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The Canada-U.S. Productivity Puzzle: Regional Evidence of the Pulp and Paper Industry, 1971-2005

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Abstract

We analyze the total factor productivity (TFP) of the pulp and paper industry in three Canadian provinces (British Columbia, Ontario, and Quebec) and in three U.S. states that are contiguously located south of the border (Washington, Illinois, and Maine) over the period of 1971 to 2005. We find that the industry in the three Canadian provinces had much higher TFP growth rates in the era following the Free Trade Agreement (FTA), signed in 1988. In terms of productivity trend, this relative TFP surge has allowed the industry in the three Canadian provinces to move ahead of Illinois and Washington and closer to Maine which is the U.S. leader in the sample. Our results in this particular case do not support the commonly accepted view that Canada has a productivity problem relative to the U.S.

Key words: *Total factor productivity, income convergence, pulp and paper industry.*

JEL Classification: D24, L73, N62.

Résumé

Nous analysons la productivité totale des facteurs (PTF) de l'industrie des pâtes et papiers de trois provinces (Colombie-Britannique, Ontario et Québec) et de celle de trois états américains contigus au sud de la frontière (Washington, Illinois et Maine) au cours de la période allant de 1971 à 2005. Nous trouvons que l'industrie dans les trois provinces canadiennes a connu des taux de croissance de la productivité totale plus élevés après l'Accord de Libre Échange signé en 1988. En ce qui concerne la tendance de la productivité, cette accélération de la PTF a permis à l'industrie de devancer l'Illinois et Washington et de se rapprocher du Maine qui est le meneur aux E.-U. dans notre échantillon. Dans ce cas particulier, notre analyse ne supporte pas le point de vue souvent exprimé que l'industrie canadienne soufre d'un handicap au chapitre de la productivité totale par rapport à leurs compétiteurs américains.

Mots clés : *productivité totale des facteurs, convergence du revenu par habitant, industrie des pâtes et papiers.*

Classification JEL : D24, L73, N62.

"Canada has a serious productivity growth problem. The statistical evidence is unambiguous and of long standing."[1]

1 Introduction

Real GDP per capita increased at a slightly lower pace in Canada than in the U.S. from 1971 to 2005, i.e. 1.94 percent versus 2.00 percent; hence the income gap between the two countries grew larger from 14.7 percent to 16.4 percent over that period (U.S. Bureau of Labor Statistics, 2009). This ratio stayed within a narrow range over the last one hundred years. The failure of Canada income per capita to converge to the southern neighbor one is puzzling due to the proximity of the two countries, the extent of their economic integration, and the large set of shared characteristics. The rise in income gap after the signing of the Free Trade Agreement (FTA) in 1988 is even more puzzling due to the reduction or removal of tariff and non-tariff barriers that brought further integration of the two economies.

Given what is at stake for Canada, the issue continues to attract widespread attention from analysts and policy makers alike. Fingers are pointed to the lower productivity of Canadian labor and of the Canadian economy in general as illustrated by the above quote. The manufacturing sector has been under special scrutiny because of data availability and also due to some theoretical considerations. Chambers and Gordon (1966) argue that labor productivity of the trade exposed sectors not only determines the wage level of these sectors but also of the non-trade exposed sectors, hence of the whole economy.

In this paper, we analyze the total factor productivity (TFP) growth and level of the pulp and paper industry in three Canadian provinces: Québec, Ontario, and British Columbia (B.C.) and in three U.S. states: Maine, Illinois, and Washington over the period of 1971 to 2005. In addition to industry size, an important criterion in selecting

[1] Council of Canadian Academies (2009), p.11.

the U.S. states is the proximity to the Canadian border in order to compare fairly homogeneous entities in terms of available wood fiber, and final goods market access: the U.S. western area (B.C. and Washington), the Great Lakes area (Ontario and Illinois), and the U.S. northeastern area (Québec and Maine). The three provinces and the three states accounted for 85.0 percent and 11.2 percent of total industry revenues of their respective country in 2005. Canada and the U.S. are two of the largest players of the world pulp and paper industry and they jointly accounted for 45.9 percent of pulp and 28.6 percent of paper and cardboard produced in 2005 (F.A.O., 2007). Canada was a net exporter of both sets of products while the U.S. was a net importer. The two countries were their most significant trade partners: the shares of Canada's exports to U.S. were 45.8 percent for pulp and 81.2 percent for paper and cardboard while Canada provided 79.2 percent of U.S. pulp imports and 76.3 percent of paper and cardboard imports (F.A.O., 2007). So Canada and U.S. pulp and paper producers are direct competitors, particularly in the U.S. market.

The exports of Canada pulp and paper industry to the U.S. are free from tariffs since the U.S. Revenue Act of 1913, known as the Underwood Act; so the 1988 FTA had no direct impact on the final goods produced by this industry. However, there were potential indirect impacts through prices of intermediate goods. Trefler (2004) analyzed the FTA effects on 213 four digit level Canadian manufacturing industries from 1989 to 1996; although he used several performance indicators, value added per worker received particular attention. He found the direct effects to be particularly significant for industries that had been submitted to the largest tariff cuts and that technical efficiency improvement was the leading cause of productivity increase relative to scale effects and sector substitution. Material inputs account for more than 50 percent of the total revenue of the pulp and paper industry; hence there is room for indirect effects to be significant, particularly if technological change displays some factor biases. Since our sample runs from 1971 to 2005[2], we are able to compare the

[2]The sample ends in 2005, due to data availability and also to the major structural change that accelerated at that time. According to information provided by the Forest Product Association of

relative TFP performance of the pulp and paper industry located on each side of the border before and after the 1988 FTA. According to Trefler (2004), the tariff cuts were relatively more important in Canada than in the U.S., hence we expect larger effects to occur on the northern side of the border, albeit through indirect effects.

The presentation proceeds as follows: in section 2, we provide a survey of previous studies dealing with pulp and paper industry TFP with emphasis on Canadian provinces and on Canada-U.S. comparisons. In section 3, we describe the basics of producing pulp and paper; this information sheds some lights on the economic environment of the industry in the North-American context. In section 4, we introduce the data underlying the analysis and in section 5, we present the methodology and the results. Finally, section 6 adds some concluding remarks.

Here are our main conclusions: first, the pulp and paper industry in the three Canadian provinces displayed much higher TFP growth rates in the post-FTA era; second, in terms of TFP levels, the three Canadian provinces have been mostly catching up since the Maine industry that was one of the leaders at the start of the period, was still ahead 35 years later. Washington and Illinois displayed rather dismal performance relative to B.C. and Ontario; finally, the better performance of the industry in the three Canadian provinces in the post-FTA era is reflected in the wage per worker that has reached the level received by U.S. workers.

2 Literature Review

There exists a very large set of applied and theoretical studies dealing with TFP measurement. They vary in terms of methodology, aggregation level, time and space coverage, time frequency, number of inputs and outputs, and price and quantity mea-

Canada (FPAC), 159 pulp and paper mills operated in Canada in 2005; this number was down to 73 in 2015. The downward spiral over such a short period, although present in all branches of the industry, hits particularly newsprint which has been staple in Canada over the last century.

surement.[3] Since our objective is to measure the TFP performance of the pulp and paper industry in three Canadian provinces and three U.S. states from 1971 to 2005, the literature survey is limited to studies that have some direct relationships in terms of regional coverage and time periods.

2.1 Canadian Regional Studies

Using the input price index approach based on a cost function with three inputs, capital, labor, and materials (KLM), Denny et al. (1981) estimated TFP growth rates and relative levels of a number of manufacturing industries in four Canadian regions in the early seventies. The results for the pulp and paper industry are displayed in Table 1. The annual TFP growth rates are negative and there is little level difference across regions except B.C. that is lagging. Using the input distance function approach applied to data on one aggregate output and five inputs (energy, virgin fiber, non-wood materials and services, production and administrative labor, and capital), Hailu (2003) estimated parametrically annual TFP growth rates over the 1970–93 period. Except for the Rest of Canada (Prairie and the Atlantic), the estimated annual growth rates were negative for this period.

To the best of our knowledge, no more recent Canadian study has been published on this topic and no study at the state level is available in the U.S.

2.2 Canada-U.S. Comparison

There are more studies providing Canada-U.S. comparisons at the aggregate industry level. Using quantity indices on three inputs (KLM), Denny et al. (1992) estimated that the industry had, on average, negative yearly performance in U.S. (-0.17 percent) and in Canada (-0.18 percent) over the 1973–80 period; in the ensuing years from 1980 to 1986, the situation got better in the U.S. (1.45 percent) but worsened in Canada

[3] Hulten (2001) presents a historical overview of TFP measurement and the major issues that are commonly encountered. Van Biesebroeck (2007) discusses various methodologies used to measure TFP and compares their effectiveness on the basis of simulated data.

(-0.48 percent). Nonetheless they evaluated the average TFP level to be slightly higher in Canada than in the U.S. (103.3) over the two periods. On the basis of a distance function applied to four outputs (pulp, newsprint, paper and board) and nine inputs, Hseu and Buongiorno (1994) estimated that TFP grew at the same pace (0.60 percent) in both countries from 1970 to 1984. Statistics Canada has a large ongoing research program on TFP measurement at various levels[4]; using quantity indices, Statistics Canada (1999) showed that Canada pulp and paper industry TFP grew at a faster pace (+0.80 percent) than the U.S. one in the first few years after the 1988 FTA, *i.e.*, from 1990 to 1995. While most studies presented thus far rely on industry data drawn from the Annual Census of Manufacturing, Keay (2000) assembled firm data (5 Canadian firms and 5 U.S. firms) to perform TFP level comparisons over time while considering three inputs (KLM). Using input price index, he measured that Canadian pulp and paper firms had, on average, higher TFP levels (122.0) relative to their U.S. counterparts over the 1971–80 and 1981–90 decades (Keay, 2000, Table 3), while using input quantity index (Keay, 2000, Table 5), he observed that the Canadian firms had slightly lower TFP levels (90.0 and 97.0). He drew the conclusion that the Canadian firms had, overall, as good TFP scores as their U.S. counterparts.[5] Hseu and Shang (2005) analyzed the TFP growth record of the pulp and paper industry in seventeen OECD countries from 1991 to 2000. They computed the Malmquist index applied to two outputs (pulp, paper and paperboard) and three inputs (wood pulp capacity, paper and paperboard capacity, and employee per unit of capital stock) and they observed that the average annual TFP growth rate was much higher in Canada (2 percent) than in the U.S. (0.2 percent) over this period.

Here are three conclusions that can be drawn from this literature survey: *first*, the TFP growth performance of the pulp and paper industry in Québec, Ontario, and B.C. was rather dismal in the seventies and the eighties; *second*, the TFP growth rate

[4]See Baldwin and Gu (2005).

[5]Keay (2000) covers a much longer period, 1911 to 1990, and includes nine industries. The pulp and paper industry is by far the largest industry in this set.

of the aggregate industry was higher in Canada than in the U.S. during the post-FTA era and *third*, there is no indication that the TFP level of the industry was lower in Canada than in the U.S.

Our goal is to assess whether these conclusions are still valid when we compare part of the pulp and paper industry operating under fairly similar conditions but on different sides of the Canada-U.S. border over the 1971 to 2005 period.

3 The Canada-U.S. Pulp and Paper Industry

The basics of paper making have remained more or less the same over the last century. Wood fiber is the main raw material. So the first stage of production is to free wood fibers from raw wood to yield pulp. There are two sets of pulp processes: in the first set, known as chemical processes, chemical products are mixed with raw wood to melt the lignin that binds fibers together. In the second set, known as mechanical processes, powerful electric motor activates abrasive stones to grind round woods or perforated metal disks to shred wood chips. At the second stage of production, cleansed fibers are mixed with additives and are spread on a rolling screen to be dried. These operations yield various kinds of paper and cardboard. Some mills produce pulp only while others specialize in making paper; however a large number of mills are integrated and they make paper out of the pulp that they produce or purchase.[6] There is a world market for pulp products. Some end products such as printing paper and newsprint are traded on world markets although transportation costs tend to limit the extent of the relevant market. Some other products such as tissue and cardboard are sold on nearby regional markets.

According to Ghosal (2009), the pulp and paper industry performs little research and development (RD) and its RD intensity (0.5%) is one of the lowest amongst industries.[7] Pulp and paper mill owners share a common technology and they purchase

[6]There are two additional upstream stages: forestry operation and lumber production.
[7]The RD intensity of the Canadian pulp and paper industry was 0.6% in 2008.

their equipment from a small group of manufacturers serving the world market. Foreign ownership provides a way to transfer information across borders. Although the majority of plants are owned by Canadians, foreign ownership has been large enough and changing to make this a significant source of information transfer.[8] Productivity improvements result from tweaking the basic production process.

Here are a few changes that took place over the sample period: *first*, pulp production moved away from round wood to wood chips[9] and to deinked and recycled paper[10]. For instance, here are the shares of wood fiber used by the Québec pulp and paper industry in 2005: round wood (14.4 percent), wood chips (64.2 percent), and recycled and purchased pulp (22.4 percent) (Gouvernement du Québec, 2008). In the early seventies only round wood was used. *Second*, water quality regulation was introduced in 1971 and stricter rules were implemented in 1992.[11] As a result, total suspended solids (TSS) and biological oxygen demand (BOD) decreased by 60 percent and 40 percent, respectively, between 1970 and 1987 and by 60 percent and 90 percent between 1987 and 1996. These changes increased electricity used by electric motors required to pump and filter liquid materials.

There is a major difference between U.S. and Canada with respect to forest land ownership which is mostly private in the former and public in the latter. Here are the shares of wood entering pulp and paper mills that came from public lands: Québec (73.0 percent), Ontario (86.0 percent), and B.C. (94.0 percent)[12] while the share for the whole U.S. industry is only 8.0 percent. Access to public forest lands in Canada is governed by long term contracts between mill owners and provinces; these contracts set constraints on the annual allowable cuts. Private land ownership and the use of

[8] According to Baldwin and Gu (2005), plants controlled by foreigners accounted for the 30.6 percent of paper and allied products in 1987 and 38.2 percent in 1999.

[9] At the pulping stage, the industry made the complementary change from abrasive stones to perforated metal disks.

[10] U.S. regulations with respect to recycled fiber content in newsprint gave rise to this change.

[11] See Environment Canada (2012). Similar water quality regulations were introduced in U.S.

[12] The information was obtained from the Department of Natural Resources of the provinces and it relates to the end of the sample period.

auctions by the U.S. Forest Service do not give rise to such rigidity; hence U.S. pulp and paper mill owners have more freedom to adjust to evolving market conditions.

4 Data

Before we proceed to the TFP analysis, here is a brief introduction to our sample. We collected data on total output and five inputs, *i.e.* labor, capital, material, electricity, and fossil fuels (coal, natural gas, and refined petroleum products). Users of natural gas and oil refined products face closely related prices across the U.S. and Canada following the 1985 price deregulation. It is not so for electricity prices that display features of regional markets despite the fact that the U.S. Federal Energy Regulatory Commission (FERC) opened electricity transmission grid to wholesale market transactions in 1996.[13] The appendix presents the statistical framework that was adopted to measure the prices and quantities. The data come from readily available government sources.[14] Some energy price series had missing figures; closely related series were used to fill these gaps.[15]

As it can be seen in Table 2, the industry outputs of the six regions were close to each other in 1971; Maine had the smallest production level at 3315 million (1992 CAD) and Illinois the largest one at 5879 million. However, their growth rates over the sample period differ significantly; Ontario and Québec grew the fastest while Washington and Maine showed little increase and B.C. and Illinois experienced decrease. The evolution of output follows a hill shaped path in the six regions; however, peaks occurred earlier in U.S. than in Canada.

Table 3 presents real input price levels and changes.[16] Wage rates were lower in the Canadian provinces in 1971 and still in 1989; however, their growth rates were

[13]The Canadian provinces that trade electricity with the U.S. brought regulatory changes to satisfy reciprocity requirements imposed by FERC.

[14]Data sources are described in the appendix.

[15]The sample can be obtained from the lead author upon request.

[16]The industry selling price index is used to convert the current dollars into 1992 dollars.

much larger afterwards and B.C. ended up with the highest wage in 2005. Rates of return to capital were within the same range in 1971 although they were somewhat lower in B.C. and Washington. There were no clear patterns in the period up to 1989; afterwards their growth went into opposite directions: positive in the Canadian provinces and negative in the American states. As expected from the findings of Trefler (2004) on the relative impacts of tariff reduction in Canada and the U.S. after the 1988 FTA, the price of materials fell in the Canadian provinces and increased in the U.S. states. The regional nature of electricity markets can be observed easily: Washington, Québec, and B.C. have much lower price in 1971 due to the large contribution of hydro resources. The electricity prices increased in all regions, except Illinois that had the highest price to start with in 1971. The Ontario industry faced one of the highest electricity price rise due to major nuclear cost overrun in the eighties and nineties and the dismal electricity market deregulation in 2002. As expected the price of fossil fuels increased in all regions; however, the increase is larger in Canada than the U.S. Although the prices of oil and natural gas were deregulated in 1985, we do not observe price convergence across the regions over time. Maine and Ontario had lower prices in 1971 and they still did in 2005. Québec and B.C. faced the largest price increases.

The information on input prices shows that regional market conditions differ significantly with respect to input price levels and changes, thus providing different benefits to productivity improvements. Yet all these plants were competing on the same markets for their final output.

5 The Productivity Record

We use the formula proposed by Caves et al. (1982) to measure TFP across regions and over time:

$$\ln \lambda_{it} = (\ln Y_{it} - \overline{\ln Y}) - \frac{1}{2}\sum_{k=1}^{K}(S_{it}^{k} + \overline{S^{k}})(\ln X_{it}^{k} - \overline{\ln X^{k}}) \tag{1}$$

where, λ_{it} represents the productivity level of region i in year t, Y_{it} is the output of region i in year t, S_{it}^k represents the cost share of factor k in region i in year t, X_{it}^k is the input k in region i in year t, k is the number of inputs, $\overline{\ln Y}$ is the average of $\ln Y_{it}$ over regions and time, $\overline{S^k}$ is the average of S_{it}^k over regions and time, and $\overline{\ln X^k}$ is the average of $\ln X_{it}^k$ over regions and time.

This index is exact in the class of constant returns Translog transformation function. A desirable feature in the present context is its transitivity; as it can be seen from 1, the TFP index provides a comparison of the TFP of region i in year t relative to the average over all regions and time periods. Hence it is independent of the choice of a particular region and time period as a basis of comparison.[17]

The results of the application of formula 1 to our sample appear in Table 4. Here are some comments: *first*, all Canadian provinces had lower TFP than their territorial counterpart in 1971 and the largest discrepancy was between B.C. (0.803) and Washington (0.904). *Second*, the Canadian provinces experienced lower TFP growth before the 1988 FTA than their territorial counterparts; Ontario (0.40 percent) is the exception relative to Illinois (0.23 percent). However, the latter still had a higher TFP level in 1988. *Third*, the three Canadian provinces had markedly higher TFP growth rates in the post 1988 FTA era; so much so that Ontario (1.088) and B.C. (1.001) moved ahead of Illinois (0.959) and Washington (0.955). However, Québec (1.024) was still lagging behind Maine (1.151). *Fourth*, Maine was one of the leaders in 1971 and was still leading in 2005; there is not a year when a Canadian region offered the best TFP performance across all six regions. In that sense, the Canadian producers have been mostly catching up in terms of TFP level while Washington and Illinois had dismal experience.

The signing of the FTA in 1988 is associated with a structural break in the evolution of the TFP in the three Canadian provinces and the three U.S. states. In order to

[17]However, it is subject to the sample at hand. The application of the equivalent index in terms of output and factor prices yields identical results.

explore this break, we will look at the partial input productivity generated by the decomposition of 1.

Before we do so, let us recall the relationship between the input bias of technological change and input price changes. Productivity improvement results when factor augmenting technological change is combined with declining input price and when factor saving technological change is combined with increasing input price; productivity worsens when the directions of input price changes are inverted. Hussain (2015) applied the Translog cost function model to analyze the input bias associated with autonomous technological change for the industry that is part of the current study. He found that technological change was generally labor, and fossil fuels saving and capital, materials, and electricity using. From Table 3, we observe that albeit for materials, all the input prices increased faster in the three Canadian provinces than in the three U.S. states. Hence we expect productivity improvements resulting from the interaction of input bias of technological change and input price changes for labor, materials, and fossil fuels and productivity decrease for capital, and electricity.

Table 5 displays the partial and total factor productivities for 1971, 1989, and 2005 for the three Canadian provinces while Table 6 shows similar information for the three U.S. states. It can be observed that the partial productivity of capital and labor increased more in the three Canadian provinces than in the three U.S. states while the materials productivity record is worse for the former. This result is expected given the interaction of technological change input biases and input price changes. The partial productivity change of electricity and fossil fuels played, in general, minor role. This is expected given their relative contribution to production.

6 Conclusion

GDP per capita is lower in Canada than in the U.S. and the century old gap has been growing after the 1988 FTA that led to further integration of the two economies.

This is a source of concern to policy makers in Canada and the lower productivity of the Canadian economy is singled out as the main contributing factor as expressed in the quotation at the introduction. The TFP performance of the pulp and paper industry in three Canadian provinces (B.C., Ontario, and Québec) and in three U.S. states (Washington, Illinois, and Maine) over the period extending from 1971 to 2005 does not support such an assessment. The 1988 FTA provides a clear inflexion point: the TFP levels of the industry in the three Canadian provinces were lower than in the three U.S. states in 1988 while they were closer to the top in 2005. This is not due to direct effect since there were no tariff on end products over the whole period of time. However, there were indirect effects associated with the prices of materials that decreased in Canada while they were increasing in the U.S. This aspect of the 1988 FTA has received little attention thus far. The better TFP performance of the Canadian industry has supported higher wages for Canadian workers who earned wages in 2005 that were more or less at par with U.S. workers.

In the world economy, Canada still holds on to its historical and declining role of extracting and processing natural resources while adapting technologies for these operations that are available in industrialized countries with a mix of local and foreign ownership. Ore mining and smelting, oil production and refining, and chemical production are instances of such development. The analysis of the TFP performance of such industries is a worthwhile area of research; our results for the Canadian pulp and paper industry over the period from 1971 to 2005 do not support the commonly accepted view that Canada TFP is lagging U.S. TFP in this industry.

Appendix: Statistical Framework

Total revenue can be decomposed into factor payments:

$$P_t Q_t = P_{lt} L_t + P_{kt} K_t + P_{mt} M_t + P_{ft} F_t + P_{elt} EL_t \tag{2}$$

where,

Q_t = total output in constant dollars;

L_t = number of workers;

K_t = value of net capital stock in constant dollars;

M_t = value of materials in constant dollars;

F_t = quantity of purchased fossil fuels (coal, petroleum products, and natural gas) in Terajoules (TJ);

EL_t = purchased electricity in TJ;

P_t = industry selling price index;

P_{lt} = average annual wage in current dollars;

P_{kt} = gross rate of return to capital in current dollars;

P_{mt} = material price index;

P_{ft} = unit price of fossil fuels, current dollars per TJ;

P_{elt} = unit price of purchased electricity, current dollars per TJ.

Note that:

$P_t Q_t$ = total revenue (TR_t) in current dollars;

$P_{lt} L_t + P_{kt} K_t$ = value added (VA_t) in current dollars.

Public information is available on the following items:

P_t, P_{lt}, L_t, K_t, P_{ft}, F_t, P_{elt}, EL_t, and also on TR_t, and VA_t.

Transformations yield the following variables:

$$Q_t = TR_t/P_t \tag{3}$$

$$P_{kt} = (VA_t - P_{lt}L_t)/K_t \tag{4}$$

$$P_{mt}M_t = TR_t - VA_t - P_{ft}F_t - P_{elt}EL_t \tag{5}$$

The same development can be performed in constant dollars. Then the equivalent to expression 4 yields the value of materials in constant dollars, which is identified as the quantity of materials. The ratio of value of materials in current dollars to its value in constant dollars yields P_{mt}, *i.e.*, the materials price index. Data for the Canadian provinces come from Statistics Canada while the U.S. data were obtained from the following sources: Annual Survey of Manufactures (ASM), Census Bureau; Bureau of Economic Analysis (BEA); State Energy Data System (SEDS), Energy Information Administration (EIA); and Bureau of Labor Statistics (BLS).

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Table 1: **Pulp and Paper Industry TFP in Canadian Regions**

	Québec	Ontario	B.C.	Rest of Canada
Denny et al. (1981)				
Growth Rate (%) (1970–75)	-0.37	-0.9	-0.25	-0.81
Average Level (1961–75)	99.6	100	95.4	99.7
Hailu (2003)				
Growth Rate (%) (1970–93)	-0.91	-0.96	-1.09	0.41

Source: Denny et al. (1981) and Hailu (2003).

Table 2: **Production**
(1992 CAD in millions)

	Québec	Ontario	B.C.	Maine	Illinois	Washington
1971	5609	5476	4430	3315	5879	4010
2005	8520	8527	4251	3326	5025	4470
a	1.23	1.3	-0.12	0.01	-0.46	0.32
b	8618	8840	5193	6419	7593	6194
c	2002	2004	2000	1985	1994	1989

Notes: a. Annual average growth rate (%).
b. Maximum over the sample period.
c. The year when production reached its maximum.
Source: Authors' compilation.

Table 3: **Input Prices**
(1992 CAD)

	Québec	Ontario	B.C.	Maine	Illinois	Washington
Wage ($ per man year)						
1971	32464	31368	40042	43396	40847	47477
1989	33204	30135	40044	46065	35945	48639
2005	44582	45761	56583	49049	40885	52659
a (71–89)	0.1	-0.2	0.0	0.3	-0.7	0.1
a (89–05)	1.7	2.5	2.0	0.4	0.8	0.5
a (71–05)	0.9	1.1	1.0	0.4	0.0	0.3
Rate of Return (%)						
1971	0.28	0.33	0.12	0.26	0.29	0.18
1989	33204	30135	40044	46065	35945	48639
2005	0.46	0.52	0.34	0.22	0.14	0.14
a (71–89)	-1.3	0.7	5.1	2.0	-0.4	2.5
a (89–05)	4.3	1.9	0.4	-3.2	-3.9	-4.3
a (71–05)	1.4	1.4	3.1	-0.6	-2.1	-0.7
Materials (1992=1.00)						
1971	0.97	0.91	0.91	0.9	0.91	0.91
1989	0.96	0.97	0.64	0.99	0.99	0.97
2005	0.73	0.81	0.72	1.19	0.96	0.95
a (71–89)	-0.1	0.3	-1.9	0.5	0.4	0.3
a (89–05)	-1.6	-1.1	0.7	1.1	-0.2	-0.1
a (71–05)	-0.8	-0.3	-0.7	0.8	0.2	0.1
Electricity ($/TJ)						
1971	5053	7847	5916	17481	18260	4805
1989	5707	8361	7612	21102	21115	10415
2005	7269	18186	8302	19445	12322	11400
a (71–89)	0.6	0.3	1.3	0.9	0.8	4.1
a (89–05)	1.4	4.6	0.5	-0.5	-3.2	0.5
a (71–05)	1.1	2.5	1.0	0.3	-1.1	2.5
Fossil Fuels ($/TJ)						
1971	3349	2494	3360	3107	4031	3691
1989	6381	2400	6210	3096	5134	4611
2005	19390	5739	16299	4989	9120	7753
a (71–89)	3.4	-0.2	3.2	-0.0	1.3	1.2
a (89–05)	6.5	5.1	5.6	2.8	3.4	3.1
a (71–05)	5.2	2.5	4.6	1.4	2.4	2.2

Note: a. Average annual growth rate (%).
Source: Authors' compilation.

Table 4: **Total Factor Productivity, 1971–2005**

Year	Québec	Ontario	B.C.	Maine	Illinois	Washington
1971	0.922	0.922	0.803	0.976	0.979	0.904
1972	0.924	0.929	0.823	0.978	1.024	0.953
1973	0.919	0.946	0.831	1.025	1.079	0.959
1974	0.937	0.967	0.827	1.041	1.082	0.968
1975	0.929	0.946	0.801	1.028	1.018	0.956
1976	0.912	0.930	0.839	1.063	1.013	0.983
1977	0.922	0.925	0.842	1.087	1.040	0.984
1978	0.935	0.941	0.860	1.137	1.070	0.974
1979	0.945	0.961	0.860	1.147	1.084	1.000
1980	0.946	0.977	0.866	1.118	1.058	0.977
1981	0.933	0.966	0.847	1.104	1.049	0.949
1982	0.924	0.973	0.864	1.093	1.057	0.939
1983	0.930	0.966	0.860	1.086	1.044	0.987
1984	0.931	0.976	0.845	1.132	1.047	1.000
1985	0.923	0.979	0.876	1.136	1.066	0.978
1986	0.913	0.987	0.885	1.122	1.071	1.022
1987	0.898	0.993	0.899	1.095	1.022	1.039
1988	0.898	0.994	0.887	1.171	1.019	1.079
1989	0.898	0.991	0.846	1.115	1.020	1.041
1990	0.903	0.992	0.828	1.080	1.017	0.977
1991	0.895	0.995	0.856	1.017	1.021	0.954
1992	0.901	0.994	0.870	0.995	1.030	0.920
1993	0.906	1.000	0.893	1.025	1.095	0.967
1994	0.913	1.007	0.854	1.036	1.102	0.974
1995	0.899	1.005	0.845	1.231	0.964	0.940
1996	0.906	1.014	0.893	1.153	1.009	0.913
1997	0.929	1.019	0.890	1.110	1.041	0.959
1998	0.922	1.039	0.895	1.137	1.009	0.924
1999	0.939	1.041	0.908	1.183	0.975	0.905
2000	0.946	1.053	0.926	1.126	0.901	0.895
2001	0.962	1.065	0.924	1.096	0.906	0.882
2002	0.991	1.082	0.935	1.109	0.939	0.887
2003	0.978	1.080	0.967	1.110	0.937	0.944
2004	0.990	1.085	0.993	1.123	0.958	0.949
2005	1.024	1.088	1.001	1.151	0.959	0.955
a (71–05)	0.30%	0.47%	0.63%	0.47%	-0.06%	0.16%
a (71–89)	-0.10%	0.40%	0.29%	0.74%	0.23%	0.78%
a (89–05)	0.92%	0.58%	1.05%	0.19%	-0.39%	-0.54%

Note: a. Average annual growth rate (%).

Source: Authors' compilation. .

Table 5: **Partial and Total Factor Productivity in Canadian Provinces, 1971–2005**

	Capital	Labor	Materials	Electricity	Fossil Fuels	TFP
Québec						
1971	1.003	0.897	1.054	0.974	0.999	0.922
1989	0.900	0.939	1.101	0.950	1.015	0.898
2005	1.039	1.060	0.927	0.941	1.066	1.024
a (71–89)	-0.57	0.25	0.23	-0.13	0.09	-0.14
a (89–05)	0.84	0.71	-1.01	-0.06	0.29	0.77
a (71–05)	0.10	0.48	-0.37	-0.10	0.19	0.30
Ontario						
1971	1.024	0.882	1.025	0.997	0.997	0.922
1989	0.974	0.947	1.085	0.988	1.002	0.991
2005	1.104	1.046	0.927	0.991	1.025	1.088
a (71–89)	-0.26	0.37	0.30	-0.05	0.03	0.39
a (89–05)	0.74	0.59	-0.93	0.02	0.13	0.54
a (71–05)	0.21	0.49	-0.29	-0.02	0.08	0.47
B.C.						
1971	0.839	0.946	1.038	0.985	0.989	0.803
1989	0.855	1.031	0.959	0.986	1.015	0.846
2005	1.019	1.083	0.911	0.948	1.051	1.001
a (71–89)	0.10	0.45	-0.42	0.00	0.13	0.27
a (89–05)	1.03	0.29	-0.30	-0.23	0.20	0.99
a (71–05)	0.55	0.39	-0.37	-0.11	0.17	0.63

Note: a. Average annual growth rate (%).

Source: Authors' compilation.

Table 6: **Partial and Total Factor Productivity in U.S. States, 1971–2005**

	Capital	Labor	Materials	Electricity	Fossil Fuels	TFP
Maine						
1971	1.052	0.977	0.907	1.032	1.016	0.976
1989	1.081	1.049	0.935	1.032	1.019	1.115
2005	0.967	1.083	1.049	1.031	1.016	1.151
a (71–89)	0.14	0.38	0.16	0.00	0.02	0.70
a (89–05)	-0.65	0.18	0.68	0.00	-0.02	0.19
a (71–05)	-0.24	0.29	0.42	0.00	0.00	0.47
Illinois						
1971	1.086	0.923	1.002	1.022	0.954	0.979
1989	1.064	0.993	0.969	1.020	0.977	1.020
2005	0.984	0.978	1.063	1.005	0.932	0.959
a (71–89)	-0.11	0.39	-0.18	-0.01	0.13	0.21
a (89–05)	-0.45	-0.09	0.55	-0.08	-0.28	-0.36
a (71–05)	-0.28	0.17	0.17	-0.05	-0.07	-0.06
Washington						
1971	0.983	1.001	0.960	1.001	0.956	0.904
1989	1.002	1.075	0.993	1.002	0.971	1.041
2005	0.916	1.087	0.990	1.007	0.963	0.955
a (71–89)	0.10	0.38	0.18	0.00	0.08	0.74
a (89–05)	-0.53	0.07	-0.02	0.03	-0.05	-0.51
a (71–05)	-0.20	0.24	0.09	0.02	0.02	0.16

Note: a. Average annual growth rate (%).

Source: Authors' compilation.