CSLS Conference on the Canada – U.S. Manufacturing Productivity Gap

January 21 - 22, 2000 Château Laurier Hotel, Ottawa, Ontario

Centre for the
Study of Living Standards
Centre d'étude des
niveaux de vie

Canada-U.S. Productivity in the Chemical Industry

Someshwar Rao
Industry Canada

Frank Lee
Industry Canada

Ron Hirshorn

Session 4 “Industry Productivity Studies in the Manufacturing Sector”
January 21 4:30 PM - 6:00 PM

CANADA-U.S. PRODUCTIVITY IN THE CHEMICAL INDUSTRY*

Someshwar Rao**, Frank Lee** and Ronald Hirshhorn***

January 2000

Prepared for CSLS Conference on the Canada-U.S. Manufacturing Productivity Gap, Ottawa, January 21-22, 1999.

* We are grateful to Jianmin Tang and Phaedra Kaptein-Russell for their assistance and comments. The views expressed in this paper are of the authors only, and do not necessarily reflect those of Industry Canada or of the federal government.

** Industry Canada

*** Economic Consultant

1. Introduction

The chemical industry is one of the most important members of Canada's manufacturing sector. The industry utilizes the country's natural resources, including oil and gas, energy and minerals, to develop a wide range of industrial and consumer products, and, in the process, provides high quality jobs for Canadian workers. Technologies developed in the chemical industry contribute to the competitiveness of a wide range of industries including textiles, petroleum refining, agriculture, rubber, autos metals, health services and construction. While the industry merits attention because of its economic importance, it is also of interest because of a number of its characteristics. Notable features include its knowledge intensity; the diverse mix of industry output which includes commodities as well as highly specialized products; and the high degree of foreign ownership within the Industry.

Canadian firms are small players in the U.S$ 1.5 trillion global chemical and chemical products industry. The industry has become increasingly globalized over the 1990s, with major firms attempting to increase the scope and depth of their global operations through mergers, acquisitions and alliances backed by direct investment. In 1995, the world's top ten producers accounted for about three-quarters of global production of chemicals, including pharmaceuticals. While the U.S. Japan and Germany account for over half of world chemical production, many newly industrialized nations have recently embarked on ambitious programs to develop globally competitive industries. In this intensely competitive environment, countries must foster the development of innovative, high performing enterprises to succeed in the competition for export markets and foreign investment.

This paper examines the market characteristics, productivity and cost performance of the Canadian chemical industry. It assesses the performance of the industry relative to other Canadian manufacturing industries and against the performance of the chemical industry in the U.S. and other G7 countries. The factors underlying the industry's recent performance are discussed and various areas of industry strength and weakness are identified.

There is a need to be cautious in interpreting the significance and broader implications of changes in the performance of individual sectors. An improvement in an industry's international competitiveness is not necessarily associated with an improvement in Canadians' per capita income. Cost competitiveness could improve because of a decline in the exchange rate that results in an effective reduction in Canadians' average real income. Alternatively, poor performance by an industry may be associated with a shift in resources out of this sector into more strongly growing activities, an adjustment that will contribute to stronger economic growth. Measures of industry performance do have implications for national economic well-being to the extent they shed light on the country's ability to achieve high rates of productivity growth. Changes in industry competitiveness that are associated with changes in labour productivity have relevance for the broader objective of improving Canadians' living standards.

In reviewing the performance of the chemical industry, we have been sensitive to the fact that competitiveness is ultimately about the economy's ability to sustain the productivity growth needed to support rising Canadian living standards. Various aspects of industry performance are examined, but particular consideration is given to understanding what the chemical industry can tell us about the ongoing efforts by Canadian firms to develop products and introduce processes that allow them to extract greater value out of the economy's scarce resources.

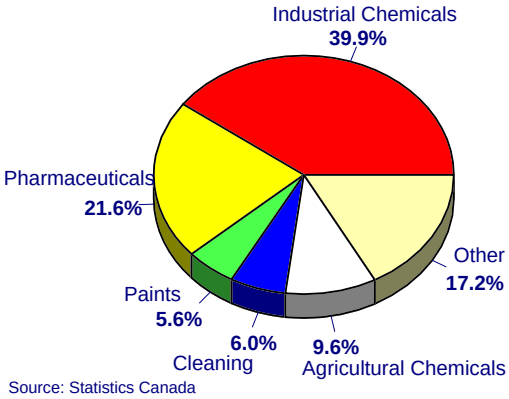
2. Industry Profile and Comparison with U.S.

General Characteristics

Measured by value added, the chemical industry is Canada's third largest manufacturing industry, exceeded only by transport equipment and food. It accounts for just over 8% of manufacturing value added and about 5% of total manufacturing employment. The Canadian chemical industry's 87,000 employees, worked in about 1400 establishments and shipped goods valued at over $30 billion in 1997.

The chemical industry is an outward-looking sector with a heavy trade orientation and a high degree of inward foreign direct investment. Almost 55% of the industry's gross output was exported in 1996, as compared to 50% for total manufacturing. The degree of foreign direct investment (FDI) as measured by the sector's inward FDI stock as a proportion of gross output was 50 percent, well above the manufacturing average of 30 percent. Foreign-controlled corporations, which accounted for 30% of total Canadian business revenues in 1996, were responsible for about 65% of chemical industry sales (based on CALURA data which lump together chemical products and textiles).

Figure 1 - Distribution of Canada's Chemicals Value-added, 1996



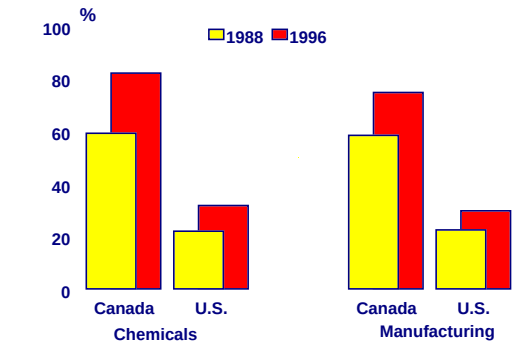
The different segments of the chemical industry are indicated in Figure 1. The industry incorporates activities with quite different characteristics and market dynamics. One important distinction is between commodity-type chemicals that are manufactured in capital-intensive facilities and specialty and formulated products. The latter, which tend to be produced in smaller facilitates that are geared to differentiating their product and service, include pharmaceuticals and medicines, paints and varnishes, soaps and cleaning compounds, crop protection chemicals, specialty and fine chemicals, and a wide variety of formulated products. Producers of specialty and formulated products invest relatively more in R&D, and this remains the case even after the relatively research-intensive pharmaceutical sub-sector is excluded. While R&D as a percentage of output is over 2 percent for producers of chemicals other than pharmaceuticals, it is less than 1 percent for the industry chemical sector that is mainly comprised of commodity chemical producers.

Canada-U.S. Comparisons

With the high degree of integration of North American chemical markets, there is special interest in assessing the competitiveness of Canadian firms relative to U.S. producers. The U.S. chemical industry is the world's largest, accounting for about 27% of total world chemical production. It also constitutes the largest manufacturing industry in the U.S. in terms of value added. With just over 1 million employees in 1996, however, the U.S. chemical industry represented about 5% of manufacturing employment, and, on this basis, it's significance within U.S. manufacturing is roughly equivalent to the importance of the Canadian industry within this country's manufacturing sector.

The U.S. chemical industry has a higher foreign trade and investment orientation than the U.S. manufacturing sector as a whole, but it is much less outward-oriented than the Canadian industry. U.S. chemical exports account for under 20% of gross output, less than half the percentage in Canada. According to the OECD's combined measure of important and export exposure, the Canadian chemical industry's exposure to foreign competition is three times that of the U.S. industry (Figure 2). Inward FDI in the U.S. chemical industry represents over 20% of output, as compared to around 5% for total U.S. manufacturing, but this is still less than half the Canadian chemical industry's FDI intensity.

Figure 2 -Exposure to Foreign Competition

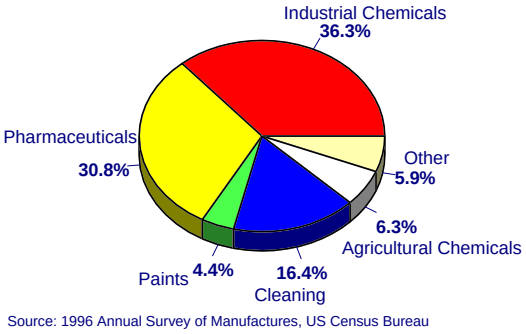


* [Exp/Gross Output]+[1-(Exp/Gross Output)]*[Imp/(Gross Output+Imp-Exp)]
Source: Science, Technology and Industry Outlook, OECD

In the U.S., as in Canada, industrial chemicals - which we focus on in a later subsection - represent the largest component of industry value added (Figure 3). A higher proportion of industry activity

is devoted to the production of pharmaceuticals and cleaning compounds in the U.S. than in Canada. These two knowledge-intensive activities account for almost half of value added in the U.S. industry. Agriculture chemicals, consisting primarily of capital-intensive chemical fertilizers, are more important in Canada.

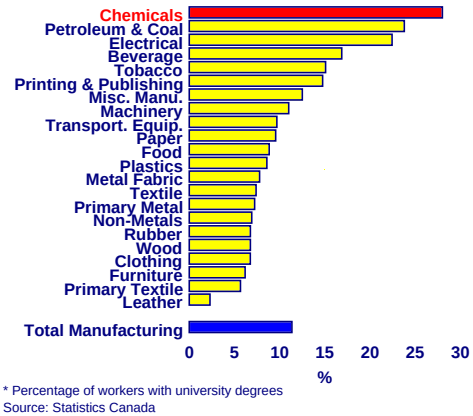
Figure 3 -Distribution of U.S. Chemicals Value-added, 1996



Source: 1996 Annual Survey of Manufactures, US Census Bureau

In both Canada and the U.S., one of the distinguishing features of the chemical industry is the high educational attainment of its workforce. In Canada, 30% of the industry's employees have a university degree, far above the 10% average for the overall manufacturing sector (Figure 4). In the U.S., almost 40% of the chemical industry's employees have a university degree, which is again higher than all other manufacturing industries. U.S. firms' lead over the Canadian industry in terms of educational attainment is in keeping with the somewhat greater importance of more knowledge-intensive chemical activities within the U.S.

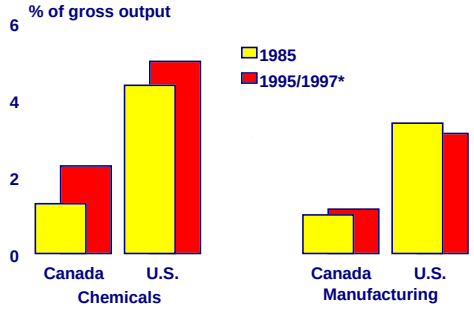
Figure 4 - Knowledge Workers* by Industry, Canada, 1997



* Percentage of workers with university degrees
Source: Statistics Canada

As well, U.S. chemical producers commit more than Canadian firms to R&D. With R&D spending amounting to 2.3% of output, Canadian firms' R&D intensity in 1995 was above that of the total Canadian manufacturing sector but still less half that of the U.S. chemical industry (Fig. 5).

Fig. 5 -R&D Business Spending

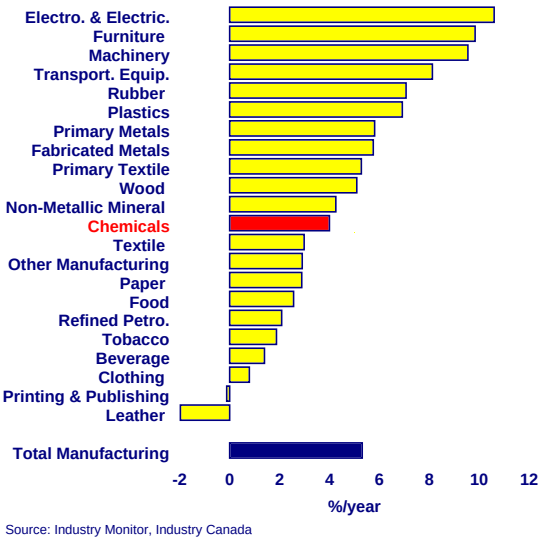


*Latest data is 1995 for the chemicals industry and 1997 for all manufacturing.
Source: Statistics Canada, U.S. National Science Foundation, 1997 ANBERD and the 1998 STAN Database, OECD

Recent Trends

The North American chemical industry has enjoyed significant but not spectacular growth, over the recent period. Since 1992, gross output of the chemical has increased at an average rate of 4% per year in Canada and 3% in the U.S. In both countries, the industry has ranked about mid-way among manufacturing industries in terms of output growth (Figure 6).

Fig. 6 -Gross-output Growth in Canadian Manufacturing Industries (1992-98)



Source: Industry Monitor, Industry Canada

North American demand for chemical products dropped substantially during the recession of the early 1990s. Output trends, however, also reflect the influence of some important longer term factors, including, particularly, the weakening demand for chemical products within industrial economies that are shifting from goods to services production. While, in the 1960s, a 1 percentage change in U.S. GDP was associated with a 2.9 percent change in the growth of U.S. chemical shipments, this has now declined to 0.9 to 1 percent.[1] Thus, the growth of the U.S. industry is now just barely keeping pace with the growth of the overall economy. While there are some dynamic components within the industry, including pharmaceuticals and some specialized consumer and industrial products, overall, chemicals constitute a mature industry. Major commodity chemical producers must contend with the long-term downtrend in real commodity prices and the prospect of relatively weak demand growth in their traditional markets.

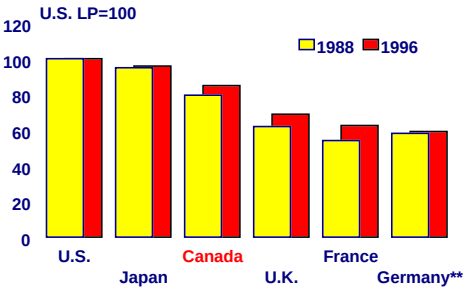
Canadian producers can overcome the constraint arising from the modest growth in North American demand by competing successfully for an increasing share of Canada-U.S. trade, by increasing sales in Southeast Asia and other rapidly growing offshore markets, and by focusing greater attention on specialized and formulated products which enjoy stronger market growth than commodity chemicals. In the case of all three options, the success of Canadian firms will depend on their ability to strengthen competitiveness by achieving a productivity performance that compares favourably with that of major chemical producers in the U.S. and abroad.

3. Productivity, Cost Performance and Profitability

Over the recent period, the Canadian industry has indeed made progress in increasing its competitiveness. In 1996, labour productivity of the Canadian chemical sector was 85% of that of U.S. industry; an average Canadian worker produced $100,000 ($U.S. 1992) worth of output, as compared to the $123,000 produced by a U.S. worker. Among the G7, Canada ranked third in labour productivity, behind the U.S. and Japan but ahead of the U.K., France and Germany. (Figure 7) The productivity gap between Canada and the two leading G7 countries, however, is smaller than it had been in the mid-1980s. Between 1988 and 1996, labour productivity in the Canadian chemical

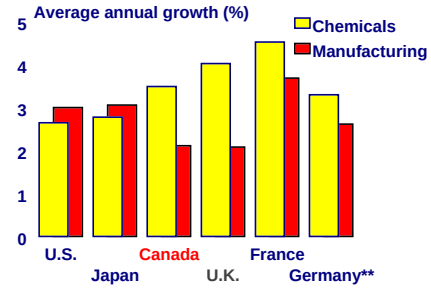
industry increased at a rapid 3.5% per year. As can be seen in Figure 8, this is well above average labour productivity growth recorded over 1988 to 1996 by the U.S. (2.6%) and Japanese (2.8%) chemical industries.

Fig. 7 - Labour Productivity* in Chemicals



* Valued-added per worker.
Source: 1998 STAN Database, OECD
PPP based on Pilat, Dirk, OECD Working Paper No. 86

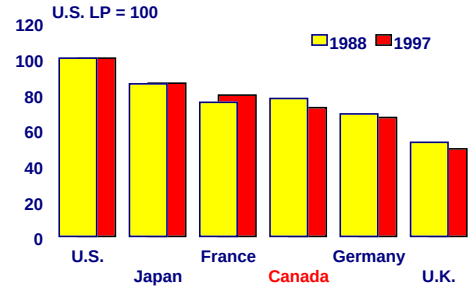
Fig. 8 - Labour Productivity* Growth in Manufacturing & Chemicals



* Valued-added per worker.
**Chemicals Growth for Germany to 1995
Source: 1998 STAN Database, OECD
PPP based on Pilat, Dirk, OECD Working Paper No. 86

Trends in the total manufacturing sector provide a useful benchmark against which to assess the performance of chemical producers (Figure 9). While, in the U.S., the productivity performance of the chemical industry lagged somewhat behind that of the total manufacturing sector over 1998 to 1996, in Canada, the chemical industry's productivity growth surpassed that of total manufacturing by about 50%.

Fig. 9 -Labour Productivity* in Manufacturing

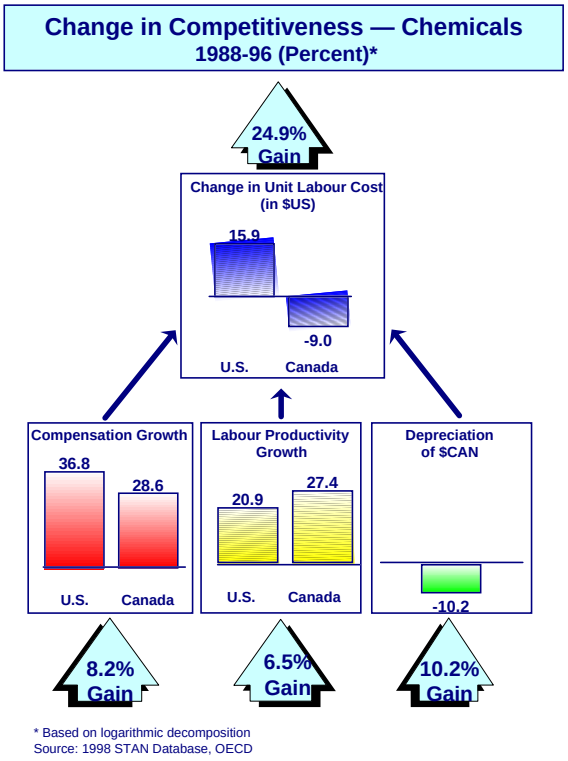


* Valued-added per worker.
Source: 1998 STAN Database, OECD
PPP based on Pilat, Dirk, OECD Working Paper No. 86

Total factor productivity growth in the Canadian chemical industry was also significant, with industry ranking third among all manufacturing industries over 1988-95. According to published BLS data, the U.S. chemical industry experienced no growth in total factor productivity over this same period, but this is not directly comparable with the Canadian results because of the different methodology employed in U.S. - including the more extensive adjustment for capital quality at the industry level and the different assumptions used to calculate capital depreciation.

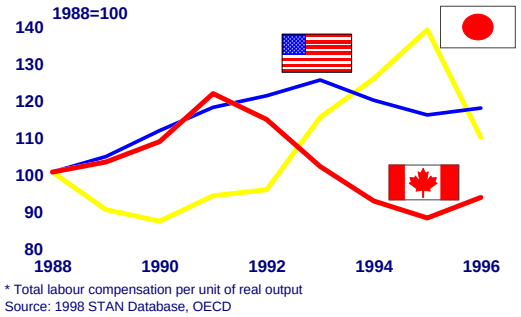
The gains Canada has achieved vis à vis the U.S. through faster labour productivity growth has been augmented by more modest increases in worker compensation and the depreciation of the Canadian dollar. The combined effect of the three factors has been to reduce the unit costs of Canadian chemical producers by 25% relative to their U.S. counterparts. Figure 10 shows that Canada's faster labour productivity growth accounted for over a quarter of this gain. A third of the improvement in Canadian unit labour costs was due to more moderate compensation growth, with the remaining 40 plus percent being the result of decline in the value of the Canadian dollar.

Fig. 10 - Change in Competitiveness



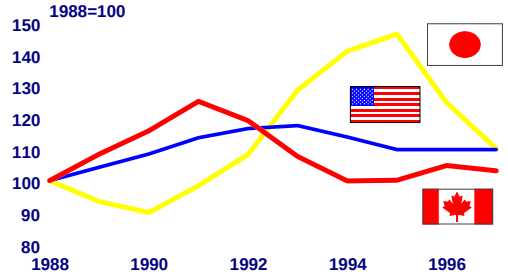
In U.S. dollars, the Canadian chemical industry's unit labour costs have decreased 20% from their high in 1991. In 1996, they were approximately 70% of U.S. unit labour costs. Canada's costs are also below those of the Japanese chemical producers, who have benefitted from the recent sharp depreciation in the yen (Figure 11).

Fig. 11 - Unit Labour Cost* of Chemical Industry (in $US)



The Canadian chemical industry has made greater gains in increasing cost competitiveness than the total Canadian manufacturing sector (Figure 12). While the competitive position of the Canadian manufacturing sector vis à vis the U.S. has improved over the 1990s, this primarily reflects the depreciation of the Canadian dollar, supplemented to a small extent by the gains from slower wage compensation. In the chemical industry, strong labour productivity growth and moderate worker compensation increases have added to the effects of the exchange rate and resulted in a more substantial improvement in cost competitiveness.

Fig. 12 - Unit Labour Cost of Manufacturing (in $US)

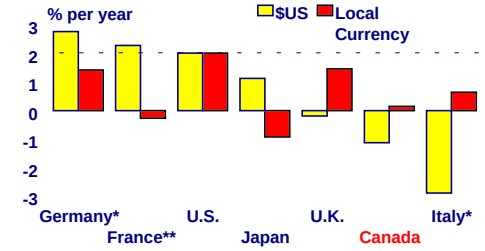


Source: Bureau of Labor Statistics

Figures 13 and 14 provide an additional perspective on the substantial progress the Canadian chemical industry has made in improving labour cost competitiveness. It can be seen that, with unit labour costs denominated in U.S. dollars, the Canadian manufacturing sector as a whole has done well compared to other G7 countries. Manufacturing labour costs per unit of output have increased very modestly, much more slowly than in the U.S., Japan, Germany and the U.K. Unlike the manufacturing sector, however, the Canadian chemical industry has made significant gains even without the contribution of a depreciating Canadian dollar. With exchange rate effects taken into account, the decline in Canadian industry's unit labour costs over 1988 to 1996 has exceeded that of all G7 countries except Italy.

Fig. 13 - Chemicals Unit Labour Cost, 1988-96

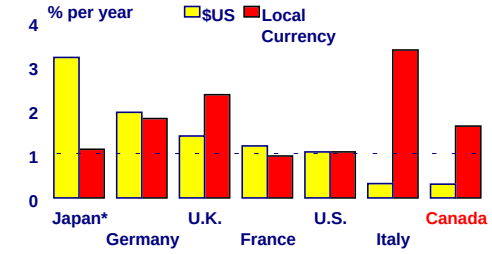
(Average Annual Change)



* 1988-94
** 1988-95
Source: 1998 STAN Database, OECD

Fig. 14 - Manufacturing Unit Labour Cost, 1988-97

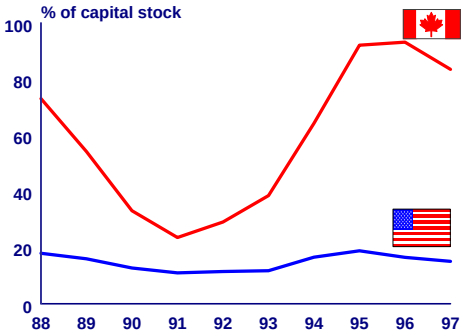
(Average Annual Change)



* 1988-96
Source: 1998 STAN Database, OECD

For commodity-type chemical products, in which Canada is largely a price taker in export markets, success in containing costs offers an opportunity for higher profits. Although profit rates in the Canadian chemical industry declined in the period prior to 1991 when the Canadian dollar was appreciating and they remained down during the recession of the early 1990s, even over this period returns were well above those achieved by U.S. producers and much better than the profit rates in Canadian manufacturing as a whole (Figure 15). After 1993, the profit rates of Canadian chemical firms rose sharply, driven by productivity gains and by a declining Canadian dollar, which reduced the U.S. dollar costs, not only of labour, but also of domestically-priced energy and material and supply inputs. In 1997, before tax return on capital stock was 83% in the Canadian chemical industry, over five times the comparable profit rate in the U.S. industry.

Fig. 15 -Profit Rate* in Chemicals**



* Before tax profits divided by net capital stock
** Includes the textile industry for confidentiality reasons
Source: Statistics Canada and Bureau of Economic Analysis

4. The Industrial Chemicals Subsector

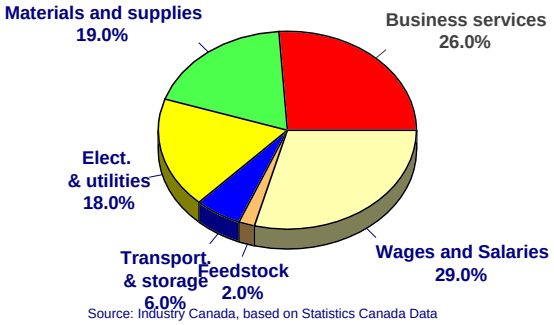
An examination of industrial chemicals, the largest subsector, can shed further light on the performance of the Canadian industry. In 1996, Canadian industrial chemical producers employed about 25,000 workers in 360 establishments. Plants, which are concentrated in Quebec, Ontario and Alberta, produce important inputs for such industries as transportation equipment, electrical and electronic products, paper and allied products and plastic products.

Industrial chemicals is made up of three major sub-groups: organic chemical firms, which produce primarily petrochemicals (e.g. polymers, ethylene, vinyl chemicals) from hydrocarbons such as are in oil, natural gas and coal; inorganic chemical companies, which manufacture a wide range of products (e.g. caustic soda, sodium chlorate, chlorine) from basic minerals such as salt that do not contain carbon; and firms specializing in the production of plastics and synthetic resins.

Industrial chemical producers tend to be capital intensive firms that produce largely undifferentiated products. As compared to the rest of the chemical sector, industrial chemical firms have a higher value added per worker, lower R&D intensity and somewhat higher export orientation. They are also particularly sensitive to changes in overall economic activity, with two highly cyclical industries, housing and autos, being among the most important users of industrial chemical products.

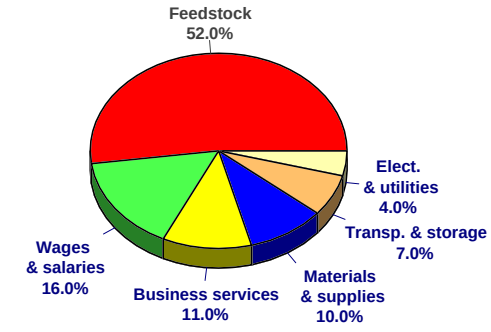
There are important differences, however, among the components of the industrial chemical sector. As can be seen in Figures 16 and 17, feedstocks constitute the most important input into the production of organic chemicals, while labour and electric power are important cost components for inorganic chemical firms. Organic chemical producers have the largest industrial chemical establishments with the highest output per worker. In 1996, value added per worker in organic chemicals was almost twice that in inorganic chemicals and about 40 percent above that in plastics and synthetic resins. Ownership is also most concentrated in organic chemicals, where the largest 4 firms account for over 65% of shipments, as compared to under 30 percent in inorganic chemicals, and just over 50% in plastics.

Fig. 16 - Cost of Inputs, Inorganic Industrial Chemicals, 1992



Source: Industry Canada, based on Statistics Canada Data

Fig. 17 - Cost of Inputs, Petrochemicals, 1992



Source: Industry Canada, based on Statistics Canada Data

Canada's traditional advantages in industrial chemicals have come from the availability of abundant resources, competitively priced electricity, a skilled workforce, a well-developed transportation infrastructure, and proximity to the world's largest market. Petrochemical firms were attracted to Canada in the late 1970s and early 1980s by the availability of relatively low cost feedstocks. Alberta producers remain in a favourable position with access to ample supplies of ethane at prices that are below those paid by major competitors on the U.S. Gulf Coast due to transportation cost differences. Meanwhile, petrochemical firms in southwestern Ontario and western Quebec that must pay higher costs than western producers for feedstocks, benefit from their proximity, relative to southern U.S. producers, to major markets - about 50% of Canadian and U.S. manufacturing capacity being within one day's trucking distance.

Electricity prices, which are an especially important factor for inorganic chemical firms, have also been affected by important market changes. In the early 1990s, when electricity prices were rising sharply in Ontario, inorganic producers located much of their new investment in Quebec. More recently, concern has focused on the impact of competition in U.S. electricity markets, which has led to negotiated prices for many major producers that are much less than posted rates and below those prevailing in Canadian provinces. U.S. chemical producers have also been better able to take advantage of opportunities for energy and cost savings through cogeneration - which has been less viable in Canada because of the reluctance of the utilities to purchase the excess power that is produced. The situation, however, is changing. With the provinces beginning to relax utility regulation, Canadian industrial chemical producers are now seeing the introduction of more competitive electricity rates and the creation of new opportunities for cogeneration.

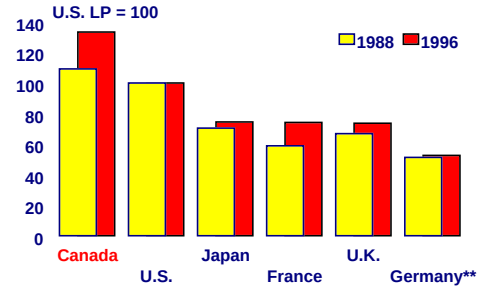
Production costs of North American firms have been influenced by other factors, including environment agreements restricting the use of chlorinated chemicals and general pressures on the industry to reduce emissions, improve waste management and increase energy efficiency. The Canadian industry, represented by the Canadian Chemical Producers' Association, has led the way in the use of voluntary standards through its Responsible Care initiative, which establishes codes of practice for all aspects of the chemical life cycle. In 1996, the chemical industry directed about 5.5%

of its capital expenditures towards environmental protection and incurred operating costs on pollution abatement, waste management and related activities of $184.2 million or about 0.5% of the value of shipments.

Among the most important factors influencing the cost competitiveness of Canadian industrial chemical producers have been movements in Canada's exchange rate and improvements in industry productivity. While its costs, in terms of U.S. dollars, were adversely affected by the rise in the Canadian dollar from a low of 69.1 U.S. cents in February 1986 to over 89 U.S. cents in November 1991, the industry subsequently rode the downward slide in the value of the Canadian currency. Although prices for some of the industry's main inputs, including oil and gas, are set in international markets and denominated in U.S. dollars, producers have benefitted from the impact of the recent depreciation on the foreign exchange costs of labour, business services, energy, storage and other inputs.

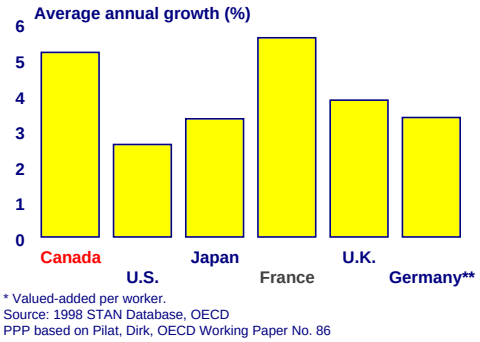
The labour productivity gains achieved by the industrial chemical subsector have been striking. Between 1988 and 1996, labour productivity in the Canadian industrial chemical industry increased at annual average rate of 5.2%, which is twice the rate achieved by U.S. firms and above the productivity growth rate of all other G7 countries except France (Figure 19). In contrast to the overall chemical sector, workers in industrial chemicals are more productive than their U.S. counterparts (Figure 18). In 1996, labour productivity was about a third higher in Canadian than in U.S. plants.

Fig. 18 - Labour Productivity* in Industrial Chemicals



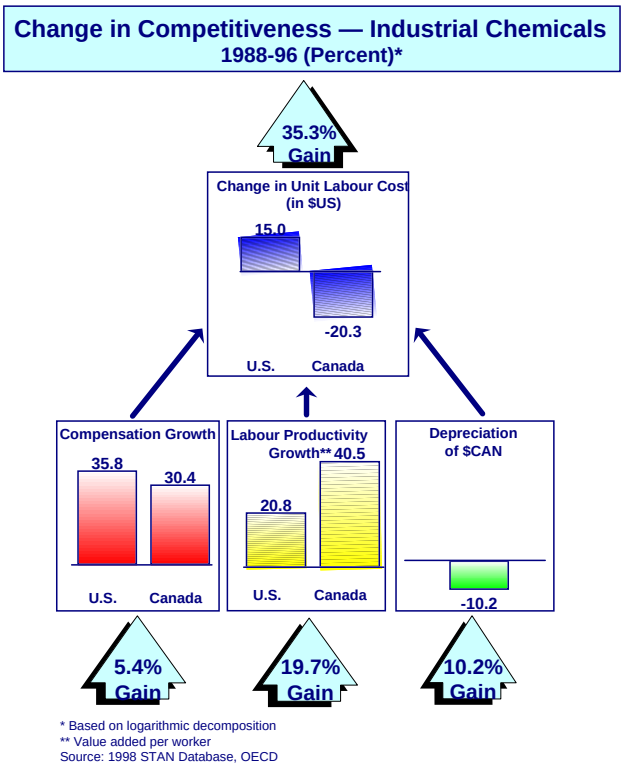
* Valued-added per worker.
** 1995
Source: 1998 STAN Database, OECD
PPP based on Pilat, Dirk, OECD Working Paper No. 86

Fig. 19 - Labour Productivity* Growth in Industrial Chemicals



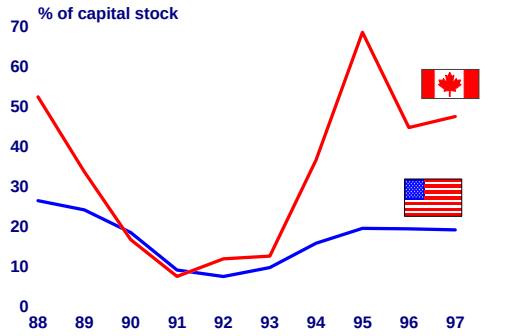
Between 1988 and 1996, Canadian producers' unit labour costs fell by 35 percent relative to those of U.S. industrial chemical firms. The decomposition in Figure 20 shows that over half of this gain was due to the stronger labour productivity growth of the Canadian industry.

Fig. 20 - Change in Competitiveness — Industrial Chemicals



Returns for industrial chemical producers have followed the industry pattern - falling form 1988 to 1991 and rising strongly after 1993 - but the fluctuations have been sharper, due in part to the greater sensitivity of product demand to overall economic conditions (Figure 21). As a result of the industry's productivity gains and its success in reducing unit labour costs (in $US), return on capital has been much higher than in the U.S. The profit rate in the Canadian industry declined after 1995, but, by 1997, it was still almost three time the rate in the U.S. industrial chemical industry.

Fig. 21 - Profit Rate in Industrial Chemicals



* Before tax operating profits divided by gross fixed assets net of depreciation
Source: The Chemical Manufactures Association and Canadian Chemical Producers' Association

5. Factors Behind the Chemical Industry's Productivity Performance

Microeconomic studies point towards a number of factors that may directly or indirectly influence industry productivity growth. The performance of an industry will be affected by shifts in resources among activities and firms with different productivity levels and growth rates, and by productivity changes within firms which may be due to increases in capital per worker, technical change, increases in labour quality, or improvements in "softer" technologies, such as management and organization.[2] Studies have noted the complementarity between these factors, so that, for example, firms that have invested in worker training and organizational redesign are better positioned to benefit from advances in technology. There has also been a recognition of the importance of market variables, such as trade orientation, which may reflect the competitive pressure on producers as well as the opportunity for firms to enjoy economies of scale.

Other, partly related, results have emerged from recent studies of firm productivity in Canada. It has been found that small-sized firms tend to be less productive that large-sized firms.[3] In terms of both labour and multi-factor productivity, foreign-controlled firms tend to be significantly more productive than Canadian-controlled firms.[4] In addition, productivity differences between Canadian industries are related to differences in the nature and strength of R&D spillovers from U.S. firms, particularly, from firms in the same industry.[5]

Weaknesses in Product Innovation

In examining the relevance of these finding to chemical producers, it is important, initially, to recognize that not all segments of the Canadian industry have benefitted equally from recent productivity gains. Those Canadian chemical firms that have made the strongest gains vis à vis the U.S. have been primarily involved in the production of commodities. Over the long term, the performance of the industry has been driven by the rapid productivity increases of the industrial chemical sector (including plastics and synthetic resins) and of other commodity producers, particularly chemical fertilizer manufacturers (Table 1).

Table 1 -Growth in Labour Productivity*, 1973-1995

(In %)	Compound growth rates		
	Output	Labour	Labour Productivity
Industrial Chemicals n.e.c.	2.5	-0.7	3.2
Chemical products n.e.c. (incl. Agricultural chem)	3.2	1.1	2.1
Plastics and Synthetic Resins	6.3	2.8	3.5
Pharmaceuticals and medicine	4.2	1.7	2.5
Paint and varnish	0.5	0	0.5
Soap and cleaning compounds	2.8	1.1	1.7
Toilet preparations	2.6	1.3	1.3
Total chemicals industry	3.2	0.7	2.5

* Labour Productivity = Output per employee

Source: Computations based on StatCan data

These results seem to support the general observation made by Trefler that Canadian firms are much better at process than product innovations.[6] Results from the chemical industry are largely

consistent with productivity data for the overall manufacturing showing that Canada has lagged behind the U.S. in high-end industries that are dependent on product innovations, but performed favourably on low-end manufacturing where gains can be made by cutting costs. In chemicals, as in other industries, these results are related to Canadian firms's relatively low commitment to R&D (as shown in Figure 5). Canada's R&D intensity (R&D as a percentage of value added) in chemicals is only about 40% of that in the U.S. and less than half the average of 14 major OECD countries.[7] Excluding pharmaceuticals, Canada's R&D intensity in chemicals has declined slightly over the past decade.

Patent data also point to Canadian producers weak performance in new product development. Canada's share of U.S. patents granted in chemicals (excl. pharmaceuticals) was higher in 1996 than in 1985, but at 1.7% it was well below, not only the U.S. (which accounted for 53%) but Japan, Germany, the U.K., Switzerland and Italy.[8] Moreover, from his examination of patent citations, Trajtenberg has found that Canadian chemical patents tend to be much less significant than U.S. patents.[9] He estimates that the "quality" of Canadian chemical patents (excluding pharmaceuticals) as indicated by citation data (adjusted to control for various factors) is about 16% below that of U.S. patents.

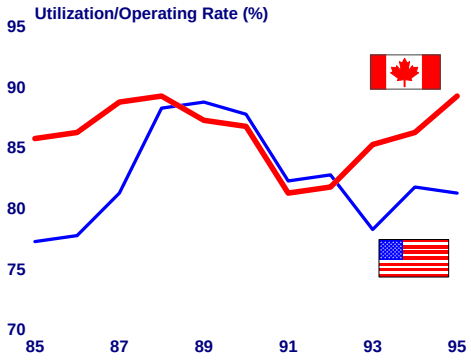
In addition, in more demanding and higher risk areas of product development, Canadian firms have been poor at commercializing research results. In biopharmaceuticals, for example, where Canadian firms have developed a significant research capacity, intellectual property and marketing rights are typically licensed to multinational drug companies well before completion of the clinical trials. Canadian biotechnology firms thereby capture a small share of the returns from significant discoveries.[10]

Cyclical Effects

The gains that chemical producers have made in terms of their ability to more productively manufacture a given set of outputs can be related to a number of factors. The labour productivity

differences between Canadian and U.S. industrial chemical firms described in Figure 16 are partly attributable to the higher capacity utilization rate of Canadian producers in the mid-'90s. While producers in both countries experienced the effects of the recession of the early 1990s, the downturn had a more sustained impact on U.S. firms and, by 1995, when the utilization rate of Canadian firms was approaching 90 percent, U.S. industrial chemical producers were still only operating at just over 80 percent (Figure 22). Labour productivity comparisons covering the 1992 to 1995 period, thus, reflect the impact of diverging capacity utilization rates in increasing capital per worker in Canada relative to the U.S. In the last few years, utilization rates in Canadian industrial chemicals have again declined, highlighting the largely transitory nature of this source of productivity growth.

Fig. 22 - Capacity Utilization Rates, Industrial Chemicals



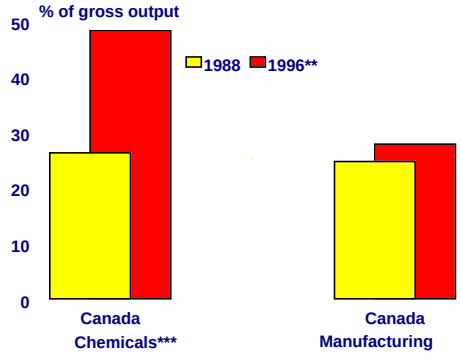
Source: Industry Canda, based on tatistics Canada and U.S. Department of Commerce, Census of Manufactures (Washington, D.C..: GPO, 1992 and updates)

For the future, a major question is whether the movement towards a global marketplace, in which prices for major chemicals depend on world rather than simply North American supply-demand balances, will lead to sharper or more moderate fluctuations in activity. If major consuming nations are going through different phases of the business cycle, expansions in some markets can help offset declines elsewhere. If, however, the growing economic interdependence among economies leads to the increasing synchronization of business cycles, industrial chemical producers face the prospect of wider swings in economic conditions. The downswings could be further aggravated if, as a recent U.S. report argues, the growth of commodity chemical plants in developing countries is creating a general tendency toward global oversupply.[11]

Structural Changes

The productivity gains achieved by commodity producers also reflect the influence of other longer-term factors. Important structural changes have occurred in the industry, stimulated, in part, by the Canada-U.S. Free Trade Agreement and NAFTA and the increasing integration of North American chemical markets.[12] By comparison to other manufacturing industries, the chemical industry has experienced a particularly large increase in trade orientation. Between 1988 and 1996, for example, while the import intensity of the total manufacturing sector grew by 35%, the chemical industry's import intensity increased by more than 60%. Over this same period, FDI as a share of chemical industry gross output almost doubled, a marked contrast to the marginal increase in FDI intensity which occurred within the total manufacturing sector (Figure 23).

Fig. 23 - FDI Intensity*



* FDI as a percentage of gross output
** 1997 for manufacturing
*** For Canada, chemical FDI intensity includes the textile industry
Source: Statistics Canada, Bureau of Economic Analysis and the 1998 STAN Database, OECD

We might expect that stronger trade and investment links will allow Canadian firms to overcome the disadvantages of a small domestic market and the limited indigenous capacity for the development of new technologies. The increased competitive pressures that occur in an open trading environment should also encourage efforts to improve productivity. Studies have shown the relevance of these considerations to the chemical industry. Bernstein has found that, over the 1964 to 1986 period, for example, spillovers from R&D in the U.S. chemical industry did indeed make a significant

contribution to multifactor productivity growth within the Canadian chemical sector.[13] These spillovers occur through trade, investment and a wide variety of other formal and informal mechanisms that facilitate knowledge and technology flows between the two countries. That FDI has been one of the important vehicles for importing technology and promoting MFP growth in the Canadian chemical industry is supported by a recent study by Gera, Gu and Lee.[14] Interestingly, however, a recent analysis by Tang and Rao finds that, over 1985 to 1995, the MFP of Canadian-controlled chemical firms was only 6 percentage points below that of their foreign-controlled counterparts.[15] The implication is that most new technology that is coming into Canada is diffusing widely within the industry and the benefits are not confined to foreign-controlled enterprises. A more recent study by Bernstein suggests that one of the most significant contributions of stronger commercial links is that they improve market access and allow Canadian chemical producers to better exploit available economies of scale. He finds that the realization of scale economies can explain the majority of the Canadian chemical industry's total factor productivity growth over 1966 to 1991.[16]

Over the recent period, there are indications that Canadian firms have significantly rationalized and restructured their operations. Through the elimination of older, less efficient plants and the rationalization of production, Canadian firms have, in part, realized gains that U.S. firms had experienced through the substantial restructuring they went through during the 1980s. Over the 1988 to 1996 period there was not a significant increase in concentration in the Canadian industry, nor was there an increase in the importance of large establishments. Indeed, the share of industry value added accounted for by establishments with over 200 employees declined slightly between 1988 and 1996. Important structural changes have occurred, however, within individual components of the chemical industry.

To understand the changes that have taken place in establishment size, it is useful to look at how size affects the productivity of different industry segments. Table 2 shows that, in organic and inorganic chemicals, large establishments do not have the edge that one might expect, in terms of labour productivity. Surprisingly, large establishments appear to generate far less output per employee than

medium-sized establishments in the inorganic chemicals subsector. Large-sized establishments do have the advantage in other subsectors including especially plastics and soaps and cleaning compounds.

Table 2- Relative Value Added per Employee, 1996

	Relative to sub-industry average			Relative to Chemical industry Average
	Small	**Med.**	**Large**	
Industrial Inorganic Chemicals n.e.c	1.19	1.27	0.60	1.08
Industrial Organic Chemicals n.e.c	0.48	1.01	1.07	2.11
Plastic & Synthetic Resins	0.73	0.76	1.29	1.45
Agricultural Chemicals	N/A	N/A	N/A	1.91
Pharmaceuticals & Medicine	0.46	0.70	1.11	0.90
Paints & Varnish	0.75	1.01	1.20	0.63
Soaps & Soap Cleaning Compounds	0.43	0.60	1.34	0.75
Toilet Preparations	0.46	0.82	1.20	0.63
Total Chemical Industries	**0.71**	**0.98**	**1.11**	**1.00**

Calculations based on StatCan data

Note: Small = 0-49 Employees, Medium = 50-199 Employees, Large = 200+ Employees

In organic and inorganic chemicals, productivity growth over the 1988 to 1996 period has been associated with an increase in the importance of medium-sized establishments (Table 3). This has also occurred, although to a lesser extent, in plastics; despite their significantly greater productivity, large-sized plastics establishments did not increase in importance over 1988 to 1996. In soaps and cleaning compounds and in pharmaceuticals, however, there has been a significant shift in activity towards more productive enterprises of 200 or more employees.

Table 3 - Distribution of Industry Value added by Establishment Size, 1998 and 1996

(In %)	**1988**			**1996**		
	S	**M**	**L**	**S**	**M**	**L**
Industrial Inorganic Chemicals n.e.c	24	31	45	24	53	23
Industrial Organic Chemicals n.e.c	2	18	80	4	37	59
Plastic & Synthetic Resins	12	28	60	8	32	59
Agricultural Chemicals	N/A	N/A	33	N/A	N/A	N/A
Pharmaceuticals & Medicine	5	19	76	3	12	85
Paints & Varnish	17	33	49	20	43	37

Soaps & Soap Cleaning Compounds	9	25	65	8	14	78
Toilet Preparations	5	20	75	3	31	65
Total Chemical Industries	**12**	**26**	**62**	**12**	**32**	**56**

Calculations based on StatCan data

Note: Small = 0-49 Employees, Medium = 50-199 Employees, Large = 200+ Employees

Data are not provided by size category for chemical fertilizers but the data that are available point to a tremendous growth in average establishment size between 1988 and 1996. In this commodity subsector, rapid productivity growth does appear to have been associated with a shift towards much larger production units.

Increases in size are reflected not just through changes in the importance of small, medium and large enterprises, but also through growth within size categories. Over 1988 to 1996, the average size of small, medium and large enterprises increased in most chemical industry subsectors (Table 4). The data reflect the major restructuring that has occured in agricultural chemicals, but they also highlight the significant rationalization that has taken place in a number of specialized chemical subsectors, where there has been a substantial increase in the scale of large establishments.

Table 4- Growth Rate of Real Average Value Added per Establishment, 1988-1996

(In %)	**Size of Establishment**			
	S	M	L	total
Industrial Inorganic Chemicals n.e.c	0.8	7.0	2.2	1.2
Industrial Organic Chemicals n.e.c	6.7	2.8	5.5	-2.5
Plastic & Synthetic Resins	0.5	2.7	2.9	3.4
Agricultural Chemicals	N/A	N/A	N/A	20.8
Pharmaceuticals & Medicine	-3.2	2.7	9.0	6.4
Paints & Varnish	6.1	6.2	9.2	4.3
Soaps & Soap Cleaning Compounds	0.9	-3.0	6.0	3.2
Toilet Preparations	2.6	8.5	9.1	5.9
Total Chemical Industries	**5.1**	**7.8**	**6.4**	**7.1**

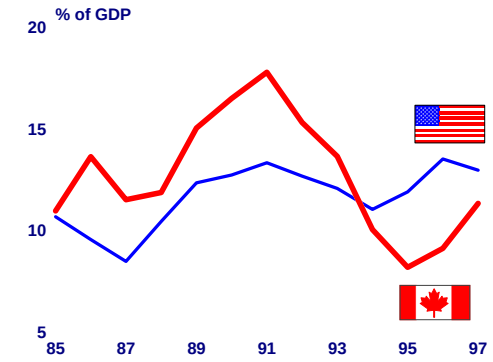
Source: Calculations based on StatCan data

Note: Small = 0-49 Employees, Medium = 50-199 Employees, Large = 200+ Employees

Improvements in labour productivity are also the result of increases in the quantity and quality of machinery and equipment. Capital investment in the chemical industry is highly cyclical, but it is significant that, over most of the period since the mid-1980s, machinery and equipment investment

as a percentage of GDP was higher in Canada than in the U.S., in contrast to the situation prevailing in the overall economy (Figure 24). In terms of technology adoption, survey results are only available for the broad category "petroleum and chemical products". Still it is notable that this industry group ranks high among manufacturing industries in the use of advanced technologies - with establishments using 5 or more technologies accounting for 73 percent of shipments in 1993 - and that there was a significant increase of over 20 percent in the proportion of shipments from the most technology-advanced establishments -i.e those adopting 10 or more technologies.

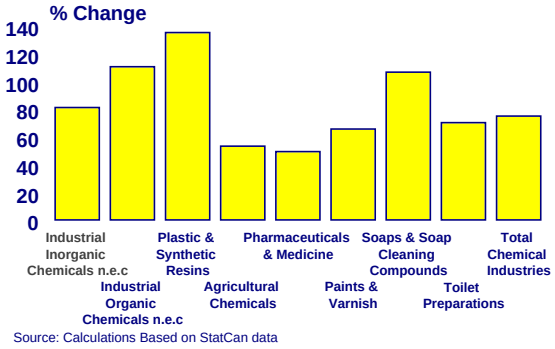
Fig. 24 - Real M&E Intensity in Chemicals



Source: Statistics Canada, US Bureau of Census

In Figure 25 changes in real fuel and electricity costs are used as a rough proxy for changes in capital available to different industry subsectors.[17] The data provide a general indication of the significant increases in capital per worker that have occurred in some commodity-producing sectors, notably organic chemicals and plastics and synthetics, as well as in the soaps and cleaning compounds subsector.

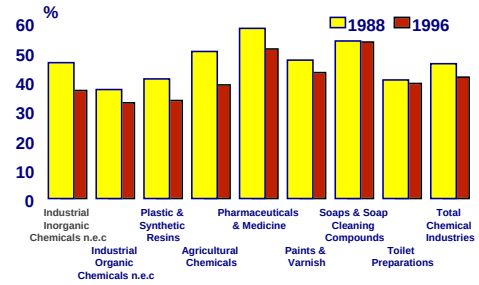
Figure 25 - Changes in Fuel and Electricity Costs per Production Employee (1988-1996)



Source: Calculations Based on StatCan data

The rationalization of production that has taken place in the chemical industry since the implementation of the FTA has been associated with an increase in the proportion of production to total employees. Companies have reduced management overhead by, in some cases, shifting administrative functions to their U.S. head offices. The data in Figure 26 indicate that most significant reorganizations have occurred in three commodity subsectors, inorganic chemicals, chemical fertilizers and plastics and synthetics.

Fig. 26 - Administrative employees as % of total employees



Source: Calculations Based on StatCan data

Therefore, important changes in size, capital intensity and organization have occurred within the chemical industry. These changes have been most significant in those subsectors experiencing the strongest productivity growth over 1988 to 1996 - namely, industrial chemicals and chemical fertilizers - but they have extended to other parts of the industry, including pharaceutical firms and producers of specialized chemical products. These developments have been accompanied by some significant shifts in economic activity. Significantly, chemical fertilizers, which experienced

significant productivity growth and has the highest level of labour productivity within chemical sector, more than tripled its share of industry value added over the 1988 to 1996 period.

6. Continuing Challenges

While fortunes of the Canadian chemical industry are significantly affected by cyclical fluctuation and by movements in the exchange rate, they also depend on how Canadian firms respond to the challenges posed by increasingly competitive global markets. Canadian producers face a number of different pressures and challenges.

In the commodity segment of the industry, the recent trend, internationally, has been towards establishing larger firms and building world-scale production facilities that can maximize potential economies of scale. Significant consolidation has occurred among North American and European commodity producers as firms pursue synergies and the benefits of increased size. Large oil companies, that are important participants in the commodity segment of the industry, have been attempting to better position themselves in the industry and to realize increased benefits from integrating petrochemical and refining operations. Although Canadian firms are small players in global commodity markets, they can more fully participate in such economies of scale and scope through strategic alliances and joint ventures. A notable example of the latter is the current partnership between Nova Chemicals and Union Carbide, two mid-size petrochemical companies, to jointly build the world's largest cracker at Joffre, Alberta. Further, Union Carbide is now merging with Dow Chemicals.

While major commodity producers are finding it more difficult to cut costs and increase efficiencies, some potentially promising new technologies have emerged. Some companies are reporting favourable results, for example, from the application of Six Sigma, a process management system that employs statistical analysis to identify variations in operating parameters and product quality. By using this tool to pinpoint maintenance and other changes needed to keep plants running close to potential, some firms have achieved significant improvements in equipment utilization.[18] Firms

are also achieving efficiencies by using e-commerce. In a recent survey, a number of global chemical firms reported that Internet-routed sales would increase from less than 1% to 16% of sales between 1999 and 2004.[19]

In specialty chemicals, considerable consolidation is also occurring internationally. Large scale is becoming more important, but it is still less important in this area than the ability to develop high quality products that effectively serve niche market demands. Specialty and formulated chemicals are less vulnerable than commodity chemicals to downturns in economic activity and they have more promising long-term growth prospects. To succeed in this segment of the business, however, Canadian firms must overcome weaknesses in product development and commercialization. Some of the efforts that are going into strengthening links among researchers in industry, government and universities should be helpful in this context.[20] In addition, to compete successfully in niche markets, Canadian specialty producers must build their competencies in marketing, distribution and customer servicing.

The importance of foreign ownership in the Canadian chemical industry gives rise to a number of special considerations. While Canada's natural resources wealth has helped to attract foreign direct investment, the country's continuing appeal as a host economy depends on a variety of factors, including the availability of skilled workers, the existence of a well-developed infrastructure and government policies that compare reasonably with those prevailing in other industrial economies. Tax rates, environment controls, intellectual property laws and drug safety regulations are all of concern to the industry and of relevance to multinationals' choice of investment location.

Along with attracting foreign investment, Canada has an interest in encouraging the establishment of mandates that permit Canadian affiliates to undertake a range of activities for the North American or world market. From his examination of affiliates in various sectors, Julian Birkinshaw has found that mandates tend to be earned and that successful subsidiaries are distinguished by their capabilities and leadership.[21] DuPont Canada, which has achieved sole supplier status for over 10 product lines within the DuPont manufacturing network, provides an instructive example of the possibilities,

within the chemical sector, for a Canadian-based affiliate to carve out a strong role for itself as part of a global enterprise.

Over the recent period, the Canadian chemical industry has been a success story. It has achieved a productivity performance that compares favourably both with other Canadian manufacturing industries and with U.S. chemical producers, and generated significant returns for investors. Canadian producers face a formidable challenge in sustaining their strong performance over coming decades that will be marked by further globalization, increasing consolidation and rapid technological change.

NOTES

1. DRI/McGraw-Hill and Standard & Poor's and U.S. Department of Commerce, *U.S. Industry & Trade Outlook '98*.

2. For example: OECD, *Science, Technology and Industry Outlook, 1998* (Paris: OECD) 1998. The relevance of these factors to Canadian manufacturing productivity performance is shown in: Frank C. Lee and Jianmin Tang, "The Productivity Gap Between Canadian and U.S. Firms," Industry Canada Working paper No. 29, April 1999.

3. Jianmin Tang and Someshwar Rao, "Are Canadian-controlled Manufacturing Firms less Productive than their Foreign-controlled Counterparts?" Industry Canada Discussion Paper, forthcoming.

4. Jianmin Tang and Someshwar Rao, ibid; and S. Globerman, J.C. Ries and I. Vertinsky, 'The Economic Performance of Foreign Affiliates in Canada, *Canadian Journal of Economics*, 27, 1994.

5. J. Bernstein, "Inter-industry and U.S. R&D Spillovers, Canadian Industrial Production and Productivity Growth," Industry Canada Working Paper No. 19, 1998.

6. Daniel Trefler, "Does Canada Need a Productivity Budget?" *Policy Options*, July/August 1999.

7. The data are from OECD, *Science and Technology Outlook, 1998* and pertain to 1995 for Canada and 1994 for the U.S. and most other countries. The 14 OECD countries are: Canada, U.S. Australia, Japan, Denmark, Finland, France, Germany, Italy Netherlands, Norway, Spain, Sweden and U.K.

8. From OECD, *Science, Technology and Industry outlook, 1998*.

9. Manuel Trajtenberg, "Is Canada Missing the `Technology Boat'? Evidence from Patent Data," paper prepared for the CSLS/Industry Canada Conference, "Canada in the 21st Century: A Time for Vision", Ottawa, Sept. 18, 1999.

10. This issue is discussed in: National Biotechnology Advisory Committee, *Sixth Report: Leading in the Next Millennium*, 1998.

11. U.S. Office of Technology Policy, *Meeting the Challenge: U.S Industry Faces the 21st Century - The Chemical Industry* (Washington: Department of Commerce) 1996.

12. Over 1998 to 1995 Canada-U.S. trade increases were much stronger among chemical products that experienced a tariff

reduction than among products whose tariff was unchanged under the FTA. The Canadian Chemical Producers' Association, "A Review of the Competitiveness of Canada's Policy and Business Environment for the Chemical manufacturing Industry," mimeo., August 1996.

13. Jeffrey I. Bernstein, "International R&D Spillovers Between Industries in Canada and the United States," Industry Canada Working paper No. 3, September 1994.

14. Surendra Gera, Wulong Gu and Frank C. Lee, "Foreign direct Investment and Productivity Growth: The Canadian Host-Country Experience," Industry Canada Working paper No. 30, April 1999.

15. Jianmin Tang and Someshwar Rao, "Are Canadian-Controlled Manufacturing Firms Less Productive than their Foreign-Controlled Counterparts?" Industry Canada Working Paper, forthcoming.

16. Jeffrey Bernstein, "Inter-Industry and U.S. R&D Spillovers, Canadian Industrial Production and Productivity Growth," Industry Canada Working Paper No. 19, February 1998.

17. This proxy will underestimate the growth of capital to the extent energy efficiency improvements have been introduced. A similar proxy was used in a cross-sectional study of labour productivity. See, S. Globerman. J.C. Ries and I. Vertinsky, "The Economic performance of Foreign Affiliates in Canada," *Canadian Journal of Economics*, Feb. 1994.

18. "New Tools for Making It" *Chemical Week*, March 3, 1999.

19. "Distribution Gets Wired" *Chemical Week*, Nov. 3, 1999.

20. These include efforts associated with federal programs such as the Networks Centres of Excellence and the Industrial Research Assistance Program.

21. J. Birkinshaw, "World Mandate Strategies for Canadian Subsidiaries," Industry Canada Working Paper No. 9, 1996.