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An Empty Promise: Average Cost Savings and Scale Economies Among Canadian and American Manufacturers, 1910-1998

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Abstract

During the debate that led up to the implementation of a bilateral free trade agreement between Canada and the U.S. on January 1, 1989, much was made of economists' claims that both nations could expect significant welfare improvements as a result of the removal of tariffs on traded goods. The welfare gains were expected to flow from average cost savings associated with the exploitation of scale economies. In this paper we show that it was overly optimistic to predict substantive reductions in average costs in response to any increases in the scale of production among Canadian or American manufacturing firms. Therefore, *ex ante* we should have expected trade liberalization between Canada and the U.S. to have had only muted scale, average cost, and welfare effects.

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1 Introduction

On January 1, 1989, a bilateral trade agreement between Canada and the United States came into effect. This free trade agreement (F.T.A.) called for the reduction, and eventual removal of Canadian and American tariff barriers on a wide range of goods traded between the two countries. In Canada, at least, there was considerable public and policy debate surrounding the negotiation and implementation of this pact. Throughout the course of the debate economists' claims that there would be considerable welfare improvements accruing to both Canada and the U.S., as a result of the reduction and removal of tariff protection, received considerable attention.

Some who participated in the debate suggested that exposing producers, particularly manufacturers, to increased competitive pressures could foster innovation and risk taking, and punish shirking and managerial incompetence, thereby accelerating the rate of technical progress and productivity growth. However, most commentators anticipated that the primary source for welfare improvements would be a reduction in average costs and a subsequent increase in exports and income, stemming from the exploitation of scale economies by manufacturing firms.

Recently a large, and growing, body of literature focusing on the effects of bilateral tariff reductions has developed. This work adopts an *ex post* perspective in an effort to determine what effect trade liberalization has had on economic variables, such as productivity (Harrison, 1994, Tybout and Westbrook, 1995, Bernard and Jensen, 1999), wages and employment (Beaulieu, 2000, Gaston and Trefler, 1997), plant production levels (Head and Ries, 1999), and the trade off between short run adjustment costs and long run efficiency gains (Trefler, 2001). In general, these studies have found that the costs and benefits associated with trade liberalization are both difficult to isolate, and unlikely to be substantial. This generalization holds with particular strength among wealthy, industrialized nations, such as Canada and the United States.

In light of the optimistic expectations regarding export and income performance improvements that were articulated prior to the introduction of the Canada-U.S. F.T.A., it is surprising that the *ex post* empirical evidence has been so muted. In this paper we abandon any reliance on hindsight in favour of an *ex ante*, longer run view. In particular, we seek to determine if the anticipated effects of bilateral trade liberalization between Canada and the U.S. were overly optimistic, given the information available prior to the implementation of the F.T.A.. We can be even more specific. The predicted welfare effects were expected to flow from the exploitation of scale economies, and a resultant convergence in average costs among Canadian and American manufacturing firms. For this prediction to have been reasonable we should observe four persistent features in a long run comparison of Canadian and American manufacturing firms prior to the implementation of the trade agreement. Perhaps most obvious, we should find substantial differences in average costs and output levels. There must also have been statistically significant scale economies available.[1] Finally, the firms' long run average costs should have been sensitive to output adjustment. This last feature implies that it would be unreasonable to associate production on flat or very moderately sloped portions of cost functions with economically substantive changes in average costs, in response to changing output levels.

In the sections below we present evidence indicating that it was overly optimistic to predict that post-F.T.A. output adjustment alone could have induced substantive average cost reductions among Canadian and American manufacturers. This evidence has been drawn from a sample of seventy-eight manufacturing firms, representing nine industries, covering the years 1910-1988. We find that prior to the implementation of the F.T.A. most Canadian firms in the sample produced considerably less output, on average, than their U.S. counterparts in the same industry. It is also apparent that there were persistent and, in some cases, quite dramatic average cost differences among the firms in the sample. The estimation of translog cost functions reveals that most of the Canadian and American firms produced subject to locally increasing returns to scale during the years preceding 1989. These findings suggest that Canadian and American manufacturers could have experienced some average cost convergence if trade liberalization induced an increase in their output levels. However, these findings do not necessarily imply that trade liberalization could have induced the output expansion required for the exploitation of all available economies of scale, or that output adjustment alone could have eliminated the observed pre-F.T.A. average cost differentials.

In an effort to determine the long run sensitivity of the firms' average costs to output adjustment, scale elasticities and elasticities of average cost with respect to output have been calculated. The elasticities indicate that over most of the twentieth century the Canadian

[1] This paper studies the connection between firm specific output and long run average costs. Therefore, throughout the paper "economies of scale" refer to internal economies only. Because they are important determinants of average costs, external economies and returns to scope are a focus of related work in progress.

and American producers in the sample operated on very flat portions of their long run average cost curves. Further investigation of the global curvature properties of the manufacturers' cost curves reveals that, prior to the implementation of the F.T.A., we should have known that increasing output levels would lead to only small decreases in average costs, and that output levels have traditionally been small fractions of minimum efficient scale.[2] More specifically, in six of the nine industries studied, the low output producers could not have reached minimum efficient scale even if they matched the high output producers' average output levels. In addition, the pre-F.T.A. average cost differentials could have been eliminated through output adjustment alone in only two of the nine industries studied. This evidence indicates that, if we anticipated export and income performance improvements resulting from increased output associated with trade liberalization and the exploitation of scale economies, then we were too sanguine.

The next section provides a brief review of some of the quantitative work that contributed to the formation of our optimistic expectations concerning the economic effects of trade liberalization. Section 3 contains a brief description of the data employed, and the average cost and output performance of the Canadian producers in the sample, relative to their American counterparts. In the fourth section the estimation of industry specific translog cost functions using unbalanced panel data is described, and local returns to scale and elasticity results derived from the estimated parameters are reported. The calculation of minimum efficient scale is also discussed in Section 4, and the extent to which average costs could have responded to substantial output adjustment is revealed. The final section proposes avenues for future research and articulates the main conclusions of the paper.

2 The Formation of Optimistic Expectations

Average costs; $C_t/Q_t = f(A_t, Q_t, W_{xt})$; are a product of technology, $f(\cdots)$, productivity, A_t, the scale of production, Q_t, and input prices, W_{xt}. The optimistic expectations regarding welfare gains stemming from trade liberalization are based on the belief that average costs will decline as competition in the domestic market, and access to a foreign market increases. We will briefly discuss some issues that have been raised concerning the relationship between technology, productivity, and tariff reductions, before turning our attention to the F.T.A.-scale

[2] "Minimum efficient scale" is defined as the level of output that can be produced at the lowest possible long run average cost, given technology, productivity and input prices. See Varian, 1992, Pg. 68.

literature.

As tariff barriers are removed, competition becomes increasingly fierce, managerial incompetence, inefficiency and shirking are punished by the market more quickly and violently. This Darwinian environment may also foster innovation and risk taking among industrial decision makers. Both of these effects could accelerate technical progress and improve productivity. Technology and productivity improvements lower average costs, and hence prices, thereby facilitating successful competition in domestic and international markets.

Keay (2000A) presents evidence indicating that, although Canadian and American manufacturers have traditionally used domestically unique technology, producers in both nations have been flexible in their employment of inputs and technology, and responsive to changing market conditions. One of the implications of these claims is that there is little evidence of incompetence, inefficiency or shirking that might require punishment among Canadian or American producers. With respect to available technological improvements in general, Keay (2000B) argues that if total factor productivity is used to judge efficiency, then the Canadian producers studied in this paper have been as efficient as their U.S. counterparts over most of the twentieth century.[3] Therefore, it is unlikely that average cost differentials could have been eliminated through technological or productivity convergence among Canadian and American firms following trade liberalization.

In addition to technological and productivity effects, there has been considerable study of the relationship between trade liberalization and the scale of production. Tariff protection, in conjunction with transport costs, differentiated products and regional tax and industrial policies, may allow firms to price their output over marginal cost. One of the implications of this "tariff-limit pricing behaviour" is that in equilibrium it may be optimal for firms to produce to the left of their point of minimum efficient scale.[4] A bilateral reduction of trade barriers and the accompanying increase in competition may, therefore, encourage firms to increase output, resulting in lower average costs as the firm moves towards its point of minimum efficient scale. This view has been consistently articulated by those who have studied the relationship between Canadian tariffs, market structure and manufacturers' performance.[5]

[3] Additional evidence on Canadian relative to American T.F.P. can be found in Denny, Bernstein, Fuss, Nakamura and Waverman, 1992.

[4] Muller and Rawana, 1990, illustrate that tariff-limit pricing and production to the left of M.E.S. may be observed in the absence of collusion among firms.

[5] In addition to the work referred to in this section, see Eastman and Stykolt, 1967, Daly, Keys and Spence, 1968, and Baldwin and Gorecki, 1986.

Wonnacott and Wonnacott (1967) produced an early and influential study that assumed tariff-limit pricing and contained optimistic estimates of the impact bilateral trade liberalization might have on Canadian manufacturers. In this work the authors disaggregated Canadian and American price and average cost differentials by industry and region in an attempt to determine what relative prices and costs might be after the bilateral removal of tariffs on manufactured products. They claimed that, "...(tariff) protection results in higher Canadian prices and costs because of three organizational factors: the size of the firm; the level of managerial efficiency necessary to survive; and oligopolistic opportunities offered by the protected market."[6] Wonnacott and Wonnacott predicted that trade liberalization would result in lower Canadian average costs and prices, increased exports and nominal wages, and an increase in Canadian G.N.P. of approximately 10.5%.[7] This expected gain in G.N.P. is dependent on their estimate of the available economies of scale among Canadian manufacturers. "(The) major gains from free trade...depend primarily on the exploitation of economies of scale, defined broadly to include not only engineering economies, but also managerial and organizational efficiencies associated with specialization and competition in a larger market."[8] They base their scale estimates on the average cost differentials between Canadian and American manufacturers which remain after accounting for all input, tax and tariff differences.[9]

A series of papers by Harris (1984), and Cox and Harris (1985 and 1986), provided additional impetus to the formation of optimistic expectations at a key juncture in the debate surrounding the negotiation of the F.T.A.. The authors used general equilibrium models of a small open economy, with a tariff-limit pricing assumption, to study the impact tariff reductions would have on Canadian manufacturers and Canadian G.N.P.. They argued that, "...freer trade, by subjecting domestic industry to increased foreign competition and allowing access to the larger world market, results in lower price-cost margins and in firms' achieving...lower costs of production."[10] Their model predicted that Canadian G.N.P. could increase by 8-12%[11] after the complete removal of tariff barriers between Canada and the United States, 2-5%[12] if Canada unilaterally removed tariff barriers, and there could be as

[6]Wonnacott and Wonnacott, 1967, Pg. 5.
[7]Ibid, Pg. 335.
[8]Ibid, Pg. 336-337.
[9]Ibid, Pg. 222.
[10]Cox and Harris, 1985, Pg. 116.
[11]Harris, 1984, Pg. 1017.
[12]Cox and Harris, 1985, Pg. 140.

much as a 37%[13] increase in the value added generated in individual sectors subject to bilateral, sectoral tariff reductions. Like Wonnacott and Wonnacott's estimates, one of the central determinants of Cox and Harris' optimistic view is their estimate of the extent to which long run average costs would fall as output expanded and economies of scale were exploited.[14] Their optimism, therefore, stems from their belief that Canadian manufacturers' average costs have been sensitive to output adjustment. The scale elasticities used in Cox and Harris' general equilibrium model are derived from econometric estimates reported in Fuss and Gupta (1979) for Canadian manufacturing industries defined at the three and four digit S.I.C. code level of aggregation.[15]

Underlying both Wonnacott and Wonnacott's, and Cox and Harris' optimistic expectations were the assumptions that firms practiced tariff-limit pricing and that average costs have been sensitive to output adjustment. The tariff-limit pricing assumption implies that the scale of production could potentially expand dramatically in response to the bilateral removal of trade barriers. However, most theoretical modelling that integrates the effects of bilateral trade liberalization with specific imperfectly competitive market structures does not predict that the scale of production will rise substantially in response to a reduction in both home and foreign tariffs.

Head and Ries (1999) survey much of this theoretical work. They illustrate that under most imperfectly competitive market structures a reduction in home tariffs will reduce the scale of domestic production. This decline in equilibrium output levels can only be matched by a concurrent expansion in production in response to the removal of foreign tariffs under very specific market structure, elasticity and relative tariff level assumptions. Head and Ries present empirical evidence that suggests that only a small proportion of the increase in Canadian manufacturing plants' average output levels following the implementation of the F.T.A. has been due to the bilateral reduction in tariffs.

In this paper we accept the tariff-limit pricing assumption because it implies an expansion of output levels following trade liberalization that is most favourable for the exploitation of any scale economies. In other words, while accepting that bilateral trade liberalization does

[13] Cox and Harris, 1986, Pg. 392.

[14] Cox and Harris do not confine themselves to the study of internal returns to scale. Intra-firm rationalization plays an important role in their scale estimates. For example, Harris, 1984, Pg. 1028, suggests that in response to bilateral free trade, Canadian production runs may be expected to increase by approximately 50% on average, leading to a reduction in average costs of nearly 8%. In this paper only internal returns to scale are studied, hence, only the effects of inter-firm rationalization have been captured.

[15] The range of their scale estimates are provided in Section 4.2.

not necessarily entail dramatic expansion in the scale of manufacturing production, we adopt an assumption regarding the expansion of output found most often in the pre-F.T.A. literature because it biases our results in favour of average cost savings. In particular, we assume that the removal of trade barriers under the F.T.A. could have facilitated a matching of output levels among Canadian and American firms in the same industry.

Our acceptance of the tariff-limit pricing assumption allows us to focus all of our attention on the second central assumption underlying the formation of *ex ante* optimism regarding the implementation of the Canada-U.S. bilateral trade agreement. There is empirical evidence to support the view that Canadian and American manufacturers have traditionally produced subject to increasing returns. However, a firm producing subject to statistically significant locally increasing returns to scale may be producing on a flat portion of their long run average cost function.

Atack (1977), James (1983) and Sokoloff (1984) have all argued that U.S. producers enjoyed very dramatic reductions in their long run average costs in response to fairly small increases in output early in their nineteenth century industrialization period. Subsequent increases in output levels, as a result of vertical or horizontal integration during the early years of the twentieth century, do not appear to have led to large average cost effects. This indicates that manufacturers in the U.S. may have employed technology characterized by very steep long run average cost curves at low output levels, but very flat long run average cost curves at higher output levels.[16]

Despite the relatively late maturation of the Canadian manufacturing sector, early twentieth century Canadian technology appears to have been similar to that employed by U.S. producers in the same industry.[17] This suggests that Canadian manufacturers may also have been producing on flat portions of their long run average cost curves through most of the twentieth century, and therefore, the existence of increasing returns to scale would not necessarily imply substantial average cost savings in response to increasing output levels.

In the sections below, we investigate not only cost and output performance, but also local returns to scale and the global curvature properties of Canadian and American manufacturers' cost functions prior to the implementation of the F.T.A.. This investigation illustrates that

[16] Similar results have been reported for French manufacturers by Nye, 1987, and Sicsic, 1994.

[17] Descriptions of the early twentieth century technology employed among Canadian and American manufacturers can be found in Wylie, 1989. Statistical tests for common technological characteristics in later periods are reported in Keay, 2000A.

we should have expected very little average cost response, even in the presence of substantial post-F.T.A. output adjustment. The presence of average costs which have been insensitive to changes in output levels calls into question Wonnacott and Wonnacott, and Cox and Harris' predictions. The exploitation of internal returns to scale does not necessarily imply a dramatic narrowing of average cost differentials between Canadian and American producers.

3 Canadian and American Average Costs and Output Levels

3.1 A Brief Comment on the Data

To conduct a long run comparison of Canadian and American manufacturers' output levels, average cost performance, and returns to scale appropriate data must be available and consistently defined in both Canada and the U.S. throughout the period of interest. Unfortunately, data published by national statistical agencies are not reported in long annual time series, nor are they defined consistently in Canada and the U.S., across industries, firms or time.[18] Therefore, the data published by Canadian and American statistical agencies must be supplemented by data from firm level sources. In particular, information has been collected from thirty-nine Canadian and thirty-nine American manufacturing firms. This information has been gathered from corporate annual reports to shareholders and annual industrial manuals, published by *The Financial Post*, *Moody's* and *Standard and Poor's*. The annual industrial manuals contain audited[19] financial information, income accounts, balance sheets, and some input and output data, for Canadian and American manufacturing firms. To be included in the industrial manuals, firms must have issued publicly traded debt or equity.

Data are available for hundreds of firms in Canada and the United States. For inclusion in the sample constructed for this paper each potential firm had to satisfy five criteria.

- Data had to be available at both the firm and industry level. Therefore, firms which did not issue publicly traded debt or equity were not included.
- Data had to be available for twenty years or more. Therefore, firms which failed quickly, were not included.
- Firms had to be closely matched to other firms in the same industry in both Canada and the U.S.. Therefore, firms which were idiosyncratic in their input and output decisions were not included.

[18] The chronological, industrial and national inconsistencies in data collection by national statistical agencies are particularly acute for capital stocks, services and value added figures.

[19] An independent auditor, whose reputation depended on accuracy, reviewed the data prior to publication in the industrial manuals used. Any changes in definitions for which adjustments could not be made and any inconsistencies in the data across years resulted in the firm being dropped from the sample.

Table 1: Sample Composition

	# Firms	Years Covered
Steel: Canada	4	1910-1990
US	7	1902-1990
Cotton: Canada	6	1908-1979
US	5	1905-1990
Silk: Canada	4	1912-1989
US	3	1912-1990
Cement: Canada	4	1910-1990
US	4	1914-1988
Sugar: Canada	3	1917-1976
US	4	1909-1986
Oil: Canada	6	1922-1990
US	5	1911-1990
Paper: Canada	5	1907-1990
US	5	1925-1988
Wine: Canada	4	1930-1990
US	3	1934-1974
Spirits: Canada	3	1925-1990
US	3	1934-1990
Total: Canada	39	1907-1990
US	39	1902-1990

Source: Keay, 2000(A), Table 1.

- Firms had to generate at least 85% of their revenue from goods produced in their home country. Therefore, firms which were multinational in production were not included.
- Firms had to generate at least 85% of their revenue from goods classed in the industry in which they have been grouped. Therefore, firms which produced widely diversified production lines were not included.

The seventy-eight firms included in this study form an unbalanced panel covering the years 1907-1990 among the Canadian firms and 1902-1990 among the U.S. firms.[20] The firms represent nine manufacturing industries. The industries are identified by their three-digit S.I.C. code. The selected manufacturers do not exhaust the set of firms which satisfied the five criteria, but they are a fairly representative sample of the Canadian and American industries in which they have been grouped and the manufacturing sectors as a whole.

From the firm level sources, data on revenue earned, labour employed, capital employed and realized capital costs have been collected. Gross sales, less sales and excise taxes, have been used to represent revenue.[21] Number of employees, including production and non-production

[20]For more detail on the specific firms included in the sample, industry coverage, sectoral coverage and the years covered by each firm, see Keay, 1999, Section 2.3.

[21]A detailed description of the derivation of all the series used in this paper, as well as an itemized listing of

workers, have been used to represent labour.[22] Data from balance sheets on the value of fixed assets at historic cost, in conjunction with data from income accounts on gross investment, have been used to generate capital stock figures. From income accounts the total payment to capital is available. This information has been divided by the capital stock figures to generate realized capital costs.[23] While additional information on firm specific prices, physical quantities of output, raw materials, labour and capital have been used if they were available, only sales, employees, capital stock figures and realized capital costs were available for all firms in all years. The firm level sources provide no information specific to individual plants or individual production establishments.

To compute relative average cost and output ratios, estimate cost functions, calculate elasticities and identify global curvature properties, additional input and output price data are required. These data are not available for all of the individual firms studied in this paper. They are, however, available for Canadian and American industries at the three-digit S.I.C. code level of aggregation. From Statistics Canada/Dominion Bureau of Statistics and Bureau of Labour Statistics sources industry specific price data have been collected. The concurrent use of industry specific price data and firm specific quantity data requires that the standard neo-classical assumptions hold. In particular, it has been assumed that the firms in the sample faced the industry average prices reported by the national statistical agencies.

Industry specific nominal wage rates have been used to represent the price of labour for each firm.[24] Weighted geometric averages of nominal prices for the products which were responsible for 50% or more of total revenue generated by each industry have been used to represent output prices for each firm. Weighted geometric averages of nominal prices for the intermediate inputs[25] which were responsible for 50% or more of the total cost of all intermediate inputs by each industry have been used to represent intermediate input prices for each firm.

The industry specific nominal output price figures have been used to deflate the firm specific revenue figures to generate firm specific physical quantities of output. The firm specific labour

the source and composition of each series, is available in Keay, 1999, Appendix 2.A. A Data Appendix following the body of this paper includes a table listing the means and standard deviations for all series.

[22]Industry and nation specific average hours worked figures have been used to adjust the number of employees for each firm to take into account differences in the length of the work week in Canada and the U.S..

[23]For a more detailed discussion of the implications of using realized capital costs see Keay, 2000(B), Section 3.1.

[24]All of the cost and price series used in this paper have been converted into Canadian dollars using the official annual average exchange rate.

[25]Intermediate inputs include raw materials, fuel and services.

figures have been multiplied by the industry specific average hours worked and multiplied by the industry specific nominal wage rates to generate firm specific total cost paid to labour figures. The cost for labour figures have been added to the firm specific payments to capital to generate firm specific value added figures. The value added figures have then been subtracted from the firm specific revenue figures to generate the total cost paid to intermediate inputs for each firm. The intermediate input cost figures have been deflated by the industry specific nominal intermediate input prices to generate firm specific physical quantities of intermediate input figures. The combination of the firm and industry specific data have also been used to calculate firm specific total cost shares.

The combination of the firm specific data, industry specific data, and an assumption that the firms in the sample were facing the industry average prices, yields all the information necessary for the calculation of industry specific average cost and output ratios, the estimation of translog cost functions, the derivation of scale elasticities and the identification of the point of minimum efficient scale for all nine Canadian and American industries.

3.2 Average Cost Performance

Prior to any detailed investigation of the *ex ante* connections between output adjustment and average cost performance, it is necessary to establish the pattern and extent of average cost differentials between Canadian and American producers. Annual firm specific average cost figures have been calculated for every firm included in the sample by adding firm specific labour, capital and intermediate input costs to derive total cost, then dividing this figure by firm specific output. Because we are interested in the connection between output and average cost at the industry and sectoral level, the experiences of individual firms are not discussed in this paper. Annual industry specific average cost figures have been derived by calculating an unweighted arithmetic average of the firm specific average cost figures for each year. For matching years and industries the ratios of Canadian relative to American average costs have been generated. The mean industry specific average cost ratios (and their standard deviations) are reported in Column 1, Table 2.

In all nine industries studied in this paper the firm level average cost distributions overlapped. This implies that the lowest average cost producer among the firms in the high cost nation had lower average costs than the highest average cost producer among the firms in the low cost nation. Despite the overlapping distributions, when averaged across firms within each

Table 2: Mean Canadian / American Industry Average Costs and Output Levels

	Column 1: Mean Average Cost Ratio (Standard Deviation)	*Column 2:* Mean Output Ratio (Standard Deviation)
Cement	0.973 (0.570)	1.465 (0.822)
Cotton	1.220 (0.211)	0.779 (0.379)
Distilleries	2.058 (1.578)	0.171 (0.221)
Oil	0.957 (0.266)	0.417 (0.164)
Paper	0.820 (0.224)	0.824 (0.793)
Silk	1.752 (0.475)	0.145 (0.177)
Steel	1.041 (0.325)	0.121 (0.066)
Sugar	1.015 (0.513)	0.467 (0.160)
Wine	0.723 (0.182)	1.539 (1.264)

nation there have been some substantial and persistent[26] average cost differences. Canadian cotton textile mills, distilleries and silk and synthetic fibre textile mills had dramatically higher average costs, at the mean of the data, relative to their American counterparts. Canadian paper mills and wineries had lower average costs, at the mean of the data. Among the nine industries represented in the sample, only Canadian and American cement manufacturers, oil refineries, steel mills and sugar refineries had average costs which were very similar.

Although the mean annual average cost ratios reported in Table 2 are quite representative of the nine industries' experiences across the entire period of study, there are some interesting time series patterns that can be identified in the average cost ratios illustrated in Figures 1-9. Canadian distilleries experienced three years (1960-1962) in which the average cost ratios were substantially higher than the mean. Canadian cement manufacturers and silk and synthetic fibre textile mills experienced increasing relative average costs throughout the period, while Canadian steel mills experienced declining relative average costs. The other industries; cotton textile mills, oil refineries, paper mills, sugar refineries and wineries; experienced unremarkable

[26]We have not formally tested for persistence among the average cost or output ratios. When we refer to the persistent differences in these ratios we mean that, among the series plotted in Figures 1-9, only steel mills' average costs and output levels appear to converge towards 1.00 over the period of study.

time series trends. Although the quantitative conclusions regarding average costs are time dependent, the qualitative conclusions discussed throughout the paper are robust across three sub-periods; pre-1940, 1940-1972, and post-1972.

Insert Figure 1-9

3.3 Output Levels

If the *ex ante* average cost differentials reported in Column 1, Table 2, and Figures 1-9 were related to a failure to exploit all available returns to scale, we would expect to find that the high cost industries produced relatively low levels of output. Although this does not necessarily apply only to the Canadian industries, we would expect lower output levels to be more common among the Canadian producers because of the small, diffuse nature of the domestic market. Annual output figures for each of the nine Canadian and American industries represented have been derived by calculating an unweighted average of the firm specific output figures for each year.[27] The mean ratio of Canadian relative to American industry output levels (and their standard deviations) are reported in Column 2, Table 2.

Similar to our average cost results, in all nine industries the firm specific output distributions overlapped. This implies that the producer with the highest output levels among the firms in the low output nation had higher output figures than the producer with the lowest output levels among the firms in the high output nation. Despite the overlapping output distributions, the Canadian cotton textile mills, distilleries, oil refineries, paper mills, silk and synthetic fibre textile mills, steel mills and sugar refineries included in the sample were producing less output per year than their U.S. counterparts, at the mean of the data. Only the Canadian cement manufacturers and wineries were producing greater mean annual output levels than the U.S. firms in the same industry. For some of the industries, particularly distilleries, silk and synthetic fibre textile mills and steel mills, the Canadian firms were producing only a small fraction of the U.S. firms' output levels. Only Canadian oil refineries and paper mills had both lower average output levels and lower average costs, at the mean of the data.

The mean output ratios, like the average cost ratios, are quite representative of the nine industries' experiences over the entire period of study. The few noteworthy exceptions to this generalization that can be seen in Figures 1-9 include output ratios that were substantially

[27] Output has been measured as firm specific total revenue deflated by an industry specific index of output prices. Where available, physical output proxies have been compared to the deflated revenue figures. The qualitative conclusions that follow are robust to the choice of output measure.

higher than the mean for paper mills and wineries during the 1950s, and cement manufacturers near the end of the period of study. The other six industries experienced no dramatic deviations from their mean ratios. Again, the quantitative conclusions with respect to relative output levels are time dependent, but the qualitative conclusions hold across three sub-periods; pre-1940, 1940-1972, and post-1972.

4 The Relationship Between Output and Average Costs

4.1 Estimating Long Run Average Cost Functions

A quick comparison of Columns 1 and 2 from Table 2, and the series plotted in Figures 1-9, reveals a coincidence between many of the high average cost industries, relative to their cross-border counterparts, and the low output industries, relative to their cross-border counterparts. However, low output levels are not necessarily associated with relatively high average costs. If low output levels were responsible for high average costs, then the manufacturers must have been producing on the locally increasing returns portion of their long run average cost functions. To determine whether the industries represented were producing subject to increasing, decreasing or constant returns to scale, we can econometrically estimate their long run average cost functions.

We can find econometric estimates of C.E.S., Cobb-Douglas and generalized Leontief cost functions for twentieth century Canadian and American manufacturing industries in the literature.[28] However, in this paper these common cost function specifications have not been employed. Instead we follow Woolf (1984) and Cain and Paterson (1981) in the choice of the translog specification. Translog cost functions are flexible in the sense that the Cobb-Douglas and C.E.S. specifications are special cases. Like the generalized Leontief, the translog allows for the direct estimation of factor substitution possibilities, biased technical changes and input specific returns to scale. However, the translog cost function also allows the joint returns to scale estimates and elasticity estimates to be output dependent. This implies that the translog specification facilitates the determination of the global curvature properties of the estimated cost functions.

Because the translog cost functions estimated for this paper are time dependent, their shape and position evolve over the period of study. This implies that we are not estimating

[28]For example, see Keay, 2000A, Park and Kwon, 1995, Diewert and Wales, 1987, Cain and Paterson, 1986, or Woodland, 1975.

single, fixed long run average cost functions over the entire 1910-1988 period. We are, however, estimating long run average cost functions with fixed evolutionary patterns over these years.[29]

A translog cost function takes the form:

$$\begin{aligned} lnC_t \;=\; & \alpha_0 + \sum_{x=1}^{n} \alpha_x lnW_{xt} + \sum_{x=1}^{n}\sum_{y=1}^{n} \alpha_{xy}(0.5lnW_{xt}lnW_{yt}) + \beta_q lnQ_t + \beta_{qq}(0.5(lnQ_t)^2) \\ & + \sum_{x=1}^{n} \beta_{qx}(lnQ_t lnW_{xt}) + \beta_{qa}(lnA_t lnQ_t) + \gamma_a lnA_t + \gamma_{aa}(0.5(lnA_t)^2) \\ & + \sum_{x=1}^{n} \gamma_{ax}(lnA_t lnW_{xt}) \qquad (1) \end{aligned}$$

We allow: $\alpha_{xy} = \alpha_{yx}$; $\sum_{x=1}^{n}\alpha_x = 1$; $\sum_{x=1}^{n}\alpha_{xy} = \sum_{x=1}^{n}\beta_{qx} = \sum_{x=1}^{n}\gamma_{ax} = 0$; x, y = labour (L), capital (K), intermediate inputs (M); C_t = total cost in time t; Q_t = physical output in time t; A_t = productivity parameter in time t; and; W_{xt} = nominal price of input x in time t.

Applying Sheppard's Lemma to the functional form (1), including firm specific fixed effects variables[30] and an additive disturbance term, imposing symmetry, and assuming that the natural logarithm of the productivity parameter can be characterized by a time trend, yields three cost share equations for each of the Canadian and American industries studied in this paper. The systems of cost share equations are linear in the natural logarithm of input prices, output and productivity, and can be estimated using unbalanced panel data.

$$\frac{W_{Lt}L_t}{C_t} = \alpha_L + \alpha_{LL}lnW_{Lt} + \alpha_{LK}lnW_{Kt} + \alpha_{LM}lnW_{Mt} + \beta_{qL}lnQ_t + \gamma_{aL}t + \mathbf{\Theta}\mathbf{V}_t + e_{Lt} \qquad (2)$$

$$\frac{W_{Kt}K_t}{C_t} = \alpha_K + \alpha_{KK}lnW_{Kt} + \alpha_{LK}lnW_{Lt} + \alpha_{KM}lnW_{Mt} + \beta_{qK}lnQ_t + \gamma_{aK}t + \mathbf{\Theta}\mathbf{V}_t + e_{Kt} \qquad (3)$$

$$\frac{W_{Mt}M_t}{C_t} = \alpha_M + \alpha_{MM}lnW_{Mt} + \alpha_{LM}lnW_{Lt} + \alpha_{KM}lnW_{Kt} + \beta_{qM}lnQ_t + \gamma_{aM}t + \mathbf{\Theta}\mathbf{V}_t + e_{Mt} \qquad (4)$$

In addition to the variables defined for equation (1): $\mathbf{\Theta}$ = a vector of fixed effects parameters; $\mathbf{V}_t$ = a matrix of firm specific fixed effects variables; and; e_{xt} = additive disturbance term which is assumed to be independently and identically distributed with a non-singular, non-diagonal covariance matrix.

[29] Generalized Leontief cost functions have also been estimated for the eighteen industries in the sample. The G.L. systems have been estimated using all of the available data, and data from three sub-periods; pre-1940, 1940-1972, and post-1972. The estimated returns to scale and technological similarities are generally consistent across the sub-periods, and independent of the cost function specification. For more detail see Keay, 2000A.

[30] The use of unbalanced panel data requires an accommodation of firm specific shifts in the estimated cost functions. Fuss, 1977, Pg. 99, argues that when the number of firms, or regions, in a panel is small the fixed effects approach is more convenient and there is no cost in terms of efficiency. Standard Breusch-Pagan specification tests confirm that the random effects approach is inappropriate for most of the systems estimated for this paper. The fixed effects parameters have been constrained to be equal across the equations in each system. This constraint implies that we are allowing a firm specific shift in the cost functions as a whole, not in the individual cost share equations.

Because the share equations (2), (3) and (4) must, by definition, sum to one, only two of these equations are linearly independent at each point in time. It is common practice to avoid the resultant problems with singular disturbance covariance and residual cross-products matrices by dropping one of the share equations from the systems to be estimated.[31] The need to measure local and global economies of scale requires an estimate for all of the parameters in the cost functions. In particular, β_q and β_{qq} do not appear in any of the cost share equations. Therefore, after including firm specific fixed effects variables and an additive disturbance term, imposing symmetry, and assuming that the natural logarithm of the productivity parameter can be characterized by a time trend, the cost function (1) has been estimated with the share equations (2) and (3) for each of the Canadian and American industries in the sample. In an effort to improve the efficiency of the estimated parameters, an iterative Zellner seemingly unrelated estimator technique (I.Z.E.F.) has been employed. This estimation technique is equivalent to maximum likelihood estimation.[32]

By definition every cost function must be continuous in input prices, homogeneous of degree one in input prices, non-decreasing in input prices and concave in input prices. The first two of these conditions are satisfied for the translog specification employed in this paper by construction. The other two conditions are dependent on the parameter estimates and independent variables for each industry. The condition requiring that costs be non-decreasing in input prices is satisfied at the mean of the data for all eighteen industries studied in this paper. The concavity condition is satisfied at the mean of the data for Canadian paper mills, sugar refineries and oil refineries and all of the U.S. industries, except wineries. All of the required conditions hold for each industry in at least a subsample of the period studied.[33]

4.2 Local Returns to Scale and Scale Elasticities

Using the estimated parameters from the Canadian and American cost functions and share equations; (1), (2) and (3); we can derive jointly determined local returns to scale estimates

[31] The econometric techniques used were drawn primarily from Berndt, 1991, Pg. 469-479, and Judge, Griffiths, Hill, Lutkepohl and Lee, 1985, Chapter 13. A complete set of econometric results is available from the author.

[32] In the systems for which there was evidence of autocorrelation among the errors, the data have been transformed as described in Berndt, 1991, Pg. 477-478.

[33] The failure rates for the systems estimated for this paper compare favourably with failure rates reported in the literature. See Diewert and Wales, 1987, Table 1.

Table 3: Local Scale and Average Cost Elasticities

	Column 1: $Joint\overline{RTS}$	*Column 2:* $\overline{\epsilon_Q}$
Cement: Canada	1.091*	-0.084
US	1.039**	-0.037
Cotton: Canada	1.698*	-0.411
US	0.997*	0.003
Distilleries: Canada	1.470*	-0.320
US	1.437*	-0.304
Oil: Canada	1.070*	-0.065
US	1.061*	-0.057
Paper: Canada	1.136*	-0.120
US	1.007**	-0.007
Silk: Canada	1.043*	-0.041
US	0.938*	0.066
Steel: Canada	1.117*	-0.105
US	0.970*	0.031
Sugar: Canada	1.069*	-0.065
US	1.017*	-0.017
Wine: Canada	1.203*	-0.169
US	1.917*	-0.478

(*) indicates statistical significance at 95%, (**) indicates statistical significance at 90%.

for each of the eighteen industries in the sample, at the mean of the data.[34]

$$
\begin{aligned}
Joint\overline{RTS} &= \frac{d\overline{lnQ}}{d\overline{lnC}} \\
&= \left(\widehat{\beta_q} + \widehat{\beta_{qq}}\overline{lnQ} + \widehat{\beta_{qL}}\overline{lnW_L} + \widehat{\beta_{qK}}\overline{lnW_K} + \widehat{\beta_{qM}}\overline{lnW_M} + \widehat{\beta_{qa}}\overline{t}\right)^{-1}
\end{aligned}
$$

The $Joint\overline{RTS}$ estimates can be more accurately described as elasticities which identify scale economies and indicate how sensitive output was to small changes in input levels. More specifically, the figures reported in Column 1, Table 3, reveal what the percentage change in output would have been in response to a 1% increase in the employment of all three inputs, evaluated at the mean of the data. If output increased by greater than 1%, then there were local economies of scale available for exploitation, at the mean of the data. If output increased by less than 1%, then we have evidence that there were local diseconomies of scale present. If the change in output would not have been statistically significantly different from 1%, then constant returns to scale applied.

From Column 1, Table 3, we can see that all nine of the Canadian $Joint\overline{RTS}$ parameters and six of the nine U.S. $Joint\overline{RTS}$ parameters are greater than one and statistically significant

[34] In this paper the term “jointly determined returns to scale” is used to distinguish the estimated returns to scale for the entire production process from input specific returns to scale estimates.

with at least 90% confidence.[35] This implies that these industries had local scale economies available for exploitation prior to the implementation of the F.T.A.. This in turn implies that it was reasonable to expect that these industries would be able to lower their long run average costs through output expansion. Three of the U.S. industries; steel mills, cotton textile mills and silk and synthetic fibre textile mills; were producing subject to decreasing returns to scale. If we assume that the lack of any statistically significant movement in output levels of greater than, or less than, 1% can be equated with constant returns to scale, then none of the eighteen industries were producing subject to constant returns.[36]

The results reported in Table 2 and Column 1, Table 3, are exactly the type of evidence that led to the *ex ante* formulation of optimistic predictions regarding changes in long run average costs in response to the F.T.A.'s bilateral tariff reductions. It is apparent that seven of the nine relatively high cost industries also had relatively low output levels and unexploited local economies of scale. Paper mills and oil refineries, two industries whose costs are primarily driven by the price and employment of their raw material inputs, were the only exceptions to this pattern. The identification of a relationship between high cost-low output industries and the presence of local increasing returns to scale is where most of the empirical work on scale and performance that was produced prior to 1989 stops. However, the presence of some disadvantages due to scale does not necessarily imply that was reasonable to expect that any expansion in production levels, induced by bilateral tariff reductions, would result in substantial average cost convergence, and export and income improvement.

More specifically, we can state that our identification of local scale economies tells us little about the sensitivity of average costs to changes in output levels. If an industry has been producing on a flat portion of its long run average cost function, it may have statistically significant returns to scale, but only minor cost savings associated with output adjustment. To quantify the responsiveness of average costs with respect to output adjustment we must focus on the magnitude, rather than simply the statistical significance, of the scale elasticities reported in Column 1, Table 3.

[35]We can reject the hypotheses that the Canadian and American industries were employing common translog cost functions, or that they were producing subject to common returns to scale, for all nine industries, with at least 95% confidence.

[36]Because we are using long time series of firm specific, rather than plant specific, data to estimate industry cost functions, there may be bias introduced as a result of firm entry and exit (the survivor problem) and changes in the quality of inputs employed and outputs produced. See Olley and Pakes, 1996. These biases will tend to exaggerate any scale effects we estimate. Because we seek to put the scale effects in the most favourable light possible, the presence of any bias of this type strengthens the conclusions presented in the final section of this paper.

Some of the industries' scale elasticities were surprisingly large. Canadian cotton textile mills, and Canadian and American distilleries and wineries, for example, all had $Joint\overline{RTS}$ parameters greater than 1.20. This indicates that, during the years prior to 1989, a 1% increase in the employment of all inputs would have resulted in an increase in these industries' output levels of over 1.2%, at the mean of the data. In general, however, both nations' producers' pre-F.T.A. scale elasticities were small.[37] Canadian and American cement manufacturers, oil refineries, silk and synthetic fibre textile mills and sugar refineries, as well as U.S. cotton textile mills, paper mills and steel mills, had scale elasticities that varied from constant returns by less than 0.10.

In an effort to provide a more economically relevant illustration of average cost sensitivity to output adjustment we can use the estimated parameters and independent variables from the cost functions and share equations; (1), (2), and (3); to calculate the elasticity of average cost with respect to output, ϵ_{Qt}, for the eighteen industries included in the sample. This calculation involves a simple transformation of the scale elasticities reported in Column 1, Table 3. However, this transformation facilitates a clearer demonstration of the variation in average costs we should have anticipated in response to small, free trade induced changes in output levels.

$$\begin{aligned}
\epsilon_{Qt} &= \frac{dln(C_t/Q_t)}{dlnQ_t} \\
&= \frac{\%\Delta(C_t/Q_t)}{\%\Delta Q_t} \\
\overline{\epsilon_Q} &= (\widehat{\beta_q} - 1) + \widehat{\beta_{qq}}\overline{lnQ} + \widehat{\beta_{qL}}\overline{lnW_L} + \widehat{\beta_{qK}}\overline{lnW_K} + \widehat{\beta_{qM}}\overline{lnW_M} + \widehat{\beta_{qa}}\overline{t}
\end{aligned}$$

The elasticity of average cost with respect to output is equal to the percentage change in average cost in response to a 1% increase in output. Average cost elasticities which are less than zero are associated with scale elasticities greater than one, and they indicate that average costs fell as output levels rose. This suggests that output levels were to the left of the point of minimum efficient scale. Positive average cost elasticities are associated with scale elasticities less than one, and they indicate that average costs increased as output levels rose. This suggests that output levels were to the right of the point of minimum efficient scale.

[37] The scale estimates reported in Table 3 are broadly consistent with other empirical estimates found in the literature. Trefler, 2001, Section 10.2, argues that 4-digit Canadian manufacturing industries were unlikely to have had $Joint\overline{RTS}$ any greater than 1.10 during the decade prior to the implementation of the F.T.A.. Cox and Harris, 1986, Table 1, provide local scale estimates for a sample of Canadian manufacturing industries that range from 1.103 to 1.277. Diewert and Wales', 1987, Table 6, estimates of $Joint\overline{RTS}$ for the American manufacturing sector range from 0.61 in 1971 to 0.94 in 1947. Additional input specific scale estimates for the early years of the twentieth century can be found in Cain and Paterson, 1986, Table 4.

Column 2, Table 3, reports the elasticity of average cost with respect to small changes in output for each of the Canadian and American industries, calculated at the mean of the data. Again we can see that, prior to the implementation of the F.T.A., all nine Canadian industries and six of the nine American industries could have reduced their average costs by increasing their output levels. However, the producers' insensitivity to output adjustment is brought into sharper focus. Only two of the Canadian industries; cotton textile mills and distilleries; could have reduced their average costs by 0.17% or more, if they had expanded output by 1%. Only U.S. wineries and distilleries could have experienced a change in their average costs of more than 0.07% following a 1% expansion of their output levels, at the mean of the data. These elasticities reconfirm our belief that, prior to 1989, most of the industries studied in this paper were producing on very flat portions of their cost functions.

The inflexibility of average costs, in response to small output changes, among both the Canadian and American industries implies that scale effects may not have been important determinants of average cost performance. An investigation of the global curvature properties of the industries' cost functions is necessary to determine if more dramatic changes in output levels could have facilitated average cost convergence, and hence, improved export and income performance.

4.3 Minimum Efficient Scale

In general, movements along a long run average cost curve in response to changing output levels are accompanied by changing elasticities of average cost with respect to output. Therefore, we should not use the local elasticity measures reported in Table 3 to identify the available average cost savings, except in response to small changes in mean output levels. To determine the extent to which it was reasonable to anticipate average cost reductions following the implementation of the F.T.A. in response to more substantive changes in Canadian and American manufacturers' output levels, we must study the global curvature properties implied by our cost function estimates. In particular, two issues remain unresolved: Was it reasonable to expect that Canadian and American manufacturers could produce output levels equal to their minimum efficient scale?; and; Was it reasonable to expect that output adjustment alone could eliminate the differences between the Canadian and American producers' average costs? If minimum efficient scale could not have been reached, then the assumption that trade liberalization would result in the exploitation of all available global returns to scale cannot hold.

Even if minimum efficient scale could have been reached, this does not necessarily mean that we should have predicted Canadian and American average cost convergence.

We can determine the output level at which the industries' long run average costs would have been minimized using the estimated parameters from the cost functions and share equations described in Section 4.1, and the independent variables, evaluated at their means. Setting the derivative of the average cost function with respect to output equal to zero, and solving for output, reveals the point of minimum efficient scale.[38]

$$lnQ^{mes} = \frac{-\left((\widehat{\beta_q} - 1) + \widehat{\beta_{qL}}\overline{lnW_L} + \widehat{\beta_{qK}}\overline{lnW_K} + \widehat{\beta_{qM}}\overline{lnW_M} + \widehat{\beta_{qa}}\overline{t}\right)}{\widehat{\beta_{qq}}}$$

Wonnacott and Wonnacott (1967; Pg. 176), and Cox and Harris (1986; Pg. 387) suggested that, in a tariff-free continental market, Canadian producers could exploit all their available returns to scale at output levels below those produced by their U.S. counterparts in the same industry. Using our estimates of minimum efficient scale for the sample of firms studied in this paper, we can investigate this possibility. In the top seven rows of Column 1, Table 4, the mean pre-F.T.A. industry output levels in Canada relative to the U.S. are reported for the industries in which Canada was the low output nation. In the remaining rows of Column 1, Table 4, the pre-F.T.A. industry average output levels in the U.S. relative to Canada are reported for the industries in which the U.S. was the low output nation. The next column in Table 4 reports the industry average output levels in the low output country, relative to the output level at minimum efficient scale, evaluated at the mean of the data, for that country. If minimum efficient scale could have been reached by matching the high output nation's mean output levels, then the ratios in Column 1 should be lower than those in Column 2.[39]

From Table 4 we can see that in six of the nine industries included in the sample minimum efficient scale could not have been reached prior to 1989, even if the low output country managed to match its counterpart's higher output levels. Only Canadian distilleries, steel mills and sugar refineries could have attained minimum efficient scale by expanding output levels up to, but not beyond, those produced by the American producers in the same industry. Some of the industries could not have come close to their minimum efficient scale by matching

[38]The second order condition for the determination of the point of minimum efficient scale requires that the average cost functions are convex in output. This condition has been imposed in the estimation of the translog cost functions for Canadian steel mills, cotton textile mills, silk and synthetic fibre textile mills, cement manufacturers and oil refineries, and U.S. oil refineries. The imposition of this constraint does not affect the qualitative conclusions regarding returns to scale discussed in Section 4.2.

[39]We can reject the hypothesis that the Canadian and American producers had common Q^{mes} for all nine industries, with at least 95% confidence.

Table 4: Output at Minimum Efficient Scale

	Column 1: $\overline{Q_{cda}}/\overline{Q_{us}}$	*Column 2:* $\overline{Q_{cda}}/Q_{cda}^{mes}$
Cotton	0.779	0.514
Distilleries	0.171	0.460
Oil	0.417	0.385
Paper	0.824	0.564
Silk	0.145	0.065
Steel	0.121	0.293
Sugar	0.467	0.943
	$\overline{Q_{us}}/\overline{Q_{cda}}$	$\overline{Q_{us}}/Q_{us}^{mes}$
Cement	0.683	0.361
Wine	0.650	0.281

Column 1: Mean industry output in low output nation relative to high output nation.
Column 2: Low output nation's mean industry output relative to minimum efficient scale, evaluated at mean of the data.

their counterpart's pre-F.T.A. output levels. Canadian paper mills would have required an increase in output of 44% to reach minimum efficient scale, but U.S. paper mills produced only 18% more output, on average. U.S. wineries would have needed to expand production levels by 72% to reach the low point on their long run average cost curves, but matching Canadian wineries' pre-1989 output levels would have increased their average output by only 35%.

Even if we consider other extreme output adjustment scenarios our basic conclusion remains intact. For example, if we assume that the low output nation doubled its pre-1989 mean output levels, again only three of the nine industries could have reached the lowest point on their long run average cost functions; Canadian cotton textile mills, paper mills and sugar refineries. It is apparent that, implicit in the anticipation of the complete exhaustion of scale economies by Canadian and American producers following trade liberalization, there was an expectation of very dramatic increases in the scale of production. It is not clear that this expectation was reasonable. Head and Ries (1999, Pg. 303) argue that, in theoretical trade models, "...home tariffs are usually anticipated to have positive effects on the size and numbers of firms with foreign tariffs having the opposite effects." Their *ex post* analysis of F.T.A. induced changes in Canadian plant sizes confirms this conclusion.

4.4 Minimum Average Costs

Bilateral trade liberalization may lead to rationalization and specialization that need not be confined by the output levels produced by the relatively high output nation. Therefore, even though in six of nine cases the low output industries represented by our sample of firms would have had to expand average production beyond that attained by the high output industry to achieve minimum efficient scale, we will assume that this might occur as a result of bilateral tariff reductions. As a result of this assumption, we can still ask if the high cost producers could have matched the lower costs of their counterparts through output adjustment alone. In an effort to bias our results towards the achievement of average cost convergence, we assume that inputs could be supplied perfectly elastically to the high cost producers, and that the low cost producers could not adjust their output levels to move towards minimum efficient scale.[40] In the first five rows of Column 1, Table 5, Canadian relative to American pre-F.T.A. average costs are reported for the industries in which Canada was the high cost nation. In the remaining rows of Column 1, Table 5, the American relative to Canadian average costs are reported for the industries in which the U.S. was the high average cost nation. The next column in Table 5 reports the average cost in the high cost country, relative to the average cost when output is at minimum efficient scale, evaluated at the mean of the data, for that country. If average cost differentials could have been eliminated through output adjustment alone, the ratios in Column 1 should be lower than those in Column 2.

Prior to the implementation of the F.T.A. only two of the nine industries studied in this paper could have experienced average cost convergence as a result of output expansion by the high cost producers. Canadian steel mills could have lowered their average costs by 35% had they managed to increase their average output levels to the point of minimum efficient scale. The U.S. steel mills had only a 4% cost advantage over the Canadian steel mills, on average. U.S. cement manufacturers could have reduced their average costs by 2.9% if they had increased their mean output levels to the point of minimum efficient scale. This would have given them a 0.2% cost advantage over the Canadian cement manufacturers. For some of the industries there was virtually no cost advantage associated with an expansion of output

[40]The first assumption implies that output expansion would not be accompanied by increasing input prices. The second assumption requires that the increased market size and competitive pressures associated with trade liberalization would have had an effect on the high cost producers' output decisions alone. Both of these assumptions bias the results reported in Table 5 towards achieving average cost convergence through output adjustment.

Table 5: Average Cost at Minimum Efficient Scale

	Column 1: $\overline{AC_{cda}}/\overline{AC_{us}}$	*Column 2:* $\overline{AC_{cda}}/AC_{cda}^{mes}$
Cotton	1.220	1.146
Distilleries	2.058	1.131
Silk	1.752	1.058
Steel	1.041	1.352
Sugar	1.015	1.002
	$\overline{AC_{us}}/\overline{AC_{cda}}$	$\overline{AC_{us}}/AC_{us}^{mes}$
Cement	1.027	1.029
Oil	1.045	1.013
Paper	1.220	1.001
Wine	1.383	1.351

Column 1: Mean industry average cost in high cost relative to low cost nation.
Column 2: High cost nation's mean industry average cost relative to average cost at minimum efficient scale, evaluated at mean of the data.

to the point of minimum efficient scale. Canadian sugar refineries, and U.S. oil refineries and paper mills, all would have experienced a decline in long run average costs of less than 1% had they moved to the low point on their long run average cost functions. Canadian cotton textile mills, silk and synthetic fibre textile mills and distilleries could have decreased average costs by between 6% and 15%. Unfortunately, these industries suffered from initial average cost differentials of between 22% and 106%.

Most of the manufacturers in the sample who produced at lower output levels than their cross-border counterparts prior to 1989 suffered from relatively high average costs, and produced on the increasing returns portion of their long run average cost functions. Given the elasticities of average cost with respect to output, it appears that production among the American and Canadian manufacturers was on relatively flat portions of their long run average cost curves. For most of the manufacturers, output would have had to expand beyond that produced by the same industry on the other side of the border to achieve minimum efficient scale. Even if minimum efficient scale could have been achieved, the high cost industry would have remained the high cost industry in seven of the nine industries studied here. It appears that the high cost producers would have had to rely on other determinants of average cost in addition the exploitation of returns to scale to achieve convergence.

5 Conclusions

On January 1, 1989, Canada and the United States implemented a bilateral trade agreement that called for the reduction and eventual elimination of tariff barriers on most traded goods. During the debate preceding the implementation of the F.T.A. those who predicted substantial welfare improvements attracted considerable attention. Their optimistic predictions were based primarily on the notion that trade liberalization would lead to output expansion, which would lead to the exploitation of scale economies, average cost convergence between Canada and the U.S., and increasing exports and income. The evidence presented in this paper suggests that, prior to 1989 there had been persistent, and in some cases substantial, average cost and output differences among Canadian and American producers. It is also apparent that many Canadian and American manufacturers were producing subject to locally increasing returns to scale. However, the producers' elasticities of average cost with respect to output were, in most cases, very low. This indicates that the manufacturers were producing on flat portions of their long run average cost curves in the years preceding the implementation of the F.T.A.. Calculations of minimum efficient scale confirm this conclusion. Those who suggested that bilateral tariff reductions could induce the exploitation of all available economies of scale were implicitly suggesting extreme output expansion scenarios. Even under these scenarios, Canadian and American producers' average costs would not have fully converged. Therefore, although there were some average cost reductions to be achieved through output adjustment, a consideration of the global curvature properties of the cost functions employed by Canadian and American producers during the 1910-1988 period could have undermined any claims that there might be economically substantive average cost convergence following the implementation of the F.T.A..

One question concerning the determinants of Canadian relative to American average cost differences springs from this conclusion. While a broader cross section of firms would be desirable prior to the formation of any definitive conclusions concerning the average cost performances of the aggregate manufacturing sectors in Canada and the United States[41], the evidence from the sample of firms studied in this paper indicates that relatively high average costs were not primarily due to the existence of untapped internal economies of scale. Other than returns to scale what may explain the observed average cost differentials? Since any

[41] For some evidence on Canadian and American average cost performance for a wider range of industries, from 1961-1988, see Lempriere and Rao, 1992, Pg. 18.

average cost function may be written, $C_t/Q_t = f(A_t, Q_t, W_{xt})$, and output level variation cannot explain average cost differences, we are, therefore, left with technology, productivity and input prices. Keay (2000A and 2000B) argues that, although Canadian and American technology has been domestically unique, there has been virtually no T.F.P. difference, on average, between the Canadian and American firms in the sample studied in this paper. If we accept these conclusions, then the observed differences between Canadian and American average costs must be due to differences in input costs[42], or some connection between output and average cost which has been unrelated to internal returns to scale. To complete our understanding of average cost differentials between Canada and the U.S., we must, therefore, turn our attention to the investigation of differences in input endowments and input markets in the two countries.

[42] Wylie, 1989, Pg. 576, argues that Canadian capital costs have been higher than American capital costs due to domestic tariffs. If this were true, then in addition to influencing scale and productivity, trade liberalization may also have lowered Canadian input prices, relative to American input prices. This effect of trade liberalization has not been considered in this paper.

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Data Appendix

Table 1: Descriptive Statistics for Data Series Employed

	N	Mean Q (σ_Q)	Mean L (σ_L)	Mean K (σ_K)	Mean M (σ_M)	Mean W_L (σ_{wL})	Mean W_K (σ_{wK})	Mean W_M (σ_{wM})	Mean P (σ_P)
Cement: Cda	77	30343.7	72995.6	27664.7	104075.9	2.91	0.94	0.92	4.02
		(24155.0)	(70079.1)	(18688.5)	(91026.6)	(3.88)	(1.13)	(0.70)	(4.33)
US	173	1104.5	50465.4	15641.5	28593.7	2.78	0.57	1.07	4.33
		(12151.5)	(45378.2)	(17967.8)	(37177.2)	(2.96)	(0.56)	(0.71)	(3.43)
Cotton: Cda	48	314340.6	149668.4	6943.8	252941.0	1.04	0.36	0.25	0.19
		(357597.8)	(150460.0)	(8452.7)	(231255.0)	(1.17)	(0.32)	(0.12)	(0.11)
US	159	686155.6	366876.7	14998.0	288660.5	2.07	0.88	0.33	0.22
		(580051.6)	(245248.0)	(8799.7)	(268223.2)	(2.64)	(0.78)	(0.22)	(0.16)
Distilleries: Cda	52	1799.7	10373.9	1711.5	8428.6	3.90	1.50	1.55	9.19
		(1336.8)	(5613.0)	(967.9)	(5536.4)	(4.70)	(2.01)	(0.99)	(6.17)
US	109	11964.0	39857.3	3290.1	52642.6	4.79	3.83	1.99	12.35
		(9011.4)	(21788.1)	(2766.2)	(38139.4)	(4.92)	(3.62)	(1.02)	(10.33)
Oil: Cda	178	3650758.0	229263.8	80400.5	155910.6	4.77	1.44	6.16	0.34
		(2874472.0)	(195216.2)	(95848.7)	(121933.9)	(6.07)	(2.23)	(8.60)	(0.43)
US	201	5921398.0	596652.9	312503.6	261389.3	4.32	0.97	5.94	0.32
		(7690327.0)	(495071.6)	(425186.8)	(298342.6)	(5.63)	(1.08)	(9.02)	(0.38)
Paper: Cda	132	273.0	80048.7	8851.1	306.0	3.39	0.77	138.66	221.90
		(226.3)	(80689.2)	(10626.1)	(253.3)	(4.70)	(0.71)	(149.39)	(221.74)
US	194	313.9	103112.0	29626.9	303.8	3.64	0.58	223.62	351.03
		(548.6)	(120103.1)	(41699.9)	(522.4)	(4.21)	(0.55)	(227.24)	(330.49)
Silk: Cda	71	30407.2	40455.5	1448.1	12355.6	1.97	0.77	3.05	0.74
		(34228.2)	(21143.5)	(919.1)	(11326.9)	(2.58)	(1.20)	(2.24)	(0.31)
US	104	241302.8	166290.5	3095.5	111198.6	2.24	1.30	2.18	0.62
		(386829.9)	(263503.1)	(3422.1)	(193832.5)	(2.67)	(1.30)	(2.22)	(0.33)
Steel: Cda	169	1513.9	359269.4	54124.0	7504.2	3.79	0.76	26.48	202.42
		(1147.5)	(236060.5)	(49992.8)	(6609.7)	(5.01)	(0.82)	(21.41)	(213.74)
US	448	8714.7	2970946.0	419571.9	29881.6	4.61	0.58	29.95	200.93
		(7934.3)	(3287819.0)	(483433.8)	(26329.0)	(6.66)	(0.64)	(30.83)	(238.96)
Sugar: Cda	31	528669.9	37108.0	6852.7	1010980.0	1.28	0.65	0.05	0.10
		(79533.2)	(10271.4)	(4282.5)	(351972.1)	(1.15)	(0.33)	(0.05)	(0.07)
US	128	1604587.0	83269.1	26711.5	3167292.0	2.38	0.46	0.07	0.11
		(1192641.0)	(72046.3)	(24211.4)	(3070864.0)	(2.87)	(0.57)	(0.07)	(0.09)
Wine: Cda	89	2459.3	8731.9	874.6	73593.7	4.18	1.69	0.09	4.55
		(1676.2)	(4727.9)	(628.2)	(57604.2)	(4.78)	(1.45)	(0.07)	(3.30)
US	59	1327.1	7634.3	1163.9	32215.9	2.07	1.01	0.10	5.13
		(1992.7)	(6927.7)	(1854.6)	(39318.0)	(1.21)	(0.83)	(0.04)	(1.14)

N = Total number of firm-year observations for which all data series are available. Source: See Section 3.1 and Keay, 1999, Appendix 2.A.