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An Econometric Model of Canadian-U.S. Trade in Automotive Products 1965-1971

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AVANT-PROPOS

L'étude qui suit décrit la construction et l'estimation d'un modèle simple des échanges de produits de l'industrie automobile entre le Canada et les Etats-Unis pendant une période d'application du fameux pacte automobile (1965-1971). Deux des dispositions de l'accord - à savoir que l'importation en franchise de pièces et de véhicules au Canada est réservée aux constructeurs authentiques et que ces derniers s'engagent à accroître la valeur ajoutée au Canada à la production dans une proportion régie par le taux de croissance des ventes de véhicules nord-américains sur le marché canadien - sont considérées dans le modèle comme procurant une subvention implicite aux producteurs canadiens de véhicules automobiles.

Vu le libre échange des produits de l'industrie automobile à la frontière canadienne, on pourrait dire que, en principe, les sociétés multinationales maximisent leurs profits, compte tenu des contraintes imposées par l'accord. Cela signifierait que les exportations et les importations sont déterminées simultanément. Malheureusement, il n'a pas été possible de construire le modèle de cette façon. En fait, on détermine d'abord les exportations, puis les importations, considérées comme une fonction récursive des exportations. Nous traduisons de cette façon (sans essayer de l'expliquer) le fait que le Canada s'est spécialisé dans l'assemblage de véhicules dans le cadre de l'accord, devenant ainsi exportateur net de véhicules automobiles assemblés et importateur net de pièces détachées.

La dernière partie de l'étude est consacrée à l'estimation de plusieurs variantes de deux équations sous forme réduite, c'est-à-dire qu'on y explique les exportations et les importations canadiennes en dollars constants (année de référence: 1961). L'analyse débouche sur la conclusion provisoire que l'élément subvention-croissance que comportaient implicitement les conditions de l'accord a contribué de façon décisive à la croissance rapide et à la rationalisation de l'industrie automobile canadienne de 1965 à 1971.

ABSTRACT

In this paper I describe the construction and estimation of a simple model of Canadian-U.S. trade in automotive products during a period of the implementation of the historic Automotive Agreement (1965-1971). Two conditions of the Agreement - that the privilege of duty-free importation of parts and vehicles into Canada is restricted to bona fide manufacturers, and that these manufacturers accept a commitment to increase Canadian value added in production at a rate governed by the rate of growth of North American vehicle sales in the Canadian market - are viewed in the model as a means of providing an implicit subsidy to Canadian automotive producers.

Given duty-free trade in automotive products over the Canadian border, one could say that, in principle, multinational corporations are maximizing profit subject to the side conditions imposed by the agreement. The implication is that exports and imports are simultaneously determined. Unfortunately, however, it was not possible to model the process in this way. Instead exports are first determined, and then imports are determined as a recursive function of exports. In this way I recognize (but do not attempt to explain) the fact that Canada has specialized in vehicle assembly under the terms of the agreement and has become a net exporter of assembled motor vehicles and a net importer of motor vehicle parts.

In my final analysis several variations on two reduced-form equations have been estimated: ie, Canadian (1961) constant-dollar exports and imports are explained. The tentative conclusion reached is that the subsidy-growth nexus implicit in the terms of the agreement was a crucial determinant of the rapid rate of expansion and rationalization of the Canadian automotive industry during the period 1965-1971.

AN ECONOMETRIC MODEL OF CANADIAN-U.S. TRADE IN AUTOMOTIVE PRODUCTS, 1965-1971

I Introduction

In this study I describe the construction and estimation of a simple model of Canadian-U.S. trade in automotive products during the transition period of the historic automotive agreement [3]. Two objectives were regarded as essential to the conduct of the study: one, the model should be simple enough to be kept within the spirit of RDX2 (the Bank of Canada Research Department quarterly econometric model of the Canadian economy [7]) so that it could be simulated under a range of alternative assumptions concerning the prevailing economic circumstances over the period; two, the model should be devised so as to deal with the economic incentives implied by the agreement.

The results of this study tend to confirm the view that, during the period 1965-1971, the safeguard provisions of the auto pact were a crucial determinant of the rapid expansion of Canadian automotive production that resulted in substantial gains in economies of scale. Whether the safeguards continue to be important depends upon one's assessment of the remaining possibilities of gains from economies of scale - an issue that is not dealt with here.

In what follows, I review the state of the automotive industry prior to the signing of the agreement. Next, I discuss what I think are the relevant features of the auto pact and describe a simple model incorporating these features. I then present the econometric estimates of the model and an analysis of the results obtained.

II The Emerging Structure of the Auto Pact

Since works that deal with the nature of the auto pact are both numerous and readily available, [2], [5], [10], [14], [15], no detailed account is necessary here. Only a few salient features need be mentioned. Essentially, the auto pact allows for duty-free trade in motor vehicles and original equipment by manufacturers who are able to meet certain stipulations. These involve both minimum production requirements (the safeguards) [10] p 3 and a growth commitment. The latter specifies that growth in value added in the Canadian industry must rise by 60 percent of the growth in Canada of passenger vehicle sales (for commercial vehicle production, by 50 percent of the growth in sales) in addition to a fixed growth commitment of $260 million. The auto pact was signed by representatives of the Canadian and U.S. governments on January 16, 1965, after which it immediately became Canadian law. The agreement became U.S. law when ratified by Congress in October 1965: until that date it was an open question whether or not the pact would be ratified.[1] From the Canadian point of view the purpose of the auto pact was, presumably, to allow the rationalization of the Canadian industry, to arrest the rate of deterioration in the Canadian trade deficit in automotive products with the United States, and to allow the Canadian industry fair and equitable participation in the North American vehicle market.

The agreement must be regarded by Canadians as having been totally successful. The fact that all the safeguard production and growth commitments were exceeded in the transition period is well documented. As well a dramatic reversal had occurred in the traditional Canadian automotive products trade deficit by the end of 1971. But certain other effects of the agreement are not so widely known. For example: (1) Coincident with the large increase in automotive products trade a remarkable degree of specialization has been achieved, in that Canada has become a large net exporter of assembled motor vehicles and a large net importer of original equipment parts (see Table 1). (2) The Canadian industry has specialized in the production of small and intermediate sized cars (see Table 2), and has chosen to import full-size and luxury models. This means that the Canadian industry is more vulnerable[2] to offshore competition (ie, from Japan) than would otherwise have been the case. (3) Although Canadian auto prices have fallen relative to U.S. auto prices, Canadian prices remain substantially higher than U.S. prices (see Appendix I). (4) Wage rates in the Canadian automotive industry rose very rapidly after the auto pact was signed. Nominal wage parity was reached in 1970. However, differences in the skill mix, the experience of the work force, and the use of overtime have kept the average Canadian nominal wage below its American counterpart (see Appendix II). Each of these effects should be incorporated within an ideal auto pact model.

The remarkable features of the Canadian automotive industry prior to 1965, compared to the U.S. industry, were the higher prices charged in Canada and the significantly smaller scale of

Table 1

THE COMMODITY COMPOSITION OF CANADA'S
AUTOMOTIVE TRADE WITH THE UNITED STATES

(Values in millions of Canadian dollars)

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Exports										
Passenger cars	0.6	20.8	66.2	346.4	820.5	1297.5	1746.1	1622.9	1990.1	2064.0
Commercial vehicles	3.9	5.5	24.4	146.2	294.5	442.5	645.6	614.1	615.1	690.9
Parts	37.9	74.3	144.2	354.4	485.8	761.0	949.4	1053.3	1371.9	1684.4
Total	42.4	100.6	234.9	847.1	1600.7	2501.1	3341.2	3290.3	3977.1	4439.5
Imports										
Passenger cars	28.8	44.3	125.4	315.5	658.2	896.7	790.6	671.8	962.8	1105.5
Commercial vehicles	21.5	25.1	47.9	98.4	144.8	203.2	279.5	283.7	378.7	523.9
Parts	558.8	659.2	852.8	1109.5	1302.3	1795.3	2317.4	2103.0	2466.9	2880.7
Total	609.1	728.6	1026.1	1524.4	2105.3	2895.3	3387.5	3058.5	3808.5	4510.1
Balance										
Passenger cars	(28.2)	(23.5)	(59.2)	29.9	162.3	400.8	955.5	951.1	1027.3	958.5
Commercial vehicles	(17.6)	(19.6)	(23.5)	47.8	149.7	239.3	366.1	330.4	236.4	167.0
Parts	(520.9)	(584.9)	(708.6)	(755.1)	(816.5)	(1034.3)	(1368.0)	(1049.7)	(1095.0)	(1196.3)
Total	(566.7)	(628.0)	(791.2)	(677.3)	(504.6)	(394.2)	(46.4)	231.8	168.6	(70.8)

( ) = deficit

Table 2

CANADIAN AUTOMOTIVE PRODUCTION AND SALES DATA, 1972

	Registrations	Production	Net Exports	Net Imports
Chrysler	23,058			23,058
Imperial	643			643
Dart	24,792	105,708	80,916	
Dodge	16,241			16,241
Challenger	2,456			2,456
Coronet Charger	11,462			11,462
Satellite	13,295	92,822	79,527	
Fury	19,461			19,461
Valiant	31,797	67,243	35,446	
Barracuda	1,839			1,839
TOTAL CHRYSLER	145,044	265,773	195,889	75,160
Torino	28,120	151,702	123,582	
Pinto	22,556	153,358	130,802	
Maverick	15,207	92,728	77,521	
Ford	40,302	14,460		25,842
Mustang	10,392	1,248		9,144
Thunderbird	2,832			2,832
Comet	13,747			13,747
Montego	12,020			12,020
Cougar	5,993			5,993
Marquis	8,674	29,009	20,335	
Metero	14,459	16,467	2,008	
Lincoln	2,498			2,498
TOTAL FORD	176,800	458,972	354,248	72,076
Buick	16,323			16,323
Buick Century	13,448			13,448
Cadillac	5,171			5,171
Camaro	1,829			1,829
Chevrolet	55,792			
Vega	20,001	265,458	165,578	
Chevelle	24,087			
Nova	18,727			18,727
Corvette	1,246			1,246
Omega	786			786
Oldsmobile	18,566			18,566
Oldsmobile Cutlass	21,320			21,320
Pontiac	30,149	88,709	41,787	
Le Mans	16,773			
Firebird	1,046			1,046
Ventura	12,175			12,175
TOTAL GENERAL MOTORS	257,439	354,167	207,365	110,637
Hornet	18,572	21,585	40,348	
Gremlin		37,335		
TOTAL AMERICAN MOTORS	18,572	58,920	40,348	

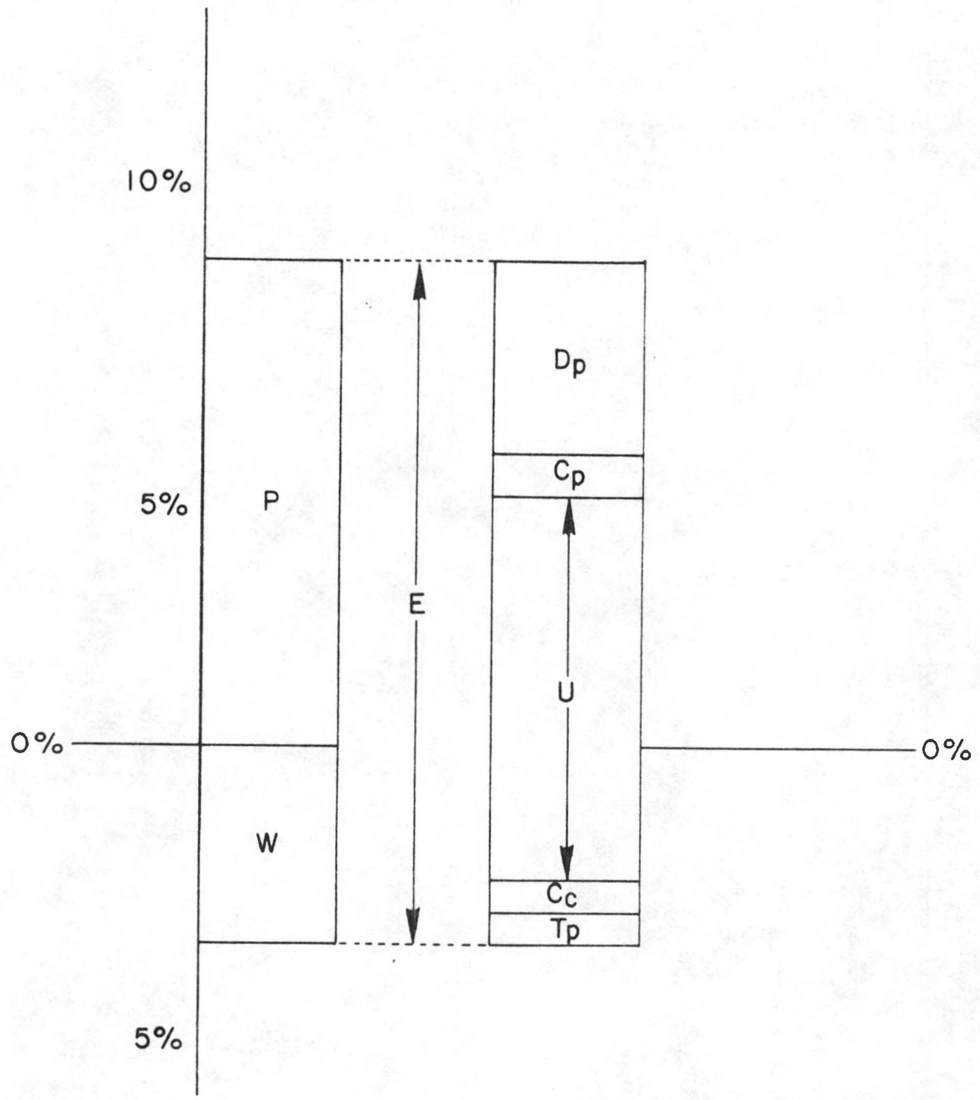
Source: Automotive News Almanac [1].

production. The possible relationship between these two factors is of particular interest and in order to analyse it I turn to the study by Ronald J. Wonnacott and Paul Wonnacott [15]. They were able to show that, by accounting for all cost differences except scale, any residual difference between the higher Canadian price and the net Canadian cost disadvantage must be attributed to the diseconomies of small scale production. The data for 1964 used by the Wonnacotts and a summary of their results is presented in [15] Figure 1, p 231.

The Wonnacotts report that Canadian prices averaged 9.5% above U.S. prices (P), and that Canadian wages averaged 30% below U.S. wages. When multiplied by the relevant input/output coefficient, the wage differential represents a 3.9% cost advantage for the Canadian producer (W); P and W sum to 13.4% (E) representing the "margin of advantages that the Canadian industry enjoys in producing for the Canadian market" [15] p 231. Against this margin of advantages higher Canadian costs must be set: (1) D_p = 4.2%, the additional costs of the 1964 model year associated with Canadian duties on imported parts; (2) C_p = 0.2%, the excess costs of machinery due to the Canadian tariff; (3) C_c = 0.8%, estimated higher Canadian capital costs; (4) T_p = 0.45%, transportation costs on imported parts. The unexplained residual (U) is 7.7%, and represents the maximum impact of diseconomies of scale. But

> "It should be noted that this does <u>not</u> mean that large-scale production in the United States is only 7.7 percent more efficient than Canadian production. Since only 60 percent

Figure 1



International differences in automobile prices and costs, 1964 model year. The baseline represents U.S. factory price (excluding indirect taxes). Exchange rate: $1.00 Can. = $0.925U.S.

of the car is made in Canada, and since this 7.7 percent is a percentage of total costs, higher costs attributable to a smaller market amount to approximately 13 percent when taken as a fraction of the Canadian-produced content alone." (Extract from [15] p 235.)

In summary, the potential gains to Canada from the increased scale of automobile production were large; of the observed 9.5 percent pure differential, up to 7.7 percent could be attributed to diseconomies of scale.

III A Model of the Auto Pact

The preamble to the auto pact states that the principal goal of the agreement is the attainment of a fair and equitable sharing of the North American automobile market by Canadian and American plants. Implicit in this goal is the assumption that the Canadian industry could be rationalized by concentrating on limited lines of production, increasing production runs, exporting the surplus production to the United States, and importing models that will no longer be produced in Canada. If Canadian production could be raised from the present relatively low level to the minimum efficient scale (MES), then, given the 1964 configuration of costs and exchange rates, the Canadian automotive industry could be expected to compete with its parent.

Assuming that known technology is the same in both countries, one must realize that until Canadian production is expanded to the level of minimum efficient scale the North

American industry will have to forego some profits as it moves along the downward sloping Canadian cost curves toward MES. Suppose each manufacturer concentrates on production in Canada of one model and chooses to import all other models, then, given the initial size of the U.S. market and the initial production capacity of the Canadian industry, some U.S. plants would continue to produce the models in which Canadian plants had decided to specialize. Thus Canadian-made cars must sell at the lower U.S. price. If one assumes that all U.S. exports are produced at MES, every sale of a Canadian-made vehicle in the United States must involve a loss to the multinational firm equal to the difference between the U.S. cost and the Canadian cost. As Canadian production becomes larger and more efficient over time this cost difference would diminish and could conceivably become negative at the 1964 cost and exchange rate configuration (see the Wonnacott analysis). Since a profit-maximizing firm in an imperfectly competitive industry[3] would not undertake this trip down the cost curve unless the discounted net future benefits at MES were sufficiently large, additional incentives may have been required to induce the auto industry to expand its Canadian production. In a growth context the additional incentives would then impinge directly on the rate of expansion. It is useful to view the remaining conditions of the auto pact in these terms.

Ordinarily the prescription of positive economics is that if the policy objective is the expansion of Canadian production the most efficient way to achieve that objective is to subsidize Canadian production directly. Political considerations may, however, have eliminated this possibility; in any case more indirect methods were chosen. In particular, only the major automobile producers were given the privilege of duty-free importation of motor vehicles and parts into Canada. This meant that Canadian prices were not constrained to fall to U.S. levels. Thus, for every unit of Canadian production replaced by a U.S. import, the multinational automobile firm receives a bonus equal to the difference between the Canadian and the U.S. price. But under these conditions why would the multinational producer not phase out all Canadian production? The answer is that the bonus had to be "earned" by satisfactory levels of Canadian production; the safeguards and the minimum growth commitments may be interpreted as having been introduced to link imports and exports. Exports are therefore indirectly subsidized by the profits that the industry makes on the substitution of U.S. production for the Canadian production sold in Canada.

The arrangement outlined above has a number of interesting ramifications. First, as long as the Canadian industry remains at inefficient levels of production, the ultimate scope of the auto pact is limited by the size of the Canadian market, so there is an upper limit on the size of the subsidy that the industry can earn. One should also consider the marginal impact of an increase in the size of the Canadian market for North American automobiles. An increase of one unit allows the industry the opportunity to earn an additional subsidy. This condition in turn requires an increase in Canadian production of value added equal to 60 percent of the increase in vehicle sales, and it must show up in increased exports, if the producer decides to earn the subsidy. So Canadian expenditure on North American automobiles is the driving variable in determining Canadian exports to the United States. Second, there is not necessarily a one-to-one relationship between imports and exports. If it is assumed that an increase in the size of the Canadian auto market is being used to earn the marginal subsidy, then Canadian production of domestic value added, which must go into exports, must rise by 60 percent of the increase in sales. However, this assumption does not mean that Canadian value added must be 60 percent of each unit of production. That is, suppose two units for exports each contain 30 percent Canadian value added, they would be acceptable. The auto companies are free to choose the optimum level of Canadian value added per unit of production based on their assessment of the relative inefficiency of Canadian production, transportation cost, and the cost of importing U.S. parts for inclusion in Canadian vehicles to be exported to the United States. If the profit-maximizing level of Canadian content per vehicle is less than 60 percent, a unit increase in the size of the Canadian market would be expected to yield more than a unit increase in exports. And the lower the Canadian content per unit of production, ceteris paribus, the greater the quantity of imported parts required. Thus a causal structure is seen to emerge. Given the cost structure, Canadian domestic consumption determines exports, while exports in combination with the optimum level per unit of Canadian value added determine the level of parts imports. Imports, then, are a function of both domestic consumption and exports.

In order to understand the decision-making processes of the multinational automobile companies, it is useful to consider the operation of a multiplant corporation within a single economy. In this context, one finds that individual plant output is essentially determined by supply and need not depend on the total demand for the firm's output. That is, market demand will influence the total output of the firm, although the production share of a particular plant (assuming that the plant is too small to supply the total market) will depend only on its cost structure and its accessibility to the market relative to the other plants under the firm's control. Consider the problem faced by the multinational automobile firm in deciding whether to serve its U.S. market from Canadian or U.S. plants. In principle the automobile company can determine the profit-maximizing supply of Canadian exports per period $(XMV12_t^*)$ based on the size of the Canadian subsidy, the relative costs of U.S.- and Canadian-produced vehicles, and subject to the side conditions of the auto pact.[4] On theoretical grounds, the size of the U.S. market can be ruled out of the Canadian export function.

The optimizing process that yields $XMV12_t^*$ will also yield the optimum quantity of imports from the United States $(MMV12_t^*)$, at least in principle. But lacking the detailed cost information possessed by the auto companies I cannot model this process directly. Rather I use the causal structure (running from exports to imports) defined earlier and build a simple recursive model designed to capture some of the simultaneous nature of the process as described below.

The major determinants of the optimal export flow ($XMV12_t^*$) can be identified. These are the size of the subsidy as measured by Canadian demand for North American automobiles and the difference between the Canadian and the U.S. factory list price, relative wages in Canada and the United States, the scale of Canadian production, and the exchange rate (PFX). Assuming the existence of adjustment costs, I define actual exports ($XMV12_t$) as a lagged function of optimum exports. Then, since exports determine the optimum subsidy and the required parts imports, imports are defined as a recursive function of exports. Thus,

$$CMV(adj)_t \equiv CMV_t - MMV13_t \quad (1)$$

$$XMV12_t^* = \Omega(CMV(adj)_t, (\frac{Pc}{Pa})_t, (\frac{Wa}{Wc})_t, ESCALE_t, PFX_t) \quad (2)$$

$$XMV12_t - XMV12_{t-1} = (1-\theta)(XMV12_t^* - XMV12_{t-1}), \ 0 \leq \theta \leq 1 \quad (3)$$

$$MMV12_t = \Phi(CMV(adj)_t, P_t, XMV12_t) \quad (4)$$

where in Equations (1) to (4)

CMV(adj) is Canadian expenditure on North American produced automobiles.

CMV is Canadian expenditure on all automobiles.

MMV13 is imports of automotive products from overseas.

$XMV12^*$ is the desired flow of Canadian automotive exports to the United States.

Wa/Wc is the ratio of the U.S. to the Canadian wage in automotive assembly, measured in Canadian dollars. (See Appendix 2 for details.)

Pc/Pa is the ratio of Canadian and U.S. factory list-price indexes, measured in Canadian dollars. (See Appendix 1 for details.)

ESCALE is a measure of the economies of scale achieved in the Canadian automotive industry - an index based on average model production.

PFX is the price of foreign exchange (C$/US$).

MMV12 is imports of automotive products from the United States.

P is the price ratio reflecting the prices of U.S.- and Canadian-produced vehicles measured as the price of imports of motor vehicles from the United States divided by price of motor vehicle consumption in Canada.

Equation (1) is a simple identity defining Canadian expenditure on North American automobiles. As I have already argued, the correct expenditure variable must be purged of sales of overseas imports. Since CMV is predicted within the consumption sector of RDX2 and since MMV13 currently is exogenous to RDX2, no further estimation is required.

It is useful to discuss the theoretical expectations for the signs of the coefficients of the variables that determine $XMV12^*_t$ (Equation (2)). With respect to the implicit subsidy for Canadian exports, I expect positive coefficients. Exports should increase, ceteris paribus, as the subsidy increases. My concept of the subsidy is reflected in sales in Canada of North American vehicles and in the difference between the U.S. and Canadian factory list price. Two additional points are relevant (1) It is not clear a priori whether the influence of both the sales and price variables can be isolated by econometric analysis, since one variable may pick up satisfactority all the effects of the subsidy, leaving no empirical role for the other variable. (2) If the assumption is that the influence of CMV(adj) can be isolated, the value of the coefficient on CMV(adj) may be much greater than 1, as I previously have argued. Regarding the relative cost variables, I expect that optimal exports will fall with a relative increase in Canadian wages, will increase with an increase in the scale of Canadian production as economies are realized, and will fall or rise with an increase in PFX.[5] Note that PFX also enters indirectly, because U.S. wages and prices are expressed in Canadian dollar terms. To summarize, the following partial derivatives are expected:

$$\frac{\partial XMV12^*}{\partial CMV(adj)} > 0 \qquad \frac{\partial XMV12^*}{\partial \frac{Pc}{Pa}} > 0$$

$$\frac{\partial XMV12^*}{\partial \frac{Wc}{Wa}} < 0 \qquad \frac{\partial XMV12^*}{\partial ESCALE} > 0 \qquad \frac{\partial XMV12^*}{\partial PFX} \lesseqqgtr 0$$

The import equation (Equation (4)) also is straightforward. Imports are a function of North American sales in Canada and of exports. The former variable may be rationalized as standing for the subsidy element of the auto pact, whereas exports represent the derived demand for imported parts. Once the automotive companies have decided on which models to produce in Canada, they are vulnerable (at least in the short run) to decisions by consumers to switch from models that are not produced domestically. If consumers decide to buy additional U.S. imports, MMV12 will deviate from the desired profit-maximizing optimum. I have therefore introduced a relative price term (P) to allow for possible demand shifts from Canadian- to U.S.-produced models. The functional form of Equation (4) is temporarily left unspecified; I report the result of experimentation in the empirical section of the paper.

The adjustment equation (Equation (3)) states that, when the actual export flow deviates from the optimal export flow, the actual adjustment in any period will be some positive fraction of that gap. Furthermore the adjustment is proportional to the size of the gap. The implicit behaviour is plausible, if one acknowledges the possibility of adjustment costs. If short-run adjustments to production were both physically possible and costless, adjustment would be instantaneous and the optimum flow would always be observed. But clearly there are costs involved: additional production facilities are put in place after a gestation period, start-up costs are incurred, labour contracts may call for overtime premiums, etc.

The adjustment function provides a useful model of industry adaptation to the automotive agreement. The signing of the pact may be viewed as having opened a large gap between desired and actual exports and as having provided a large incentive to increase exports during the initial quarters of the agreement. Later, when exports began to increase, the gap narrowed and the rate of increase slowed down.

However, the basic appeal of the adjustment function is clear only after some simple algebraic manipulation. Equation (3) may be rewritten as

$$XMV12_t = (1-\theta)\ XMV12_t^* + \theta\ XMV12_{t-1} \tag{5}$$

Equation (5) implies

$$XMV12_{t-1} = (1-\theta)\ XMV12_{t-1}^* + \theta\ XMV12_{t-2} \tag{6}$$

and so on for t-2, t-3,... A series of successive substitutions for $XMV12_{t-i} (i=1,2,...)$ in equation (5) then yields

$$\begin{aligned} XMV12_t &= (1-\theta)\ XMV12_t^* + (1-\theta)\theta\ XMV12_{t-1}^* + (1-\theta)\theta^2\ XMV12_{t-2}^* + \dots \\ &\quad \dots + (1-\theta)\theta^n\ XMV12_{t-n}^* + \dots \\ &= (1-\theta) \sum_{\tau=0}^{\infty} \theta^{\tau}\ XMV12_{t-\tau}^* \end{aligned} \tag{7}$$

Thus the adjustment equation is a special case of the more general class of hypotheses that actual exports are a weighted average (or a distributed lag) of all past values of the optimum export flow. In this example the weights sum to unity and decline geometrically.

With a little more manipulation, Equation (7) is susceptible to econometric analysis. Thus, lag Equation (7) by one period and the result is

$$XMV12_{t-1} = (1-\theta) \sum_{\tau=1}^{\infty} \theta^{\tau-1}\ XMV12_{t-\tau}^* \tag{8}$$

Multiplying Equation (8) by θ and subtracting the result from equation (7) yields

$$XMV12_t = (1-\theta)\ XMV12_t^* + \theta\ XMV12_{t-1} \tag{9}$$

which is readily recognized as Koyck's transformation.

Linearizing Equation (2) and substituting it into Equation (9) I get

$$XMV12_t = (1-\theta)\beta_0 + (1-\theta)\beta_1 CMV(adj)_t + (1-\theta)\beta_2 \left(\frac{Pc}{Pa}\right)_t + (1-\theta)\beta_3 \left(\frac{Wc}{Wa}\right)_t + (1-\theta)\beta_4\ ESCALE_t + (1-\theta)\beta_5\ PFX + \theta\ XMV12_{t-1} \tag{10}$$

Since all structural coefficients are identified in Equation (10), it is the estimating form I adopt as the basic equation for statistical experimentation.

The reader should be aware of two potential difficulties associated with the use of the Koyck transformation. The first problem is that, if, during the stochastic specification of a model with a lagged dependent variable, serial correlation of the error term is introduced, the ordinary least squares estimating procedure will yield inconsistent estimates. Since it can be shown [12] that, in the partial adjustment model utilized here, the error component of the reduced form equation will not be serially correlated unless the structural equations are also serially correlated, the ordinary least squares procedure could be appropriate. However, even casual experience with quarterly time series data suggests that the presence of autocorrelation is the rule rather than the exception. Therefore, in what follows, autocorrelation in the structural equation has been presumed and more appropriate estimation techniques have been employed. Generally speaking, two categories of procedures - instrumental variables techniques or some variation on the maximum-likelihood principle - are available. In my empirical work, both methods have been used. An instrumental variable technique due to Liviatan [8] and the modified Hildreth-Lu routine in Massager [9] are each capable of producing consistent estimates, and both methods were employed.

The second problem is that the use of geometrically declining weights may be an unnecessarily restrictive form of the distributed lag. However, as shown above, the model is a special case of the class of models based on a distributed lag of past values of the optimum export flow. In fact, one can generalize the form of the distributed lag for these models. Equation (7]

$$XMV12_t = (1-\theta) \sum_{\tau=0}^{\infty} \theta^{\tau} XMV12^*_{t-\tau}$$

may be generalized as

$$XMV12_t = W(L)(XMV12^*_t) \qquad (11)$$

where W(L) is some unspecified rational lag generating function [6].

Clearly, for Equation (7) $W(L) = (1-\theta)/(1-\theta L)$

where L is the lag operator.

A more general form, capable of yielding the more conventional hump-shaped response, is

$W(L) = (a/1-bL-cL^2)$

which, when substituted into Equation (11), gives

$$XMV12_t = (a/1-bL-cL^2)\ XMV12^*_t$$

or

$$XMV12_t = a\ XMV12^*_t + b\ XMV12_{t-1} + c\ XMV12_{t-2} \quad (12)$$

That is, simply by adding additional lagged dependent variables, one can generalize the Koyck transformation in the direction of the more usual Almon procedures. In practice, the flow-adjustment model is not as restrictive as is usually thought to be the case, and I have proceeded to experiment along these lines.

IV Empirical Results: The Export Equations

1. Variable construction

The estimation of Equation (10) required data series that are not included in the RDX2 data set. It is therefore worthwhile to discuss their construction before describing the empirical results. In particular, I explain the construction of the wage series, the scale series and the price series.

(a) The wage series

Detailed U.S. wage rates are available at three increasingly disaggregated levels of the Standard Industrial Classification [11]: SIC37 transportation equation, SIC371 motor vehicles and equipment, SIC3711 motor vehicles, and SIC3714 motor vehicle parts and accessories. These data, which are available monthly, are average hourly earnings, including overtime, in U.S. dollars. Comparable Canadian data are available in the CANSIM series: D708385 motor vehicles, D708386 assembling, D708387 parts and accessories. Again the data are average hourly earnings, available on a monthly basis. In order to construct quarterly series, months were averaged by quarters and U.S. data were converted to Canadian dollars at the PFX quarterly rates used in RDX2. The respective coverages of the U.S. and Canadian series are reasonably comparable and three possible series can be constructed: PFX*SIC371/D708385, PFX*SIC3711/D708386, and PFX*SIC3714/D708387. However, given that the auto pact specifically excludes parts production for the aftermarket, that the total industry data as well as the parts and accessories data include earnings in aftermarket production, and that the industry has concentrated its Canadian expansion in assembly, the assembly series is preferable on theoretical grounds. When experiments were conducted with all three series, the assembly series yielded marginally superiod results and was therefore used in the work reported here.

(b) The scale series

A scale series is introduced to capture gains in the industry realized from economies of scale. Assuming that the minimum efficient scale of production has been constant for the duration of the auto pact and that U.S. production has always been at the MES, one can measure Canadian gains in economies of scale relative to the inefficient pre-1965 Canadian conditions of production without destroying the consistency of the model. Accordingly, I built an index of economies achieved (ESCALE) based on the length of the average model production run relative to its length in 1965.[6] These data are a quarterly series, based on annual model-year production. Note that the series captures two sources of scale economies: rationalization, and growth in production. Thus the series will reflect economies achieved by reducing the number of models produced, even if total production is constant. This series is superior to a measure based solely on growth of production in that use of the latter would effectively reduce Equation (10) to the status of an identity. Alternative measures are clearly possible, but to date I have not made additional experiments.

(c) The price series

This was the most difficult series to construct, and therefore the one in which I have the least confidence. The price variable is designed to measure the size of the subsidy to Canadian producers implicit in the auto pact. The theoretically correct measure, which should pertain solely to North American production, is the difference between the Canadian and the U.S. selling price, net of sales and excise tax, and differences in dealer margins. For the United States I used the series "Index of output price - motor vehicles and parts" (DRI-PQ371) and, for Canada, the "Index of industry selling price - motor vehicle manufacturers" (CANSIM D600705).[7] First, neither series is conceptually correct, although they do appear to be the closest alternatives available. Second, both series are indexes. The base year is different in each case, and there is no reason to believe that the price weights are similar. Third, the U.S. series is in U.S. dollars, and had to be converted to Canadian dollars. In order to get around the base year problem, the U.S. series was first converted to Canadian dollars and then shifted to a base of 1.000 in 1964. The Canadian series was also converted to a 1964 base, at a level of 1.095 in 1964. Thus, an index of relative prices, obtained by dividing the converted Canadian series by the converted U.S. series, has a level of 1.095 in 1964, which is the Wonnacotts' independent estimate of relative prices in that year, and captures the relative movements of the original series in subsequent years.[8] Given the tenuous methods whereby this series was constructed, its rather ambiguous performance in the regressions is not too surprising.

2. Interrelationships among the independent variables

Clearly my so-called structural equation (Equation (10)) is itself a reduced form representation of the automotive industry, although it would be possible to build a micro-model of the industry. Such a project is outside the conceptual framework of RDX2 [7] and has not been attempted here. However, consideration of such a framework may yield useful insights with respect to the interpretation of my own model. For example, political pressure may result in realized economies of scale being passed on to the consumer in the form of a narrowing price differential instead of being translated into increased exports. In this case, the inverse of the price series may satisfactorily capture the effect of scale economies. Similarly wage demands may appropriate scale gains and a similar interpretation would ensue. Thus there are theoretical reasons for expecting collinearity of variables, and the entire variable list would be unlikely to survive empirical testing. Indeed, it did not and a careful interpretation of results is therefore required.

3. The results

The results are presented in Table 3, where four separate equations appear. As pointed out above, the ordinary least squares technique is an inappropriate one in the presence of a Koyck distributed lag; I have attempted to provide consistent estimates by using both the Liviatan and Hildreth-Lu (H-L) procedures. The former approach is an instrumental variable technique in which an instrument for the lagged dependent variable is constructed as a linear combination of lagged values of the independent variables. In regard to the H-L technique, it is probable that, under correct specification of the estimating equation, the H-L is equivalent to a maximum likelihood procedure and will, therefore, produce consistent estimates.

The first thing to notice about Table 3 is that the estimating period is 4Q65 to 4Q71. The prediction interval for 3Q65, which was calculated from this regression, implies that the auto pact had no statistically identifiable effect on exports until the fourth quarter. Since the fourth quarter also coincided with the ratification of the auto pact by the U.S. Congress and with the annual model changeover, 4Q65 is a reasonable initial observation for my regressions. Second, seasonal variation is an important component of the model. Consistent with the existing treatment of seasonality in RDX2 [7], I have used the constrained seasonal dummies scaled by the lagged dependent variable since I found them to be marginally superior to the simple Qi formulation in improving the fit of the regressions. The expenditure variable (CMV(adj)) was entered as

Table 3

EXPORT EQUATIONS
(4Q65-4Q71)

Independent Variable	A H-L Full Linear	B H-L Reduced Linear	C Liviatan Reduced Linear	D OLS Reduced Linear
Constant	710.95 (.6)	315.63 (.5)	-3,310.98 (-2.8)	3,471.98 (-3.2)
QC1* J1L(XMV12)	-.03 (-.5)	-.02 (-.3)	-.03 (-.8)	-.03 (-.8)
QC2* J1L(XMV12)	.07 (1.8)	.07 (1.9)	.06 (1.7)	.05 (1.6)
QC3* J1L(XMV12)	-.24 (-4.9)	-.23 (-5.1)	-.24 (7.0)	-.24 (-7.4)
J4A(CMV(adj))	1.52 (1.8)	1.75 (2.8)	1.34 (2.45)	1.45 (3.0)
$(PRICE)^{-1}$	-	-	2,844.33 (2.8)	2,927.24 (3.1)
J1L(XMV12)	.59 (2.3)	.51 (2.8)	.61 (4.9)	.61 (5.3)
ESCALE	173.51 (1.4)	196.34 (1.6)	-	-
WAGE	232.8 (.4)	-	-	-
PFX	-2,067.20 (-1.5)	-1,553.98 (-1.8)	-	-
Summary Statistics				
see	54.26	52.94	53.40	50.36
RB^2	.980	.978	.956	.959
cov	10.52%	10.26%	10.35%	9.75%
dw	2.07	2.05	1.60	2.29
rho	-0.27	-0.24	-	-

The t-ratios are reported in parentheses.

a four-quarter moving average, also in response to seasonal variation. This was done because the seasonal variations in production and consumption fail to coincide, a point that raises an additional interpretative issue concerning the model. The model is a representation of the automotive manufacturers' calculation of optimal export flow and a longer-run adjustment towards the optimum. Given the existence of adjustment costs, it is reasonable to model these calculations as if they are based on seasonally adjusted data. Since CMV(adj) is an important determinant of the optimum flow (and the only determinant with a strong seasonal pattern), I have attempted to remove the seasonal influence by using the four-quarter moving average in place of the raw quarterly data. Use of the smoothed series has improved the behaviour of the equation materially. Third, my misgivings about the possibility of isolating all structural elements appear to have been justified. Looking first at equations A and B (where H-L full linear and H-L procedures are used reduced linear) I note that the signs of the coefficients are as theoretically expected although statistical significance (as reflected in the t-ratios) is in many cases less than desired. With the exception of the wage variable, all the coefficients are at least as large as their standard errors. Although the wage variable possesses the correct sign, its significance was so weak that it was dropped from subsequent regressions. Dropping the wage variable has the immediate effect of raising the significance of all variables. (See Equation (B), H-L reduced linear technique.) The price of foreign exchange becomes significant, and the power of the scale variable is also improved. Additional experimentation is reported in Equations (C) and (D), which differ from each other in terms of the estimation procedure used. Here the inverse of price is allowed to be the proxy for scale effects; the coefficient is significant and possesses the expected positive sign.

Undoubtedly the most striking feature of the econometric results is the remarkable stability and robust significance of the coefficients on expenditure and lagged exports. The coefficient on consumption expenditure is about 1.4 whereas the coefficient on lagged exports is about .6. These results are remarkably stable over a wide range of experiments and are unaffected by the omission or inclusion of any of the other theoretically relevant variables. This is an extremely encouraging result in view of the fact that Canadian expenditure on North American vehicles (CMV(adj)) is the driving variable in the model of lagged adjustment.

Some interesting conclusions concerning the transitional period of the auto pact may tentatively be drawn from the econometric results.

i) It will be recalled that in my view, the major feature of the auto pact was the implicit subsidy to Canadian automotive production that was achieved by allowing privileged duty-free imports into Canada and by tying that privilege to an increase in Canadian value added equal to 60 percent of the growth in the Canadian market. Clearly, the size of the subsidy is ultimately limited by CMV(adj). Furthermore, the marginal increase in CMV(adj) allows the marginal subsidy to be earned and consequently requires the marginal export. From a technical point of view it has been impossible to separate out the impact of variations in the size of the subsidy;[9] instead the total impact has been captured by CMV(adj). But for the transitional period 1965-1971, the conclusions seem clear enough: the growth commitment-implicit subsidy arrangement made an important contribution to the success of the auto pact.

ii) The introduction of the terms of the auto pact appears to have altered the impact of "offshore" competition on our balance of trade. Since the expenditure variable is defined as

CMV(adj) = CMV-MMV13,

ie, total expenditure minus imports from the rest of the world, for a given value of total consumption (CMV constant), a dollar increase in offshore imports leads to a dollar decrease in CMV(adj) and, therefore, to a reduction in Canadian export production. Reduced CMV(adj) also leads to a reduction in imports from the United States and, therefore, "offshore" competition will have an additional indirect effect on the automotive balance of trade as well as the obvious direct effect.

iii) I have produced evidence that the industry has achieved a more efficient level of production subsequent to the signing of the auto pact, and that these gains have made a positive contribution to the Canadian export position. However, if the magnitude and significance of the coefficient on the scale variable in my equation are to be taken literally, they do suggest that the efficiency gains may have been less than is commonly imagined.

iv) The Agreement has resulted in impressive wage gains for Canadian members of the United Automobile Workers Union, and the question arises as to whether these gains have restricted the industry's expansion relative to what it would have been in their absence. Although theoretically possible, the fact that I could not isolate a statistically significant coefficient on the wage variable does not support the position that U.A.W. income gains have come at the expense of increased employment opportunities.

v) One interesting feature of the auto pact is that while it specified a growth commitment in value added, the automobile producers were free to choose per unit value added. Carl Beigie has calculated that by 1968, per unit value added may have been as low as 28 percent, [2] p 68. My equation suggests that it may have been below 20 percent by 1971.[10] In other words the degree of continental integration achieved during the course of the auto pact has been extremely large, with simple vehicle assembly strongly indicated as the source of Canadian comparative advantage.

Finally it is relevant to turn to two additional points of interpretation of the model. First, regarding the specification of the distributed lag, the simple Koyck transformation yielded results that were superior to more general lag formulations. The simple Koyck transformation is therefore retained in the results reported here. Second, the verbal description of the model is made in terms of deriving the optimum production share of Canadian plants in the total North American market, but the model has been fitted in level form without explicit reference to total North American production. Since Canadian production now amounts to only about 11 percent of the total, this omission may not be a serious problem in practice.

V Empirical Results: The Import Equation

1. Choice of functional form

In my formal exposition of the model the import equation was specified as a function of the consumption of North American motor vehicles, exports to the United States, and a relative price term. The functional form of the import equation was deliberately left unspecified because economic theory can offer no direction as to the choice of functional form in such a case. At best theory will indicate the signs of partial derivatives (for example, a positive consumption effect [unless imports are inferior goods], a negative price effect, etc.) and may perhaps place a priori restrictions on the magnitude and time path of certain elasticities. However, econometric estimation requires the restriction that the functional form be linear in the coefficients being estimated. As a result, the confrontation of weak theory by strong estimation requirements usually results in the general function form

$$MMV12_t = \Phi(CMV(adj)_t, P_t, XMV12_t) \tag{13}$$

being estimated as the simple linear form

$$MMV12_t = \alpha_0 + \alpha_1 CMV(adj)_t + \alpha_2 P_t + \gamma_3 XMV12_t + u_t \tag{14}$$

The result clearly satisfies the linear estimating restriction and may be formally justified as the first order Taylor series expansion of the (probably nonlinear) general form, Equation (13). Unfortunately the linear estimating form often possesses undesirable theoretical properties, especially with respect to the dynamic behaviour of the elasticities of particular variables. For example, MMV12 may be dominated by strong secular growth (as a result of the signing of the auto pact), whereas P may not be so dominated. Now the price elasticity of imports $\eta_{M,P}$, implied by the linear form of Equation (14), is given by the formula

$$\eta_{M,P} = \left(\frac{P_t}{MMV12_t}\right)\left(\frac{\partial MMV12_t}{\partial P_t}\right) = \alpha_2\left(\frac{P_t}{MMV12_t}\right)$$

If, as hypothesized, $\frac{\partial MMV12_t}{\partial t} > 0$, then $\lim_{t\to\infty} \eta_{M,P} = 0$. This result is theoretically unjustified. Since the result obtains because of the choice of the linear functional form, the obvious solution appears to be to experiment with more complicated functional forms. I did this and experimented with the following functional forms:

(a) Natural logarithmic specifications

The general form of Equation (13) may be specialized to

$$MMV12_t = \alpha_0 CMV(adj)_t^{\alpha_1} \, XMV12_t^{\alpha_2} \, P_t^{\alpha_3},$$

which yields the estimating form

$$\ln MMV12_t = \alpha_0^* + \alpha_1 \ln CMV(adj)_t + \alpha_2 \ln XMV12_t + \alpha_3 \ln P_t \quad (15)$$

Equation (15) finesses the elasticity problem by imposing constant (but not equal) elasticities on all variables. Thus,

$$\eta_{M,P} = \partial \ln MMV12_t / \partial \ln P_t = \alpha_3,$$

where α_3 is derived directly from Equation (15). This formulation has the disadvantage of imposing constant elasticities on all other independent variables in addition to the problem variable.

(b) Ratio specifications

The general form of Equation (13) may also be specialized as

$$MMV12_t = CMV(adj)_t \Psi(P_t, XMV12_t),$$

which yields the estimating form

$$MMV12_t / CMV(adj)_t = \alpha_0 + \alpha_1 XMV12_t + \alpha_2 P_t \quad (16)$$

This formulation can mitigate the arbitrary decline in the price elasticity if the scale variable (in this case $CMV(adj)_t$) exhibits a substantial growth trend. Since one can show that the price elasticity implied by equation (16) is

$$\eta_{M,P} = \alpha_2 \, P_t \, CMV(adj)_t / MMV12_t,$$

if $\lim_{t \to \infty} (CMV(adj)_t)/(MMV12_t) = k$, where k is finite, then $\lim_{t\to\infty} \eta_{M,P}$ is finite if $\lim_{t\to\infty} P_t$ is finite.

Equation (16) however, also implies that the consumption elasticity of imports is unity. Therefore, before one accepts Equation (16) as an estimating form, it is desirable to test the unit elasticity assumption directly. This can be done by fitting the following equation

$$MMV12_t/CMV(adj)_t = \alpha_0 + \alpha_1 XMV12_t + \alpha_2 P_t + \alpha_3 CMV(adj)_t \qquad (16')$$

If the coefficient α_3 is not statistically significant, there is evidence in favour of the more restrictive equation (Equation (16)).

Regarding the choice of ratio form, more complicated formulations are possible. For example,

$$MMV12_t/(CMV(adj)_t+XMV12_t) = \alpha_0 + \alpha_1 XMV12_t + \alpha_2 CMV(adj)_t + \alpha_3 P_t \qquad (17)$$

In this case the price elasticity of imports becomes

$$\eta_{MMV12_t,\ P_t} = P_t(CMV(adj)_t+XMV12_t)\ \alpha_3/MMV12_t$$

and may possess reasonable dynamic properties. And so on, for even more complicated formulations. The point is that the choice of a functional form can be based upon the criterion of best fit, subject to the qualification that the elasticities implied by the fit be reasonable (ie, not too implausible). This is the technique used in this study. However, a judgement of plausibility requires prior beliefs as to the distribution of the likely outcome of the estimation procedure, and recognition of this point leads logically to estimation by full-blown Bayesian econometrics. Although no attempt has been made to do that here, the direction for future research is clear enough.

2. Tests of temporal stability of the import equation

Since the auto pact involved such a major restructuring of production arrangements, it is necessary to know whether this shift involved statistically significant shifts in the coefficients of the import equation and, indeed, whether the structure of the proposed equation is valid over a sample time period including data drawn from both sides of the auto pact negotiations. One suspects that it is not.

Accordingly, five functional forms, linear[11], logarithmic, inverse semi-logarithmic, and two ratio forms were fitted for the sample period 1Q58 to 4Q71 inclusive. The sample was then partitioned into two subsamples - 1Q58 to 4Q64, and 1Q65 to 4Q71 - and a Chow test was computed under the null hypothesis of no difference between the two sample periods. The results are reported in Table 4.

Table 4

CHOW STATISTICS FOR TEST OF SAMPLE HOMOGENEITY

Functional Form	Test Statistic	Critical Point at 5%	Result
Linear	2.1825	2.18	Reject
Logarithmic	8.9891	2.18	Reject
Inverse semi-log	5.6537	2.18	Reject
Ratio A The dependent variable is MMV12/CMV(adj).	6.9203	2.25	Reject
Ratio B The dependent variable is MMV12/(CMV(adj) + XMV12).	2.7097	2.18	Reject

As is clearly indicated in Table 4, the null hypothesis must be rejected, and this result is taken as evidence that the periods before and after the auto pact must be treated separately. The bulk of the research reported here has been concentrated on the latter period.

When considered separately, however, the tests reported in Table 4 must be regarded with some suspicion, since the selection of the breakpoint is arbitrary and requires justification. As reported above, the auto pact (including the duty remission on imports scheme) became Canadian law in January 1965, and this event has been used as the initial justification for selecting 1Q65 as the breakpoint in the experiments reported in Table 4. But the auto pact did not become U.S. law until October 1965, and this event could have been used as justification for selecting as the breakpoint any date up to and including 4Q65. That date may be further justified because it would also coincide with the first production shipments of the 1966 model year, and the model year change-over may have been selected as the point to begin of the automotive industry rationalization. In principle, the question is susceptible to empirical testing. Accordingly Chow tests were computed for each equation for all the breakpoints 1Q65 to 4Q65 inclusive. The null hypothesis was rejected in each instance and I therefore failed to resolve the issue in this manner. An additional procedure was then utilized, which may be described as follows: Pick the last theoretically admissable starting date for the post-pact regression (4Q65) and compute the regression. Compute a 95 percent prediction interval for the dependent variable for the next-to-last possible starting date (3Q65). If 3Q65 falls within the computed interval, repeat the procedure, commencing the regression with 3Q65, and compute the prediction interval of the dependent variable for 2Q65, and so on. When an observation falls outside the prediction interval, stop. Accept this as evidence that the true breakpoint has been found. Obviously this is an extremely tedious procedure, and it was carried out only for the Ratio A functional form which, for other reasons reported below, turns out to be my favourite equation. This test established 1Q65 as the breakpoint. I have therefore proceeded on this basis.

3. Estimated equations for the post auto pact period

The results for five functional forms are reported in Table 5. All equations were fitted to the sample period 1Q65-4Q71.[12] The basic functional form (Equation (15)) has been expanded to include four dummy variables - three seasonal dummies (Q_1, Q_2, Q_3) and a dummy variable designed to capture the influence of strikes in the auto industry (QAUTST*CMV(adj))[13] and a constant term.

Two general comments on the results presented in Table 5 are germane at this point. First, regardless of the functional form chosen, the results conform to theoretical expectations. The price term is highly significant and negative, implying that an increase in the price of imports, ceteris paribus, will reduce imports. The variable for motor vehicle exports to the United States (XMV12) has a positive sign, is highly significant, and yields a crude measure of the import content of Canadian motor vehicle exports. Expenditure on North American vehicles is also significant and possesses the expected positive sign.[14] Second, the dummy variables are statistically significant in a large number of cases, and in all cases make a positive contribution to the R^2 of the equation.

Because the transformations employed in the regressions reported in Table 5 are nonlinear, the reported summary statistics are not directly comparable. Approximate comparability may be achieved by re-transforming all residuals to a common basis (original data units), and then recomputing the summary statistics for the transformed residuals.[15] Results are reported in Table 6

Table 5

ESTIMATED EQUATIONS FOR AUTOMOBILE IMPORTS
(1Q65-4Q71)

	Functional Form				
Independent Variables[1]	Linear[2]	Logarithmic[3]	Inverse Semi-Log[4]	Ratio A[5]	Ratio B[6]
CONSTANT	981.7129 (2.64)	-.3367 (-.16)	8.55750 (5.28)	2.53097 (5.10)	1.39676 (3.33)
Q1	-30.8401 (-1.82)	-.0619 (-1.23)	-.03266 (0.45)	-.02518 (-1.14)	-.02147 (-1.15)
Q2	-64.4786 (-2.26)	-.1229 (-1.47)	-.29591 (-2.47)	-.10267 (-4.79)	-.07733 (-2.50)
Q3	-65.3384 (-3.38)	-.2424 (-4.33)	-.16440 (-1.96)	-.09932 (-3.86)	-.06030 (-2.78)
CMV(adj)	.4729 (3.37)	.7229 (2.18)	.00185 (3.12)	-	.00019 (1.25)
XMV12	.5031 (14.27)	.3398 (11.44)	.00108 (7.24)	.00062 (16.82)	.000098 (2.55)
PRICE	-990.6244 (-2.75)	-3.6600 (-3.26)	-3.98501 (-2.54)	-2.00366 (-4.46)	-1.09645 (-2.70)
QAUTST* CMV(adj)	.0332 (4.45)	.0082 (3.57)	.00006 (1.75)	.00004 (4.06)	.000025 (2.98)
		Summary Statistics			
see	29.74	.085	.123	.038	.032
RB^2	.9707	.9630	.9223	.9684	.7397
cov	6.34%	1.39%	2.02%	6.10%	8.47%
dw	1.78	1.17	1.49	2.17	1.60

[1] The t-ratios are reported in parentheses.

[2] $MMV12 = \alpha_0 + \alpha_1 Q_1 + \alpha_2 Q_2 + \alpha_3 Q_3 + \alpha_4 \, CMV(adj) + \alpha_5 \, XMV12 + \alpha_6 \, PRICE + \alpha_7 \, QAUTST*CMV(adj)$

[3] $\ln MMV12 = \alpha_0 + \alpha_1 Q_1 + \alpha_2 Q_2 + \alpha_3 Q_3 + \alpha_4 \ln CMV(adj) + \alpha_5 \ln XMV12 + \alpha_6 \ln PRICE + \alpha_7 \, QAUTST*\ln CMV(adj)$

[4] $\ln MMV12 = \alpha_0 + \alpha_1 Q_1 + \alpha_2 Q_2 + \alpha_3 Q_3 + \alpha_4 CMV(adj) + \alpha_5 XMV12 + \alpha_6 \, PRICE + \alpha_7 \, QAUTST*CMV(adj)$

[5] $\frac{MMV12}{CMV(adj)} = \alpha_0 + \alpha_1 Q_1 + \alpha_2 Q_2 + \alpha_3 Q_3 + \alpha_4 XMV12 + \alpha_5 PRICE + \alpha_6 \, QAUTST*CMV(adj)$

[6] $\frac{MMV12}{(CMV(adj) + XMV12)} = \alpha_0 + \alpha_1 Q_1 + \alpha_2 Q_2 + \alpha_3 Q_3 + \alpha_4 CMV(adj) + \alpha_5 XMV12 + \alpha_6 PRICE + \alpha_7 QAUTST*CMV(adj)$

Table 6

TRANSFORMED SUMMARY STATISTICS FOR REPORTED IMPORT EQUATIONS
(1Q65 - 4Q71)

Summary Statistics	Functional Form: Linear	Logarithmic	Inverse Semi-log	Ratio A	Ratio B
see	29.74	36.28	64.21	28.301	40.528
RB^2	.9707	.9536	.8906	.9745	.9491
cov	6.34%	7.73%	13.68%	6.03%	8.64%
dw	1.78	1.42	1.59	2.18	1.60

Only the semi-log form is really inferior on the basis of this comparison, with a standard error more than twice that of the simple linear form. The logarithmic function also may be judged inferior to the remaining three equations, in this case on the basis of its relatively low Durbin-Watson (dw) statistic. Given the good Durbin-Watson statistics obtained for both the linear and the ratio A functional forms, the low dw on the logarithmic equation can be interpreted as evidence of a mis-specified functional form.

Turning to Table 7, three import elasticities - the price elasticity ($\eta_{M,P}$) , the expenditure elasticity ($\eta_{M,C}$) , and the export elasticity ($\eta_{M,X}$) - are evaluated at three sample points for each of the five functional forms. Having already rejected both logarithmic functions, I concentrate my attention on the linear and the two ratio forms.

Table 7

POINT ELASTICITIES IMPLIED BY ESTIMATED EQUATIONS

Function Form	Evaluated at	$\eta_{M,C}$ [1]	Elasticity $\eta_{M,X}$ [2]	$\eta_{M,P}$ [3]
Linear	1Q65	1.4754	.0805	-4.9631
	Sample Mean	.9884	.4125	-3.9625
	4Q71	.5060	.6188	- .9906
Logarithmic	1Q65	.7229	.3398	-3.6600
	Sample Mean	.7229	.3398	-3.6600
	4Q71	.7229	.3398	-3.6600
Inverse Semi-logarithmic	1Q65	1.1643	.0892	8.6872
	Sample Mean	1.4386	1.8726	8.5279
	4Q71	1.4534	2.5739	8.2888
Ratio A	1Q65	1.0000	.0605	-6.8100
	Sample Mean	1.0000	.3049	-4.3517
	4Q71	1.0000	.5988	-2.2285
Ratio B	1Q65	1.4411	.0574	-3.9118
	Sample Mean	1.0518	.3479	-3.3093
	4Q71	.8083	.7383	-2.5923

[1] $\eta_{M,C}$ = percentage change in imports associated with a 1% change in automobile expenditures.

[2] $\eta_{M,X}$ = percentage change in imports associated with a 1% change in automobile exports.

[3] $\eta_{M,P}$ = percentage change in imports associated with a 1% change in relative prices.

(a) Linear form

As anticipated, the price elasticity declines dramatically toward the end of the sample period, and is therefore likely to create serious problems when used in projections that extend far beyond the end of the sample period. In addition, the expenditure elasticity exhibits the same properties, falling to a level of .5060 by 4Q71. Again one would expect this to create problems for projection exercises. Since there is no theoretical reason to expect either a declining expenditure or price elasticity, I conclude that the linear form is an inadequate specification and therefore reject it.

(b) Ratio A

In contrast to the linear form Ratio A constrains the expenditure elasticity ($\eta_{M,C}$) to be 1. This is a potentially serious restriction, and I therefore fitted the auxiliary regression

$$\frac{MMV12}{CMV(adj)} = j(\text{constant, seasonals, strike, } CMV(adj)), XMV12, P)$$

The coefficient of CMV(adj) was both small and statistically insignificant, and I took this as evidence that $\eta_{M,C} = 1$ was an acceptable restriction. As well, the ratio form ameliorates the declining price elasticity problem. Although the rate of decline is rapid, the decline is to an absolute level of 2.2285 by 4Q71, which is more in line with my prior beliefs. The export elasticity rises to .5988 by 4Q71; I interpret its rising trend as representing the increasing integration of the Canadian and U.S. industry over the course of the auto pact.

(c) Ratio B

The elasticity results for Ratio B are qualitatively similar to those reported for Ratio A, and there is little to choose between A and B. Ratio B more effectively stabilizes the price elasticity, and shows a moderately higher end value for the export elasticity. The expenditure elasticity does decline over the sample period, but not so dramatically as to offend my priors.

On the basis of the results presented here, I moderately prefer the Ratio A formulation of the import equation to Ratio B, and favour it strongly over the remaining alternatives. This preference is based on its marginally superior statistical fit and on the fact that my elasticity priors are not sufficiently strongly held to differentiate between A and B. However, I would not be greatly distressed if a consensus were to favour either of the ratio forms.

VI Conclusions and Directions for Future Research

The proposed model of trade in automotive products consists of an identity and two equations:

$$CMV(adj) \equiv CMV - MMV13 \tag{18}$$

$$\begin{aligned} MMV12 = CMV(adj) * [& \underset{(5.10)}{2.53097} - \underset{(-1.14)}{.0251}\, Q1 - \underset{(-4.79)}{.10267}\, Q2 \\ & - \underset{(-3.86)}{.09932}\, Q3 + \underset{(16.82)}{.0062}\, XMV12 - \underset{(-4.46)}{2.00366}\, P \\ & + \underset{(4.06)}{.00004}\, QAUTST * CMV(adj)] \end{aligned} \tag{19}$$

see = .038 RB2 = .9684 cov = 6.10% dw = 2.17

$$XMV12 = \underset{(.5)}{315.63} - \underset{(-.3)}{.02}\ QC1*J1L(XMV12) + \underset{(1.9)}{.07}\ QC2*J1L(XMV12)$$

$$- \underset{(-5.1)}{.23}\ QC3*J1L(XMV12) + \underset{(2.8)}{1.75}\ J4A(CMV(adj)) \qquad (20)$$

$$+ \underset{(2.8)}{.51}\ J1L(XMV12) + \underset{(1.6)}{196.34}\ ESCALE - \underset{(-1.8)}{1553.98}\ PFX$$

see = 52.94 RB2 = .978 cov = 10.26% rho = -0.24 dw = 2.05

These equations appear to track the sample period reasonably well. In addition, they yield some interesting insights into the importance, during the transitional period, of the production-subsidy arrangement and of the increased importance of intensified offshore competition.

What of future research? Clearly additional work needs to be done on the price series used in this study, and will be undertaken in the near future. In addition, by pointing out the significance of offshore competition, I draw attention to a serious weakness in RDX2 - ie, treating MMV13 as an exogenous variable. Given the growth on offshore sales to a level of almost 25 percent of the Canadian market, it is becoming increasingly necessary to treat MMV13 endogenously. My model is set so as to facilitate that step, and an obvious next step would be to develop a market-share equation for MMV13.

Appendix 1

RELATIVE AUTOMOBILE PRICES IN THE UNITED STATES AND CANADA

Year	Index (P_{Canada}/$P_{United\ States}$)	Year	Index (P_{Canada}/$P_{United\ States}$)
1Q61	1.171	1Q67	1.060
2Q61	1.171	2Q67	1.061
3Q61	1.123	3Q67	1.061
4Q61	1.128	4Q67	1.060
1Q62	1.122	1Q68	1.059
2Q62	1.098	2Q68	1.055
3Q62	1.081	3Q68	1.060
4Q62	1.094	4Q68	1.057
1Q63	1.095	1Q69	1.055
2Q63	1.105	2Q69	1.040
3Q63	1.125	3Q69	1.038
4Q63	1.101	4Q69	1.034
1Q64	1.102	1Q70	1.037
2Q64	1.092	2Q70	1.041
3Q64	1.092	3Q70	1.093
4Q64	1.097	4Q70	1.058
1Q65	1.087	1Q71	1.062
2Q65	1.086	2Q71	1.055
3Q65	1.086	3Q71	1.035
4Q65	1.079	4Q71	1.061
1Q66	1.082		
2Q66	1.079		
3Q66	1.078		
4Q66	1.061		

Source: See Section 4 Empirical Results: The Export Equations, Variable Construction, The Price Series.

Appendix 2

AVERAGE HOURLY EARNINGS - AUTOMOBILE ASSEMBLY

Year	U.S. Wages in Canadian $	Canadian Wages	Ratio of U.S. to Canadian Wages
1Q61	2.83	2.30	1.23
2Q61	2.88	2.32	1.24
3Q61	3.06	2.39	1.28
4Q61	3.15	2.42	1.30
1Q62	3.13	2.44	1.28
2Q62	3.24	2.50	1.30
3Q62	3.35	2.49	1.35
4Q62	3.42	2.56	1.34
1Q63	3.36	2.56	1.31
2Q63	3.38	2.61	1.30
3Q63	3.46	2.58	1.34
4Q63	3.59	2.68	1.34
1Q64	3.49	2.64	1.32
2Q64	3.52	2.68	1.31
3Q64	3.65	2.75	1.33
4Q64	3.61	2.67	1.35
1Q65	3.66	2.90	1.26
2Q65	3.67	2.85	1.29
3Q65	3.69	2.84	1.30
4Q65	3.79	2.87	1.32
1Q66	3.72	2.91	1.28
2Q66	3.74	2.91	1.29
3Q66	3.86	2.96	1.30
4Q66	3.92	3.01	1.30
1Q67	3.85	3.00	1.28
2Q67	3.89	3.08	1.26
3Q67	3.98	3.13	1.27
4Q67	3.98	3.17	1.26
1Q68	4.23	3.24	1.31
2Q68	4.25	3.46	1.23
3Q68	4.29	3.59	1.19
4Q68	4.42	3.59	1.23
1Q69	4.40	3.57	1.23
2Q69	4.44	3.65	1.22
3Q69	4.68	3.81	1.23
4Q69	4.63	3.83	1.21
1Q70	4.61	3.89	1.19
2Q70	4.62	4.07	1.14
3Q70	4.52	4.21	1.07
4Q70	4.46	4.09	1.09
1Q71	4.96	4.40	1.13
2Q71	4.94	4.42	1.12
3Q71	4.93	4.45	1.11
4Q71	4.96	4.50	1.10

Source: See Section 4 Empirical Results: The Export Equations, Variable Construction, The Wage Series.

FOOTNOTES

1 At that point, it was made retroactive to the initial signing date.

2 Note that vulnerability is really a double-edged sword. Increased vulnerability may mean that Canada has as much to gain as to lose from foreign competition, since exchange rate adjustments, which erode the offshore competitive position, may lead to increased demand for Canadian-produced substitutes. Here "vulnerable" refers to the increased potential instability of the industry brought about by direct competition with Japan.

3 "Imperfectly competitive" is used in the technical sense - that is, the firm exercises some control over the supply price.

4 In fact, this is an extremely difficult problem; a constrained Lagrangian formulation is indicated.

5 The importance of PFX may be seen from the following example: Assume initially that PFX = 1.000 and that the optimal production of an automobile in Canada requires six hours of Canadian labour (at \$5 per hour) and \$70 in imported parts. Canadian content is 30 percent. Let the Canadian dollar depreciate until PFX = 1.100. Then a Canadian automobile is valued at \$70 x 1.100 + \$30 = C\$107, and Canadian content has fallen to (30/107) 28 percent. If the response is to increase production to make up for the

reduction in Canadian content, $\frac{\partial XMV12^*}{\partial PFX} > 0$. But if instead the fraction of inefficient Canadian content is raised, optimal $XMV12^*$ may fall, in which case $\frac{\partial XMV12^*}{\partial PFX} < 0$. Note too, that when single-equation estimating techniques are used, the result is probably biased toward a negative coefficient because of a reverse causation running from exports to PFX. That is, larger exports, ceteris paribus, imply an appreciating Canadian dollar (a lower PFX).

6 Constructed from data contained in Ward's Automotive Yearbook [13], various issues.

7 The DRI series are available from Data Resources Incorporated. The CANSIM series are available from Statistics Canada.

8 The series is reproduced in Appendix I.

9 However, it is true that an increase in PFX (depreciation of the Canadian dollar), ceteris paribus, will reduce the size of the subsidy and, therefore, optimum exports. Furthermore, the sign on PFX (equations A and B) is negative. Although there are other reasons for expecting a negative sign on PFX (see above), a possible interpretation is that PFX is picking up the effect of the subsidy. Such an interpretation would of course increase the credibility of the model and could yield a measure of the impact of variations in the size of the subsidy.

10 Obtained as follows: Referring to Equation (10), one finds that the estimated coefficient of CMV(adj) (call it B_1) is equal to $(1-\theta)\beta_1$. Since an estimate of θ is obtained directly as the estimated coefficient of $XMV12_{t-1}$ the structural parameter $\beta_1 = \frac{B_1}{1-\theta}$. If one takes B at 1.4, and θ at .6, $\beta_1 = 1.4/.4 = 3.5$. The interpretation of β_1 is that it represents the marginal value of exports generated by marginal growth in the Canadian market. Since a $1 increase in Canadian sales generates $3.50 in exports, the Canadian content of which must be $.60, the required content per unit may be as low as .60/3.5 = 18.5 percent.

11 The ordinary least squares estimate of the linear form exhibited weak evidence of heteroscedasticity of the error term. Thus, all results reported for the linear form are generalized least squares estimates (GLS), obtained by transforming the data by $1/\sqrt{CMV(adj)}$. All other equations have been estimated by the ordinary least squares procedure.

12 Some procedural explanation is required. The usual approach is to hold back from the data set employed for estimation a small portion of the time series to be used for ex post testing of the equation. I held back 1Q71-4Q71, and performed my experiments on 1Q65-4Q70. Ex post forecasts then were made for the 1971 data and, since these observations fell within the required prediction intervals, the data set was recombined and the equations were re-estimated for 1Q65-4Q71. Only these last results are

reported in Table 2. For a justification of this technique see Dhrymes [4].

13 QAUTST is an existing RDX2 variable.

14 My theory requires that the relevant variable be expenditure on North American vehicles, not total expenditure (N.A. + offshore imports) as currently used in RDX2. I conducted some experiments with the linear form in which the RDX2 variable was substituted for the more restricted expenditure concept. The result was to reduce the explanatory power of the equation, and I take this as additional weak evidence in favour of my model.

15 For example, in the case of the logarithmic transformation, the transformed residuals may be obtained by taking the antilogarithm of the predicted dependent variable and then performing a Massager operation 45 [9].

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