteria 1 – 7 with 1 – 11
1072	64.8	247	85	65.6
1081	63.5	29	26	10.3
1832	36.7	52	39	25.0
3360	32.6	74	41	44.6
3042	21.9	154	101	34.4
2860	14.4	611	307	49.8
2513	5.3	471	292	38.0
3320	1.0	24	16	33.3

Two inferences can be drawn from these numbers. First, comparing the first four ranked industries with the last four, we see that the smaller the number of establishments yielded by criteria 1 to 11 for the first four, the greater is the percentage change in the coefficient on K_3 comparing criteria 1 to 7 with 1 to 11. (The exception to this is SIC 3320.) Second, if the industries are ranked instead by percentage decline in number of observations (i.e., establishments) between criteria 1 to 7 and 1 to 11, then comparing the percentage change in the coefficient on K_3 in the top four with the bottom four, we see little difference in this coefficient. Hence, reducing the number of observations to an absolutely smaller number does matter, rather than the percentage decline in establishments, with respect to the coefficient on K_3.

In sum, we find considerable stability in returns to scale, and the output elasticity with respect to labour as different selection criteria are used to estimate equation B.2. However, the coefficient on K_3 does vary considerably, changing significance for two industries (SIC 1081 and 1072). Furthermore, the sensitivity seems to be greater in industries where application of all eleven selection yielded a small sample of establishments.[9]

Summary and Conclusion

The main conclusions of this section can be summarized as follows:

- The fuel and electricity proxy for capital services performs as well as measures based upon investment surveys for the 1970s and also seems to suffer less of an error-in-variable problem.
- Although in Chapter Three we selected L_2 as the measure of labour input on a priori grounds, the total number of employees entered either as a single number (L_1) or as two separate components (NS, NW) performed as well. Hence, our results can be compared with other studies that have used these latter series of variables to represent the labour input.
- The inclusion of H4 (product diversity) in the production function does not affect the scale elasticity.
- The inclusion of output valuation dummy variables in the production function does not, usually, impact upon the scale elasticity.
- The scale elasticity and the output elasticity with respect to labour are quite stable with respect to the application of various sample selection criteria. However, the capital proxy — cost of fuel and electricity — is sensitive to the sample selection criteria, particularly when only a small number of establishments remain after application of all 11 selection criteria.[10] Hence the use of less restrictive criteria should provide more precise estimates of the scale elasticity without causing any great upward bias in the estimate because a larger number of smaller establishments are included in the larger sample that is derived from the less restrictive set of criteria.

Appendix C
Sensitivity of Industry Scale Elasticity Estimates to Alternative Estimation Techniques and Production Function Choices

In the previous appendix, we focused on the extent to which our estimates were affected by the choice of different proxies for capital and labour and the extent to which different sample criteria yielded different scale economy estimates. Here we present several alternative scale economy estimates for the same sub-sample of eight industries used in Appendix B (see Table B-1) that different estimation techniques yield. We also ask whether our choice of the Cobb-Douglas as opposed to less restrictive production functions (the CES and the translog) affect our scale estimates significantly. Many of the variables used here are introduced and defined in Chapter Three.

Estimation Techniques

The parameters of the production function can be estimated either directly or indirectly using different estimation techniques. Fuss et al. (1978) has summarized the errors imbedded in the process that generates the observations on outputs, costs, inputs and factor prices from which we can estimate the parameters of the production process. These arise from: (a) the technology of the production unit; (b) the environment of each firm, particularly the market environment; (c) the behaviour of the production units; and (d) the process of observation, which often involves measurement errors. Each of these stochastic errors yields a possible source of bias or error in the various estimation procedures that can be used.

In light of these various sources of stochastic error, Fuss et al. (1978) examine the errors that arise in using different ways to estimate the parameters of the production function. They conclude that the direct estimation of the production function, possibly with the use of an instrumental variable, is the preferred route. We therefore followed this procedure. While direct estimation of the production function has long been stressed as involving potential bias problems arising from simultaneity, the errors in measurement of variables such as wage rates or labour share that exist in census data are sufficiently large, in our opinion, that the recommendation of Fuss et al. (1978) for direct over indirect estimation methods was sensible.

While prior judgement therefore guided our choice of estimation technique, we experimented with alternate procedures. In doing so, we focused on the stability of the results yielded by these other procedures. Since we had two samples, one for 1970 and one for 1979, we asked whether an alternate technique to that adopted yielded more or less stable results than our preferred method. In what follows, we report on our findings. We trust that they are enlightening — both for those who are evaluating the significance of our results, and equally for those who embark on a similar exercise with a similar data base.

Ordinary Least Squares (OLS) Versus Instrumental Variables (IV) Estimation of the Production Function

In determining the degree of returns to scale we used OLS and the instrumental variable technique to estimate the Cobb-Douglas production function:

$$\ln Y = k + a \ln L_2 + b \ln K_3 \tag{C.1}$$

where Y, L_2 and K_3 are defined in Chapter Three. Our interest centres on whether:

- a + b is greater than 1, indicating increasing returns to scale;
- a + b equals 1, indicating constant returns to scale; or
- a + b is less than 1, indicating decreasing returns to scale.

As discussed in Chapter Four, an alternate method to OLS in estimating the Cobb-Douglas production function involves the use of the instrumental variable technique (IV). Equation C.1 thus becomes

$$\ln Y = k + a \ln L_2 + b \ln \ddot{K}_3 \tag{C.2}$$

where $\ddot{K}_3$ is estimated using the predicted values from the equation,

$$\ln \ddot{K}_3 = h + c\text{UNCRK} \tag{C.3}$$

and UNCRK is the rank of the unconsolidated firm owning the *i*th establishment. The latter instrument is chosen because of the error in variable that occurs when energy usage is chosen to proxy capital services.

The results of the OLS and the IV estimation for our sample of industries are presented in Table C-1. We report the returns to scale estimate, for both 1970 and 1979, from using OLS in Column 1, and from using IV in Column 2. It is evident that the IV technique yields scale coefficients that are slightly higher than those produced by OLS. We extended our experiments beyond this sample to estimate the returns to scale at both the 2-digit level and for all 4-digit industries — but do not report the results here. Generally, the IV technique yielded more stable coefficients, whether we examine the coefficients attached to labour and capital or the returns to scale estimate. Therefore we opted for the instrumental variable technique outlined herein.

We also compared the IV and OLS estimates of returns to scale by

TABLE C-1 A Comparison of the Returns to Scale Yielded by OLS and IV Techniques for Eight 4-Digit Canadian Manufacturing Industries, 1970 and 1979[a]

	Estimation Technique	
	OLS[b] (1)	IV[c] (2)
SIC = 1072		
1970	1.068	1.140
1979	1.087	1.261
SIC = 1081		
1970	1.117	1.210
1979	1.088	1.166
SIC = 1832		
1970	0.997	1.069
1979	0.967	0.910
SIC = 2513		
1970	1.083	1.173
1979	1.187	1.261
SIC = 2860		
1970	1.048	1.148
1979	1.047	1.180
SIC = 3042		
1970	1.015	1.175
1979	0.982	1.236
SIC = 3320		
1970	1.054	1.134
1979	1.062	1.087
SIC = 3360		
1970	0.977	1.127
1979	0.902	1.078

Source: Statistics Canada, special tabulations.

a. Using criteria 1 to 7 to select the sample of establishments for each industry. See Chapter Three for details.

b. Equation C.1 estimated using ordinary least squares (OLS).

c. Equation C.2 estimated using a ranking instrument (UNCRK) on the capital variable K_3.

calculating simple and rank correlations for the two sets of estimates for 1970 and 1979. For 1970, excluding the two 4-digit industries for which no estimate was made, the simple correlation was −0.0967, the rank correlation 0.5057. The corresponding correlations for 1979, excluding the eight 4-digit industries for which no estimate was possible, were −0.2914 and 0.2877, respectively. These correlations seem somewhat low and in the case of the simple correlation were unexpectedly negative. This was primarily due to several "outlier" estimates of returns to scale, defined as having either (a) negative returns, or (b) returns greater than 3, in

TABLE C-2 The Effect of Using the Wage Rate as an Instrument on the L_2 for Eight 4-Digit Canadian Manufacturing Industries, 1970 and 1979[a]

	Returns to Scale	
Industry	1970	1979
1072 (1)[b]	1.14	1.26
(2)[c]	1.65	1.60
1081 (1)[b]	1.21	1.17
(2)[c]	1.31	2.16
1832 (1)[b]	1.07	0.91
(2)[c]	1.46	0.79
2513 (1)[b]	1.17	1.26
(2)[c]	1.48	1.53
2860 (1)[b]	1.15	1.18
(2)[c]	1.23	1.98
3042 (1)[b]	1.18	1.24
(2)[c]	1.23	1.97
3320 (1)[b]	1.13	1.09
(2)[c]	2.08	1.98
3360 (1)[b]	1.13	1.08
(2)[c]	2.08	0.07

Source: Statistics Canada, special tabulations.
a. Using criteria 1 to 7 to select the sample of establishments for each industry. See Chapter Three for details.
b. Equation C.2 estimated using only a ranking instrument (UNCRK) on the capital variable K_3.
c. Equation C.2 estimated using a ranking instrument (UNCRK) on capital (K_3) and the wage rate for production workers (W_1 = VW/MHRSWR) on labour (L_2).

either 1970 or 1979, using either IV or OLS. If the five industries where this occurred are excluded, then the correlations for the remaining 153 industries become 0.5225 and 0.5585 for 1970, and 0.3926 and 0.4202 for 1979, all of which are significant at .0001. Hence, we can conclude that although IV and OLS yield different estimates of returns to scale, they are closely correlated.

We also experimented with separate instruments for *both* the labour and the capital term. In addition to the ranking instrument that we used for the capital proxy (UNCRK), we employed the wage rate (W_1) as instrument for labour, as suggested by Fuss et al. (1978). The results are reported in Table C-2. For each industry, the estimates are reported using just the instrument on capital (row marked 1) and using two instruments (row marked 2). The addition of the instrument on labour generally leads to very much larger estimates of scale economies. Moreover, the estimates are no longer relatively stable between 1970 and 1979.

Therefore, we elected not to use W_1 as an instrument on labour when estimating the production function.

Alternate Forms of the Production Relationship

Because of potential endogeneity problems with the regressors, various indirect alternatives have been suggested, most of which use one or more of the first order conditions for profit maximization. These conditions (setting the marginal revenue product of a factor equal to the factor cost) along with the production function can be used to express: factor inputs as function of factor costs; output as a function of factor costs; costs or profits as a function of unit factor costs; or factor shares (i.e. wages as a proportion of output) as a function of the production function input elasticities.

In order to examine the effect of using the first order conditions for labour, we start with the Cobb-Douglas:

$$Y = k\, L_2{}^a\, K_3{}^b \tag{C.4}$$

then setting $W_1 = \partial Y/\partial L_2$ yields:

$$\ln L_2 = k + c \ln W_1 + d \ln K_3 \tag{C.5}$$

where $c = \dfrac{1}{a-1}$, $d = -b/(a-1)$ and $a+b = (1+c-d)/c$.

We estimated C.5 (a labour demand function) using both criteria 1 to 7 and 1 to 11 as set out in Chapter Three for each of 1970 and 1979. The results for the scale economy estimate, a + b, are reported in Table C-3. The results are not similar for 1970 and 1979. Because of this lack of stability, we rejected this alternative for our estimation technique. The instability problem essentially results because of the transformation required in parameter estimates from equation C.5 to yield the returns to scale estimates.

The first order conditions have most often been used in the factor share form to provide indirect estimates of the parameters of the production function. Assuming each factor is paid to marginal product yields estimators for the coefficients of the Cobb-Douglas:

$$Y = k\, L^a K^b \tag{C.6}$$

$$a = WL/Y \text{ where W is the wage rate,} \tag{C.7}$$

$$b = rK/Y \text{ where r is the cost of capital.} \tag{C.8}$$

Neither wages nor rates of return are required for this formulation since the share of labour and capital are on the right hand side of C.7 and C.8. One problem with the above formulation is that accurate values of factor shares are not readily available from census data. For instance, if

TABLE C-3 Returns to Scale Estimate Using a Labour Demand Function[c] for Eight 4-Digit Canadian Manufacturing Industries, 1970 and 1979

	Returns to Scale	
Industry	1970	1979
1072 (1)[a]	−2.25	0.14
(2)[b]	−0.49	0.53
1081 (1)[a]	0.97	1.54
(2)[b]	0.96	1.67
1832 (1)[a]	0.69	1.74
(2)[b]	0.66	1.76
2513 (1)[a]	−18.86	0.01
(2)[b]	−5.32	0.07
2860 (1)[a]	−0.79	1.89
(2)[b]	0.07	1.68
3042 (1)[a]	0.01	3.56
(2)[b]	0.34	3.33
3320 (1)[a]	5.12	1.27
(2)[b]	0.29	0.14
3360 (1)[a]	1.73	1.51
(2)[b]	1.62	1.57

Source: Statistics Canada, special tabulations.

a. Estimated returns to scale using equation C.5 and criteria 1 to 7 to select the sample of establishments for each industry. See Chapter Three for details.

b. Estimated returns to scale using equation C.5 and criteria 1 to 11 to select the sample of establishments for each industry. See Chapter Three for details.

c. Equation C.5 estimated using OLS and the wage rate for production workers (W_1 = VW/MHRSWR).

the above formulation uses reported value added to represent Y and calculates rK as Y – WL, as is normally done, the estimate of wage share is biased downward and the capital share upward because purchased services are not excluded from value added, an issue discussed at some length in Chapter Five. Another problem arises with the estimation of wage share because reported wages underestimate the compensation package. We nevertheless pursued this avenue because the share approach has been so widely used, if only to compare the estimates that result from its use to our own.

We adopt an indirect method of estimating the Cobb-Douglas used by Zohar (1982, Vol. 1, pp. 102–103), based on Diwan's (1968) methodology. If we start with the Cobb-Douglas function:

$$Y = k\,L^{a}\,K^{b} \qquad \text{(C.9)}$$

then assuming each factor is paid its marginal revenue product

$$s_i = rK/WL = b/a \qquad \text{(C.10)}$$

where r is the rate of return on capital and W is the wage rate. Then defining Z as

$$Z = \ln L_2 + h \ln K_3 \text{ where } h = b/a, \quad (C.11)$$

a can be estimated from

$$\ln Y = \ln k + aZ + U_t, \quad (C.12)$$

and the estimate of scale elasticity is

$$a + b = \hat{h} \cdot \hat{a} + \hat{a}. \quad (C.13)$$

We estimate h across our data set of industry establishments by assuming (as do Griliches and Ringstad, 1971, p. 73) that

$$s_i = s_{ki}/s_{Li} = (b/a) R_i \quad (C.14)$$

where R_i is the deviation of the observed capital/labour ratio from the optimal. As with Griliches and Ringstad (1971), we assume R_i is a random variable with $E(R_i) = 1$, and that R_i is distributed lognormally. This leads to the following estimte of h

$$h = s_K/s_L = \exp (\bar{s} + \tfrac{1}{2} [(n-1) \sigma_s^2]/n) \quad (C.15)$$

where $s_i = \ln (s_{Ki}/s_{Li})$, $\bar{s}$ and σ_S^2 are the sample mean and variance of S, and n is the number of observations in the sample.

Since reported or census value added overstates real value added by the inclusion of purchased services, we used the correction factor $CORR_c$, previously derived (see Appendix A) to correct for this. However, it was not available for each establishment so we make only a correction of the industry estimate. The results of this indirect approach, along with those derived by directly estimating the production function with the ranking instrument on the capital variable, are presented in Table C-4. The factor share estimates are uniformly lower and in some cases very much so. But because of the mismeasurement of labour's share, these estimates are biased.

Even with the correction for the services component of value added, the factor share technique outlined above will yield biased scale economy estimates because the share of wages is understated. The portion of the compensation package (up to 30 percent) that is not included in reported wages is excluded from the calculation of h. Thus h is biased downward. It can be shown that this yields an upward bias in the estimate of a. The net effect depends on the relative output elasticities (b, a) as well as the size of the omitted remuneration.

The type of bias that can result from the use of the indirect share approach can be best illustrated in a more direct fashion. If we presume that only labour is paid its marginal revenue product, the output elasticity of labour can be calculated from equation C.7. The industry wage share is presented for each of our sample in Table C-5, Column 1. In

TABLE C-4 A Comparison of Returns to Scale with Direct and Indirect Estimation Approaches for Eight 4-Digit Canadian Manufacturing Industries, 1970 and 1979[a]

	OLS with Instrument[b]		Indirect OLS with Share Approach[c]	
Industry	1970	1979	1970	1979
1072	1.14	1.26	1.02	1.01
1081	1.21	1.17	1.10	0.87
1832	1.06	0.91	0.92	0.73
2513	1.17	1.26	1.01	1.01
2860	1.15	1.18	0.94	0.92
3042	1.18	1.24	0.85	0.82
3320	1.13	1.09	0.80	0.96
3360	1.13	1.08	0.86	0.80

Source: Statistics Canada, special tabulations.

a. Using criteria 1 to 7 to select the sample of establishments for each industry. See Chapter Three for details.

b. Equation C.2 estimated using only a ranking instrument (UNCRK) on the capital variable K_3.

c. Estimated using equations C.10 to C.15. No ranking instrument was used for K_3 in equation C.11.

TABLE C-5 A Comparison of Labour's Wage Share, Corrected and Uncorrected, and the Output Elasticity of Labour Derived from IV Estimation of the Production Function, for Eight 4-Digit Canadian Manufacturing Industries, 1970

Industry	Census Reported Share[a] (1)	Corrected Share[b] (2)	Our Labour Output Elasticity[c] (3)
1072	0.569	1.003	0.915
1081	0.303	0.543	0.534
1832	0.522	0.880	0.945
2513	0.462	0.837	0.837
2860	0.533	0.844	0.794
3042	0.396	0.674	0.768
3320	0.427	0.789	0.964
3360	0.468	0.707	0.863

Source: Statistics Canada, special tabulations.

a. From equation C.7 using reported census data.

b. Corrects share for purchased service component and under-reporting in census of wage compensation.

c. As derived from equation C.2 with ranking instrument (UNCRK) on K_3.

order to correct for the two biases mentioned, we calculated the proportion of value added made up of purchased services (see Appendix A and Chapter Five) and the ratio of the total compensation to wages paid for time worked. The latter was derived from an unpublished survey done by Statistics Canada for 1978. Together these are used to adjust labour's share and the corrected share is presented in Column 2 of Table C-5. In all cases the share of labour increases substantially. We present our own estimates of labour's elasticity from the direct estimation of the production function in Column 3.

Our estimates in column 3 are quite close to the corrected shares in column 2 and both are considerably above the reported labour share in column 2. Use of the latter is likely to seriously bias downward the estimate of labour's output elasticity and the overall scale elasticity. While we could have used the correction factors to adjust labour's share and used these in one or other of the indirect approaches (either by constraining the labour coefficient to be equal to factor share, or by using the Zohar-Diwan h technique), we felt there to be sufficient imperfections in these correction factors (they generally are available only at the 3-digit level, not the 4-digit level being used here) to render this technique less precise than the direct method we finally adopted.

While we therefore have relative confidence in the use of the Cobb-Douglas and the direct estimation approach, we did attempt another indirect approach — using the restricted profit function suggested by Lau and Yotopolous (1971). Using the Cobb-Douglas production function

$$Y = k\, L^{a}\, K^{b} \qquad \text{(C.16)}$$

and assuming labour is paid its marginal product, it can be shown that

$$\ln P = b_0 + b_1 \ln W_1 + b_2 \ln W_2 + b_3 \ln K_3 \qquad \text{(C.17)}$$

where P is value added (taking into account the service correction) less wages and salaries; W_1 is wage rate of production workers; W_2 is salary of non-production workers; and K_3 is capital proxy.

The scale elasticity may be derived as $(b_1 + b_2 + b_3)/(1 + b_1 + b_2)$. Since the wage rate may be less correlated with the error term than labour, this formulation may contain less simultaneity bias. On the other hand, wage rates may be measured inaccurately. As in the direct estimation technique, we proxy K with energy expenditures (K_3) and use the Bartlett ranking instrument on this variable.

The scale estimates from this approach are reported in Table C-6. Column 1 presents the estimates of the value added production function which are analogous to those presented in Table C-1 — see note a to Table C-6 for details. Column 2 reports the estimates of equation C.17 with production and non-production workers separately. Column 3 uses, for equation C.17, a combined category of production and non-production workers. The results of the two methods are generally similar. The indirect profit function possesses somewhat less stability across the two years (SIC = 1072, 2513, 2860, 3320 and 3360) and one serious error (SIC = 2860, particularly for 1970). Therefore we chose not to pursue this alternative further.

While we estimated scale economies using a production function, we could have pursued the alternate route of using a dual cost function. The

TABLE C-6 A Comparison of Returns to Scale Estimated Directly from the Cobb-Douglas and Using a Cobb-Douglas Restricted Profit Function for Eight 4-Digit Canadian Manufacturing Industries, 1970 and 1979[a]

	Cobb-Douglas Direct	Cobb-Douglas Restricted Profit Function	
Industry	(1)[b]	(2)[c]	(3)[d]
SIC = 1072			
1970	1.144	1.214	1.249
1979	1.169	1.054	1.046
SIC = 1081			
1970	1.156	0.994	1.052
1979	1.000	0.990	0.987
SIC = 1832			
1970	1.059	0.943	0.964
1979	1.022	0.900	0.859
SIC = 2513			
1970	1.432	1.413	1.301
1979	1.312	1.082	1.094
SIC = 2860			
1970	1.154	3.464	2.109
1979	1.177	1.334	1.269
SIC = 3042			
1970	1.222	1.128	1.126
1979	1.340	1.065	1.085
SIC = 3320			
1970	1.150	0.847	0.850
1979	1.144	1.144	1.062
SIC = 3360			
1970	1.035	1.039	1.068
1979	1.001	1.127	1.133

Source: Statistics Canada, special tabulations.

a. Criteria 1 to 7, outlined in Chapter Three, were used initially to select the sample of establishments. However, in some cases $W_1 = 0$ and/or P was less than or equal to 0. Hence two additional criteria were introduced: if $W_1 = 0$, then delete the establishment; and if P is less than or equal to zero then delete. The number of establishments using criteria 1 to 7 as compared with 1 to 7 plus the additional two, saw a decline, for all eight industries, of 14.7 percent in 1970 and 8.5 in 1979. As a result of these two additional criteria the results in Column 1 of this table and Column 2 of Table C-1 do not always agree.

b. As derived from equation C.2 with a ranking instrument (UNCRK) on K_3.

c. Estimated using equation C.17 with a ranking instrument (UNCRK) on K_3. W_1 is defined as VW/MHRSWR, W_2 as VS/NS where all these terms are defined at the establishment level, in Chapter Three.

d. Equation C.17 estimated as detailed in footnote c to this table, but instead of W_1 and W_2, W is used, defined as (VW + VS)/(NW + NS) – average annual earnings for wage and salary workers. See Chapter Three for details concerning the definitions.

latter approach has been used by Fuss and Gupta (1981) at the 3-digit industry level using averages across plant size classes. Since we ultimately chose a Cobb-Douglas production function and the dual cost function to this production function is relatively easy to estimate, we examined whether the scale economy estimates that can be derived from this dual cost function were very different from our own.

The relevant dual cost function is

$$\ln C = a_0 + a_1 \ln TSH + a_2 \ln W_1 + a_3 \ln W_2 + a_4 \ln M \tag{C.18}$$

where C is cost = materials, energy, salaries and wages; TSH is output (total sales); W_1 is wage rate of production workers; W_2 is salary of non-production workers; and M is unit cost of materials. The returns to scale estimate is $1/a_1$.

The advantage of this formulation is that the input unit costs W_1, W_2, and M are more likely to be unrelated to the error than labour and capital in the production function and thus simultaneity bias may be reduced. On the other hand, the unit wage costs are measured with an error and this may offset the advantages of this approach. Finally, unit material costs per establishment are not available and this may lead to a specification bias, depending among other factors on whether these unit costs vary much across establishments.

We estimated equation C.18 without materials input unit costs (M) and report the scale estimates in Table C-7, columns 2 and 3. In each case we use a Bartlett instrument on TSH. Column 1 contains our previous scale

TABLE C-7 Scale Estimates Derived from the Dual Cost Function for Eight 4-Digit Canadian Manufacturing Industries, 1970 and 1979[a]

	Cobb-Douglas Direct	Dual Cost Function Estimates		Cobb-Douglas with materials
Industry	(1)[b]	(2)[c]	(3)[d]	(4)[e]
SIC = 1072				
1970	1.144	1.131	1.107	1.071
1979	1.169	1.088	1.105	1.102
SIC = 1081				
1970	1 156	1.059	1.042	1.094
1979	1.000	0.999	1.030	1.067
SIC = 1832				
1970	1.059	1.105	1.068	0.942
1979	1.022	0.978	0.974	0.950
SIC = 2513				
1970	1.432	1.076	1.093	1.007
1979	1.312	1.221	1.194	1.060

TABLE C-7 (cont'd)

Industry	Cobb-Douglas Direct (1)[b]	Dual Cost Function Estimates (2)[c]	(3)[d]	Cobb-Douglas with materials (4)[e]
SIC = 2860				
1970	1.154	1.040	1.043	1.089
1979	1.177	1.046	1.043	1.087
SIC = 3042				
1970	1.222	1.071	1.068	1.065
1979	1.340	1.094	1.100	1.060
SIC = 3320				
1970	1.150	2.110	2.044	0.984
1979	1.144	0.912	1.045	1.014
SIC = 3360				
1970	1.035	1.023	0.991	1.026
1979	1.001	0.980	1.015	0.996

Source: Statistics Canada, special tabulations.

a. Criteria 1 to 7, outlined in Chapter Three, were used initially to select the sample of establishments. However, in some cases $W_1 = 0$ and/or P was less than or equal to 0. Hence two additional criteria were introduced: if $W_1 = 0$, then delete the establishment; and if P is less than or equal to zero then delete. The number of establishments using criteria 1 to 7 as compared with 1 to 7 plus the additional two, saw a decline for all eight industries, of 14.7 percent in 1970 and 8.5 in 1979. As a result of these two additional criteria the results in Column 1 of this table and Column 2 of Table C-1 do not always agree.

b. As derived from equation C.2 with a ranking instrument (UNCRK) on K_3.

c. Estimated using equation C.18 with an instrument on Q and without the last term in the equation, $a_4 \log M$.

d. Estimated using equation C.18 with a ranking instrument (UNCRK) on TSH, without the last term in the equation, $a_4 \log M$, and with W_1, and W_2 combined to form W, as defined in footnote d of Table C-6.

e. Starting with a production function of the form

$$TSH = AL_2^{a} K_3^{b} M^{d}$$

where TSH = sales, L_2 = labour input, M = materials (TOTMAT), and K_3 = capital proxy.

The first order side conditions are

$$\frac{WL_2}{TSH} = a \text{ and } \frac{PM}{TSH} = d$$

We estimate a and d using the approach of Griliches and Ringstad (1971, p. 73). Then b was estimated as follows:

$$\log TSH - \hat{a} \log L_2 - \hat{d} \log M = k + b \log K_3$$

where K_3 was fuel and electricity with the ranking instrument (UNCRK) on K_3. Unlike Columns 1 to 3 of this table, only criteria 1 to 7 were used to select the sample of establishment.

elasticity estimates from the value added function. Generally, the estimates from the dual function are lower. However, the scale estimates are not completely comparable since costs here include materials while the production function was based on value added as output. Therefore we re-estimated the scale elasticity from a production function using gross sales as output and including materials as a separate input. The resulting scale elasticity estimates are reported in column 4. There is much more similarity between these and the dual cost estimates, although in one case (SIC = 3320) the dual cost function is unstable when 1970 and 1979 are compared. We conclude again that the direct estimation of the Cobb-Douglas produces results that are somewhat more stable than alternatives and generally of the same magnitude.

Alternate Functional Forms

Since the Cobb-Douglas production function is a relatively simple construct, we examined whether the use of a somewhat more complex version of the production function would significantly affect our scale estimates. The first candidate that we examined was the constant elasticity of substitution (CES) function.

$$Y = B\,[\delta K^{-p} + (1-\delta)\,L^{-p}]^{-u/p} \tag{C.19}$$

for which the elasticity of substitution (σ) is still constant but no longer equal to 1, as it is in the Cobb-Douglas. For estimation purposes we use the logarithmic approximation (see Griliches and Ringstad, 1971, p. 9):

$$\begin{aligned}\ln (Y/L_2) \simeq\ & a_0 + a_1 \ln L_2 + a_2 \ln (K_3/L_2) \\ & + a_3\,[\ln (K_3/L_2)]^2\end{aligned} \tag{C.20}$$

where a_1 is equivalent to a + b – 1 estimated from the Cobb-Douglas. The equation reduces to the Cobb-Douglas where $a_3 = 0$.

We report the results from an OLS estimation of equation C.20 with and without the $[\ln (K_3/L_2)]^2$ term in Table C-8. Columns 1 and 4 contain the estimate of the extent to which the estimate obtained from the Cobb-Douglas (CD) of the scale elasticity exceeds one for the years 1970 and 1979; Columns 2 and 5 contain the comparable estimate from the CES estimate for the same years. The differences are not such as to suggest that much is to be gained from moving from a CD to a CES if we are only interested in scale elasticity estimates. Generally a_3 was not significantly different from zero, but when it was, the two scale elasticity estimates did not differ much more than where it was not.

We also extended our investigations to the translog which can be written as follows:

$$\begin{aligned}\log Y =\ & k + a_0 \ln L_2 + a_1 (\ln L_2)^2 + b_1 \ln K_3 \\ & + b_2 (\ln K_3)^2 + \delta\,(\ln K_3 \cdot \ln L_2).\end{aligned} \tag{C.21}$$

We tested whether the Cobb-Douglas might be rejected in favour of the translog by jointly testing the significance of those variables in the translog and not in the Cobb-Douglas, using a standard reduction in sum of squares of residuals type test. The results are reported in Table C-9. Of

TABLE C-8 A Comparison of Returns to Scale Estimates from the Cobb-Douglas and the CES Production Functions for Eight 4-Digit Canadian Manufacturing Industries, 1970 and 1979[a]

	1970			1979		
	CD[b]	CES		CD	CES	
Industry	a+b−1 (1)[b]	a_1 (2)[c]	a_3 (3)[d]	a+b−1 (4)[b]	a_1 (5)[c]	a_3 (6)[d]
1072	.068	.068	.017 (.69)[e]	.087	.071	−.123 (.00)[e]
1081	.117	.124	.338 (.26)[e]	.088	.093	.111 (.40)[e]
1832	−.003	−.013	.164 (.36)[e]	−.032	−.005	−.667 (.01)[e]
2513	.083	.088	.081 (.00)[e]	.187	.186	.039 (.01)[e]
2860	.048	.049	.036 (.06)[e]	.047	.046	−.016 (.51)[e]
3042	.015	.026	.118 (.00)[e]	−.018	.001	.100 (.01)[e]
3320	.054	.050	−.009 (.96)[e]	.062	.050	−.107 (.61)[e]
3360	−.023	−.023	−.003 (.98)[e]	−.098	−.102	−.084 (.44)[e]

Source: Statistics Canada, special tabulations.
a. Using criteria 1 to 7 to select the sample of establishments for each industry. See Chapter Three for details.
b. Estimated from equation C.1 using OLS.
c. Estimated from equation C.20 using OLS, where the scale economy term is the coefficient on ln L_2, a_1.
d. Estimated from equation C.20 using OLS, where a_3 is the coefficient on $[\ln (K_3/L_2)]^2$.
e. The level significance at which a_3 is different from zero.

TABLE C-9 Test for Significance[a] of Translog[b] over Cobb-Douglas[c] for Eight 4-Digit Canadian Manufacturing Industries, 1970 and 1979[d]

Industry	1970	1979
1072	$F(3,310) = 6.65$[e]	$F(3,238) = 8.81$[e]
1081	$F(3,37) = 0.49$	$F(3,20) = 1.86$
1832	$F(3,57) = 0.78$	$F(3,43) = 3.47$[f]
2513	$F(3,552) = 5.41$[e]	$F(3,462) = 2.36$
2860	$F(3,680) = 5.90$[e]	$F(3,602) = 4.10$[e]
3042	$F(3,204) = 7.70$[e]	$F(3,145) = 3.28$[e]
3320	$F(3,7) = 0.29$	$F(3,15) = 0.52$
3360	$F(3,66) = 0.97$	$F(3,65) = 2.77$[f]

Source: Statistics Canada, special tabulations.
a. We tested to see whether the CD might be rejected in favour of the translog by jointly testing the significance of those variables in the translog not in the CD, using a standard reduction in sum of squares of residuals type test.
b. Using equation C.21 and OLS.
c. Using equation C.1 and OLS.
d. Using criteria 1 to 7 to select the sample of establishments for each industry. See Chapter Three for details.
e. Significant at the 1 percent level.
f. Significant at the 5 percent level.

TABLE C-10 Parameter Estimates of the Translog Production Function[b] for Eight 4-Digit Canadian Manufacturing Industries, 1970 and 1979[a]

SIC	Year	Coefficient: Log L_2	Log K_3	$(\text{Log } K_3)^2$	$(\text{Log } L_2)^2$	Log L_2• Log K_3
1072	1970	−0.56	0.17	0.007	0.072	−0.016
	1979	0.47	−0.05	−0.127[c]	−0.100[c]	0.250
1081	1970	0.54	1.07	0.34	0.268	−0.627
	1979	6.61[e]	−6.03[e]	0.23[e]	0.290	0.096
1832	1970	3.51	−0.86	0.11	−0.08	−0.09
	1979	9.96	3.37	−0.59[d]	0.08	0.81
2513	1970	−0.09	0.80[d]	0.08[c]	0.13[c]	0.19[c]
	1979	1.33[d]	0.02	0.03[d]	0.01	−0.05
2860	1970	1.51[c]	−0.48[e]	0.04[d]	−0.02	−0.006
	1979	1.68[c]	−0.89[c]	−0.03	−0.10[d]	0.157[d]
3042	1970	−0.58	0.89	0.11[c]	0.15[d]	−0.23[c]
	1979	−1.33	1.04	0.09[d]	0.19[d]	−0.23[d]
3320	1970	5.81	−4.92	−0.32	−0.58	0.94
	1979	0.79	−1.08	−0.15	−0.15	0.37
3360	1970	−0.46	0.25	−0.12	0.055	0.003
	1979	−1.49	−0.23	−0.10	−0.008	0.216

Source: Statistics Canada, special tabulations.
a. Using criteria 1 to 7 to select the sample of establishments for each industry. See Chapter Three for details.
b. Using equation C.21 and OLS.
c. Significant at 1 percent level.
d. Significant at 5 percent level.
e. Significant at 10 percent level.

the sixteen tests, seven were significant at the 1 percent level, two at the 5 percent level.

Because the translog therefore might be capturing some additional information in the data set, we estimated the coefficients for this production function and report them in Table C-10. Three observations are noteworthy. First, in a number of cases (SIC = 1072, 1081, 1832, 2513) the signs of variables whose coefficients are significant in one or other year have a change in sign of the coefficient. Second, there are few significant coefficients. Multicollinearity appears to be creating most of this problem.

In order to compare the scale coefficients yielded by the Cobb-Douglas and the translog forms of the production function, we estimated each using OLS regression techniques. Two versions of the translog were used — the unrestricted production function and the production function along with the first order side condition that presumes cost

TABLE C-11 Returns to Scale as Estimated from a Cobb-Douglas[b] and a Translog Production Function to Eight 4-Digit Canadian Manufacturing Industries, 1970 and 1979[a]

	1970			1979		
Industry	Cobb-Douglas[b]	Translog Unrestricted[c]	Translog Restricted[d]	Cobb-Douglas[b]	Translog Unrestricted[c]	Translog Restricted[d]
1072	1.068	0.986	1.032	1.087	1.031	1.070
1081	1.117	1.130	1.125	1.088	1.092	1.103
1832	0.997	0.951	1.002	0.967	1.004	0.946
2513	1.083	1.079	1.075	1.187	1.187	1.185
2860	1.048	1.035	1.040	1.047	1.020	1.036
3042	1.015	1.014	1.008	0.982	0.998	0.960
3320	1.054	0.976	1.047	1.062	1.098	1.062
3360	0.977	0.947	0.946	0.902	0.880	0.879

Source: Statistics Canada, special tabulations.
Note: The translog elasticities were estimated at the geometric mean.
a. Using criteria 1 to 7 to select the sample of establishments for each industry. See Chapter Three for details.
b. Using equation C.1 and OLS.
c. Using equation C.21 and OLS.
d. Using equation C.21 and OLS, and the first order side condition, with appropriate first order side condition for labour.

minimization in labour markets (i.e., that labour is paid its marginal revenue product). As was noted in the section on estimation techniques, the use of side conditions has been advocated in improving the parameter estimates. We choose not to use the capital cost side condition because of our belief that labour is more readily adjustable than capital and that the returns to capital more closely approximate a residual that is less likely, in the short run, to equate to its marginal revenue product.

The estimates of the scale elasticity, using value added as output, are reported in Table C-11 for our eight-industry sample set. The elasticities reported here were calculated at the geometric mean (see Griliches and Ringstad, 1971, p. 10 or Zohar, 1982, Vol. 1, p. 105 for the scaling required). A comparison of the results indicates little difference between the Cobb-Douglas and the translog — especially in the estimates derived from the joint estimation of the translog and the labour first-order side condition. We conclude that the Cobb-Douglas adequately summarized the information in our data set on average scale economies.

Appendix D
Supplementary Tables and Data

This appendix consists of a number of tables which either present in more detail material included in the text of the monograph (Table D-1), or provide the underlying data upon which particularly important calculations are made (Tables D-2 to D-5). Minimal comments on each table are provided in this appendix because, as the notes to the tables indicate, adequate discussion of the derivation of the tables is usually provided elsewhere in the monograph.

The scale elasticities estimated from a cost function approach and a production function are presented in Table D-1, at the 3-digit level using the 1960 SIC. This table supplements Table 4-5, which presents such data at the 2-digit or industry-group level of classification.

The remaining three tables present the arguments used to estimate TFP1 to TFP4, as defined in Chapter Six: the estimates of scale elasticity are detailed in Tables D-2 and D-3; Canada/U.S. ratios of manhours and relative plant scale in Table D-4; Canada/U.S. ratios of capital stock and capital stock per manhour in Table D-5; and finally Canada/U.S. ratios of value added in Table D-6. All of the data are presented for the sample of 107 4-digit industries, the selection of which is discussed in Chapter Six. The estimates of scale elasticity in Tables D-2 and D-3 are also a supplement, in part, to Table 4-12 above.

TABLE D-1 Detailed Comparison of Scale Elasticity Estimates from Cost Function and Production Function at the 3-Digit SIC Level for 91 Canadian Manufacturing Industries

Industry (1)	Category[a] (2)	Fuss-Gupta Cost Function[b] 1965–68 (3)	Cobb-Douglas Production Function[c] 1970 (4)
101	Slaughtering and Meat Processing	1.08	1.18
103	Poultry Processors	1.10	1.13
105	Dairy Product	1.00	1.21
111	Fish Products	1.03	1.11
112	Fruit and Vegetable Canners	1.00	1.38
123	Feed Manufacturers	1.01	1.03
124	Flour Mills	1.00	1.36
125	Breakfast Cereals	1.03	
128	Biscuits	1.02	1.29
129	Bakeries	1.10	1.14
141	Soft Drinks	1.10	1.35
143	Distilleries	1.12	1.18
145	Breweries	1.06	1.76

TABLE D-1 (cont'd)

Industry Category[a] (1)	(2)	Fuss-Gupta Cost Function[b] 1965–68 (3)	Cobb-Douglas Productions Function[c] 1970 (4)
147	Wineries	1.07	1.98
151	Leaf Tobacco Processing	1.01	0.91
153	Tobacco Products	1.02	1.32
163	Rubber Tire and Tube	1.06	1.18
169	Other Rubber Products	1.02	
172	Leather Tanneries	1.05	1.08
174	Shoe Manufacturers	1.00	1.06
175	Leather Gloves	1.03	1.25
1792	Boot and Shoe Findings	1.11	1.14
1799	Other Leather Products	1.01	1.10
183	Cotton Yarn and Cloth Mills	1.00	1.25
193	Wool Yarn Mills	1.03	1.20
197	Wool Cloth Mills	1.05	
201	Synthetic Textiles	1.01	n.a.
231	Hosiery Mills	1.01	1.07
239	Other Knitting Mills	1.00	0.99
2441	Women's Clothing	1.05	1.18
2442	Women's Clothing Contractors	1.48	1.67
246	Fur Goods	1.04	1.20
248	Foundation Garments	1.02	1.22
2511	Shingle Mills	1.06	1.81
2513	Sawmills and Planing Mills	1.16	1.17
252	Veneer and Plywood	1.04	1.09
2541	Sash, Door and Other Mill Work	1.12	1.08
2542	Hardwood Flooring	1.00	n.a.
256	Wooden Boxes	1.01	1.11
261	Household Furniture	1.04	1.10
264	Office Furniture	1.00	1.10
266	Other Furniture	1.00	1.15
271	Pulp and Paper Mills	1.04	1.23
272	Asphalt Roofing	1.08	1.13
2731	Folding Carton And Set-Up Boxes	1.03	1.20
2732	Corrugated Boxes	1.06	1.13
2733	Paper and Plastic Bags	1.04	1.17
274	Other Paper Converters	1.00	1.23
286	Commercial Printing	1.05	1.15
287	Plate-Making, Type-Setting, etc.	1.06	1.18
289	Publishing and Printing	1.07	1.23
291	Iron and Steel	1.02	1.13
292	Steel Pipe and Tube	1.15	1.06
294	Iron Foundries	1.06	1.12
301	Boiler and Plater Works	1.03	1.25
302	Fabricated Structural Metal	1.00	1.06
303	Ornamental and Architectural Metal	1.06	1.28
304	Metal Stamping, Pressing, etc	1.04	1.18
305	Wire and Wire Products	1.06	1.20
306	Hardware, Tool and Cutlery	1.01	1.12

TABLE D-1 (cont'd)

Industry Category[a] (1)	(2)	Fuss-Gupta Cost Function[b] 1965–68 (3)	Cobb-Douglas Productions Function[c] 1970 (4)
307	Heating Equipment	1.01	1.39
311	Agricultural Implements	1.05	1.14
316	Commercial Refrigeration and Air Conditioning	1.12	1.34
321	Aircraft and Parts	1.00	1.02
323	Motor Vehicles	1.01	1.16
324	Truck Body and Trailers	1.20	1.07
325	Motor Vehicle Parts and Acce.	1.03	1.10
331	Small Electrical Appliances	1.02	1.33
332	Major Appliances	1.03	1.13
334	Household Radio and TV Receivers	1.10	1.10
335	Communication Equipment	1.00	1.07
336	Industrial Electrical Equipment	1.00	1.13
337	Battery Manufacturers	1.05	1.46
341	Cement Manufacturers	2.66	0.64
347	Concrete Products	1.00	1.33
348	Ready-Mix Concrete	2.80	1.83
3511	Clay Products (domestic clays)	1.05	1.46
3512	Clay Products (imported clays)	1.06	1.15
3561	Glass Manufacturers	1.10	1.27
3562	Glass Products	1.03	1.26
3651	Petroleum Refining	1.03	1.47
3652	Lubricating Oils and Grease	1.03	2.50
372	Mixed Fertilizers	1.05	1.28
374	Pharmaceuticals and Medicines	1.07	1.20
375	Paints and Varnish	1.11	1.51
376	Soap and Cleaning Compounds	1.06	1.39
377	Toilet Preparations	1.06	1.13
382	Jewellery and Silverware	1.08	1.09
383	Broom, Brush, and Mop	1.01	1.34
3931	Sporting Goods	1.03	1.10
3932	Toys and Games	1.03	1.06

Source: Unpublished Statistical Appendix to Fuss and Gupta (1981), and Statistics Canada, special tabulations.

a. The Fuss and Gupta (1981) estimates in column 3 are based upon the 1960 Standard Industrial Classification, while the Cobb-Douglas estimates in column 4 are based upon the 1970 Standard Industrial Classification. The SIC code (column 1) and name (column 2) are for the 1960 SIC as taken from Fuss and Gupta (1981). See Appendix A, Table A-3 above for a concordance between the 1960 and 1970 SIC.

b. Fuss and Gupta (1981) estimate

$$\log AC = b + aQ + c/Q$$

where AC = average cost, Q = quantity, and a, b, and c are constants. This can be rewritten as $TC = Qe^{b+aQ+c/Q}$, where TC = total cost. Using this relationship the cost elasticity is; $aQ - c/Q + 1$. The appendix to Fuss and Gupta (1981) provides Q = MES, a and c. We evaluate the cost elasticity at Q = 1/2MES, with its reciprocal being the scale elasticity presented in the table.

c. The Cobb-Douglas scale elasticity is that derived from equations 4.4 and 4.5 as discussed in Chapter Four.

TABLE D-2 Returns to Scale in the Canadian Manufacturing Sector for 107 4-Digit Industries, 1970

4-Digit SIC (1)	Returns to Scale[a] Labour (2)	Capital (3)	(2)+(3) (4)	Labour Elasticity Assuming Constant Returns to Scale[b] (5)	Number of Establishments Used to Estimate Returns to Scale[c] (6)
1011	0.55942	0.56265	1.12207	0.88229	189
1012	0.62199	0.44036	1.06234	0.86283	61
1020	0.87024	0.19511	1.06535	0.95745	112
1031	0.82441	0.43806	1.26247	0.91331	97
1032	0.52611	0.48835	1.01445	0.68826	15
1040	0.96101	0.25284	1.21385	0.88290	311
1050	1.15029	0.02411	1.17440	0.69088	24
1060	0.97404	1.23055	2.20460	0.86691	112
1071	0.84715	0.37453	1.22167	0.84302	26
1072	0.91541	0.22419	1.13960	0.96770	319
1081	0.62304	0.52158	1.14462	0.72173	46
1091	0.59526	0.60021	1.19547	0.95268	111
1092	1.25837	−0.13313	1.12524	0.56270	24
1093	0.99733	0.16915	1.16647	0.66312	25
1094	0.87348	0.86289	1.73637	0.47989	11
1530	1.19589	0.20917	1.40507	0.51272	14
1720	0.92458	0.11439	1.03898	0.77160	25
1740	0.81333	0.18411	0.99744	0.89534	122
1750	0.60819	0.43951	1.04770	0.88902	16
1792	0.74383	0.55165	1.29548	0.85107	20
1810	0.88302	0.29691	1.17993	0.81502	26
1820	0.85076	0.23538	1.08615	0.75958	35
1831	0.99704	0.24703	1.24406	0.67173	9
1851	0.69587	0.31957	1.01544	0.75021	14
1860	0.82859	0.26304	1.09163	0.78799	26
1871	0.87717	0.82167	1.69884	0.99098	14
1872	0.57626	0.39967	0.97593	0.85431	41
1891	0.64067	0.17523	0.81590	0.65282	7
1892	0.65569	0.29244	0.94813	0.80733	25
1893	0.68435	0.30208	0.98644	0.79309	54
1894	0.67433	0.33081	1.00514	0.74478	44
2310	0.78421	0.28094	1.06515	0.79459	75
2391	0.54753	0.35596	0.90349	0.77243	46
2450	0.66980	0.40002	1.06983	0.86165	104
2460	0.79414	0.40512	1.19926	0.81465	79
2480	0.73552	0.40683	1.14235	1.01500	26
2491	1.03356	0.41378	1.44734	0.71213	6
2492	0.61281	0.33830	0.95111	0.83021	26
2520	0.73731	0.34963	1.08694	1.03383	69
2543	0.76372	0.52322	1.28695	0.94422	43
2560	0.78860	0.40878	1.19738	0.80464	62
2580	0.66786	0.77611	1.44396	0.91077	28
2591	1.00757	0.05146	1.05903	0.82123	17
2593	0.53878	0.81137	1.35015	0.76598	9

TABLE D-2 (cont'd)

4-Digit SIC (1)	Returns to Scale[a] Labour (2)	Capital (3)	(2) + (3) (4)	Labour Elasticity Assuming Constant Returns to Scale[b] (5)	Number of Establish-ments Used to Estimate Returns to Scale[c] (6)
2640	0.69616	0.46309	1.15924	0.81785	37
2680	0.40587	0.80046	1.20633	0.85482	30
2710	1.23297	0.03554	1.26851	0.75346	112
2720	0.97728	0.55018	1.52746	0.56969	7
2731	0.62699	0.52332	1.15031	0.83749	65
2732	0.94502	0.32896	1.27397	0.89234	57
2733	0.80887	0.34136	1.15023	0.81543	61
2860	0.79602	0.35215	1.14817	0.87216	691
2910	0.92557	0.21377	1.13934	0.72930	39
2920	0.87806	0.15936	1.03743	0.71583	21
2940	0.79298	0.25123	1.04420	0.78021	65
3010	0.90388	0.28660	1.19048	0.82378	41
3020	0.93210	0.15217	1.08427	0.74888	70
3031	0.86404	0.31226	1.17630	0.80565	87
3041	0.46319	0.70247	1.16566	0.72242	64
3042	0.76586	0.39326	1.15912	0.75453	215
3060	0.73202	0.36798	1.10000	0.80128	209
3070	0.63495	0.56168	1.19663	0.80710	33
3110	0.94404	0.19813	1.14217	0.75691	40
3160	0.59115	0.70611	1.29726	0.75136	25
3210	0.91603	0.10830	1.02433	0.95374	34
3230	0.92946	0.19901	1.12847	0.80760	11
3242	0.76727	0.37152	1.13879	0.91126	70
3243	0.88520	0.38560	1.27080	0.79662	9
3250	0.93610	0.22849	1.16459	0.62211	106
3260	0.81659	0.14238	0.95897	0.91406	8
3270	0.78463	0.29450	1.07913	0.95940	36
3280	0.73638	0.35768	1.09406	0.91450	77
3310	0.32442	0.76733	1.09175	0.73996	25
3320	0.89277	0.19702	1.08979	0.80024	16
3330	0.64747	0.46668	1.11415	0.81302	39
3340	0.67881	0.37623	1.05504	1.04911	9
3350	0.86578	0.20972	1.07550	0.88351	98
3360	0.83603	0.25752	1.09355	0.70641	76
3380	0.84670	0.20440	1.05110	0.69627	28
3511	0.91278	0.37877	1.29156	0.83660	35
3512	0.57200	0.43842	1.01042	0.90371	16
3530	0.42054	0.75842	1.17896	0.74974	32
3542	0.93433	0.39725	1.33158	0.89742	25
3561	1.12089	0.24279	1.36368	0.65143	10
3562	0.87911	0.32521	1.20433	0.74667	34
3570	0.83461	0.07917	0.91377	1.13880	7
3580	0.59821	0.24596	0.84417	0.55203	7
3591	1.02449	0.34828	1.37278	0.57964	7
3720	0.63988	0.38115	1.02103	0.72750	15

TABLE D-2 (cont'd)

4-Digit SIC (1)	Returns to Scale[a] Labour (2)	Capital (3)	(2)+(3) (4)	Labour Elasticity Assuming Constant Returns to Scale[b] (5)	Number of Establishments Used to Estimate Returns to Scale[c] (6)
3730	0.72745	0.38925	1.11671	0.57277	14
3750	0.70783	0.60926	1.31710	0.76823	67
3760	0.97321	0.25270	1.22591	0.94369	22
3770	0.12609	1.11963	1.24572	0.89321	23
3791	0.82533	0.28619	1.11151	0.76490	9
3911	0.68252	0.39182	1.07433	0.73197	31
3912	0.03867	1.16680	1.20546	0.76275	6
3913	0.30408	0.99317	1.29725	0.84559	7
3914	0.72125	0.19980	0.92105	0.96345	23
3920	0.59820	0.40504	1.00324	0.88042	91
3931	0.66710	0.48468	1.15178	0.86421	46
3932	0.65838	0.44604	1.10442	0.80275	26
3970	0.62864	0.39442	1.02306	0.80089	95
3991	0.53960	0.61681	1.15641	1.05548	24
3992	0.73118	0.43328	1.16446	0.81511	20
3993	0.99722	−0.08526	0.91196	0.73478	16
3994	0.79069	0.35556	1.14625	0.73221	15
3996	1.02024	0.34095	1.36119	0.76101	12

Source: Statistics Canada, special tabulations.

a. Using equations 4.3 and 4.4. As noted in Chapter Four in estimating returns to scale the 1970 and 1979 data were pooled for most industries. Hence if the scale elasticities in columns 2, 3 and 4 of this and Table D-3 are the same then the observations have been pooled for the two years.

b. The labour coefficient is estimated from the first-order side conditions that have the wage rate set equal to the marginal revenue product. (Griliches and Ringstad, 1971, p. 73). This coefficient used the pooled 1970 and 1979 data and was used in estimating TFP1 and TFP2.

c. The number of establishments that remain after applying criteria 1 to 7. See Chapter Three and Table 3-2 for details. To estimate the pooled 1970 and 1979 scale parameters the number of observations used is this column plus column 5 in Table D-3.

TABLE D-3 Returns to Scale in the Canadian Manufacturing Sector for 107 4-Digit Industries, 1979

4-Digit SIC (4)	Return to Scale[a] Labour (2)	Capital (3)	(2)+(3) (4)	Number of Establishments Used to Estimate Returns to Scale[b] (5)
1011	0.55942	0.56265	1.12207	167
1012	0.62199	0.44036	1.06234	49
1020	0.87024	0.19511	1.06535	134
1031	0.82441	0.43806	1.26247	57
1032	0.52611	0.48835	1.01445	17

TABLE D-3 (cont'd)

4-Digit SIC (1)	Return to Scale[a] Labour (2)	Capital (3)	(2) + (3) (4)	Number of Establishments Used to Estimate Returns to Scale[b] (5)
1040	0.79986	0.38474	1.18460	175
1050	1.15029	0.02411	1.17440	28
1060	0.97404	1.23055	2.20460	144
1071	0.84715	0.37453	1.22167	18
1072	0.90173	0.35909	1.26083	247
1081	0.62304	0.52158	1.14462	29
1091	0.59526	0.60021	1.19547	30
1092	1.25837	−0.13313	1.12524	26
1093	0.99733	0.16915	1.16647	33
1094	0.87348	0.86289	1.73637	22
1530	1.19589	0.20917	1.40507	12
1720	0.92458	0.11439	1.03898	19
1740	0.81333	0.18411	0.99744	80
1750	0.60819	0.43951	1.04770	6
1792	0.74383	0.55165	1.29548	21
1810	0.88302	0.29691	1.17993	17
1820	0.85076	0.23538	1.08615	22
1831	0.99704	0.24703	1.24406	8
1851	0.69587	0.31957	1.01544	8
1860	0.82859	0.26304	1.09163	25
1871	0.87371	0.26304	1.09163	14
1872	0.57626	0.39967	0.97593	31
1891	0.64067	0.17523	0.81590	5
1892	0.65569	0.29244	0.94813	18
1893	0.68435	0.30208	0.98644	19
1894	0.67433	0.33081	1.00514	27
2310	0.54505	0.45712	1.00217	34
2391	0.54753	0.35596	0.90349	42
2450	0.66980	0.40002	1.06983	89
2460	0.79414	0.40512	1.19926	74
2480	0.73552	0.40683	1.14235	18
2491	1.03356	0.41378	1.44734	7
2492	0.61281	0.33830	0.95111	13
2520	0.73731	0.34963	1.08694	57
2543	0.92308	0.50056	1.42364	52
2560	0.78860	0.40878	1.19738	58
2580	0.66786	0.77611	1.44396	18
2591	0.67739	0.42128	1.09867	20
2593	1.31823	0.25423	1.57246	18
2640	0.69616	0.46309	1.15924	44
2680	0.40587	0.80046	1.20633	29
2710	1.23297	0.03554	1.26851	132
2720	0.97728	0.55018	1.52746	6
2731	0.62699	0.52332	1.15031	48
2732	0.94502	0.32896	1.27397	54
2733	0.80887	0.34136	1.15023	66

TABLE D-3 (cont'd)

4-Digit SIC (1)	Return to Scale[a] Labour (2)	Capital (3)	(2)+(3) (4)	Number of Establishments Used to Estimate Returns to Scale[b] (5)
2860	0.78322	0.39728	1.18049	611
2910	0.92557	0.21377	1.13934	46
2920	0.87806	0.15936	1.03743	16
2940	0.79298	0.25123	1.04420	46
3010	0.90388	0.28660	1.19048	46
3020	0.93210	0.15217	1.08427	71
3031	0.86404	0.31226	1.17630	114
3041	0.69892	0.41672	1.11564	96
3042	0.76586	0.39326	1.15912	154
3060	0.73202	0.36798	1.10000	172
3070	0.63495	0.56168	1.19663	30
3110	0.94404	0.19813	1.14217	58
3160	0.59115	0.70611	1.29726	16
3210	1.00286	0.11808	1.12094	25
3230	0.92946	0.19901	1.12847	15
3242	0.76727	0.37152	1.13879	54
3243	0.88520	0.38560	1.27080	23
3250	0.93610	0.22849	1.16459	147
3260	0.81659	0.14238	0.95897	11
3270	0.78463	0.29450	1.07913	36
3280	0.73638	0.35768	1.09406	61
3310	0.32442	0.76733	1.09175	19
3320	0.89277	0.19702	1.08979	24
3330	0.64747	0.46668	1.11415	32
3340	0.67881	0.37623	1.05504	3
3350	0.86578	0.20972	1.07550	71
3360	0.83603	0.25752	1.09355	74
3380	0.84670	0.20440	1.05110	37
3511	0.91278	0.37877	1.29156	22
3512	0.57200	0.43842	1.01042	14
3530	0.42054	0.75842	1.17896	29
3542	0.93433	0.39725	1.33158	21
3561	1.12089	0.24279	1.36368	8
3562	0.87911	0.32521	1.20433	25
3570	0.83461	0.07917	0.91377	8
3580	0.59821	0.24596	0.84417	13
3591	1.02449	0.34828	1.37278	7
3720	0.63988	0.38115	1.02103	8
3730	0.72745	0.38925	1.11671	34
3750	0.70783	0.60926	1.31710	48
3760	0.97321	0.25270	1.22591	23
3770	0.12609	1.11963	1.24572	20
3791	0.82533	0.28619	1.11151	16
3911	0.68252	0.39182	1.07433	21
3912	0.03867	1.16680	1.20546	5
3913	0.30408	0.99317	1.29725	3

TABLE D-3 (cont'd)

4-Digit SIC (1)	Return to Scale[a] Labour (2)	Capital (3)	(2) + (3) (4)	Number of Establishments Used to Estimate Returns to Scale[b] (5)
3914	0.72125	0.19980	0.92105	29
3920	0.59820	0.40504	1.00324	80
3931	0.66710	0.48468	1.15178	46
3932	0.65838	0.44604	1.10442	12
3970	0.62864	0.39442	1.02306	67
3991	0.53960	0.61681	1.15641	9
3992	0.73118	0.43328	1.16446	9
3993	0.99722	−0.08526	0.91196	10
3994	0.79069	0.35556	1.14625	9
3996	1.02024	0.34095	1.36119	3

Source: Statistics Canada, special tabulations.

a. Using equations 4.3 and 4.4. As noted in Chapter Four, in estimating returns to scale the 1970 and 1979 data were pooled for most industries. Hence if the scale elasticities in columns 2, 3 and 4 of this and Table D-2 are the same, then the observations have been pooled for the two years.

b. The number of establishments that remain after applying criteria 1 to 7. See Chapter Three and Table 3-2 for details. To estimate the pooled 1970 and 1979 scale parameters the number of observations used is this column, plus column 6 in Table D-2.

TABLE D-4 Canada/U.S. Relative Manhours and Plant Scale for 107 4-Digit Canadian Manufacturing Industries, 1970 and 1979

4-Digit SIC	Canada/U.S. Relative Manhours[a] 1970	Canada/U.S. Relative Manhours[a] 1979	Canada/U.S. Relative[b] Plant Scale 1970	Canada/U.S. Relative[b] Plant Scale 1979
(1)	(2)	(3)	(4)	(5)
1011	0.085814	0.088484	0.56747	0.50375
1012	0.088534	0.107777	0.69827	0.82238
1020	0.499521	0.609855	0.28028	0.36752
1031	0.112477	0.094124	0.59199	0.49462
1032	0.067697	0.104332	0.63864	0.83044
1040	0.165664	0.153546	0.62393	1.22409
1050	0.116171	0.108981	0.50685	0.56121
1060	0.152972	0.151309	0.36594	0.39678
1071	0.155913	0.128489	0.26850	0.32664
1072	0.162674	0.143144	0.68693	0.44109
1081	0.137413	0.124872	0.53291	0.49718
1091	0.116258	0.099315	0.61264	0.76481
1092	0.296785	0.310555	1.03795	0.60602
1093	0.181815	0.268067	0.46152	0.46726
1094	0.090449	0.151989	0.17997	0.24643
1530	0.135452	0.113612	0.15753	0.15850
1720	0.113095	0.099619	1.13555	0.89083

TABLE D-4 (cont'd)

4-Digit SIC	Canada/U.S. Relative Manhours[a]		Canada/U.S. Relative[b] Plant Scale	
	1970	1979	1970	1979
(1)	(2)	(3)	(4)	(5)
1740	0.106490	0.122530	0.49279	0.94003
1750	0.330027	0.215218	0.66040	0.77921
1792	0.140213	0.192686	0.73966	0.81596
1810	0.029529	0.021220	0.95911	1.52188
1820	0.266265	0.274543	0.52085	0.86216
1831	0.070336	0.057868	0.32658	0.57334
1851	0.116017	0.066374	0.48377	0.30571
1860	0.082115	0.100598	0.38714	0.65875
1871	0.143203	0.094242	1.04284	0.80272
1872	0.163958	0.169313	0.59362	0.41048
1891	0.095122	0.067872	0.35241	0.50796
1892	0.076320	0.095177	0.71545	0.65206
1893	0.069872	0.067459	0.29395	0.33875
1894	0.041201	0.046831	0.12395	0.09724
2310	0.105184	0.087724	0.51243	0.28676
2391	0.039672	0.057831	0.31970	0.34174
2450	0.110890	0.103519	0.62283	0.99753
2460	0.610385	0.705978	0.84775	1.13082
2480	0.189798	0.183848	0.51238	0.52560
2491	0.053262	0.058230	0.28203	0.51839
2492	0.128608	0.082695	0.52493	0.82403
2520	0.164101	0.188434	1.01137	0.88918
2543	0.092906	0.116676	1.28399	1.27722
2560	0.093059	0.109090	1.38183	1.67971
2580	0.086096	0.061345	0.36824	0.14119
2591	0.110317	0.111920	1.28815	1.06159
2593	0.103764	0.369973	0.62871	0.97595
2640	0.125315	0.152092	0.25244	0.19607
2680	0.054048	0.073235	0.22986	0.19406
2710	0.331687	0.367275	0.90845	1.14605
2720	0.054349	0.064896	0.67641	0.86340
2731	0.128473	0.116705	1.13989	1.15629
2732	0.084062	0.106380	1.69491	1.44321
2733	0.137563	0.130078	0.74621	0.64104
2860	0.095880	0.102620	0.44477	0.41030
2910	0.090164	0.115494	1.57609	1.92198
2920	0.236492	0.239986	1.42927	1.51276
2940	0.066867	0.066691	0.23682	0.19773
3010	0.079765	0.067096	2.38836	0.81425
3020	0.178139	0.178308	2.39428	1.76671
3031	0.089245	0.137000	0.64681	0.55765
3041	0.048108	0.057902	0.64372	0.54950
3042	0.108504	0.105337	0.74166	0.96037
3060	0.095629	0.124942	0.10229	0.14086
3070	0.156932	0.217661	0.43216	0.75925
3110	0.075299	0.110331	0.33238	0.41503
3160	0.022051	0.033168	0.05704	0.13020

TABLE D-4 (cont'd)

4-Digit SIC	Canada/U.S. Relative Manhours[a]		Canada/U.S. Relative[b] Plant Scale	
	1970	1979	1970	1979
(1)	(2)	(3)	(4)	(5)
3210	0.068909	0.075781	0.36702	0.34392
3230	0.105089	0.135673	1.61149	1.92160
3242	0.045165	0.078660	0.61068	0.97804
3243	0.079305	0.141993	0.60642	1.02165
3250	0.064023	0.080606	0.25801	0.28710
3260	0.137513	0.197721	0.51424	1.20088
3270	0.096115	0.087717	0.15940	0.16670
3280	0.070626	0.087026	0.19756	0.26419
3310	0.090639	0.082464	0.32148	0.32867
3320	0.124947	0.133210	0.25991	0.28470
3330	0.121554	0.125793	0.63508	0.28324
3340	0.100322	0.042845	0.17650	0.13388
3350	0.047145	0.036742	0.48482	0.47185
3360	0.079390	0.086762	0.55535	0.50968
3380	0.127698	0.129663	1.93939	0.84782
3511	0.074725	0.094279	0.81304	0.84965
3512	0.043918	0.042032	0.36709	0.38878
3530	0.045933	0.090935	0.30568	0.66404
3542	0.098821	0.114351	2.80278	5.15002
3561	0.087422	0.089374	0.53722	0.58415
3562	0.038449	0.044167	0.42745	1.02905
3570	0.111167	0.096802	0.35630	0.34467
3580	0.105708	0.152844	0.56146	0.91023
3591	0.062603	0.072853	1.43776	1.29931
3720	0.115345	0.077631	0.87808	0.84135
3730	0.074558	0.086433	0.46747	0.70155
3750	0.108869	0.099323	0.58889	0.71158
3760	0.083547	0.102942	1.36697	0.92536
3770	0.128281	0.147654	0.16452	0.27672
3791	0.133831	0.165399	0.66052	2.28668
3911	0.034605	0.038328	0.28089	0.13484
3912	0.041018	0.048751	0.16327	0.12375
3913	0.008906	0.010899	0.04678	0.05708
3914	0.111199	0.091572	0.12313	0.09830
3920	0.079587	0.082498	0.32943	1.65934
3931	0.096629	0.122319	0.97885	1.04923
3932	0.059078	0.069230	0.18882	0.26920
3970	0.120116	0.132574	0.78857	0.54481
3991	0.142187	0.121163	0.80118	0.45430
3992	0.086102	0.078399	0.48490	0.69230
3993	0.157825	0.141914	0.28085	0.34772
3994	0.044142	0.052824	0.39462	0.62884
3996	0.072995	0.056392	0.14323	0.15707

Source: Statistics Canada, special tabulations.

a. Defined as L_c/L_u. See Appendix A for full definition.

b. Refers only to larger plants in both Canada and the U.S. Defined as EFF1T. See Appendix A for full definition.

TABLE D-5 Canada/U.S. Relative Capital Stock and Capital Stock per Manhour for 107 4-Digit Canadian Manufacturing Industries, 1970 and 1979

4-Digit SIC	Canada/U.S. Relative Capital Stock[a]		Canada/U.S. Relative Capital Stock per Manhour[b]	
	1970	1979	1970	1979
(1)	(2)	(3)	(4)	(5)
1011	0.445580	0.572094	5.19238	6.46549
1012	0.113511	0.180825	1.28211	1.67777
1020	0.656013	0.772334	1.31328	1.26642
1031	0.105728	0.093838	0.94000	0.99696
1032	0.085716	0.130812	1.26617	1.25381
1040	0.148296	0.138835	0.89517	0.90419
1050	0.112079	0.118034	0.96477	1.08308
1060	0.076570	0.117300	0.50055	0.77523
1071	0.127313	0.148305	0.81656	1.15422
1072	0.126997	0.142368	0.78068	0.99458
1081	0.153418	0.092933	1.11647	0.74423
1091	0.091326	0.125334	0.78554	1.26198
1092	0.230935	0.213838	0.77812	0.68857
1093	0.126869	0.136853	0.69779	0.51052
1094	0.090503	0.112284	1.00060	0.73876
1530	0.084052	0.063712	0.62053	0.56079
1720	0.164315	0.074221	1.45289	0.74505
1740	0.065115	0.053915	0.61147	0.44002
1750	0.171494	0.101457	0.51964	0.47142
1792	0.307527	0.502285	2.19329	2.60675
1810	0.050962	0.045069	1.72581	2.12389
1820	0.162763	0.164373	0.61128	0.59871
1831	0.062551	0.061262	0.88931	1.05865
1851	0.222838	0.118872	1.92073	1.79093
1860	0.083414	0.146756	1.01582	1.45884
1871	0.362869	0.197285	2.53395	2.09338
1872	0.420314	0.444268	2.56355	2.62394
1891	0.086655	0.068693	0.91098	1.01210
1892	0.083215	0.055543	1.09034	0.58358
1893	0.094136	0.059438	1.34725	0.88110
1894	0.028286	0.025235	0.68653	0.53886
2310	0.137305	0.113005	1.30538	1.28820
2391	0.055881	0.079017	1.40858	1.36635
2450	0.091853	0.104884	0.82833	1.01318
2460	0.138288	0.170536	0.22656	0.24156
2480	0.222035	0.157872	1.16985	0.85871
2491	0.169345	0.091543	3.17948	1.57211
2492	0.208611	0.108341	1.62208	1.31013
2520	0.180370	0.104562	1.09914	0.55490
2543	0.068405	0.068401	0.73628	0.58625
2560	0.273228	0.148598	2.93609	1.36216
2580	0.067178	0.036276	0.78027	0.59134
2591	0.361688	0.104710	3.27864	0.93558

TABLE D-5 (cont'd)

4-Digit SIC	Canada/U.S. Relative Capital Stock[a]		Canada/U.S. Relative Capital Stock per Manhour[b]	
	1970	1979	1970	1979
(1)	(2)	(3)	(4)	(5)
2593	0.988380	0.999047	9.52529	2.70033
2640	0.213453	0.128923	1.70334	0.84766
2680	0.004116	0.004785	0.07615	0.06533
2710	0.388909	0.409642	1.17252	1.11536
2720	0.363259	0.228946	6.68384	3.52789
2731	0.147844	0.127395	1.15078	1.09159
2732	0.080571	0.128343	0.95847	1.20646
2733	0.179204	0.163999	1.30270	1.26078
2860	0.110935	0.131682	1.15703	1.28320
2910	0.101749	0.112326	1.12849	0.97257
2920	0.205706	0.199041	0.86982	0.82938
2940	0.027474	0.031222	0.41088	0.46817
3010	0.083825	0.080883	1.05090	1.20548
3020	0.230907	0.162663	1.29622	0.91226
3031	0.077830	0.118537	0.87210	0.86523
3041	0.333218	0.105580	6.92641	1.82344
3042	0.102784	0.101413	0.94729	0.96275
3060	0.084348	0.125538	0.88203	1.00477
3070	0.058456	0.076253	0.37249	0.35033
3110	0.042951	0.067747	0.57041	0.61404
3160	0.014654	0.028611	0.66454	0.86260
3210	0.045751	0.041943	0.66394	0.55348
3230	0.038102	0.044353	0.36257	0.32691
3242	0.026494	0.021248	0.58661	0.27013
3243	0.054795	0.079404	0.69094	0.55921
3250	0.099166	0.095100	1.54892	1.17981
3260	0.181321	0.541988	1.31858	2.74118
3270	0.302539	0.293596	3.14768	3.34710
3280	0.107817	0.076602	1.52659	0.88021
3310	0.063387	0.080107	0.69933	0.97142
3320	0.085073	0.079271	0.68088	0.59508
3330	0.012974	0.014116	0.10674	0.11221
3340	0.035094	0.025056	0.34982	0.58480
3350	0.037897	0.039742	0.80382	1.08163
3360	0.060743	0.047289	0.76512	0.54504
3380	0.054168	0.050778	0.42419	0.39162
3511	0.143547	0.129657	1.92099	1.37525
3512	0.053045	0.057188	1.20781	1.36058
3530	0.093796	0.073200	2.04199	0.80496
3542	0.125896	0.198027	1.27398	1.73175
3561	0.080965	0.084541	0.92614	0.94592
3562	0.028819	0.027287	0.74954	0.61782
3570	0.135087	0.109507	1.21517	1.13125
3580	0.314140	0.277711	2.97177	1.81696
3591	0.104197	0.139706	1.66441	1.91765
3720	0.336231	0.308314	2.91501	3.97153

TABLE D-5 (cont'd)

4-Digit SIC	Canada/U.S. Relative Capital Stock[a]		Canada/U.S. Relative Capital Stock per Manhour[b]	
	1970	1979	1970	1979
(1)	(2)	(3)	(4)	(5)
3730	0.057861	0.093977	0.77606	1.08729
3750	0.077380	0.168430	0.71077	1.69578
3760	0.086368	0.146676	1.03377	1.42485
3770	0.045163	0.060282	0.35206	0.40827
3791	0.051962	0.051714	0.38826	0.31266
3911	0.029931	0.028164	0.86493	0.73482
3912	0.038795	0.054607	0.94580	1.12014
3913	0.008398	0.003560	0.94291	0.32660
3914	0.171328	0.201447	1.54074	2.19987
3920	0.054382	0.045909	0.68331	0.55649
3931	0.072846	0.077455	0.75387	0.63322
3932	0.056719	0.033141	0.96008	0.47871
3970	0.123511	0.102418	1.02827	0.77254
3991	0.130866	0.079107	0.92038	0.65290
3992	0.170384	0.128342	1.97887	1.63705
3993	0.154038	0.099436	0.97601	0.70068
3994	0.040441	0.039213	0.91615	0.74234
3996	0.066971	0.049336	0.91747	0.87487

Source: Statistics Canada, special tabulations.

a. Defined as K_c/K_u where both are defined in more detail in Appendix A above. See also Chapter Five concerning how U.S. and Canadian prices of capital are made comparable.

b. Defined as $(K_c/L_c) / (K_u/L_u)$. See note a and Appendix A for details.

TABLE D-6 Canada/U.S. Relative Value Added and Value Added per Manhour for 107 4-Digit Canadian Manufacturing Industries, 1970 and 1979

4-Digit SIC	Canada/U.S. Relative Value Added[a]		Canada/U.S. Relative Value Added per Manhour[b]	
	1970	1979	1970	1979
(1)	(2)	(3)	(4)	(5)
1011	0.090433	0.079755	1.05383	0.90135
1012	0.043385	0.050812	0.49003	0.47146
1020	0.230274	0.203415	0.46099	0.33355
1031	0.069944	0.059539	0.62185	0.63255
1032	0.037714	0.064666	0.55710	0.61981
1040	0.067299	0.086772	0.40624	0.56512
1050	0.043466	0.038270	0.37416	0.35116
1060	0.035815	0.068494	0.23413	0.45268
1071	0.082257	0.056981	0.52758	0.44347
1072	0.089785	0.075634	0.55193	0.52837

TABLE D-6 (cont'd)

4-Digit SIC	Canada/U.S. Relative Value Added[a]		Canada/U.S. Relative Value Added per Manhour[b]	
	1970	1979	1970	1979
(1)	(2)	(3)	(4)	(5)
1081	0.080695	0.062377	0.58724	0.49953
1091	0.084906	0.088193	0.73032	0.88801
1092	0.152172	0.222518	0.51273	0.71652
1093	0.099290	0.175476	0.54610	0.65460
1094	0.030388	0.071161	0.33596	0.46820
1530	0.051396	0.051693	0.37944	0.45499
1720	0.064870	0.047473	0.57359	0.47655
1740	0.074405	0.094466	0.69871	0.77097
1750	0.209201	0.119536	0.63389	0.55542
1792	0.102845	0.151013	0.73349	0.78373
1810	0.021186	0.015325	0.71747	0.72220
1820	0.118574	0.134519	0.44532	0.48997
1831	0.040304	0.082753	0.57302	1.43003
1851	0.122084	0.056120	1.05229	0.84551
1860	0.049532	0.074044	0.60320	0.73604
1871	0.098750	0.064405	0.68958	0.68339
1872	0.105627	0.074590	0.64423	0.44054
1891	0.051044	0.063737	0.53661	0.93908
1892	0.054416	0.056647	0.71300	0.59518
1893	0.052737	0.039975	0.75477	0.59259
1894	0.019032	0.023601	0.46192	0.50395
2310	0.068252	0.072274	0.64888	0.82389
2391	0.024719	0.044819	0.62309	0.77501
2450	0.063437	0.073952	0.57207	0.71439
2460	0.295423	0.434080	0.48399	0.61486
2480	0.081980	0.081236	0.43193	0.44187
2491	0.033514	0.039377	0.62923	0.67624
2492	0.072837	0.058753	0.56635	0.71047
2520	0.060251	0.083149	0.36716	0.44126
2543	0.043028	0.069454	0.46314	0.59527
2560	0.072824	0.095656	0.78256	0.87686
2580	0.044723	0.048237	0.51945	0.78632
2591	0.075651	0.087102	0.68576	0.77825
2593	0.037492	0.193255	0.36132	0.52235
2640	0.068603	0.079374	0.54745	0.52188
2680	0.024462	0.027703	0.45259	0.37828
2710	0.239954	0.292033	0.72344	0.79513
2720	0.032790	0.049852	0.60332	0.76819
2731	0.077567	0.105268	0.60376	0.90200
2732	0.062435	0.075125	0.74273	0.70620
2733	0.090535	0.112877	0.65814	0.86777
2860	0.065410	0.087333	0.68221	0.85103
2910	0.085757	0.109683	0.95112	0.94969
2920	0.166659	0.183064	0.70471	0.76281
2940	0.045641	0.049162	0.68257	0.73717

TABLE D-6 (cont'd)

4-Digit SIC	Canada/U.S. Relative Value Added[a]		Canada/U.S. Relative Value Added per Manhour[b]	
	1970	1979	1970	1979
(1)	(2)	(3)	(4)	(5)
3010	0.054107	0.041299	0.67833	0.61552
3020	0.171319	0.169517	0.96172	0.95069
3031	0.058739	0.129075	0.65818	0.94215
3041	0.034848	0.051340	0.72437	0.88668
3042	0.076595	0.088543	0.70592	0.84057
3060	0.053037	0.094627	0.55461	0.75736
3070	0.103408	0.125769	0.65894	0.57782
3110	0.047670	0.070963	0.63308	0.64319
3160	0.011023	0.026989	0.49990	0.81372
3210	0.046985	0.032760	0.68184	0.43229
3230	0.118330	0.039868	1.12599	0.29385
3242	0.020334	0.041437	0.45020	0.52679
3243	0.049771	0.134031	0.62760	0.94393
3250	0.053765	0.089313	0.83979	1.10802
3260	0.088497	0.066461	0.64355	0.33614
3270	0.062061	0.028767	0.64570	0.32796
3280	0.042129	0.107731	0.59651	1.23791
3310	0.068892	0.059265	0.76007	0.71868
3320	0.078367	0.086216	0.62720	0.64722
3330	0.089956	0.082081	0.74005	0.65251
3340	0.059461	0.053033	0.59270	1.23778
3350	0.028044	0.024259	0.59485	0.66024
3360	0.071407	0.065864	0.89944	0.75914
3380	0.130536	0.110151	1.02223	0.84951
3511	0.047388	0.083172	0.63417	0.88219
3512	0.032075	0.037805	0.73034	0.89942
3530	0.028157	0.090178	0.61301	0.99167
3542	0.073432	0.135212	0.74307	1.18243
3561	0.050909	0.077291	0.58233	0.86481
3562	0.029059	0.048558	0.75579	1.09941
3570	0.066080	0.048921	0.59442	0.50537
3580	0.086600	0.111887	0.81924	0.73204
3591	0.069199	0.066366	1.10536	0.91096
3720	0.108595	0.129621	0.94148	1.66971
3730	0.044679	0.085529	0.59925	0.98954
3750	0.061598	0.061393	0.56580	0.61811
3760	0.039360	0.070290	0.47111	0.68282
3770	0.028388	0.050983	0.22130	0.34529
3791	0.074208	0.163998	0.55449	0.99153
3911	0.023263	0.030991	0.67226	0.80857
3912	0.043891	0.070147	1.07002	1.43889
3913	0.007020	0.008688	0.78820	0.79709
3914	0.063859	0.070537	0.57428	0.77029
3920	0.047961	0.091977	0.60262	1.11490

TABLE D-6 (cont'd)

4-Digit SIC	Canada/U.S. Relative Value Added[a]		Canada/U.S. Relative Value Added per Manhour[b]	
	1970	1979	1970	1979
(1)	(2)	(3)	(4)	(5)
3931	0.046860	0.067758	0.48494	0.55395
3932	0.038396	0.042327	0.64992	0.61140
3970	0.095569	0.088877	0.79565	0.67039
3991	0.082371	0.061132	0.57931	0.50454
3992	0.047577	0.044353	0.55256	0.56574
3993	0.070521	0.069321	0.44683	0.48847
3994	0.032809	0.045478	0.74327	0.86094
3996	0.035790	0.034516	0.49030	0.61206

Source: Statistics Canada, special tabulations.

a. Defined as RELVA4, equation 5.17. For both the United States and Canada value added is adjusted for differences in prices and purchased service inputs. See Chapter Five, for details.

b. Defined as RELVA4 • (L_u/L_c). See footnote a and L_u and L_c as defined in Appendix A.

Appendix E
The Impact of Capacity Utilization Differences on Canada/U.S. Productivity

None of the TFP estimates reported in Chapter Six, Tables 6-3 to 6-6 make corrections for capacity utilization. If capacity utilization was particularly low in Canada relative to the United States, the TFP estimate will be biased downward — at least if we define output in terms of potential production rather than realized output. Correction for levels of capacity utilization is made difficult by the different methodologies used to calculate utilization rates. Table E-1 contains three publicly available rates for the United States and two for Canada. The U.S. "preferred" and "practical" rates are derived from a survey sent to the industry. The preferred rate is the rate which the manufacturer would prefer not to exceed, due to cost or other considerations. Practical capacity is defined as the greatest level of output the plant could achieve within the framework of a relevant work pattern. The Federal Reserve rate is based on estimates of production capacity. The two Canadian indices are constructed from estimates of production capacity. Both use capital/output ratios of peaks in the business cycle to indicate potential output available from a given capital stock — but the Bank of Canada adjusts this ratio over time to reflect improvements in productivity, while Statistics Canada does not appear to do so.

The calculated ratios are, on average, not the same, either across the two countries or within each. This lack of comparability rules out any meaningful corrections for difference in capacity utilization across the two countries for a particular year. The U.S. ratios are always lower than for Canada and there is no reason to believe that the Canadian manufacturing sector is generally more efficient in matching capacity to demand than the U.S. manufacturing sector.

Nonetheless, since we compare Canadian to U.S. data for years that do not correspond exactly (1979 Canada to 1977 U.S.), we might still ask whether the size of the Canadian and U.S. capacity utilization rates in these years, relative to the decade average, biases the calculated TFP measure. In order to do so we assume that the average capacity utilization rates for 1970–79 for the two countries should be the same and then calculate the difference of the 1977 and 1979 rates from the average for the Federal Reserve, Statistics Canada, and the Bank of Canada series. If the production function is $Q/U = AL^aK^b$ where U is capacity utilization, then the bias in the reported TFP measure will be (U_u/U_c) where U_u is the 1977 U.S. utilization rate relative to its decadal average and U_c is the 1979 Canadian utilization rate relative to its decadal average. For this calculation we use the Federal Reserve and the Bank of Canada capacity utilization rates, respectively. We then multiply the estimated value for TFP1 reported in Chapter Six, Table 6-2 by these correction factors and

TABLE E-1 Capacity Utilization of Canadian and U.S. Manufacturing Sectors, 1970–1982

	United States			Canada	
	Bureau of Census				
Year	Preferred Rate	Practical Rate	Federal Reserve	Statistics Canada	Bank of Canada
1970	—	—	79.2	82.9	86.7
1971	—	—	78.0	83.6	87.1
1972	81	—	83.1	86.1	90.2
1973	84	—	87.5	90.8	95.6
1974	75	68	84.2	90.0	94.3
1975	75	67	73.6	80.8	84.7
1976	76	68	80.2	82.4	87.1
1977	79	72	82.4	81.8	86.4
1978	81	74	84.4	85.7	88.6
1979	80	75	85.7	86.6	91.6
1980	76	69	79.0	—	85.9
1981	72	66	—	—	83.5
1982	64	58	—	—	71.3

Source: U.S. Department of Commerce, Bureau of Census, Current Industrial Reports *Survey of Plant Capacity*, 1977 and 1982; *Federal Reserve Bulletin*, various years; Statistics Canada, Cat. no. 21-003, 1979; and *Bank of Canada Review*, various years.

Note: Preferred rate from 1974 to 1982 taken from 1982 Survey; for 1972 and 1973 from 1977 Survey.

TABLE E-2 Corrections in TFP1 for Capacity Utilization Across 107 4-Digit Canadian Manufacturing Industries, 1979

	Mean Level	
	Uncorrected[a]	Corrected[a]
TFP1	0.73	0.72

Source: Statistics Canada, special tabulations.
a. See text for explanation.

report both the corrected and uncorrected measures in Table E-2. The correction moves the 1979 relative Canada/U.S. TFP estimate down by 1 percentage point. We conclude that corrections for capacity utilization have a minor effect.

The above modification does, however, assume that both capital and labour are fixed factors. If we modify the assumption, then the appropriate correction requires an assumption about the short run output elasticity of labour. If both short and long elasticities are 1, then there is no bias in our uncorrected estimates in Table E-2. If both the elasticities are less than 1, then the correction we use will be too great when U.S. capacity utilization is below the Canadian, as it was for the two years that we are comparing. Since the differences reported in Table E-2 are minor, we have not proceeded to refine our estimates further.

A brief word as to the unimportance of capacity corrections for our purposes is nevertheless in order. The productivity slowdown during the 1970s has been ascribed to low levels of capacity utilization during this decade. Indeed, one study ascribes much of this slowdown to utilization effects (Helliwell et al., 1985). However, this literature focuses on a different issue than is addressed here. It concentrates on the rate of growth of output relative to inputs where the latter are properly weighted by factor elasticities. We focus on cross-country efficiency differences. While the degree of capacity utilization may have a large impact on measures of relative growth rates, it has much less of an impact on relative inter-country TFP comparisons because a different base is used for comparisons.

A brief example is in order. While the numbers chosen are arbitrary, we believe they illustrate the point. Suppose there is only one factor (labour) and the production relationship is

$$Q_c = A_c L_c^{\propto}$$

$$A_u = A_u L_u^{\propto}$$

where Q = output, L = input of labour, c = Canada, u = United States. Let us assume that in period one, the relative inter-country TFP measure is 0.8 (i.e., $A_{ci}/A_{ui} = 0.8$); that A grows by 3 percent in each country between the first and second period (i.e., there is a 3 percent productivity growth); that output remains constant in Canada due to increasing excess capacity while utilization remains constant in the United States; and that growth of inputs is the same in the two countries (r percent). Then measured rates of productivity growth (rate of output relative to input change properly weighted) will be 0 percent in Canada and 3 percent in the United States. The Canadian figure is biased downward by 100 percent. However, the measured inter-country productivity difference will be

$$\frac{A_{c2}}{A_{u2}} = (.8)(1/[(1 + r)^{\propto} (1 + .03)]).$$

In order to assess the second term (the percentage error), we need to assign values to $\propto$ and r. This is made easier by the fact that this term is just the Canadian utilization rate in the second period. If we presume a large decline in utilization of about 10 percent, the term is just .90. In this case, the estimated TFP will be 10 percent too low.

If we proceed to repeat the same analysis by assuming that both countries have unused capacity in the second period, then

$$\frac{A_{c2}}{A_{u2}} = (.8) \frac{U_u}{U_c}$$

where U is the capacity utilization rate. This is the correction factor used in Table E-2 where average utilization rates are used as the mean for each country and derivations from the mean are used to measure relative excess capacity for a particular year.

Notes

CHAPTER 1

1. See Canada, Department of External Affairs (1983).
2. See Canada, Department of External Affairs (1985).

CHAPTER 2

1. Providing both outputs and inputs are marked up by the tariff level, the effective tariff rate can be used to correct value added for different price levels. We discuss this issue at greater length in Chapter Five.
2. Caves et al. (1980) had to predict a large number of observations that were missing in their data base because of the confidentiality of provisions of the *Statistics Act*. The present study, with the cooperation of Statistics Canada, was able to build a comprehensive data base covering all 167 4-digit Canadian manufacturing industries.
3. Bernhardt (1981) suffered from a paucity of observations. Starting with 29 industries in 1979 and 26 in 1963, his final sample used only 15 matched industries for the two years.
4. Spence (in Caves et al., 1980), Saunders (1980), and Bernhardt (1981) do attempt to consider scale economies at the industry level, but they have to rely upon rough proxies for it.
5. Although there are 167 4-digit industries, most of the results in this monograph apply only to a subsample of between 100 and 125 industries. This reduced sample is a result of our excluding miscellaneous industries and those with a bad match to U.S. definitions. Further details may be found in Baldwin and Gorecki (1983b, Appendix A, pp. 96–120).
6. On deficiencies in the earlier Economic Council of Canada (1967) study, see Gorecki (1976a, pp. 11–12).
7. We estimated mean value added per establishment from our sample for the early 1970s for 125 matched Canada/U.S. 4-digit industries. The value of this ratio of means for Canada relative to the U.S. was 0.751, with a standard deviation of 0.448.
8. The industries that were matched by ITC seem broadly representative of the entire sample. For example, the ratio of Canadian mean plant size to U.S. mean plant size, for matched and unmatched (in brackets) industries for 1963, 1967, and 1972 was: .85 (.80); .84 (.80); and .88 (.89), respectively.
9. Canada, Statistics Canada (1979b, pp. 38–39).
10. See Masson and Shaanan (1982, p. 418), Scherer at al., (1975, pp. 182–83), and Weiss (1976, pp. 132–36).
11. Muller (1982) has criticized plant scale efficiency studies in general for being subject to measurement error in their use of MES proxies. While the mean of the top 50 percent of the size distribution is correlated with other MES proxies, this correlation is less than 1. And there is evidence that this MES proxy is greater than the MES derived from the engineering technique. Scherer et al. (1975, Table 3.12, p. 85) find for 12 industries that the proxy used here is 1.53 that of the MES proxy derived from the engineering technique. However, to the extent that this bias occurs both in Canada and the United States, EFF1T, the relative plant scale variable, being a ratio, will go some way to correct for this.
12. The sample of 125 industries is drawn from the universe of 167 4-digit Canadian manufacturing industries; industries were omitted either because they were classified as miscellaneous or because of difficulties in matching U.S. and Canadian industry definitions. The mean Canadian plant size (sales) of the top half of the employment distribution for the entire industry sample, for this sample less miscellaneous industries (144 industries) and for the matched set (125 industries) was 24.4, 27.7, and 29.2 ($

millions), respectively. Full details of the matching between U.S. and Canadian industries may be found in Baldwin and Gorecki (1983b, Appendix A, pp. 96–128). The resulting sample used here accounted for approximately 70 percent of the manufacturing sector's sales in the 1970s.

13. No conclusions can be drawn about the trend in this ratio during the 1970s, since the 1970 matching compares Canadian 1970 to U.S. 1972 data and the 1979 matching compares Canadian 1979 to U.S. 1977 data. Another problem is that we have not been able to correct for differing utilization rates at different points in time in the two countries.
14. This is not strictly speaking correct, since a plant can produce products outside of the industry to which it is assigned on the basis of the majority of its production. But the primary product specialization ratio is sufficiently high, on average 90 percent of the 4-digit level, that N should serve as a good proxy for potential diversification. For a further discussion of the adequacy of the Herfindahl index see Baldwin and Gorecki (1983a, Appendix B, pp. 135–45).
15. This conclusion needs to be modified if initially multi-product economies are so large as to offset production run length economies that are lost as plant diversity increases.
16. We performed the same regression for 1979. The results were similar and are therefore not reported here. See Baldwin and Gorecki (1983a).
17. See Baldwin and Gorecki (1983a) for discussion of the production run length results.

CHAPTER 3

1. For a detailed discussion of the definition of an establishment, see Canada, Statistics Canada (1979b, pp. 11–13) and Canada, Dominion Bureau of Statistics (1970, pp. 7–11).
2. These definitions are discussed in much greater detail in Canada, Statistics Canada (1979b, pp. 23–26).
3. These definitions are discussed in much greater detail in Canada, Statistics Canada (1979b, pp. 26–29).
4. As noted in the introduction to this chapter, a number of establishments are excluded for the purposes of estimation. In this process all "short form" establishments are excluded. For such establishments service inputs are included with materials and supplies. The description in the text refers to definitions as they apply to "long form" establishments. For greater detail see Canada, Statistics Canada (1979b) and the section titled "Sample Selection," below.
5. It should be noted that between 1970 and 1979 reporting of this item has not been uniform. To cite the relevant Statistics Canada publication: "Before totalling inputs with respect to non-manufacturing activity, purchases of goods for resale in the same condition as purchased are adjusted for the net change in inventory of such goods. This input element if [sic] thus made comparable with other non-manufacturing input elements, all of which relate to values purchased and used. Prior to introduction of this adjustment with the 1976 Census of manufacturers, the published total of materials, supplies and goods for resale at the total activity level includes a figure for purchases of goods for resale in the same condition as purchased rather than a cost of goods sold figure relating to such activity" (Canada, Statistics Canada, 1979b, p. 29).
6. On Canada's capital stock and expenditure data see Canada, Statistics Canada (1981a, pp. 37–38) and Gaston (1983). The former publication is an annual Statistics Canada publication. Capital expenditure data are collected independently of the Annual Census of Manufactures — Statistics Canada (1979b). Furthermore, the capital expenditure survey is based upon a sample of manufacturing establishments, not the universe. The discussion in the text was also based upon discussions with Statistics Canada officials and unpublished documents.

7. For details of the price indices see, for example, Canada, Statistics Canada (1979a, pp. 54–57).
8. For full details see Canada, Statistics Canada (1979b, pp. 29–38, p. 68). We refer to this as "total value of production" instead of the more usual term "gross output."
9. As will be apparent in the discussion on sample selection, only long-form establishments are used. For short-form establishments, as noted above in footnote 4, services are included in materials and supplies, so value added estimated for such establishments has services deducted.
10. Note should be taken of the caveats in the previous section concerning services not being netted out of value added.
11. See Canada, Statistics Canada (1979b, pp. 11–15, p. 23, pp. 40–44) for further details.
12. See Canada, Statistics Canada (1979b, p. 44). These figures refer to "small" establishments, which appear to be largely short-form establishments. See Canada, Statistics Canada (1979b, pp. 43–44).
13. See Canada, Statistics Canada (1982, p. XV). These figures refer to "small" establishments, which appear to be largely short-form establishments. See Canada, Statistics Canada (1979b, pp. 43–44).
14. These figures concerning short-form establishments for 1970 and 1979 are drawn from the same sources as footnotes 12 and 13, respectively.
15. The problem with CST and H4 occurs because these variables are available for 1974 but not 1970. The process of matching CST and H4 to establishments in existence in both 1974 and 1970 causes certain difficulties, which require the deletion of a large number of establishments which existed for 1974 but not 1970.

CHAPTER 4

1. We recognized that there may, however, not be the same degree of returns to scale as plant size increases. Tentative experiments with scale estimates derived from a translog for average plant size, that is higher than the geometric mean, did not produce much change in the estimates — at least for those industries where the number of observations might reasonably be expected to yield estimates of the non-linearity in scale estimates. Nevertheless, more work might be expected to modify this conclusion. We should, however, note that the number of degrees of freedom in many industries probably limits the precision that might be expected of any such estimates.
2. The wage share in the census is biased downwards because of the exclusion of part of the remunerative package from measured wages.
3. As Table 4-1 indicates, the elasticity of output with respect to labour (L_2) and capital (K_3), is usually significantly different from zero except for Tobacco Products, and greater for labour than capital, with that attached to labour typically falling somewhat and that attached to capital increasing over the 1970s. Taking the ratio of the coefficient for 1970 for a given industry to the corresponding value of the coefficient in 1979, we find that the coefficients in labour in Table 4-1 are much more stable than those on capital.
4. If instead of using Zohar's Cobb-Douglas estimates, we focus on the translog coefficients, then our conclusions about the reasonableness of our estimates change very little. Five of nineteen industries (Tobacco, Rubber and Plastics, Leather, Textiles, and Wood) are not bracketed by the time series estimates. These are all industries where the cross-sectional estimates indicate some scale economies but the time series estimates suggest there are diseconomies.
5. Griliches and Ringstad (1971, p. 102) show that the bias in the returns to scale parameter when price differentials are omitted is equal to the coefficient of the logarithm of price regressed on the logarithm of labour, with the capital/labour ratio also included

as an explanatory variable. Where larger firms charge lower prices and the capital/labour ratio does not also increase so much with size as to make the above mentioned coefficient on labour turn positive, the bias will be negative, leaving us with an underestimate of scale economies.

6. In order to compare the 2-digit or industry group results with the 4-digit results, all the 4-digit industries within a given 2-digit industry start with the two digits in parenthesis after the title of each industry group in Tales 4-1 to 4-5.
7. The table also indicates why there has been a slight shift from the increasing returns to scale category to the constant returns classification. In 1979, fewer of the industries falling in the range from 1.05 to 1.10 were significantly different from 1 than in 1970.
8. For example, using rule 1 but excluding all industries with fewer than 30 observations correctly predicts decreasing returns in 100 percent of cases, constant returns in 100 percent of cases and increasing returns in 90.9 percent of cases in 1970. For 1979 the corresponding percentages are 40, 100 and 87.5 respectively.
9. As the previous discussion indicates, w is not the agglomerative economy coefficient per se. But a zero value means the average production run is produced with the same unit input irrespective of the number of products produced — as long as input per run is the same.
10. The 2-digit SIC codes of these industries are 23, 24, 26, 28, 29, 31 and 35.
11. The 2-digit SIC codes of these industries are 17 and 39.
12. The 2-digit SIC codes of these industries are 16, 25, 29, 30 and 31.
13. See Baldwin and Gorecki (1983a, p. 10) for further details on this point.
14. It should be noted that where N4D = 1 this does not necessarily result in H4 being a constant, because the plant can diversify into products outside its primary industry.
15. This refers, of course, only to instances where the equation in footnote a of Table 4-13 could be estimated.
16. Using data in Table 4-13, (93 + 56)/(14 + 3).
17. For all the 11 instances for which N4D = 1, the coefficient on H4 was insignificant, with the corresponding numbers for N4D = 2 being 18 and 4.
18. On the other hand if we rank the industries in our sample for 1970 and 1979 separately by the coefficient of variation of log H4 and compare the incidence of a significant coefficient on log H4 in the top and bottom ten industries, we find no differences between these two groups of industries for 1970 and 1979. In 1970 two industries in the top and bottom ten industries, ranked by the coefficient of variation of log H4, have a significant coefficient on N. In 1979 the corresponding number is zero.
19. 1040, 1050, 2660, 2680, 2710, 2860, 2890, 3060, 3541, 3914, and 3994. Compare to footnote d of Table 4-14.
20. 1620, 1650, 1720, 2520, 2710, 2980, 3020, 3070, 3150, 3562, 3799 and 3931. Compare to footnote f of Table 4-14.
21. 1020, 1083, 2980, 3730, 3782, 3920 and 3999. Compare to footnote e of Table 4-14.
22. 1011, 2543, 2732, 3243, 3520 and 3991. Compare to footnote g of Table 4-14.
23. See last few footnotes and Table 4-14.
24. There is some evidence to support this viewpoint. As noted in Table 4-15, D3 consists of two categories: those establishments for which the census form recorded "other" and those for which the question was not answered. In 1970, the former category consisted of 493 establishments, the latter 3630. In 1979, the corresponding numbers were 413 and 254, respectively.
25. $1.12 = 0.10\,(0.14 \cdot 80)$.
26. For 1970, somewhat similar results were recorded for d_1 (with d_1 being negative and significant in two instances): d_2 was positive in seven cases and in three of these significant, while in only one instance was a negative coefficient significant. In 1970, d_3 was usually negative with significance occurring in seven instances (six negative and one positive). In 1979, d_3 was positive on ten occasions and negative on ten occasions, with significance being observed in three instances (one positive, two negative).

CHAPTER 5

1. This differs somewhat from Saunders (1980) formulation, since we assume that the world price and the U.S. price are the same. Since the majority of Canada's trade is with the United States, this seems a fair assumption. Furthermore because of the way ERP is defined (see Appendix A for full details) the term 1 – ERP appears rather than 1 + ERP. We derive RELVA2 more formally, using the following terms,

Let V_c = value added per manhour in the Canadian industry; V_u = value added per manhour in the U.S. industry; e_c = physical net output per manhour, Canada; e_u = physical net output per manhour, U.S.; P_c = Canadian price of output; P_u = U.S. price of output; t = Canadian nominal tariff on inputs; n = Canadian nominal tariff on outputs; a_c = unit cost of materials in Canada; a_u = unit cost of materials in U.S.; E = Exchange rate; and ERP = effective rate of protection. Then:

$$V_c = e_c\,(P_c - a_c) \qquad \text{(i)}$$

$$Vu = e_u\,(P_u - a_u) \qquad \text{(ii)}$$

and:

$$\frac{e_u}{e_c} = \frac{V_c}{V_u}\,\frac{(P_u - a_u)}{(P_c - a_u)} \qquad \text{(iii)}$$

We assume that the Canadian price is equal to the U.S. price in Canadian dollars plus the tariff. Hence,

$$P_c = (E \cdot P_u)(1+n) \qquad \text{(iv)}$$

$$a_c = (E \cdot a_u)(1+t). \qquad \text{(v)}$$

Substituting (iv) and (v) into (iii) yields:

$$\frac{e_c}{e_u} = \frac{V_c}{V_u}\,\frac{P_u\ a_u}{(E \cdot P_u)\,(1+n) - (E \cdot a_u)\,(1+t)} \qquad \text{(vi)}$$

$$\frac{e_c}{e_u} = \frac{V_c}{V_u}\,\frac{P_u - a_u}{[P_u(1+n) - a_u(1+t)]}\,\frac{1}{E}\,.$$

However:

$$\frac{P_u - a_u}{[P_u\,(1+n) - a_u\,(1+t)]} = 1 - \text{ERP} \qquad \text{(vii)}$$

Since the effective tariff is estimated as follows on our data base,

$$\text{ERP} = \frac{V^{1} - V}{V^{1}}$$

where V^1 = value added per unit *after* tariffs are imposed, and V = valued added per unit of output *before* tariffs are imposed.

But $P_u - a_u = V$

and $P_u(1+n) - a_u(1+t) = V^1$.

Hence, $\text{ERP} = 1 - \dfrac{V}{V^1}$

or $\dfrac{V}{V^1} = 1 - \text{ERP}$.

Thus substituting (vii) into (vi) the relative physical productivity variable is:

$$\frac{e_c}{e_u} = \frac{V_c}{V_u}(1-\mathrm{ERP})\frac{1}{E} \qquad \text{(viii)}$$

2. Spence in Caves et al. (1980, p. 261) uses a variant of the labour productivity measures discussed here while incorporating some of the factors mentioned in the next section. He refers to it as technical efficiency (TE) and defines it as follows:

$$\mathrm{TE} = \log S_c = \log \frac{V_c}{V_u} + \log \frac{w_u + r_u Q_u}{w_c + r_c Q_c} - \log(1-\mathrm{ERP})$$

where V_c, V_u, and ERP are as defined above and w_u and w_c are U.S. and Canadian wage rates, respectively, r_u and r_c is the price of capital in the U.S. and Canada, respectively. TE is the same as RELVA2 except for the second term.

3. The industries concerned were, using Frank's (1977, Table 6, pp. 49–53) industry names, Synthetic Textile Mills, Men's Clothing Mfg., Sawmills, Sash and Door Mills, and Household Furniture.
4. Full details are provided in footnote a of Table 5-1.
5. For shipment figures, we used a gross output price index (GPINX) and for the inputs, an input price index (INPINX). See Appendix A for further details concerning these price indices.
6. Inclusion of an intercept in either equation 5.4 or 5.5 does not change this conclusion.
7. These variables are all defined in much greater detail in Appendix A. The variables generally refer to 1970 and are combined to form one of Frank's (1977) multi-4-digit industries by using the total number of industry employees as weights.
8. While Hazledine (1980) finds the relative Canada/U.S. price ratio is a function of industry characteristics such as the tariff rate and concentration, his approach differs from ours in that he was examining output prices while we are interested in the deflator that should be used to correct value added, and that is therefore a hybrid of output and input prices.
9. Our discussion of RELVA in this section has concentrated on value added per manhour. This is for two reasons: the Frank (1977, Table 7, pp. 56–60) relative productivity measures are measured in manhours; and the analysis in Chapters Three and Four measures the labour input in manhours. Nevertheless we replicated much of the analysis in the text and notes for value added per employee. (Copies of the table are available on request from the authors). The correlation between RELVA2 using employees and manhours to measure the labour input is 0.9791, and the corresponding correlation for RELVA3 is 0.9838. In all instances these correlations refer to the 25-industry sample, RELVA2 using ERP and RELVA3 using Canadian weights.
10. For a discussion see U.S. Department of Commerce (1981, pp. xxiv–v).
11. Across the 167 4-digit Canadian manufacturing industries for 1979, on average (weighted and unweighted), the primary industry of a plant accounted for 90 percent of the plant's output. The primary industry is that to which the largest proportion of the plant's output is classified. Unfortunately, comparable figures do not exist at the company level — defined as "the legal entity" — in contrast to the enterprise, defined as "a company or a family of companies which as a result of common ownership are controlled or managed by the same interests" (Canada, Statistics Canada, 1979b, pp. 16 and 17, respectively). However, figures for the enterprise show that at the enterprise level in the manufacturing sector, in 1978, the primary industry accounted for 0.7570 of the enterprise's total output (Canada, Statistics Canada, 1983, Text Table XIV, p. 22). Note that the enterprise ratio is a weighted average.
12. The method was as follows. We estimated sales and wages and salaries for each 3-digit industry using establishment census industry data — S_E, WS_E — and company data derived from corporation financial statistics industry sources, (S_c, WS_c). In order to allocate the corporation-based book value of capital at the 3-digit level (BV) to each industry so that establishment-based data could be used, we calculated the average ratio of sales and remuneration (wages and salaries) of the census industry to the

corporation financial statistics industry definition and used this ratio to apportion the book value to a census industry basis.

13. Canadian constructed capital stock estimates can be found in Canada, Statistics Canada cat. no. 13-211, *Fixed Capital Flows and Stocks*, various years.
14. U.S. estimates can be found in United States, Department of Commerce, Bureau of Economic Analysis (1982) and also United States, Department of Labour (1979).
15. For this effort we are indebted to Richard J. Landry, Chief, Capital Stock Division, Construction Division, Statistics Canada.
16. In the United States, two sources are available on the book value of capital — the Annual Survey of Manufacturers (ASM) and the Internal Revenue Service. (For further details see United States, Department of Labour (1979, pp. 3–4, 8–11) and United States, Department of Commerce (1981, Table 3b, pp. 1-57–1-58, p. A-4).) In contrast, for Canada only Corporation Financial Statistics (CFS) are available. (For further details see Canada, Statistics Canada, *Corporation Financial Statistics*, Cat. no. 61-207, published annually). The IRS and CFS are comparable in that both are based upon company records, while ASM is an establishment-based data series. Hence, in order to derive the book value of capital we used CFS and IRS sources.

    The reader will note that most of the definitions in Table 5-5 are in terms of establishment-based data sources. Hence, it could be argued that ASM might be more appropriate than IRS for the United States. We selected IRS over ASM for two reasons. First, IRS is the data source used to correct V_u for purchased services, so we have already developed the industry concordance between the IRS data source and the establishment based classification system. Second, to the extent that a similar bias occurs in the United States and Canada for company-based data, use of IRS rather than ASM will go some way to offset this possible source of bias.
17. Since the gross fixed Canadian and U.S. capital stocks are expressed in 1972 dollars and the exchange rate was essentially at par in 1972, no exchange rate correction is necessary. The 6 percent figure is taken from Economic Council of Canada (1983, Table 9-2, p. 112). It should be remembered that this estimate makes no correction for price differences. If one takes a weighted average of the Canadian exchange rate for the previous sixteen years, using as weights the percentage of total investment in machinery and equipment, then this weighted average allows at least for exchange rate corrections that should be made to the book value of the Canadian capital stock. Sixteen years is chosen because this is the life used by the U.S. authorities (Blades, 1983). Then the weighted average exchange rate for 1970 is 1.045 and in 1979, 1.062. Therefore, making the exchange rate adjustment and not allowing for the higher prices in Canada due to tariffs would reduce to relative capital/labour ratio using book value to about 1.0. We do not make this correction in our TFP estimate because the book value Canada/U.S. ratio is already lower than the gross fixed capital stock ratio.
18. The resulting capital/labour ratio using book value rather than gross fixed capital is biased downward by 3 percentage points. Substituting the relative capital/labour ratios into our TFP estimate, and using a mean coefficient of .385 on our capital variable derived from our production function estimates, yields an approximation to the bias that is contained in our reported TFP estimates. The bias is about 1 percentage point in the early seventies and about 1.5 percentage points in the late seventies. Thus, while book value probably yields a different TFP measure than would gross fixed value if it were available, its use probably has little effect on our conclusions.
19. See footnote 16 for further details.
20. Of course, such adjustments are not applicable to that portion of the capital stock listed under Buildings, which in 1979 accounted for approximately 26 percent of depreciable assets, our definition of the capital stock [Canada, Statistics Canada, 1981b, Table 2A, p. 77; line 12/(Line 11 + line 12)].
21. Frank (1977, p. 69, footnote 23).
22. Canada, Department of External Affairs (1983, p. 99).
23. Economic Council of Canada (1983, Table 9-2, p. 112).
24. Economic Council of Canada (1983, Table 9-3, p. 114).
25. It should be noted that West's definition of capital is somewhat wider than that

employed here. We use depreciable assets whereas West (1971, p. 81) also included inventories and land.

26. This included not only the nominal tariff but the 4 percent federal sales tax applicable in 1963 and 8 percent for the exchange, West (1971, p. 81). West's (1971) estimates seem low when compared to others. See references in footnote 23 above. Part of the reason is that mentioned in the previous footnote.

CHAPTER 6

1. See Berndt (1980) and Denny and Fuss (1983) for a discussion of these issues.
2. The assumption that the factor elasticities are the same could be relaxed, but only at a substantial computational cost. We would require U.S. production functions for our 167-industry sample. Denny and Fuss (1983) have extended standard TFP measures to allow for such differences across two countries — but find that this extension adds little or nothing for a comparison of efficiency levels between Ontario and British Columbia. The reasons why these two regions of North America are similar suggest it is likely that the United States and Canada are also the same and that the Tornqvist index used here is adequate.
3. In adopting the Griliches and Ringstad method, we correct the individual labour share estimates by reducing each plant's value added by the percentage of value added that services account for in the industry as a whole. (This variable is defined as $CORR_c$ for Canada and $CORR_u$ for the U.S. See Chapter Five and Appendix A for further details.) See Appendix C, equations C.14 and C.15, for actual methodology employed.
4. We believe that the use of the Canadian scale estimate as opposed to one derived from U.S. data — where plants are on average larger and therefore the scale parameter may be less — is the appropriate one, because we are asking what might happen to productivity should Canadian plant scale increase. We recognize, however, that we may overstate the impact of scale economies if scale economies decline dramatically over plant size ranges likely to be experienced were EFF1T to move from its present mean value of 0.7 to unity. The data presently at hand do not permit us to examine this issue. The matter is clearly one that requires further investigation.
5. The removal of head offices was secured through criteria 1 and 5. See Table 3-2 for details.
6. See discussion in Appendix A under BV_c. The criteria used was that if COVER70 and/or COVER79 (as defined in Appendix A under BV_c) for an industry was less than 0.50 or greater than 1.50 it was excluded.
7. In some instances, as noted in Chapter Four, the scale estimates were nonsensical. For example, the returns to scale for SIC 1082 were 611.6 in 1970 and 0.79 in 1979 with a pooled 1970 and 1979 estimate of -0.27. In other instances the pooled 1970 and 1979 estimate was much higher or lower than the range of 1970 and 1979 estimated separately.
8. The reported TFP measures do not take into account possible differences in capacity utilization measures. We evaluated the biases that might have resulted from this omission and concluded they were minor. This matter is discussed at length in Appendix E.
9. A rough estimate of the error that might be made on average by dropping the variance term can be given. The average returns to scale in manufacturing estimated in Chapter Five for the entire manufacturing sector is 1.15. Clarke (1979, Table 2, p. 423) reports σ^2 varying from 5.68 for the U.K. Tobacco Industry to 1.46 for Lace. Prais (1976, p. 51) reports σ^2 for the plant size distribution in the United Kingdom to be around 3. Thus a large estimate of $\sigma_c^2 - \sigma_u^2$ is probably around 2 — with the Canadian variance being smaller than the U.S. because of a smaller number of large plants. Together then the omitted term would be around 0.16, which translates to a missing term of about 1.17. Thus a TFP measure of 0.80 should be corrected to yield a value of about 0.94.

CHAPTER 7

1. In general we estimated regression equations for the maximum number of industries for which data were available for all of the variables. Hence there are differences in sample size used for TFP, EFF1T, and HERF4D. For further details see Baldwin and Gorecki (1983a, 1983b) and Chapter Five.
2. This occurred for NRP and ERP in 1979 where 1978 data were used, for ADVDM in 1979 where 1977 data were used; for all the trade variables (CA, IMP, EXP), which employed 1971 data to approximate 1970; for the 1970 diversity and length of production variables, which were approximated by 1974 data; and for RD 1970 which employed 1975 data. In the case of EFF1T and TFP measures, while Canadian data refer to 1970 and 1979, U.S. data refer to 1972 and 1977. See Appendix A and reference cited at the end of the last footnote for further details.
3. The instance where this is most likely to be seriously remiss is for RD70, since the value is for a year five years away (1975). However, RD for 1975 is highly correlated with RD for 1979 (.970), suggesting that even here the problem is not that serious.
4. Nominal and effective tariffs and advertising variables were based on a 122-industry division of the manufacturing sector, while RD statistics were available at the 3-digit level, which divided the manufacturing sector into 112 industries. Finally, the trade data (i.e. imports and exports used to derive INTRA, EXP, IMP, CA) needed some minor prorating for 21 4-digit industries. Appendix A provides details on the database and sources.
5. An alternate approach can be derived from stochastic models of firm size distribution. These models (Simon and Bonini, 1958; Ijiri and Simon, 1964) use as a basis for their analysis some form of "Gibrat's Law." When entry is incorporated into these models, the distribution will be determined by two variables — the average growth rate per firm and that portion of growth of the industry attributable to new firms. Thus, it is the determinants of entry that this approach would lead us to include in the analysis. The variables that have been shown to determine entry (Baldwin and Gorecki, 1983c) are growth, market size, entry barriers, and profitability. These are generally the same, as the more traditional literature has suggested. See Baldwin and Gorecki (1983b, 22–26) for further discussion of the issues raised here.
6. We would expect that effective rather than nominal tariffs determine relative plant scale because the former are a better measure of the extent to which protection provides a margin that could be wasted through excessive entry. To test for the different effects of effective and nominal tariffs, one might include in the same equation the variables ERP, HVTRHCR, EASTV, NRP, and terms corresponding to HVTRHCR and EASTV defined for nominal tariffs. The high concentration/high tariff terms (nominal and effective) are sufficiently highly correlated as to preclude their inclusion in some regression equations. However, such is not the case with ERP and NRP; hence both are included. For the correlation matrix see Baldwin and Gorecki (1983b).
7. Saunders (1980) allows for a form of non-linearity whose complexity creates some difficulty in separating the different effects of protection. He uses an interaction term that is (1) inversely related to the degree of tariff protection; (2) inversely related to the U.S. cost disadvantage ratio (value-added per worker in small plants relative to large plants); (3) is inversely related to the ratio of Canadian market size relative to a U.S. MES estimate; and (4) positively related to U.S. market size. Our formulation explicitly considers 1 and 3 together and by including 1 and 3 separately allows for a test of the differential effect of each.
8. We also include the variable MARCVA to capture the ability of large and small firms to coexist side by side. Where MARCVA is large this suggests that large firms have no advantage over small. The expected relationship with EFF1T is negative.
9. Caves et al. (1980) suggest that CDR derived from Canadian data may suffer from what they call the truncation effect and that the U.S. cost disadvantage ratio (USCDR) should be used. We therefore experimented with this variable but found it inferior to that chosen here. Caves et al. (1980), in some instances but not in the relative efficiency

chapter (10), capture some of the effect discussed here by using MESMSD where USCDR is less than .9.

10. If MESMSD is defined using the domestic plant size distribution to define MES, and if the top four firms were all single plant units and possess exactly 50 percent of the market, there would be no difference between CON and 1/MESMSD. CON will generally be higher than the latter if leading firms possess multiple plants.
11. Ideally one would like to allow for changes in the other variables that would accompany a movement to completely free trade.
12. The exception was HVTRHCR, which was insignificant in 1970. We also experimented with changes in foreign ownership, changes in effective tariff rates, and changes in an intra-industry trade variable. None of these proved to be significant.
13. We experimented with changes in foreign ownership in high tariff/high concentration/high foreign ownership (FORHCVDF) and found no significant effect.
14. Elimination of variables with insignificant coefficients in Table 7-1 did not affect the sign or significance of the others in a meaningful way.
15. We also experimented with the inclusion of ERPDIF but excluded three industries whose effective tariff rate change suggested possible measurement error — 1510, 3651, and 3652 — Leaf Tobacco Processors, Petroleum Refining, and Manufacturers of Lubricating Oils and Greases. Our conclusion that changes in effective tariffs do not matter outside of high concentration industries is confirmed. See Baldwin and Gorecki, (1983b, note 31, p. 138).
16. See Gorecki (1979, Table 5-4, pp. 188–89) for details.
17. Economic Council of Canada (1983, Table 9-3, p. 114) and the discussion in Chapter Two above.
18. For additional discussion, see Scherer et al. (1975, pp. 355–81) on optimal unbalanced specialization in a multiplant framework.
19. For a discussion of the possible endogeneity (with a negative finding) of the number of ICC products per industry, see Baldwin and Gorecki (1983a, Appendix D, pp. 151–57).
20. As with EFF1T, we experimented with other trade variables than CA, and IMP. Intra-industry trade (INTRA) and export intensity (EXP) were used but not reported here because of their failure to reveal any additional information.
21. Results for HERF5D (diversity defined using the 5-digit ICC classification) and average production run length are reported in Baldwin and Gorecki (1983a). This source also discusses the impact of removing aberrant industries (Ibid., Appendix C, pp. 146–50).
22. We include a caveat that PLESTV is highly correlated with AVPSQ. When the latter is included, PLESTV is not significant. This does not, however, change our interpretation of the results. Recall that the significance of the squared plant size variables was to place an upper limit on product run length as plant size expanded. It is therefore this phenomenon that the Eastman/Stykolt term is catching.
23. See Baldwin and Gorecki (1983a).
24. RELDIV5D is defined as (1 – HERF5D)/(1 – (1/N5D)).
25. We also truncated the sample used to estimate TFP1 using the same criterion as for TFP3 and TFP4. Contrary to the latter, the significance of many variables actually fell. This suggests that, in the case of TFP1, outliers yield valuable information. For details of the impact of excluding outliers in the case of EFF1T and HERF4D see Baldwin and Gorecki (1983a, 1983b). In general the impact was not substantial for the latter two variables.

Appendix A

1. A company "is the legal entity," whereas an enterprise is "a company or a family of companies which, as a result of common ownership, are controlled or managed by the same interests" (Canada, Statistics Canada, 1979b, pp. 16 and 17 respectively). An unconsolidated enterprise refers to an enterprise's activities within a particular industry, while the consolidated enterprise refers to all of the enterprise's activities no matter where they are located.
2. See previous footnote for definition of a company.

Appendix B

1. We use OLS for estimation.
2. See Maddala (1977, pp. 293 – 319) for further details.
3. For example, as noted in the discussion of K_1 and K_2 in the text of Chapter Three, these two variables are likely to better approximate capital services if the plants are of the same vintage. The only information we have on this issue can be represented in the following variable:

   DZ = 1 if the plant existed in the industry in 1979 but not 1970,
   0 otherwise.

   Using this variable the equation

   $$\log Y = k + a \log L_2 + b \log K_2 + c\, DZ \cdot \log K_2$$

   was estimated. The coefficient c was never significant, with the standard error rarely being less than the parameter estimate. Furthermore the coefficient on K_2 and L_2 did not differ materially from these reported in Table B-3.
4. The procedure involved estimating the equations

   $$\log Y = k + a \log L_1 + b \log K_3 \qquad \text{(B.3)}$$

   $$\log Y = k + a \log L_1 + b \log K_2 \qquad \text{(B.7)}$$

   $$\log Y = k + a_1 \log NW + a_2 \log NS + b \log (g_1K_2 + g_2K_3) \qquad \text{(B.8)}$$

   where L_1, NW, NS are defined in the text. OLS was used to estimate b in equations B.3 and B.7 while NLIN — non-linear regression, using the Gauss-Newton iterative method — was used to estimate B.8. Our purpose was to compare the b coefficient yielded by B.8 to b in equation B.3 and B.7. With two exceptions, for the eight industries in Table B-1 for 1979, the value of b in equation B.8 was *within* the range 0.90–1.10 of the value of b in equation B.3; but, in contrast, with one exception, the coefficient b in the equation B.8 fell *outside* the range 0.45–1.45 of the value of b in equation B.7. Indeed, in several instances the difference was a factor of 10. Hence, the use of more sophisticated NLIN methods yields little in the way of improvement for the estimation of the capital services variable.
5. Although not presented, the corresponding results for 1970 are similar to those reported in the text for 1979.
6. If we compare the parameter estimates of equation B.2 plus or minus 10 percent with the corresponding parameter estimates for equations B.3 and B.4, we find that $L_2 \pm .10$ includes the coefficient on L_1 and NS + NW for all industries except SIC 1081, where the $L_2 \pm 0.12$ would be required to encompass the parameter estimates on L_1 and NS + NW. Undertaking the corresponding exercise for those instances where K_3 is significant, we find that only for SIC 1072, 3042, 3360 (equation B.3 only), and 2513 (equation B.3 only) do the coefficients on K_3 in equations B.3 and B.4 lie with the $\pm$ 1.10 the coefficient on K_3 in equation B.2.

7. As with the previous footnote, we compare the scale elasticity and coefficients between equation B.2 and B.5 by estimating intervals of ± 10 percent. In every instance the scale elasticity of B.2 compared with B.5 falls within this range, but L_2 for 1832 for B.2 compared with L_2 for 1832 for B.5 falls by 11.8 percent, while K_3 increases by 19.3 percent; and K_3 for 3320 increased by 31 percent.
8. One possible reason may have been the practice in Chapter Three of assigning all values of CST that were missing to D3. If equation B.6 is re-estimated for SIC 1832, but with all missing values of CST omitted, than a = 0.838 (t-value = 2.71), b = –0.0366 (t-value = –0.17), and d_2 = –2.331 (t-value = –4.11). This does not change the substance of the text on this point.
9. Although these conclusions apply to 1979, we did some preliminary work for 1970. Comparing scale elasticity for equation B.2 yielded for criteria 1 to 7 and 1 to 11. The results, like those reported in the text for 1979, showed considerable stability.

	Scale Elasticity from EQ B.2	
SIC	**Criteria 1–7**	**Criteria 1–11**
1072	1.068	1.083
1081	1.117	1.075
1832	0.984	1.060
2513	1.083	1.080
2860	1.047	1.034
3042	1.015	0.974
3320	1.054	1.023
3360	0.976	0.989

No scale elasticity estimate varied by as much as 3360 in 1979 (0.903 to 0.995) comparing criteria 1 to 7 and 1 to 11 and, like the 1979 results, no particular bias could be deduced comparing the results of criteria 1 to 7 and 1 to 11.

10. Even though this is the case we show in Chapter Six the influence of the scale parameter on capital is minimal in our total factor productivity estimates, because the relative Canada/U.S. capital/labour ratio is close to unity for the median industry.

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ECONOMICS
Industrial Structure

The Role of Scale in Canada-U.S. Productivity Differences in the Manufacturing Sector 1970–1979

JOHN R. BALDWIN and PAUL K. GORECKI

This is the sixth of seven volumes dealing with **Industrial Structure** (see list in back of book), included in the Collected Research Studies of the Royal Commission on the Economic Union and Development Prospects for Canada.

Evidence indicates that Canada's manufacturing sector is less productive than that of the United States. Among the contributing factors usually cited are sub-optimal plant scale, short production runs, foreign ownership and trade barriers. This study attempts to measure the contributions of these factors to productivity differences between the two countries.

The authors identify the scale effect as critical and attribute to it about one-third of Canada's productivity disadvantage. They suggest that trade also plays an important role. Trade affects relative plant scale, which in turn affects relative productivity. Impediments to trade – tariff barriers, low import levels, low foreign investment – all have a negative impact on productivity.

A strong argument emerges from this study that the liberalization of trade over the postwar period has improved the competitiveness of Canadian industry and that continued reduction of trade barriers is in Canada's best interests.

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