Bank of Canada
Technical Reports

Rapports techniques
Banque du Canada

October 1982

Technical Report 33

AN ECONOMETRIC MODEL OF THE STEEL TRADE

Richard Dion

ACKNOWLEDGEMENTS

This research was conducted in 1981, while the author was working in the International Department of the Bank. The author would like to thank his colleagues in the Balance of Payments Division for their helpful comments and suggestions. Kevin Clinton merits special mention for his encouragement. Marie Lamarre proved indispensable in setting up the data base; Judy DiMillo and Debra Bigelow also deserve credit for their help at various stages ot the project. All views expressed are those of the author alone.

CONTENTS

ABSTRACT

In this report, the author uses steel as a case study for an analysis at the industrial level of forces at work in the international economy that have had an important impact on recent Canadian economic performance. Prominent among those forces are cost competitiveness and aggregate demand in Canada and abroad.

The author presents a model of the steel industry featuring relative price effects on trade and consumption volumes as well as price, volume, productivity and wage responses to demand pressure.

Simulations over the period 1977Q1-80Q1 suggest that the industry's output and profits have benefited from the depreciation of the Canadian dollar. They also reveal that an increase in the price of foreign exchange causes the relative price of steel to rise, discouraging steel consumption. In addition, imports are further reduced by substitution from foreign to domestic sources. As regards the trade balance in steel, this favourable substitution effect is counteracted after a while by the impetus that depreciation gives to domestic aggregate demand. The model is thus able to shed light on some otherwise puzzling developments. For example, the surge of steel imports and slowdown of exports in 1979, a period in which the Canadian industry's cost competitiveness was strong, can be explained in terms of the depreciation-aided acceleration of domestic economic activity, which resulted in tight constraints on the ability of the industry to satisfy additional customers' orders.

RÉSUMÉ

Ce rapport examine comment des forces relativement importantes dans la détermination de notre performance économique récente, notamment notre compétitivité et la pression de notre demande intérieure, opèrent à un niveau industriel aussi désagrégé que celui de l'acier.

L'auteur présente un modèle de cette industrie dans lequel les prix relatifs et la pression de la demande jouent un rôle très significatif. Alors que le Canada s'avère un preneur de prix dans son commerce extérieur, la détermination du prix intérieur reflète la position dominante des producteurs canadiens dans le marché domestique.

Des simulations couvrant la période 77Q1-80Q1 suggèrent que l'industrie de l'acier a bénéficié de la dépréciation du dollar canadien. Elles révèlent également qu'un affaiblissement du dollar canadien fait monter le prix relatif de l'acier, décourageant ainsi le consommation et, de là, les importations. Celles-ci sont également réduites par la substitution à des sources domestiques d'approvisionnement. Néanmoins, l'impulsion fournie à l'activité intérieure par la dépréciation tend à neutraliser l'impact des effets de substitution sur la balance commerciale pour les produits de l'acier. La montée des importations et le ralentissement des exportations d'acier en 1979, par suite de contraintes de capacité, suggèrent que les effets d'activité ont été plus importants que les effets de substitution au cours de la période.

1 INTRODUCTION

Prices and profits in the tradeable goods industries in Canada have increased because of the lower value of the Canadian dollar, particularly since 1978. The consequent stimulus to output has resulted in import substitution and export penetration. Yet econometric evidence on this situation is practically nonexistent at the individual industry level, attention having been focused instead on broader groupings. This paper attempts partially to fill the gap by analyzing, with the aid of a small econometric model, the impact of shocks to the exchange rate and other variables on the Canadian steel industry in the period 1977Q1-80Q1.

The steel industry is of course sufficiently important for a study of its behaviour to be interesting for its own sake. But the primary purpose of this paper is to use steel as a case study of underlying forces at work in the international economy that have had an impact on our recent economic performance.

Steel is a particularly suitable industry for such an analysis, because Canada exports and imports large quantities of steel products that are also produced for the domestic market. Such a pattern of significant two-way trade flows involving homogeneous goods provides a rich context for a study of the effects of movements in relative prices, such as the exchange rate and the price of energy, as well as the effects of changes in the level of aggregate demand both in Canada and in the United States.

The model developed in this paper features relative price effects both on consumption and on trade. The results of simulations suggest that relative price effects on steel consumption are quite significant. For instance, an exchange rate shock simulation indicates that a depreciation of the Canadian dollar reduces steel consumption over time through a rise in the real price of steel. This reduction delays substantially the eventual deterioration of the trade balance that would have resulted from intensified demand pressure.

The dynamics of the model are such that the indirect effects of depreciation on domestic activity tend after a while to dominate the direct substitution effects stemming from the change in the relative prices of exports and imports, in terms of their influence on the trade balance.

This conclusion does not allow for the long-run response of capacity growth to the output and profits signals, since total capacity is exogenous in the model.[1] However, one observes that the recovery of steel consumption in Canada, which had been indirectly stimulated by the lower value of the Canadian dollar, considerably intensified demand pressure from 1978 such that capacity constraints led to a surge of imports and a slowdown of exports in the course of 1979.

Since domestic steel consumption is importantly affected by developments in the auto industry, shocks to domestic automotive consumption as well as to U.S. activity are also described. In both cases, the response of output, trade and profits is appreciable.

Before presenting the model and the simulation results, I review the structure and functioning of the Canadian steel industry and the international setting in which it operates.

2 CHARACTERISTICS OF THE CANADIAN STEEL INDUSTRY

The industry comprises a few integrated producers, which operate coke ovens, blast furnaces and rolling mills, as well as several non-integrated producers whose "mini-mills" use electric furnaces fed primarily by steel scrap. The integrated producers located in Ontario,[2] from which data for parts of this study are drawn, accounted for 75 per cent of Canadian steel shipments in 1979. They have consistently been more profitable than the rest of the industry and probably more export-oriented since mini-mills appear largely to serve local markets.

Steel is an energy-intensive industry. If coking coal, one of the ingredients in steel, is taken into account, energy costs would approach 20 per cent of operating costs versus about 3 per cent for total manufacturing. Even excluding coal, however, steel remains an energy-intensive industry since the share of fuel and electricity in its total operating

---

[1] All modelling attempts failed.

[2] Stelco, Algoma and Dofasco. The other two integrated producers, Sidbec-Dosco in Quebec and Sysco in Nova Scotia, are wholly owned by the respective provincial governments.

costs in 1978 was between two and three times larger than in total manufacturing (7.5 per cent against 2.2 per cent). Rapidly rising energy prices should therefore translate into an increase in the relative price of steel. Despite this, the steel industry selling price index rose at an average annual compound rate of growth of 13.9 per cent from end-1973 to end-1979, not much more than the 11.1 per cent annual increase for all manufacturing industries. The possibility of import penetration is one factor that probably restrains steel prices, but foreign steelmakers also face much higher costs, and Revenue Canada watches closely for dumping. A more important factor constraining prices in the long run is the decline in the intensity of steel use associated with changes in technology, increased reliance on substitutes and intensified downsizing of, for instance, cars.

Since the rise in energy prices, the industry has initiated a series of projects to reduce energy consumption per ton of steel. Data from the Ferrous Metals Energy Conservation Task Force (1981) show a continuous decline in energy use per ton of raw steel produced from 1975 to 1980, with 1980 nearly seven per cent lower than 1975.

Integrated steel is much more capital intensive than non-integrated steelmaking,[3] although capital costs for the whole industry do not seem higher than in other industries. Moreover, although average weekly wages and salaries have been much higher in steel than in total manufacturing (by 22 per cent in the period 1970-1978), so has value added per employee (by 20 per cent). Thus, the ratio of wages and salaries to value added averaged 52.9 per cent over the period 1970-78, compared with 50 per cent for total manufacturing and 33.9 per cent for petroleum refining.

Capacity in the steel industry is hard to evaluate. As in many other industries, the link between capital expenditures and capacity expansion is not a rigid one. For example, investment costs may be directed at modernization, pollution control, or replacement rather than at expansion. Moreover, time may vary between the allocation of capital expenditures and the completion of various capacity additions. Finally, as Dack (1975) points out, rarely does a producer reach the stage where capacities of all

---

[3] Industry, Trade and Commerce reports that tool steel production is about 40 times as labor intensive as tonnage steel production.

divisions, from raw material mining to final rolling mill operations, balance each other. Thus, for example, an addition to furnace capacity contributes little to overall capacity if a bottleneck already exists down the line. Unfortunately, the capacity figure that is available for the industry applies only to raw steel, measured as furnace capacity. Perhaps interpolation through peaks of total shipments would be a better measure of relevant capacity because it would capture bottlenecks at the rolling mill level (see Appendix B, "Capacity" heading). In the model, the correlations of annual real capital expenditures with annual changes in furnace capacity and with interpolated peak shipments turned out to be not significantly different from zero.

As the structure of the Canadian economy changed over the last few decades, so did the industrial distribution of steel shipments. Construction is still the prime user (30 per cent in 1979) but railway consumption has dropped in favour of pipe and tubes (18 per cent) and the auto industry (21 per cent). These shifts reflect the growth of the domestic oil and gas industry and the impetus provided by the Auto Pact to the automotive industry in Canada.

The Canadian steel industry has been successful when compared with its U.S. and European counterparts. It has achieved higher profitability than its foreign rivals, including the Japanese.[4] Favourable factors include: (1) rapid market expansion associated with the development of the automotive and oil and gas industries in Canada; (2) capacity expansion well matched to demand growth, so that capacity utilization has been maintained at high, low unit cost, levels; (3) early adoption of new cost-saving technologies, including basic oxygen furnaces and continuous casting processes; and (4) conservative financial strategy.[5] Most of the industry's postwar expansion has been financed internally; moreover, integrated producers have undertaken most of their major iron ore and coal developments through joint ventures, thus reducing their financial exposure

---

[4] See Appendix A, Table 4, for some evidence of this.

[5] See the industry profiles by Industry, Trade and Commerce and by the Bank of Nova Scotia in its Monthly Review of October 1975.

(see Bank of Nova Scotia, 1975).

The cyclical behaviour of exports and imports is evident from Table 1: boom in 1974, depression in 1975, recovery in 1977 and 1978, and boom in 1979. Capacity constraints in that year of peak domestic consumption forced a decline in exports and a surge of imports. Figure 1, based on constructed trade and domestic shipments data (see Appendix B), displays the behaviour of the exports/total shipments and imports/domestic consumption ratios over the period 1971Q1-80Q1. In periods of boom (1974 and 1975), the former had a tendency to fall while the latter rose very rapidly.

Table 1

CANADIAN EXPORTS AND IMPORTS OF STEEL MILL PRODUCTS (Thousands of net tons)

Year	Exports	Imports	Balance
1970	1,731	1,582	149
1971	1,643	2,285	- 642
1972	1,633	2,426	- 793
1973	1,683	2,322	- 639
1974	1,932	3,357	-1,425
1975	1,406	1,699	- 299
1976	1,979	1,368	611
1977	2,356	1,558	798
1978	3,034	1,767	1,267
1979	2,940	2,366	374

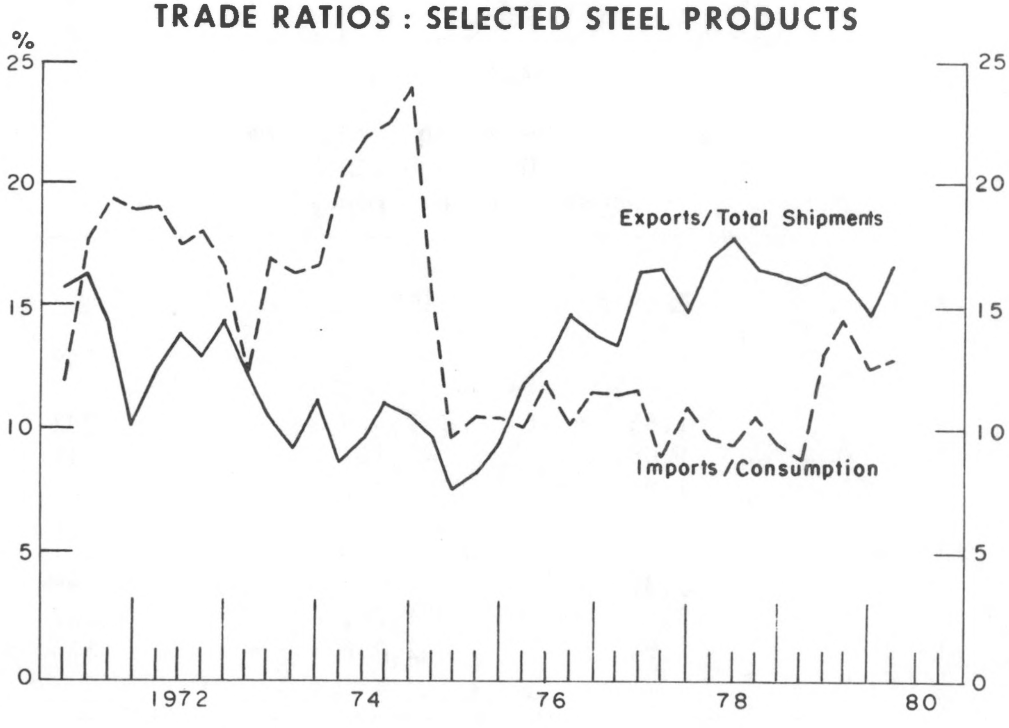
Source: American Iron and Steel Institute

Canada's trade in steel products is largely with the United States, which accounted for over three-quarters of our exports and half of our imports in value terms. Canada's share of total U.S. steel imports was 14 per cent in 1978, somewhat below Japan and the EEC, which each accounted for about 30 per cent of U.S. imports (and 20 per cent of Canadian imports).

The relatively high cost of shipping steel overland has determined the nature of the competition faced by Canadian producers. The three large integrated steelmakers have a rather firm grip on the sizeable southern Ontario market. Moreover, they are relatively close to the important U.S. Great Lakes market where they generally face less competitive U.S. producers. Canadian steelmakers nearer to the coast are much more vulnerable to European and Japanese competition.

Figure 1

TRADE RATIOS : SELECTED STEEL PRODUCTS



3 THE INTERNATIONAL ENVIRONMENT

3.1 Output and Trade

In the 20-year period from 1960 to 1979, world steel output more than doubled, growing at an average compound annual rate of 4.1 per cent, somewhat slower than the 5.7 per cent registered for world industrial production.[6] Although the number of producing countries increased rapidly and many developing countries acquired integrated iron and steel industries, the United States, the EEC, Japan and the U.S.S.R. together still accounted for 70 per cent of total production in 1979 compared with 79 per cent in 1960. Over the period, however, the United States and the EEC saw their share of world output decline. Japan had, by the beginning of the 1970s, already become a major producer and developing countries such as Brazil, Mexico and South Korea have since experienced rapid output growth. Canada maintained its share at about 2 per cent throughout the period.

In contrast to Japan and the EEC, which have large trade surpluses in steel, the United States produces mostly for the domestic market and relies to a much larger extent on imports to accommodate consumption. Indeed, U.S. exports and imports respectively accounted for 4 per cent and 18 per cent of world steel trade (excluding intra-EEC and intra-COMECON trade) in 1978. Canada has maintained a more or less balanced position in recent years, accounting for about 3 per cent of world trade.

3.2 Competitiveness

Lower energy and unit labour costs place Canadian producers in a favourable competitive position relative to U.S. and European rivals. As shown in Table 2, costs per unit of energy and coal were lower for Canadians than for their main competitors in 1978. But despite Canada's abundance of iron ore, unit costs of iron ore to Japanese and European steelmakers were much lower, largely because of freight costs. Ocean freight is much cheaper than inland freight, so that iron ore can be delivered to coastal mills in Europe from Sept-Iles at lower delivered prices than to the mills in Hamilton. As for Japan, which imports iron ore from Australia, South America and other countries, not only are most of its steel plants located on deep ocean harbors, but also special deep-water facilities have been constructed that are capable of receiving the new

---

[6] See Appendix A for data on output, trade and sales/costs ratios at the international level.

Table 2

AVERAGE UNIT COSTS, 1978
(U.S. dollars)

	Iron Ore (per metric ton)	Coal (per metric ton)	Natural Gas (per mcf)	Electricity (per kwh)
U.S.	35.00	71.90	1.84**	28.44*
Canada	34.10	63.29	1.78	12.92
EEC (excluding Denmark and Ireland)	15.90	82.60	2.55**	34.28*
Japan	22.20	68.00	N/A	31.68*

* value for second quarter
** assuming same unit consumption as in 1977

Source: Statistics Canada, Iron and Steel Mills (41-203), and O.E.C.D. Progress Report on the Economic Analysis of the Problems of the Steel Industry, SC(78), December 1978.

generation of large ore carriers.[7]

As Table 3 shows, Japanese steelmakers enjoy relatively low unit labour costs, as they benefit both from high labour productivity and from a low hourly compensation level. The table is based on unpublished data from the U.S. Bureau of Labor Statistics which, unfortunately, does not include Canada in its intercountry comparison. On the basis of an estimate of hourly compensation for Canada and assuming output per man-hour roughly similar in Canada and in the United States, unit labour costs in Canadian steel would be substantially lower than in the United States and Europe. Similar unit labour costs would mean that Canada's productivity was much lower, given the higher level of compensation in the United States.

One indicator of production efficiency at the rolling mill level is the yield of finished steel products per net ton of raw steel. In the period 1970-77, this yield averaged .75 in Canada, .70 in the

[7] For more details on these developments, see Warren (1975) Chapter 1, and the U.S. Government (F.T.C.) Report of 1977.

Table 3

STEEL PRODUCTIVITY AND LABOUR COSTS, 1978

	U.S.	Canada	Britain	France	Germany	Japan
			Index U.S.=100			
Hourly compensation	100	70	38-39	71	88	61-63
Unit labour cost	100		86-91	93-101	93-99	49-58
Output per man-hour	100		47-49	71-77	89-94	106-129
			U.S. dollars			
Hourly compensation	14.26	9.12**	5.46-5.61	10.16	12.46	8.74-9.05
Unit labour cost per metric ton	130.19		111.96-118.47	122.38-131.49	121.08-128.88	63.79-75.51

* Unit labour costs for Canada were not estimated because the BLS method of calculation required information that was not available.

** Calculated as AHH* (1+SC) where AHH represents average hourly earnings, iron and steel mills, and SC is the ratio of supplementary employment costs and paid pensions to wages and salaries at Stelco. SC is not available for the industry as a whole.

Source: U.S. Bureau of Labor Statistics. Unpublished data, available upon request.

United States, .73 in the EEC[8] and .85 in Japan. On that basis, therefore, Canada would be a relatively efficient producer. The higher Japanese yield is explained by more extensive use of continuous casting and computerization.

4 THE MODEL

The primary purpose of the model is to trace in as much detail as possible the effects of shocks to relative prices and aggregate demand variables on trade, production, prices and profits in the steel industry. Therefore, the model features relative price effects on volumes as well as the effects of demand pressure on price, volume, productivity and wages.

---

8 Excluding Ireland and Denmark.

Capacity growth is exogenous because all modelling attempts failed, although lagged output, real steel price, demand pressure and profits were among the variables tested. The problem was that investment expenditures and capacity were not closely related over the sample period. Most equations were estimated over the period 1971Q1-80Q1. The model can be branched to the Bank of Canada's model RDXF (see Robertson and McDougall), though without specific feedback from steel variables to macroeconomic variables.

The price and volume data for exports, imports and domestic consumption have been restricted to products that are essentially comparable so that substitution effects could be better captured, and the coverage is therefore not as extensive as that available in various commodity classifications. For example, the constructed export and import volumes would account for about 65 per cent of the Canadian exports and imports of steel mill products over the 1971-79 period as reported by the American Iron and Steel Institute. Details on data construction can be found in Appendix B.

Following are descriptions of the price, volume and other main equations in the model.

4.1 Price Equations

The price equations are set out in Table 4. Export and import prices depend on the U.S. domestic price and Japanese export price (Equations (1) and (2)). European export prices could not be tested because they were unavailable.[9] The Japanese price influences our own export price because Japanese and Canadian steelmakers compete for a share of the U.S. market. In any case, the Japanese price may act as a reference price for the market, since the Japanese are the lowest-cost producers.[10] Our domestic

---

[9] This may result in biased coefficients for the included explanatory variables, if the European export price is a relevant explanatory variable.

[10] In fact, the steel "trigger" prices in the United States, which are intended to signal dumping, are based on Japanese costs. The trigger price mechanism has contributed to higher U.S. import prices for steel since 1978, when it was introduced. A dummy variable for the trigger price

Table 4

PRICE EQUATIONS

Export Price

LOG(PXTI) = .6905 + .4684*LOG(PW22*PFX)+ .4680*LOG(PXJS3*PFX3) (1)
(1.72) (3.11) (2.87)

S.E.E. = .0568 RB^2 = .9672 D.W. = 2.0748 rho = .6442
Period: 1971Q2-80Q1

Import Price

LOG(PMTI) = .7723 + .3830*LOG(PW22*PFX)+ .6170*LOG(PXJS3*PFX3) (2)
(2.44) (1.65)

S.E.E. = .0953 RB^2 = .9435 D.W. = 2.1749 rho = .6123
Period: 1971Q1-80Q1

Domestic Price

LOG(PIRST) = 1.3488 + .244*LOG(NULCS) + .3738*LOG(POILCO)
(1.88) (1.89) (4.44)

+ .0953*LOG(PCOAL2*PFX) + .1455*J4A(LOG(UORDST)) (3)
(1.32) (1.93)

+ .1767*LOG(PIRON2*PFX)
(1.50)

S.E.E. = .0165 RB^2 = .9971 D.W. = 2.101 rho = .667
Period: 1971Q2-80Q1

Note: In all tables of regression output, t-ratios are in parentheses.

Variables in Table 4

PXTI Export price index (1971=100) of steel products
PW22 U.S. wholesale price index, steel mill products
PFX Canadian dollar price of U.S. dollars

(continued overleaf)

Variables in Table 4 (continued)

PXJS3	Japanese export price of metals and related products, a good proxy for the Japanese export price of steel, since 77 per cent of the value of metal exports in 1979 was ascribable to steel products (Source: Bank of Japan, Economic Statistics Monthly).
PFX3	Canadian dollar price of the Japanese yen (B3407)
PMTI	Import price index (1971=100) of steel products
PIRST	Industry selling price index, iron and steel mills (D527101)
NULCS	Index of normalized unit labour costs in the steel industry (see Appendix B)
POILCO	Industry selling price index for petroleum and coal products (D544000)
PCOAL2	U.S. producer prices of coal (Survey of Current Business)
UORDST	Unfilled orders to shipments, iron and steel mills (D313345 and D313329 respectively)
J4A	Four-quarter moving average operator
PIRON2	U.S. producer price index for iron ore

price, on the other hand, (equation (3)) is found to be quite insensitive to foreign prices; rather, it is best explained by two other factors, input costs and domestic demand pressure, that exert no empirically significant influence on our trade prices. Such a pattern of price discrimination would be expected if Canadian firms face highly price elastic demand in foreign markets and much less elastic demand internally. Since imports accounted for only roughly 14 per cent of domestic consumption in the period 1971Q1-80Q1,[11] the industry has some degree of monopoly power within Canada but not outside. Kindleberger (1968, p. 153) observes that "a company which operates largely in the domestic market . . . is likely to use a more flexible price policy on foreign sales", that is, to vary its export price according to the competitive situation abroad. Export and import prices for steel appear to be insensitive to U.S. demand pressure in steel, once foreign prices are taken into account, probably reflecting the fact that movements in foreign prices themselves incorporate a response to U.S. business conditions.

---

mechanism, when included in the export price equation, appeared with a negative sign and was thus left out. Note that Canadian steel companies have been allowed to sell below the trigger prices.

11 Based on constructed data.

The sum of the foreign price elasticities has been constrained not to exceed 1 in the import price equation (equation (2)), as passthrough of exchange rate and foreign prices exceeding 100 per cent would not have been warranted. The sum of the elasticities of the domestic price to input prices or costs is .89, thus nearly satisfying linear homogeneity. The elasticity of the price of energy inputs (POILCO) appears very high, but it presumably also captures the influence of other material costs that are strongly influenced by energy prices.

In the domestic price equation, the U.S. price for coal is used because most coal is imported by Canadian steelmakers. A much smaller proportion of iron ore, however, is imported, and the U.S. producer price for iron ore in the equation PIRON2*PFX is best seen as a proxy for the corresponding domestic price, which is unavailable. Normalized unit labour costs (NULCS) have been preferred to actual in spite of poorer fit, because in simulations it may not be warranted to have the domestic price swing in response to purely cyclical productivity changes.

4.2 Volume Equations

The volume equations are set out in Table 5. Domestic consumption of steel products (DC) responds to selected final demand components[12] (equation (4)) and gradually also to the real price of steel. Given that the estimated long-run elasticity of activity is, at 1.18, not significantly different from unity, the equation suggests that in the absence of change in the real price of steel, consumption would eventually grow at about the same pace as final demand. The downward trend in the ratio of consumption of steel products to final demand components actually observed over the sample period has been picked up in the equation by the

---

[12] The advantage for our purposes of relying on final demand components instead of real domestic products for industries using steel is that the former are endogenous in RDXF. Note also that in equation (4), the final demand components are not corrected for their import content. When imports of automotive products and machinery and equipment were in fact excluded in the final demand term, results were not as good as in equation (4). In particular, the long-run elasticities to activity and relative prices were uncomfortably high.

Table 5

VOLUME EQUATIONS

Domestic Consumption

```
LOG(DC) = 2.9540 + .3127*LOG(CMV+XOTHER+XMVP2+IME)
         (3.9124) (2.99)

          - .8688*J4A(LOG(PIRST/PGPP)) + .7357*J1L(LOG(DC))          (4)
            (-3.14)                       (10.03)

     S.E.E. = .0437    RB2 = .8719     D.W. = 1.4846
     Period: 1971Q1-80Q1
```

Imports

```
LOG(MT) = 1.887 + 2.9369*LOG(DC) + .9982*J1L(LOG(DC))
         (-5.89) (7.46)             (2.455)

- .5694*J1L(LOG(UCAPS2)) - .7075*LOG(PMTI/PIRST) - 3.065*LOG(PTS)   (5)
  (-1.78)                  (-3.72)                  (-7.05)

     S.E.E. = .1012    RB2 = .9118    D.W. = 1.9636    rho = .5450
     Period: 1971Q1-80Q1
```

Exports

```
LOG(XT) = -7.6657 + 1.9025*J2A(LOG(UMD2))
          (-1.92)   (4.05)

          + 1.0993*LOG(PXTI/PIRST) - 1.9570*LOG(PXTI/(PW22*PFX))
            (2.23)                   (-3.60)

          - .0137*LOG(DS*PRESS) + .6624*LOG(UCAPS2)                  (6)
            (-1.72)               (2.31)

     S.E.E. = .1118    RB2 = .879    D.W. = 1.76    rho = .3635
     Period: 1971Q2-80Q1
```

Variables in Table 5

DC	Domestic consumption of steel products
CMV	Consumer expenditure on motor vehicles and parts
XOTHER	Exports of manufactured end products, excluding autos and parts
XMVP2	Exports of autos and parts to the U.S.
IME	Business investment in machinery and equipment
PGPP	Price deflator for gross private business product
J1L	One-quarter lag operator
MT	Imports of steel products
UCAPS2	U.S. operating rate, raw steel (Survey of Current Business)
PTS	Capacity in Canadian steel (see Appendix B, p. 42)
XT	Exports of steel products
UMD2	Gross output originating in U.S. durable manufacturing
DS	Steel shipments to domestic users
PRESS	Demand pressure dummy, which equals 1 in 73Q1-74Q4 and 79Q3-79Q4, and 0 elsewhere.
J2A	Two-quarter moving average operator.

relative price term, whose influence builds up considerably over time. The increased real price of steel after the first oil price shock has encouraged substitution, downsizing of products and changes in technology.[13] From 1971 to 1977, the price of steel increased faster than prices of aluminum, cement and plastics. Aluminum and cement caught up in the following two years, but plastics remained a long way behind. Besides the relative price of steel, a relative price term for energy was tried in distributed lag form in order to capture substitution to lighter materials in response to higher fuel prices. This variable turned out to have positive signs, however, and was consequently dropped out.

Imports (MT) are determined by the levels of consumption and capacity in Canada, by the capacity utilization rate in the U.S. steel industry and by relative prices (equation (5)). The estimated coefficients are such that if consumption and capacity grow at the same rate over a period of time, imports will increase at about the same pace as consumption; this is consistent with the absence of trend in the import/consumption ratio over

---

[13] Raddock (1981) observes a similar downward trend in the share of steel in the production of industrial materials in the United States. He notes: "Thus, in the 1970s changes in technology have reduced the use of steel about 2 to 3 percent per year" (p.123).

the sample period. The U.S. operating rate has a significant negative influence on imports, which is not surprising since half of our steel imports come from the United States.

Exports (XT) depend on U.S. activity, on relative price incentives to Canadian supply and U.S. demand, and on demand pressure both in Canada and in the United States (equation (6)). The negative, albeit weak, elasticity of domestic demand pressure indicates that exports are crowded out by shipments to domestic users in periods of capacity constraints.

The export equation is not a structural supply or demand equation, but a pragmatic specification that embodies demand effects as well as supply responses. Given the way price behaviour is modelled, the major channel for the influence of relative costs in simulations is through profitability and the associated supply response. On the other hand, the strength of the effect of the competitiveness and the U.S. activity variables is such that export volume cannot be modelled purely as a supply function.

4.3 Other Equations

a) Unfilled Orders to Shipments

Unfilled orders relative to shipments respond gradually to the pressure of total demand on domestic capacity:

$$\underset{}{LOG(UORDST)} = \underset{(-19.19)}{-.4971} + \underset{(3.89)}{1.0385}*J8A(LOG((DC+XT)/PTS)) \qquad (7)$$

S.E.E. = .0817 RB^2 = .5520 D.W. = 1.776 rho = .3636
Period: 1972Q2-80Q1

J8A: eight-quarter moving average operator.

Total demand was used instead of total shipments because of the obvious negative correlation of the latter with UORDST. More flexible lag forms were tried without success.

b) Profits

Profits before tax (PROF)[14] are determined in the model largely by sales receipts and costs. However, an equation including only these two elements produces residuals which, over the period 1978Q1-80Q1, are significantly positively correlated with the exchange rate (PFX) and UORDST. Not surprisingly, therefore, these variables appear with strong positive coefficients in the profit equation.

```
PROF = -114.431 + 114.029*J4A(PFX)
       (-2.67)     (2.72)

       + .2594*((STA*PIRST+XT*PXTI)/1000) + 52.182*UORDST
         (4.08)                              (3.03)

       - .2664*(.325*POILCO + (.325*PCOAL2 + .35*PIRON2)*PFX)
         (-2.62)

       - .2383*ULCS + .4989*J1L(PROF)
         (-1.51)      (5.88)                                    (8)
```

S.E.E. = 6.4175 (8.79 per cent at the mean) RB^2=.9685 D.W.=2.07
Period: 1971Q2-80Q1

PROF	Pre-tax profits of Stelco, Dofasco and Algoma
STA	Domestic selling price for steel
PXT1	Export price index (1971=100) of steel products
ULCS	Actual unit labor costs in steel (see Appendix B)

There are several reasons for the "independent" contribution of the exchange rate (PFX) and unfilled orders to shipments (UORDST). The selling price index (PIRST), does not properly reflect premiums or discounts to Canadian dollar list prices, which are influenced by PFX and UORDST. Also, the segment of the industry to which PROF relates is more profitable and also probably more export-oriented than the rest of the industry. Thus the growth of (STA*PIRST+XT*PXTI) and the elasticity of profits to it may be underestimated when PFX stimulates sales and profits. Furthermore, PROF is also determined by net income from investment, which is probably enhanced

---

[14] See Appendix B for details on the construction of the profit series.

by PFX. Finally, economies of scale at high operating rates would be captured by unfilled orders to shipments (UORDST).

c) Productivity

Labour productivity in steel (PRODS) has, according to equation (9), fluctuated around a trend growth of about 2 per cent per year. Cyclical gains can be measured using the operating rate.

```
LOG(PRODS) = - .3538 +.4368*LOG(TS/PTS)
               (-2.35) (3.96)

             + .00484*QQTIME                                    (9)
               (3.40)
```

S.E.E. = .0285 RB^2 = .855 D.W. = 1.95 rho = .666
Period: 1971Q2-80Q1

PROD	RDPS/EMPS, where RDPS and EMPS are respectively indexes of real domestic product and employment for the iron and steel mills industry (see Appendix B)
TS	Total shipments of steel products
QQTIME	Quarterly time trend, equals 1 in 1950Q1

d) Average Weekly Earnings

I opted for an equation that would link wages in the steel industry (AWWS) to those in the industrial sector in Canada (WNIC) and in the U.S. steel industry[15] (WS2, in U.S. dollars), and to demand pressure in the steel sector. Effects of unemployment and price expectations at the macro level are transmitted to the sector through WNIC. As shown in Figure 2, AWWS has been consistently higher than WNIC but lower than WS2. The gap between AWWS and WNIC has widened noticeably since 1977, as has the wage differential between Canadian and U.S. steelworkers, in favour of the latter.

---

[15] Many studies, e.g., Taylor et al. (1973), Perry (1975), and Wurzburger (1978) have found the U.S. wage rate to be a significant explanatory variable in a Canadian wage equation. For an analysis of various rationales for inclusion of a U.S. wage in a Canadian wage equation, see Wurzburger.

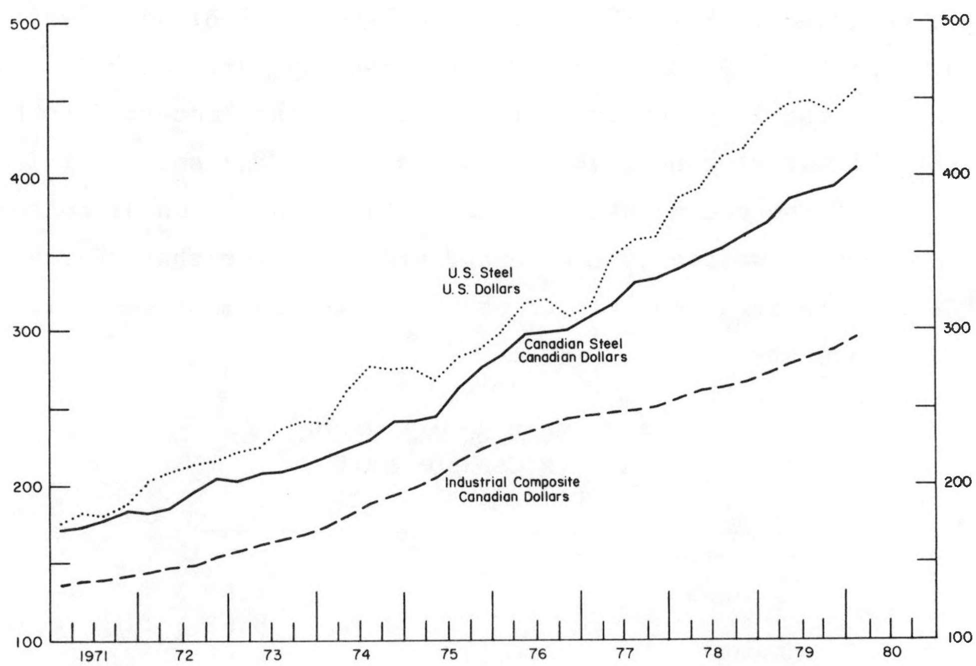
AWWS = -80.269 +32.537*UORDST +.1927*J1L(WS2)
(-1.82) (2.18) (2.38)

+ 1.2802*WNIC
(5.78) (10)

S.E.E. = 4.502(1.6 per cent at the mean) RB^2=.995 D.W.=1.807 rho=.86
Period: (1972Q3-80Q1)

AWWS Average weekly earnings, iron and steel mills (D703076)
WS2 Average weekly earnings, U.S. blast furnaces and steel mills (U.S. Bureau of Labor Statistics, Employment and Earnings)
WNIC Average wage of industrial composite excluding special payments and including loss due to strikes (Bank of Canada model RDXF)

Figure 2
AVERAGE WEEKLY WAGES AND SALARIES



Consistent with other studies (Wurzburger, 1978), U.S. wages that were not corrected for exchange-rate variations fared much better than corrected wages in explaining Canadian wages. This suggests that wage emulation in the bargaining process ignores changes in the exchange rate.

4.4 Identities

The model includes four identities:

(1) Shipments to domestic users: DS=DC-MT

(2) Total shipments: TS=XT+DS

(3) Canada-Japan exchange rate: PFX3=PFX23*PFX where PFX23 is the U.S. dollar price of Japanese yen

(4) Unit labour costs: ULCS=(AWWS*(1+RYWSLP))/(1.870543* PRODS) where RYWSLP is the ratio of supplementary labour income to wage income in the National Accounts.

4.5 Dynamic Simulation Errors

The simulation errors of the model for the period over which the shocks are performed, 1977Q1-80Q1, are displayed in Table 6. Profits (PROF) and imports (MT) show the largest errors by far. In both cases, the results reflect the large underprediction errors that occurred in the extremely tight market conditions prevailing in 1979, especially in the cyclical peak of the second half. Indeed, underprediction of consumption (and hence domestic shipments and demand pressure) for that year had a large effect on imports and profits as these two are most sensitive to cyclical developments.

Table 6

ROOT MEAN SQUARE ERROR AS PER CENT OF MEAN
(1977Q1-80Q1)

AWWS	1.69
DC	8.62
DS	6.49
MT	29.42
PIRST	1.44
PMTI	5.93
PRODS	2.62
PROF	17.97
PXTI	5.12
TS	5.92
UORDST	6.32
XT	9.09

5 SIMULATION RESULTS

In designing shocks, one has to pay attention to asymmetries in the reactions that would be expected in the real world but that the model cannot duplicate. For instance, capacity is exogenous in the model but capacity utilization is not. Given that the steel industry experienced full capacity utilization for a number of quarters over the sample period, shocks that stimulated total shipments should result in simulated output exceeding absolute capacity in these periods. To avoid this situation, shocks were imposed that involve declines in capacity utilization via decreases in total shipments.

The various shocks to the model are described in this section in the following order:

A. PFX = .98PFX
The Canadian dollar price of the U.S. dollar is lower by 2 per cent.

B. POILCO = 1.02POILCO and PENERG=1.02PENERG
The price of energy in Canada is higher by 2 per cent (the world price as well as PCOAL2 are constant).

C. CMV = .98CMV
Consumer expenditures on automotive products in Canada are lower by 2 per cent.

D. UMD2 = .98UMD2 and UCAPS2 =.98UCAPS2
U.S. durable manufacturing output and U.S. operating rate in steel are lower by 2 per cent.

All shocks were initiated in 1977Q1 and effects observed up to 1980Q1. Shocks to PFX and to POILCO involved full model simulations of the Bank of Canada's model RDXF. In the second case, PENERG, the price of consumer energy in RDXF, had to be shocked as well, since POILCO is not an RDXF variable. Also, XMVP2 was made endogenous in the shock to CMV, as the latter is a significant determinant of the former, following from the Auto Pact. Figures 3 through 6 show shock-minus-control results in percentage terms.

Figure 3a

RESPONSES TO SHOCK : PFX=PFX* .98

With Relative Price Effect on Consumption of Steel

Shock Minus Control

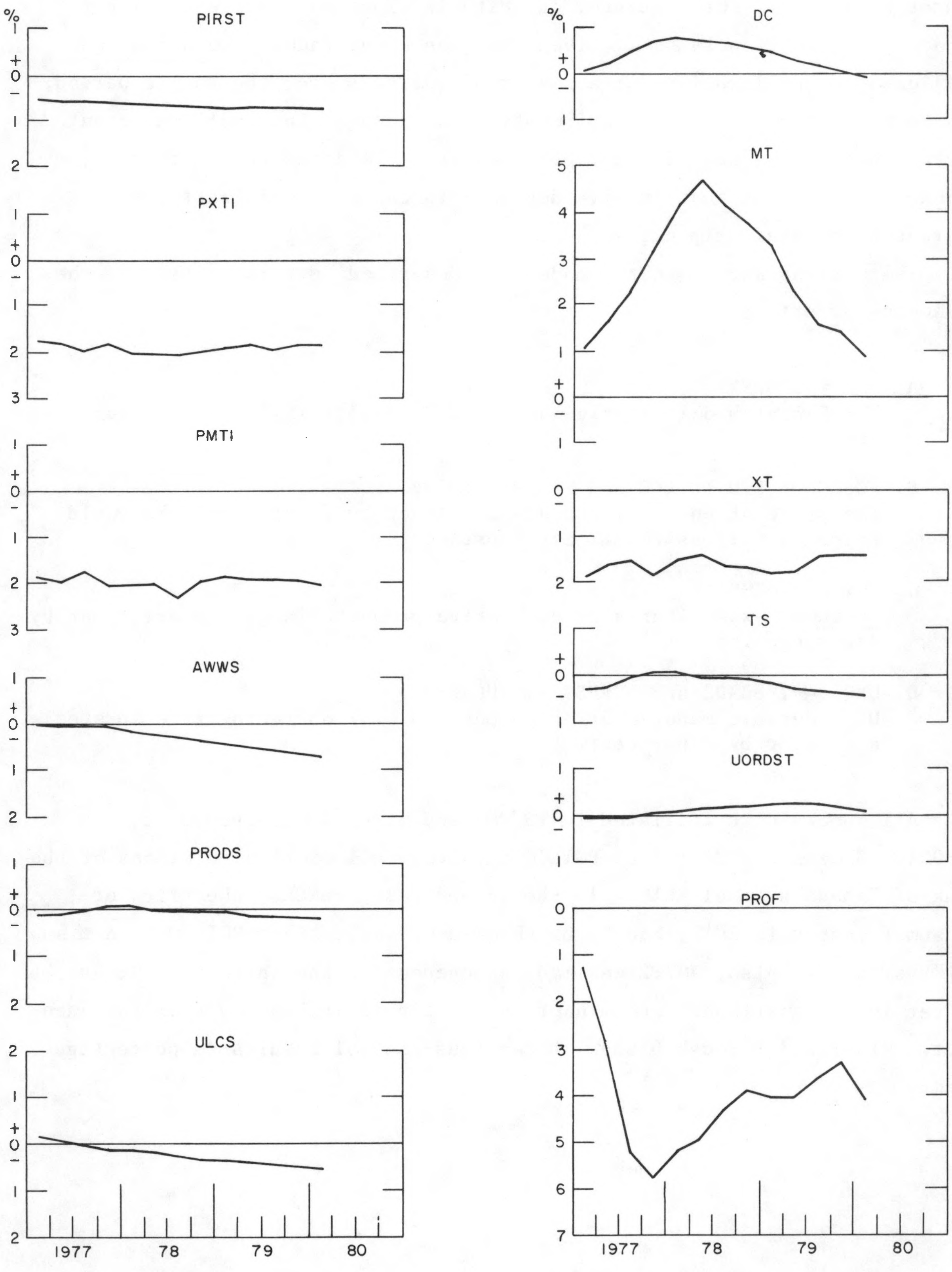


Figure 3b

RESPONSES TO SHOCK : PFX=PFX* .98

No Relative Price Effect on Consumption of Steel

Shock Minus Control

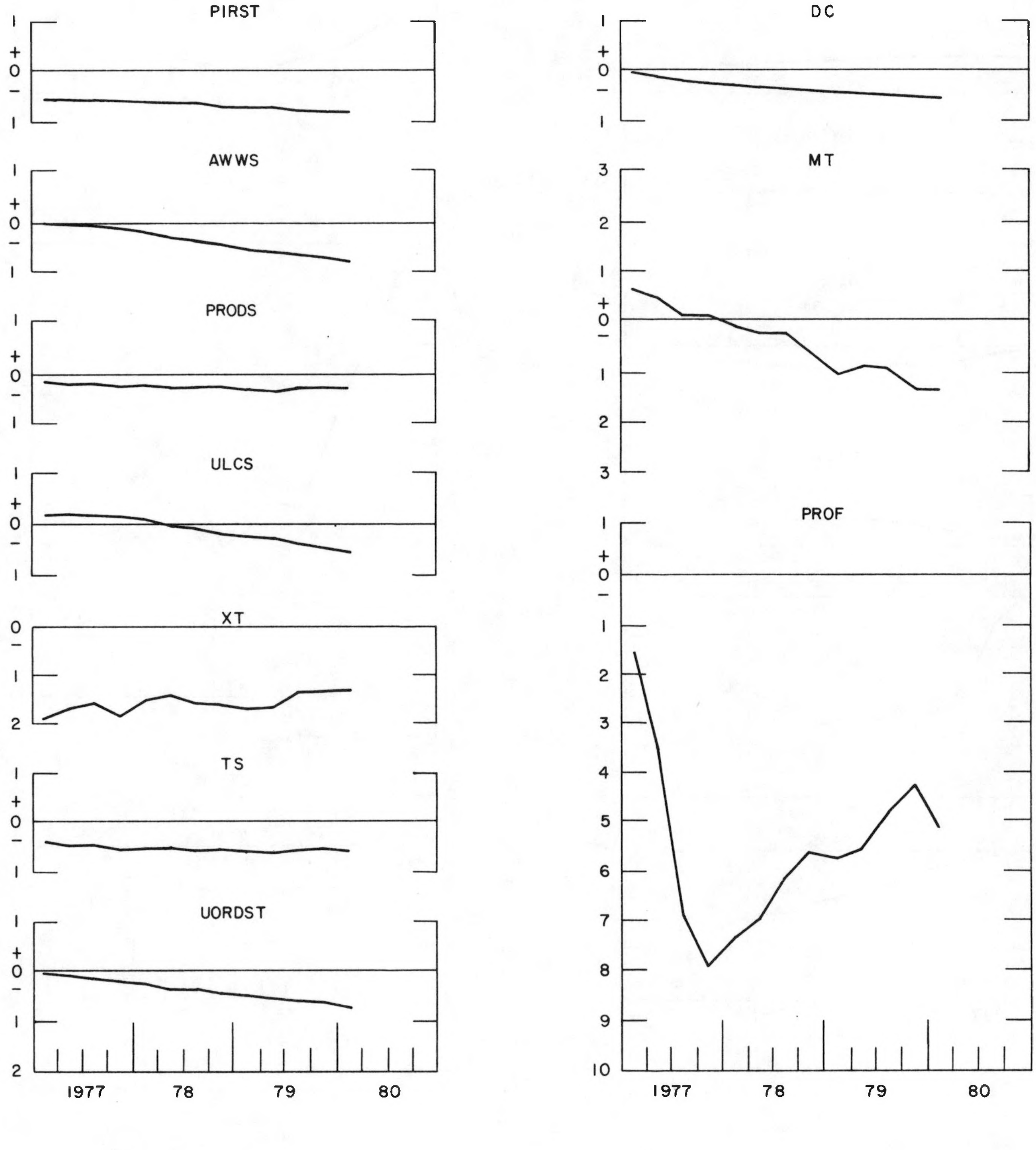


Figure 4
RESPONSES TO SHOCK : POILCO=POILCO* 1.02
Shock Minus Control

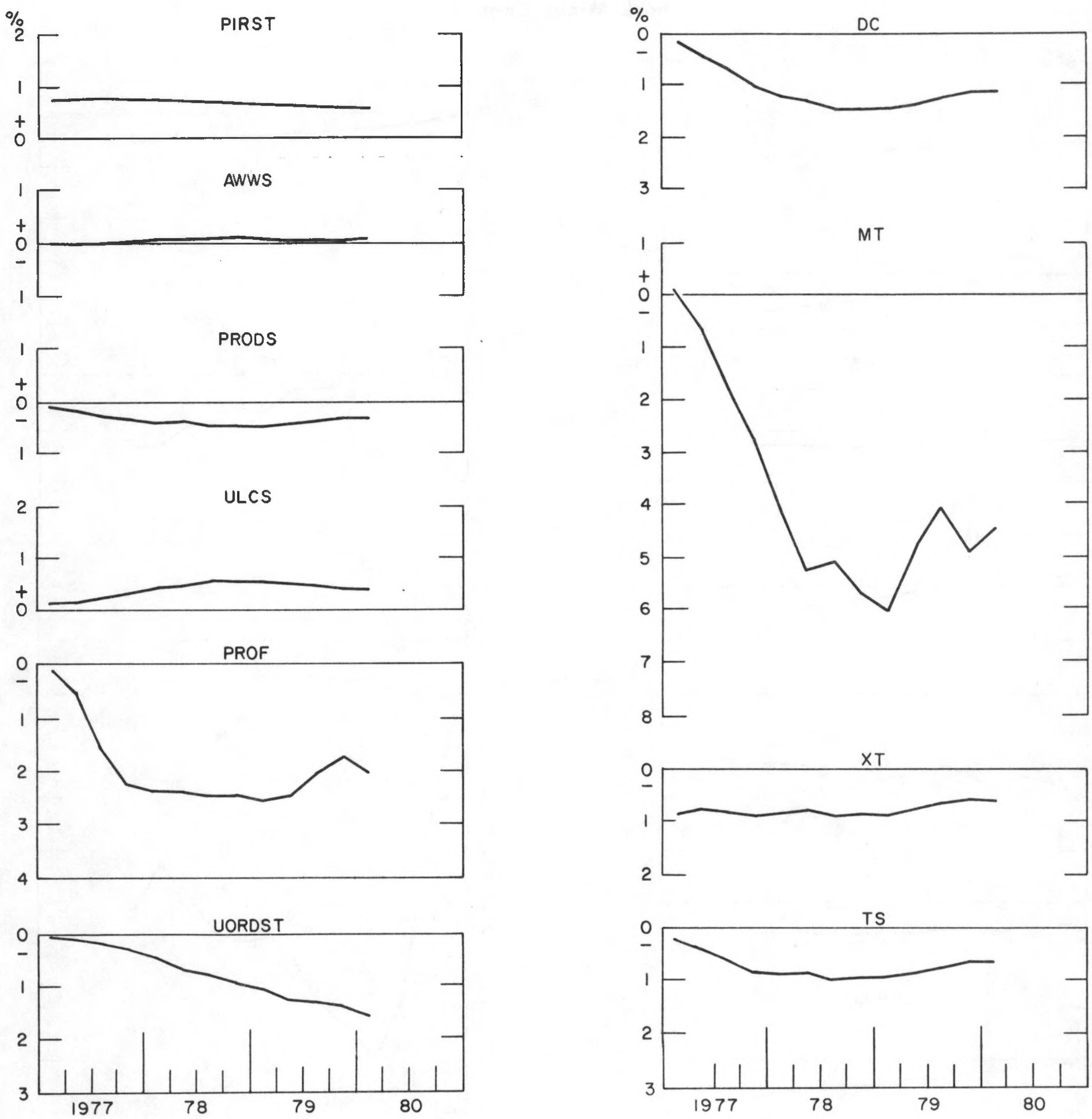


Figure 5

RESPONSES TO SHOCK : CMV=CMV* .98

Shock Minus Control

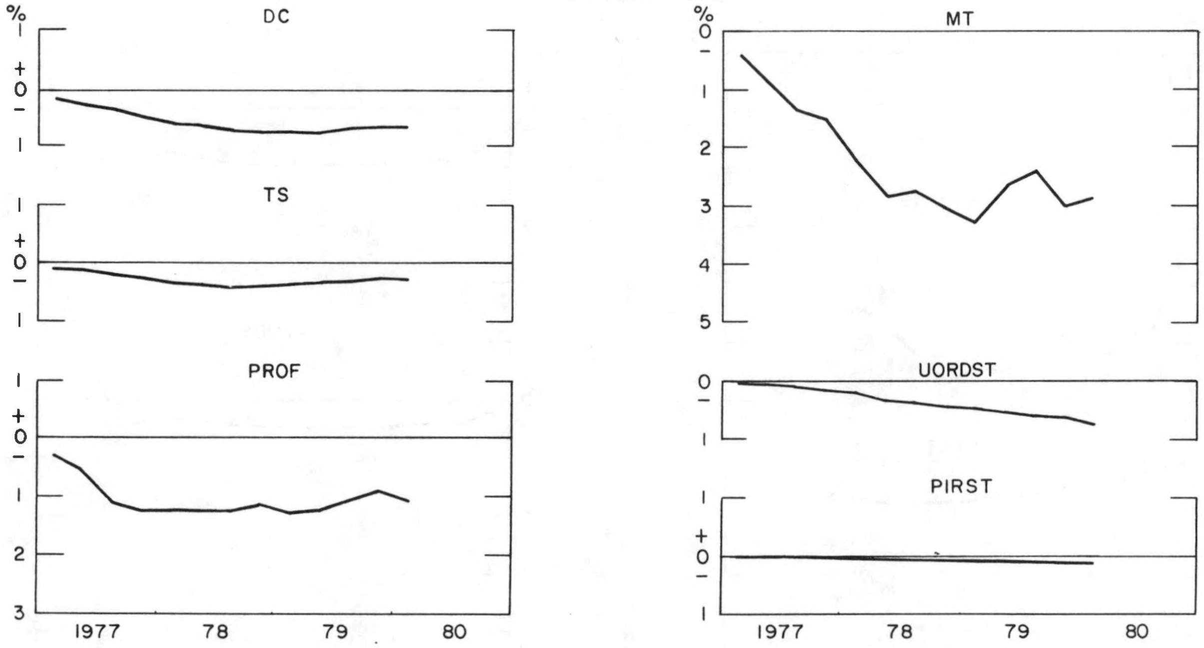
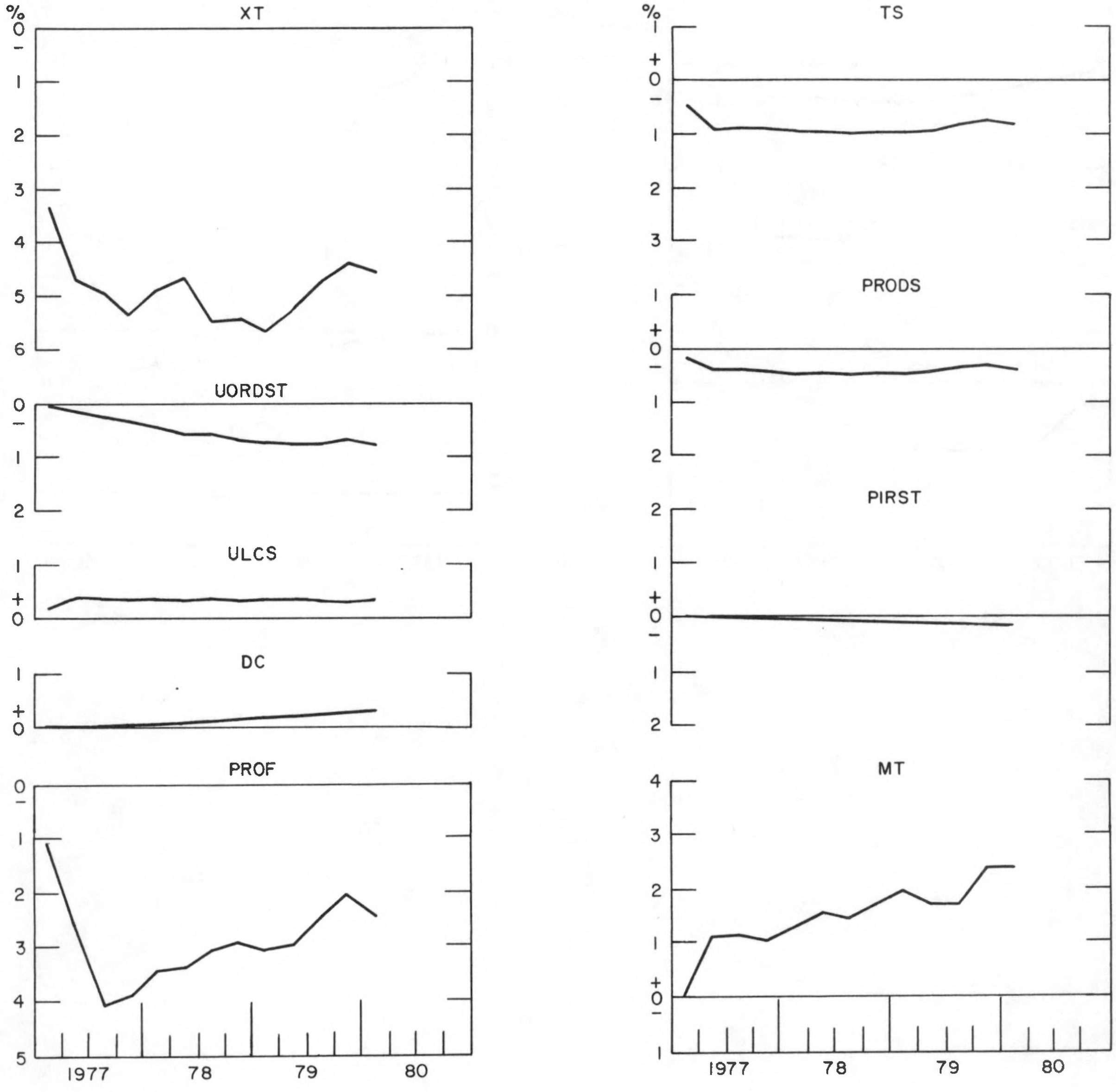


Figure 6

**RESPONSES TO SHOCK : UMD2=UMD2* .98
UCAPS2=UCAPS2* .98**

Shock Minus Control



A. Canadian Dollar Appreciation (PFX = .98PFX)

The appreciation of the Canadian dollar is almost fully reflected in lower trade prices; the terms of trade improve slightly as the transmission to import prices is somewhat more complete than that to export prices. The domestic steel price is lower by over half a per cent due to reduction in both material input costs and normalized unit labour costs; the latter reflect a wage decrease in response to dampened price inflation.

In the first five quarters, consumption is increasingly higher than in the control solution as the impact of the decline in the real price of steel more than offsets the overall weak effect of the decrease in final demand components. Thereafter, as the fall in output (PGPP) and the weakening of final demand progress, consumption adjusts downward until it actually falls below the control solution in the final quarter of the simulation.

Imports rise in response to the increase in consumption and to the fall in their relative prices, reaching a peak relative to control after a year, then returning almost to control by the end of the period. Exports are weaker by about 1.5 per cent over the whole period because relative prices move in such a way as to make exports less profitable to Canadian producers and more expensive to foreign customers. Canadian producers have to cut their Canadian dollar export prices relative to the domestic price and costs in order to remain competitive with foreign steelmakers. Moreover, the adjustment of the export price being gradual and not quite complete, exports become more expensive to foreigners.

Total shipments, capacity utilization, productivity and unit labour costs are all lower. Profits drop by as much as 5.7 per cent because the volume of business diminishes and because unit profits (PROF/TS) are smaller.

In the simulation just described, the movement of the relative price of steel exerts a surprisingly strong effect in delaying the expected consumption response to an exchange rate change. The improvement in the real trade balance that eventually results from the slackening of aggregate demand caused by the appreciation is also delayed substantially. This can be inferred from Table 7, which reports two simulation results for consumption and imports, one that reflects relative price effects on consumption, corresponding to the results described earlier, and one that does not.

Table 7

RESPONSE TO PFX SHOCK: PFX = .98PFX
(Shock minus control, per cent)

		Model with Relative Price Effects on Consumption		Model without Relative Price Effects on Consumption	
		Consumption	Imports	Consumption	Imports
1977	1	.07	1.04	-.07	.64
	2	.22	1.62	-.14	.47
	3	.44	2.29	-.20	.07
	4	.68	3.16	-.25	.09
1978	1	.75	4.15	-.29	-.10
	2	.70	4.66	-.31	-.26
	3	.68	4.11	-.37	-.25
	4	.55	3.73	-.40	-.69
1979	1	.43	3.29	-.44	-1.03
	2	.30	2.26	-.47	-.88
	3	.16	1.58	-.48	-.92
	4	.03	1.40	-.51	-1.32
1980	1	-.09	.87	-.54	-1.36

In the model without relative price effects on consumption, imports start declining after only a year, as indirect activity effects more than offset the direct substitution effects of lower relative import prices. This pattern is consistent with the surge of imports and slowdown of exports observed in 1979, which resulted from capacity constraints stemming partly from the stimulating impact of the depreciation of the Canadian dollar on aggregate demand in Canada. If relative price effects on consumption are as significant as the model suggests, then the moderating impact on consumption of the rise in the real price of steel induced by the depreciation prevented a much worse deterioration of the trade balance in steel than actually occurred in 1979. Figure 3b shows the effects of a shock to the exchange rate in the model without relative price effects on consumption.

The identity for the Canada-Japan exchange rate (PFX3=PFX23*PFX) included in the model means that in the simulations described earlier the Canadian dollar appreciated not only against the U.S. dollar but also against the yen. If instead PFX3 had been kept at its actual value, the results would have been somewhat different, especially for trade. The prices of exports and imports would have declined by less than one per cent, and imports would have been weaker because their relative prices would have decreased less. Exports would have been more profitable to Canadian producers, but at the same time much more expensive to foreign customers; on balance, they would have declined at a faster pace. Consumption, demand pressure, profits and domestic price would have changed little from the previous simulations.

B. Higher Energy Prices (POILCO = 1.02POILCO and PENERG = 1.02PENERG)

Higher domestic energy prices (POILCO and PENERG), keeping world prices constant, result in higher unit labour costs as productivity declines as a result of lower capacity utilization and as wages are affected by expectations of higher inflation. The domestic steel price is about .5 to .75 per cent higher as the increase in input costs more than offsets the impact of reduced demand pressure. The real price of steel is higher than in the control solution, which is consistent with the fact that steel is a relatively energy-intensive industry.

Consumption decreases by as much as 1.5 per cent in response to the higher real price of steel and to the weakening of final demand components.[16] This, combined with falling demand pressure, leads to a much lower level of imports. Exports too diminish as a supply response to competitive pressures that prevent the price from rising as much as the domestic price. Profits fall by as much as 2.6 per cent.

---

[16] As mentioned earlier, the model does not take account of the possible longer-run impact of different energy prices on energy projects, adjustments of industrial structure, consumption habits, et cetera.

C. Lower Automobile Purchases (CMV = .98CM)

Domestic steel consumption and shipments are depressed by smaller consumer expenditures on autos (CMV) and hence by a gradual decline in auto exports as automotive production tends to adjust to lower domestic consumption in the context of the Auto Pact.[17] The decline in steel consumption relative to capacity results in much lower imports. Exports change little and the trade balance in steel improves markedly. The domestic price declines slightly, due mostly to slackening demand pressure. Profits are smaller by as much as 1.3 per cent in 79Q1.

D. Lower U.S. Demand (UMD2 = .98UMD2 and UCAPS2 = 2.98UCAPS)

In this simulation, both U.S. durable manufacturing output (UMD2) and capacity utilization in U.S. steel (UCAPS2) are lower by 2 per cent, consistent with U.S. steel output being down 2 per cent while U.S. steel capacity is unaffected, over the simulation horizon. In this context, Canadian steel exports are lower by about 5 per cent over the period, bringing total demand for Canadian steel down relative to capacity. Productivity then declines as a result of the lower capacity utilization and pushes unit labour costs up. Normalized unit labour costs change little, however, so that the domestic steel prices decline slightly in response to slackening demand pressure. Imports from the United States are nonetheless stronger because U.S. producers have more free capacity to accommodate Canadian customers. Profits are lower by as much as 4 per cent in 1977Q3.

---

[17] This behaviour assumes symmetrical working of the Auto Pact, one important aspect of which is that firms are required not to let the growth of value added in Canadian production fall below certain proportions of the growth in domestic sales. One econometric model of Canada-U.S. automotive trade including domestic auto consumption as a determinant of exports can be found in Alexander; it implicitly assumes symmetrical working of the Pact.

6 CONCLUSION

This paper provides some econometric evidence on the possible responses of the steel industry, specifically its output, trade, prices and profits, to assumed changes in relative prices and activity. A model of the steel industry was built in which relative prices and demand pressure play an important role and in which Canada is a price maker in the domestic market and a price taker in foreign markets. Simulations with the steel model linked to the Bank of Canada's RDXF model suggest that the industry has benefited from the weaker Canadian dollar since 1977 and from the relatively low domestic price of energy in Canada.[18]

The dynamics of the model are such that if the relative price effects on steel consumption were sterilized, the indirect effects of exchange rate movements on domestic activity would tend after a while to dominate the direct substitution effects, in terms of the trade balance in steel. Although this conclusion ignores the long-run response of capacity growth to output and profit signals, since total capacity is exogenous in the model, it may be a reasonable representation of behaviour over the cycle. For example, it is consistent with the surge of imports and slowdown of exports observed in 1979 at a time of capacity constraints in the steel industry, which stemmed partly from the stimulative impact of depreciation on aggregate demand in Canada.

Real price effects on steel consumption are nevertheless quite significant in the model. A depreciation of the Canadian dollar reduces the intensity of steel use, and hence consumption, through a rise in the real price of steel. In turn, this delays substantially the eventual deterioration of the trade balance that would result from heightened demand pressure. Thus the model suggests that net steel exports would have been much lower in 1979 had it not been for the dampening effect on consumption

---

[18] The analysis does not take account of some important longer-run feedbacks of a relatively low energy price. For example, if adjustments of industrial structure and consumption habits to high energy prices are made more rapidly abroad, then Canada's trading position could become outmoded. The current state of the auto industry, one of the most important users of steel, illustrates this point.

of the rise in the real price of steel that had been previously induced by the depreciation.

Another interesting result relates to the response of unit labour costs to price shocks. A higher level of the domestic energy price (keeping the world price constant) raises unit labour costs fairly soon both by reducing productivity and by inducing higher wages. A depreciated Canadian dollar, however, leads to higher labour costs only after several quarters, because the initial stimulus to output causes a short-run increase in productivity which is only later offset by the wage response. Movements of unit labour costs have an immediate effect on profits. The domestic steel price, on the other hand, responds to normalized unit labour costs and hence is insensitive to short-run productivity changes.

APPENDIX A

DATA ON OUTPUT, TRADE AND SALES/COST RATIOS

Table A-1

WORLD RAW STEEL OUTPUT
(Percentage shares)

	Canada	United States	E.E.C.	Japan	U.S.S.R.	Brazil, Mexico and S.Korea	World Output
			(Percentage share of world output)				(000 metric tons)
1960	1.5	25.9	28.1	6.4	18.8	1.0	348,124
1965	2.0	26.0	24.8	9.0	19.8	1.2	459,000
1970	1.9	20.0	23.2	15.7	19.5	1.6	594,000
1971	1.9	18.9	22.1	15.3	20.8	1.8	579,400
1972	1.9	19.3	22.2	15.5	20.0	1.8	626,500
1973	1.9	19.8	21.6	17.3	19.0	1.9	690,000
1974	1.9	18.8	22.0	16.6	19.3	2.1	704,800
1975	2.0	16.4	19.8	15.9	21.9	2.4	644,980
1976	2.0	17.2	19.8	15.9	21.5	2.5	675,520
1977	2.0	16.9	19.0	15.3	21.9	2.9	671,540
1978	2.1	17.5	18.8	14.5	21.4	3.1	706,000
1979	2.1	16.5	18.8	15.0	20.0	3.9	746,000

Source: United Nations, Statistical Yearbook, various issues

Table A-3

IRON AND STEEL IMPORTS *
(Percentage shares)

	1970	1971	1972	1973	1974	1975	1976	1977	1978
Canada	3.65	4.48	4.31	3.81	4.18	3.06	3.04	3.09	2.38
United States	18.40	22.69	21.94	15.36	16.60	12.53	14.26	18.46	17.89
E.E.C.	15.10	11.86	12.91	12.63	8.81	9.75	12.54	11.54	10.08
Japan	1.74	0.68	0.64	1.07	0.96	0.40	0.75	0.64	0.90
Developed market economies	62.07	60.28	59.36	53.25	49.17	43.31	47.48	49.52	45.45
Developing market economies	27.78	28.99	28.45	31.61	36.20	38.52	33.55	34.46	36.18
Centrally planned economies	10.07	10.58	12.08	14.93	14.37	17.92	19.00	15.95	18.09

* Excluding intra-EEC and intra-centrally planned Europe and U.S.S.R.

Source: United Nations, Monthly Bulletin of Statistics, various issues.

Table A-2

IRON AND STEEL EXPORTS *
(Percentage shares)

	1970	1971	1972	1973	1974	1975	1976	1977	1978
Canada	3.56	3.28	3.02	2.54	2.39	2.22	2.73	2.97	2.96
United States	11.02	6.57	6.18	6.73	7.45	7.33	6.04	4.95	4.15
E.E.C.	32.64	35.43	34.92	35.50	36.02	36.83	30.17	32.70	34.66
Japan	24.65	29.52	26.88	27.48	31.41	30.31	33.20	31.27	28.70
Developed market economies	86.81	88.55	86.56	88.16	90.01	90.90	88.25	88.28	88.20
Developing market economies	4.95	3.56	5.17	4.94	4.61	3.766	5.63	5.51	6.07
Centrally planned economies	8.16	7.82	8 26	6.88	5.30	5.30	6.12	6.21	5.73

* Excluding intra-EEC and intra-planned Europe and U.S.S.R.

Source: United Nations, Monthly Bulletin of Statistics, various issues.

Table A-4

OVERALL EFFICIENCY INDICES *
Average 1972-1978

Enterprise	Index	Enterprise	Index
Dofasco	118.9	Estel	106.7
Stelco*	117.6	Nippon Steel	106.6
Thyssen-Hütte	116.1	Klockner-Werke	106.5
Peine-Salzgitter	114.4	Kawasaki Steel	104.7
Sumitomo Metal	114.2	Vöest-Alpine	103.4
Ensidesa	113.8	Usinor	103.2
Algoma	111.6	Arbed	102.8
Krupp Hüttenwerke	110.1	British Steel	100.7
U.S. Steel	109.6	Cockerill	98.6
Italsider	109.4	Sacilor	98.4
Bethlehem Steel	108.0	Hainaut-Sambre	97.3
		TMM Forges	95.9

* Index = sales/(costs of sales + depreciation)

** Average for 1977 and 1978; comparable figures for Algoma and Dofasco are 110.5 and 116.7 respectively.

Source: F. Peco, "How Steelmaking Enterprises Can Become Internationally Competitive", Table 4, p. 135 in O.E.C.D., Steel in the 80's, Paris 1980. Annual Reports of Algoma, Dofasco and Stelco.

APPENDIX B
DATA CONSTRUCTION

Sources on Steel

There are many sources of data on trade in steel products. Statistics Canada's Primary Iron and Steel (41-001) provides data on aggregate export volumes based on information from producers. Exports by Commodities (65-004) and Imports by Commodities (65-007) report the values and volumes of disaggregated steel imports and exports, based on customs documents. Several aggregate value series are compiled from this source and appear, for example, in exports and imports based on the Standard Commodity Classsification, in exports based on the Bank of Canada Commodity Classification, and in imports based on End-Use Classification. Price index series are also available, based on the Export Commodity Classification, the Bank of Canada Commodity Classification and the Standard Commodity Classification. In addition, the United Nations publishes data on the U.S. dollar values of aggregate exports and imports of Canadian iron and steel mills products with several countries. The American Iron and Steel Institute has a section in its Annual Statistical Report on various aspects of Canadian steel, including a breakdown by products of exports and imports in volume terms.

Prices and Volumes

I used only export, import and domestic consumption data that would reflect the inclusion of comparable products, so that substitution effects could be better captured. The model deals in fact with five categories of carbon steel products: wire rods (W), bars (B), plates (P), sheets (S) and shapes (S). Table B-1 identifies the components included in this study. The numbers for exports and imports are Trade Canada individual commodity numbers.

The set of identities in Table B-2 summarizes the way I constructed seasonally adjusted values ($), volumes, and prices (P) for exports (X), imports (M) and domestic consumption (DC). Note that values are not

Table B-1

CATEGORIES OF STEEL PRODUCTS INCLUDED

	Exports (65-004)	Imports (65-007)	Shipments to Domestic Users (41-001)
Wire rods	44450	44450	Wire rods
Bars	44430	44405 44406 44407 44409 44427	Concrete reinforcing; other hot rolled bars
Plates	44520	44502 44503 44504	Plates
Sheets	44530 44540 44555 44599	44531 44532 44533 44534 44537 44538 44555 44559 44561	Hot rolled sheets Hot rolled strips Cold reduced sheets and strips Galvanized sheets
Shapes	44659	44605 44607 44610 44611 44613 44615 44616 44618 44620 44630 44645	Structural shapes

available for domestic consumption, and that its attached price in the model is the industry selling price index for iron and steel (SIC 291).

The subscript sa appears only for components that were seasonally adjusted. The lowest F value for which seasonal adjustment was carried out was 8.95. Note that $MT\$_{sa}$, MT_{sa}, and DC_{sa} are sums of seasonally adjusted components and have not been seasonally adjusted separately. Prices of both exports and imports are ratios of raw values to raw volumes.

Table B-2

IDENTITIES USED IN THE MODEL

Values	Definition	Source
Exports:	XT\$ = XW\$+XB\$+XP\$+XS\$+XA\$	Exports by commodities (65-004)
Imports:	$MT\$_{sa} = MW\$_{sa} + MB\$_{sa} + MP\$_{sa} + MS\$_{sa} + MA\$_{sa}$	Imports by commodities (65-007)
Volumes	**Definitions**	**Sources**
Exports:	XT = XW+XB+XP+XS+XA	Exports by commodities
Imports:	$MT_{sa} = MW\$_{sa}/UVMW+...MA\$_{sa}/UVMA$ with UVMW = MW\$/MW, etc..., where UV represents raw unit values	Imports by commodities
Domestic Consumption:	$DC_{sa} = DCW_{sa} + DCB + DCP + DCS_{sa} + DCA_{sa}$ with DCW = DSW+MW, where DS represents shipments to domestic users, etc...	Imports by commodities and primary iron and steel (41-001)
Prices		
Exports:	PXT = XT\$/XT	
Imports:	PMT = MT\$/MT	

Unit Labour Costs

The construction of the index of unit labour costs in steel proceeded in the following way. I started with the three basic series:

$RDPS_{sa}$: index of real domestic product, iron and steel mills (D100480), quarterly, seasonally adjusted, 1971=100;

AWWS: average weekly earnings, iron and steel mills (D703076), monthly, raw;

EMPS: employment index, iron and steel mills (D700176), monthly, raw.

AWWS and EMPS were collapsed, and EMPS was seasonally adjusted (F=83.4). Then, I defined:

ALIS = AWWS*(1+RYWSLP)

where RYWSLP is the ratio of supplementary labour income to wage income in the National Accounts. ALIS can be taken as a proxy for average weekly compensation in the steel industry over a quarter. ALIS was indexed to 1971=100 and the index of unit labour costs in steel (1971=100) was calculated as:

$ULCS = ALIS*EMPS_{sa}/RDP_{sa}$

Normalized unit labour costs, NULCS (1971=100), were obtained by substituting "normal" productivity for actual in the calculation of unit labour costs.

NULCS = ALIS/NPRODS

"Normal" productivity is that which prevails at the average capacity utilization rate. It was calculated by simulating equation (9) with TS/PTS, the operating rate, fixed at its mean value for the period 1971Q1-80Q1.

Capacity

I have tested two measures of capacity: the first, PTS, is a quarterly linear interpolation through peaks of total shipments. It can capture bottlenecks at the rolling mill level. The second represents steel furnace capacity, CAP. There is only one steel furnace capacity figure available each year: that prevailing as at January 1. Quarterly average values for CAP were obtained by interpolating an end-of-quarter capacity series in a linear fashion, and by calculating from it a two-period moving average. PTS fared better than CAP in the regressions.

Profits Before Tax

Statistics Canada does not publish quarterly profit data on the steel industry. Therefore, I drew my profit figures from FRI data on Stelco, Dofasco and Algoma. Unfortunately, such data were available on a quarterly basis from 1975Q4 only and on an annual basis from 1969. I decided to use the annual information covering the period 1971-75 in a quarterly regression over 1971Q2-80Q1. I interpolated a quarterly average profit series from 1971 to 1975, PROF, in the following way:

Q1 = A1*.75+A0*.25
Q2 = A1
Q3 = A1*.75+A2*.25
Q4 = A1*.5 +A2*.5

with A1: profits of the current year
A2: profits of the previous year
A3: profits of the next year

From 1976 on, I relied on the actual quarterly values of PROF, which I seasonally adjusted in view of their strong seasonality.

APPENDIX C

LIST OF MNEMONICS

AWWS	Index of real domestic product, iron and steel mills (D100480), quarterly, seasonally adjusted, 1971-100
ALIS	Proxy for average weekly compensation in the steel industry over a quarter
CMV	Consumer expenditure on motor vehicles and parts
DC	Domestic consumption of steel products
DS	Steel shipments to domestic users
EMPS	Employment index, iron and steel mills (D700176), monthly, raw
IME	Business investment in machinery and equipment
JxA	Moving average operator; x is number of quarters
JxL	Lag operator; x is number of quarters
MT	Imports of steel products
NULCS	Index of normalized unit labour costs in the steel industry
PCOAL2	U.S. producer prices of coal (Survey of Current Business)
PENERG	Price of consumer energy in Canada (RDXF)
PGPP	Price deflator for gross private business product
PFX	Canadian dollar price of the U.S. dollars
PFX3	Canadian dollar price of the Japanese yen (B3407)
PIRON2	U.S. producer price index for iron ore
PIRST	Industry selling price index, iron and steel mills (D527101)
PMTI	Import price index (1971-100) of steel products
POILCO	Industry selling price index for petroleum and coal products (D544000)
PRODS	Labour productivity in steel: RDPS/EMPS where RDPS and EMPS are respectively indexes of real domestic product and employment for the iron and steel mills industry

PRESS	Demand pressure dummy, which equals 1 in 1973Q1-1974Q4 and 1979Q3-1979Q4, and 0 elsewhere
PROF	Pre-tax profits of Stelco, Algoma and Dofasco
PTS	Capacity in Canadian steel
PW22	U.S. wholesale price index, steel mill products
PXJS3	Japanese export price of metals and related products, proxy for the Japanese export price of steel
PXTI	Export price index (1971-100) of steel products
QQTIME	Quarterly time trend, equals 1 in 50Q1
$RDPS_{sa}$	Index of real domestic product, iron and steel mills (D100480), quarterly, seasonally adjusted, 1971=100
STA	Domestic selling price of steel
TS	Total shipments of steel products
UCAPS2	U.S. operating rate, raw steel (Survey of Current Business)
UMD2	Gross output originating in U.S. durable manufacturing
UORDST	Ratio of unfilled orders to shipments, iron and steel mills (D313345 and D313329 respectively)
XMVP2	Exports of autos and parts to the U.S.
XOTHER	Exports of manufactured end products, excluding autos and parts
XT	Exports of steel products

BIBLIOGRAPHY

Alexander, W.E. "An Econometric Model of Canadian-U.S. Trade in Automotive Products 1965-1971", Technical Report 3. Ottawa: Bank of Canada, 1974.

Bank of Nova Scotia. "Canada's Steel Industry", Monthly Review, October 1975.

Dack, W.L. "Canada's Steel Industry Expands in a Big Way". Canadian Geographical Journal, October 1975.

Government of Canada (Department of Industry, Trade and Commerce). The Canadian Primary Iron and Steel Industry Profile. No date.

Government of Canada (Department of Energy, Mines and Resources). Canadian Industry Energy Conservation Task Forces, 1980 Reports, 1981.

Kindleberger, Charles P. International Economics, fourth ed., 1968. Homewood, Ill.: Richard D. Irwin.

Organization for Economic Cooperation and Development. Progress Report on the Economic Analysis of the Problems of the Steel Industry, SC (78). Paris, December 1978.

Organization for Economic Cooperation and Development. Steel in the 80's. Paris, 1980.

Perry, G.L. "Determinants of Wage Inflation Around the World". Brookings Papers on Economic Activity, 2, 1975, pp. 403-435.

Raddock, R.D. "Cyclical and Secular Developments in the U.S. Steel Industry". Federal Reserve Bulletin, 67 (2), February 1981.

Robertson, H. and M. McDougall. The Structure and Dynamics of RDXF, Technical Report 26. Ottawa: Bank of Canada, 1982.

Steel Company of Canada. Annual Report 1979, 1980.

Taylor, L.D., S.J. Turnovsky and T.A. Wilson. "The Inflationary Process in North American Manufacturing". Prices and Incomes Commission, Ottawa, 1973.

U.S. Federal Trade Commission. The United States Steel Industry and Its International Rivals. Washington, November 1977.

Warren, K. World Steel: An Economic Geography. New York: Crane-Russak, 1975.

Wurzburger, B.W. "A Neo-Keynesian Model of Nominal Wage Determination in Canada", Technical Report 11. Ottawa: Bank of Canada, 1978.

Printed in Canada Imprimé au Canada