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PRODUCTION OF U.S. SUBSIDIARIES AND
EXPORTS OF PARENT COMPANIES TO CANADA

by

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INTRODUCTION

The purpose of this paper is to see whether Vernon's "product-cycle hypothesis" is or is not supported by empirical evidence.

The paper is divided into four parts.

In Part I, we present an overview of the existing literature. We discuss in some detail Vernon's hypothesis, which has been challenged by T. Horst.

In Part II, we present our empirical model and discuss the variables included in it.

In part III, our empirical results are presented and evaluated on the basis of a priori criteria, as well as on the basis of econometric criteria.

Finally, part IV includes our conclusions from the conducted test, taking into account all the results that we have obtained.

PART I

AVAILABLE LITERATURE (1)

1. VERNON'S "PRODUCT CYCLE" HYPOTHESIS :

Vernon (2) and others (3) consider foreign direct investment (FDI) as a natural stage in the dynamic process of the development of a product. The process requires a necessary condition. As Vernon explains, the firms must first acquire a specific advantage over the producers in less developed markets. In fact he points out that in rich countries (like the US) firms are stimulated to acquire that advantage. Indeed those firms operate in countries with high per capita incomes, where consumers are more demanding in terms of quality and number of products available. As a consequence the firms will be induced to increase their research and development (R & D) effort in order to take advantage of the potential market. Another fact that enhances R & D is that in those countries labor unit costs

(1) This section draws on the exposition of chapter 7 of Non-Price Decisions: The Firm in a Modern Context, by A.Koutsoyiannis, 1982, Macmillan, U.K, as well as on other sources, as per references below.

(2) R.Vernon, "International Investment and International Trade in the Product Cycle", Quarterly Journal of Economics, vol 80, 1965, pp.190-207.

(3) W.Gruber, D.Mehta and R.Vernon, "The R & D factor in International Trade and International Investment of United States Industries", Journal of Political Economy, vol 75, 1967, pp.20-37.

are high, and therefore firms will have an incentive to develop more capital intensive processes. In summary, the specific advantage is acquired in the form of new products or processes.

Once the specific advantage has been acquired, four stages will follow.

1/ In the first stage of the product's life-cycle, the firm is producing for the domestic market. There is little or no standardization. Cost considerations are not important at this stage for several reasons. The lack of standardization causes the firms to give priority to the continuity of the supply at that stage. Cost considerations play also a secondary role because of the new product's low price elasticity which increases the monopoly power of the innovating firm.

Furthermore, firms want to watch closely their customers' reactions, so as to change the specifications of the new product, if required.

Finally the innovating firm will want to spy closely on competitors' attempts to "copy" the firm's new product.

For the above reasons the firm will stay in the home market at the first stage of the development of the new product.

2/ The second stage in the product's life-cycle is the

stage of maturity. The product attains some degree of standardization which facilitates its production, and exporting takes place. Competitors have developed substitutes of the product, and cost considerations become more important (since the monopoly power of the innovator is reduced). Exports increase initially at a fast rate. However, gradually the advantage of the innovator decreases since local producers in foreign countries are better informed on the preferences of the buyers. Moreover, tariffs might be imposed in order to protect the local producers.

3/ At the third stage of the product's cycle, foreign direct investment (FDI) becomes a necessity, due to the following reasons:

Firstly, tariffs may rise in the foreign countries in an attempt to block imports (of the previously "new" product).

Secondly, scale economies from concentrating production in the home country are eventually exhausted. A plant in the foreign market can solve this problem.

Finally prompt service in the foreign country becomes essential in view of the increased competition of local producers.

In summary, FDI becomes inevitable: it seems to be the best alternative, considering that the entrepreneur does not want to lose his share in the foreign markets. Thus, Vernon considers exports and FDI as distinct sequential stages in

the dynamic process of the development of a new product.

4/ At the fourth stage of the product's cycle, foreign subsidiaries will export from the foreign country to other world markets, and might even ship back to the mother country. This will take place only if the costs of exporting back are less than the other cost advantages that exist in producing in the foreign country.

It is apparent that Vernon has put forward a theory about international trade and foreign direct investment based on a strictly defined time pattern: foreign direct investment is the inevitable successor to exporting.

2. HORST'S HYPOTHESIS

Vernon's hypothesis has been challenged by T.Horst (4). According to Horst, the exports of a firm and its subsidiary sales in a given foreign country are alternative methods of maintaining a "target" share (of the firm) in a foreign market. A firm is interested in its total share of the market abroad, and in order to maintain it, the firm would export, invest, or use the best possible combination of these two activities.

(4) T.Horst, "The Industrial Composition of U.S. Exports and Subsidiary Sales to the Canadian Market", American Economic Review, 1972, pp.37-45.

Exports and FDI are seen by Horst as alternative methods for exploiting the technological advantage that a firm possesses.

In order to test his hypothesis, Horst uses a sample of 18, two-digit, U.S. manufacturing industries for the year 1963. He defines three endogenous variables, that he regresses on R & D. These endogenous variables are the following:

(i) Subsidiary production of U.S. firms in the jth Canadian market $(SP_{us})_j$ as a percentage of of the sum of world exports to Canada (M) plus the total Canadian production (C):

$$\left[SP_{us} / (C+M) \right]_j$$

The regression of this variable on R & D yielded a correlation coefficient $R_1^2 = 0.48$.

(ii) The exports of the jth U.S. industry to Canada $(E_{us})_j$ as a percentage of the sum of world exports to Canada (M)_j plus the total Canadian production (C):

$$\left[E_{us} / (C+M) \right]_j$$

The regression of this variable on R & D yielded a correlation coefficient $R_2^2 = 0.33$.

(iii) The sum of the two preceding variables, $(SP + E) / (C+M)$. This sum, Horst regresses on R & D, and he obtains an "aggregate" $R^2 = 0.63$. The fact that R^2 is greater than the other two correlation coefficients (R_1^2 and

R_1^2) leads Horst to the conclusion that exporting and foreign direct investment represent alternative methods of exploiting the same technological advantages in a foreign country.

Three main problems have to be stressed regarding Horst's conclusions (5).

-First, many explanatory variables are missing from Horst's specifications. There are many determinants of foreign direct investment and of exports to be considered other than R & D.

-Secondly, an appropriate test of Vernon's hypothesis can not be conducted by using a cross-industry sample. The substitution of foreign direct investment for exports can be satisfactorily explored only by a study of these activities over time.

-Finally, Horst's conclusion, based on the relationship between the correlation coefficients of his three regressions, is not satisfactory from a theoretical point of view (5).

(5) See A.Koutsoyiannis, *op.cit.*, pp.363-365.

3. SOME TESTS OF VERNON'S PRODUCT CYCLE HYPOTHESIS:

(a) The Study of Gruber, Mehta and Vernon

W.Gruber, D.Mehta and R.Vernon have attempted to test the product-cycle hypothesis (5a). Their sample (for the year 1962) is composed of nineteen manufacturing industries, which the authors classified into two categories: "research intensive industries" and "other industries", with low research activity. The "research intensive" industries are, aircraft and other transport equipment, electrical machinery, scientific instruments, chemicals and non-electrical machinery.

The authors find that the above five industries account for 72% of the U.S. exports of manufactured goods and for 89.4% of R & D expenditures. From this they conclude that export performance is a function of R & D, which defines the competitive strength of U.S. industries. Furthermore their study shows that industries with the strongest R & D activities have also the strongest new product differentiation. Finally, they find (i) that high indirect labor costs are positively related with R & D, and (ii) that high capital intensity does not show any systematic relationship with R & D. From this, they conclude that the

(5a) W.Gruber, D.Mehta and R.Vernon: "The R & D factor in International Trade and International Investment of United States Industries".

economies of scale and other barriers to entry stem from having a successful marketing and product innovation, and that these economies are not the consequence of high capital intensity.

Subsequently, the authors argue that industries with comparatively high export sales of products with scientific and technical aspects will have a high propensity to invest in manufacturing subsidiaries.

The authors conclude that US exports and subsidiary sales are substitutes over time. This assertion is compatible with the product-cycle hypothesis.

The Vernon-Gruber-Mehta empirical study has several shortcomings. The most important weakness of this study is the use of cross-section data. The dynamic process implied by the product-cycle hypothesis can be adequately tested only by time series data, which allow the exploration of the substitutability of FDI for exports over time.

(b) The Study of T.Wells

Another test of Vernon's hypothesis has been conducted by L.T.Wells (6). This test concentrates on consumer durables

(6) L.T.Wells, "Test of a Product Cycle Model of International Trade: US Exports of Consumer Durables", Quarterly Journal of Economics, vol.83,1969, pp.152-162.

and has several shortcomings.

The author is testing variables (which, according to him, are determinants of the product cycle) by looking at the effect they have on U.S. exports. It is apparent that this approach cannot give any direct information on FDI or on its determinants since they are not explicitly taken into account in the first place. The only result that the study provides us with, is that the U.S. industries, producing technologically sophisticated products, appear to have been in the second stage of the product cycle (exporting) during the period 1952-63. In other words, the product cycle is not being tested over time. The "test" refers only to the second stage of the product cycle, and it is in this sense that Well's paper is not relevant to the Vernon-Horst controversy.

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* *

It is evident that to date the product-cycle hypothesis has not been tested adequately. In this paper we attempt to test Vernon's hypothesis, using a different approach.

PART II

THE EMPIRICAL MODEL

A. SPECIFICATION: THE VARIABLES

We intend to test Vernon's product-cycle hypothesis versus Horst's alternative, using a suitable empirical model.

Our model will have as an endogenous variable the sales of U.S. subsidiary firms in Canada (SP_{US})_j as a percentage of the Canadian market ($C+M$)_j (6a). Throughout this study the dependent variable will be denoted as "Y". The compilation of this variable is explained in Appendix I, page 81 of this paper.

The subsidiary sales, of course, depend on the amount of foreign direct investment (FDI). Thus, we will present the main determinants of FDI proposed by various authors, and identify those of them that we will use in our empirical model. Having presented these determinants, we will proceed with the discussion of additional variables that we will include in our set of regressors.

(i) VARIABLES DEFINED BY ECONOMIC THEORY (7)

(6a) These variables have been defined on page 6.

1. The "Specific-Advantage" Hypothesis

The first determinant of FDI is based on the "specific advantage hypothesis" which includes the following:

(a) The technological advantage, which can be described as a unique asset that a firm possesses, and that could be cheaply transferable into another country and with difficulty or not at all imitated (8).

b) Entrepreneurial excess capacity. As J.Servan Schreiber (9) stressed, firms would expand out of the border in order to be able to use their excess of stock of managerial talent. Given the special skills of the management, FDI would give an efficiency advantage to the affiliate over the rival producers in the host country.

(c) Multiplant economies: Authors such as Eastman, Stykolt (10) and Caves (8), have pointed out the fact that firms, having exhausted single plant economies and still enjoying multi-plant economies, will invest abroad. They will thus be able to take advantage of further economies.

(7) The following discussion draws on Koutsoyiannis 's Non-Price Decisions; The Firm in a Modern Context, 1982, Macmillan, U.K., (pp314-327), as well as on other references cited in subsequent footnotes.

(8) R.E.Caves, "Causes of Direct Investment:Foreign Firms' Shares in Canadian and UK Manufacturing Industries", Review of Economics and Statistics, 1974, pp.279-293.

(9)J.J.Servan Schreiber, The American Challenge, Atheneum, 1968.

(10)Eastman and Stykolt, The Tariff and Competition in Canada, MacMillan, Toronto, 1967.

The influence of the above factors on the dependent variable is expected to be captured by the R & D variable that we introduce explicitly in our empirical model (see below).

2. The "R & D" Hypothesis

Some authors have suggested that the effort of R & D is linked to the tendency to invest abroad. An explanation of this would be that with R & D activities the firm seeks to preserve its oligopolistic position by continuously producing superior products or processes. It is evident that the "R & D" hypothesis is supplementary to the "specific advantage" hypothesis.

Horst's estimated relationships between exports and R & D as well as between FDI and R & D support this hypothesis (11). His findings show that the correlation between the exports of U.S. and R & D as well as between FDI and R & D are positive. Several other empirical studies provide evidence in support of the R & D hypothesis.

On the basis of that hypothesis, we will introduce into our model a variable that will measure the R & D activity of the US industries. This variable will be denoted by "R & D".

(11) T.Horst, "The Industrial Composition of US Exports and Subsidiary Sales to the Canadian Market".

The sign of the coefficient of this variable is expected to be positive.

3. The "Capital-Abundance" Hypothesis

This hypothesis relates to the usual factor endowments theory of international trade, according to which capital will be transferred from the countries which are well endowed towards countries that are poorly endowed with it.

The evidence on the "Capital-Abundance" hypothesis is inconclusive. Thus, we will not include any variable for this factor in our set of regressors.

4. The "Barriers to Entry" Hypothesis

This hypothesis states that foreign firms will be attracted in a foreign market if barriers to entry (BTE) exist and are expected to persist in the long run. This is due to the fact that when a firm invests horizontally abroad, it enjoys advantages for overcoming barriers (such as capital requirements, minimum efficient size, advertising, absolute cost advantages of various types, R & D intensity) (12).

(12) P.K.Gorecki, "The Determinants of Entry by Domestic and Foreign Enterprises in Canadian Manufacturing Industries: Some comments and Empirical Results", Review of Economics and Statistics, Nov 1976, pp.485-88.

We have used in our model two different measures of barriers to entry. First, the concentration ratio of the four largest firms of each industry seemed to us a good proxy for measuring barriers to entry, since it is related to the market share of the firms. We assume that the firms act according to the classical theory of barriers to entry (13),(14). This variable will be denoted by "CR". The sign of the coefficient of this variable is expected to be positive.

Secondly, we have calculated the profitability of the Canadian industries, irrespective of ownership (foreign or domestic) of firms, and we considered it as a proxy for the entry barriers. We have denoted this variable by Π_c . The sign of the coefficient of this variable is expected to be positive.

5. The "Tariff" Hypothesis

Some writers argue that tariffs are a powerful determinant of foreign direct investment. Since tariffs impede exports, the way by which the exporting firm can keep its share of the market; is to invest in the foreign country, that is, install production facilities (in the host

(13) J. Bain, Barriers to New Competition, Harvard University Press, 1956.

(14) A.Koutsoyiannis, Modern Microeconomics, 2nd edition, 1979, Macmillan, U.K., Chapters 13 and 14.

country). The probability that a firm will invest in a foreign market (after tariffs have risen) is much greater if the firm in question possesses some kind of specific advantage (product differentiation, for example).

Horst (15) has tested the importance of tariffs on the firm's choice between exporting and investing abroad. Using Canadian data, he found that tariffs are an important determinant of FDI.

Harold Crookell (16) argues that a decrease in Canadian tariffs might decrease U.S. direct investment. As he puts it, a decrease in tariffs would "make trade an increasingly viable alternative to FDI"(16).

J. Lunn (17), in studying U.S. investments in the EEC, concludes that tariffs are an important determinant of foreign direct investment.

Several studies have provided additional evidence in support of the "tariff hypothesis". However, other researchers have reached the opposite conclusion, that is, that tariffs are unrelated to FDI. Thus, the available

(15) T.Horst, "The Industrial Composition of US Exports and Subsidiary Sales to the Canadian Market".

(16) H.Crookell, "The Future of US Direct Investment in Canada", Business Quarterly, Summer 1983, pp.22-27.

(17) J.Lunn, "Determinants of US Direct Investment in the EEC", European Economic Review, Amsterdam, number 1, Jan.1980, pp.93-100.

empirical evidence on the impact of tariffs on FDI is inconclusive. This state of affairs might be attributed to the difficulties encountered when attempting to find reliable data on tariffs.

In our study we encountered the same difficulties. In fact, it was impossible to obtain tariff data per industry (for the industries investigated in this paper). Thus, we did not include any tariff variable explicitly in our set of regressors.

6. The "Lower Production Costs" Hypothesis

This hypothesis refers to the factor-cost differences between countries. According to this hypothesis, FDI will take place because production costs are lower in the host country. The most important of these costs are wages and the costs of raw materials and energy. Local firms may be unable to take advantage of cost differentials for various reasons:

(i) Local firms might not have specific advantages: they might not have the "superior knowhow" and efficient managerial personnel that foreign firms have.

(ii) They might not be able to draw advantages from scale economies, as foreign firms can, since the latter export in other countries of the world, while local firms may not have penetrated foreign markets.

(iii) The cost of finance might be higher for local producers, since they don't have the internal funds that the multinationals possess.

Some authors argue that cost differences are not decisive in the decision to invest abroad. Recall, for example, that Vernon postulated that FDI is a matter of time: once a (foreign) firm has secured a share in the market of the host country by exporting, eventually that firm will proceed with FDI (i.e. will install production facilities abroad in order to maintain its share).

It has been shown by Brash (18) that "actual average production cost" is a "minor motivation to invest abroad".

However, other researchers (e.g. Caves(19)) have found that relative factor costs seem to be a significant determinant of the choice between FDI and exporting.

In view of the above controversial evidence, we have included into our model two types of factor-costs:

The first is the relative costs of raw materials and energy in Canada and the US. The variable that we included in our empirical model is the ratio of the two relevant price indexes (20). We denoted this variable by $P_{r,c} / P_{r,us}$.

(18) D.T.Brash, American Investment in Australian Industry, Australian National University Press, 1966.

(19) R.Caves, "Causes of Direct Investment: Foreign Firms' Shares in Canadian and U.K. Manufacturing Industries".

The sign of the coefficient of this variable is expected to be negative.

The second factor-cost variable that has been introduced into our model is the ratio of the wage rates in Canada and the U.S. This variable reflects the wage differential between the two countries. We denote this variable by W_c/W_{us} (20). The sign of the coefficient of this variable is expected to be negative.

7. The "Foreign Government Inducements" Hypothesis

Examples of such inducements, offered by a foreign government, are:

(i) the granting of preferential tax treatment to subsidiaries;

(iii) profit-tax incentives;

(iii) depreciation allowances;

(iv) favorable interest rates and credit conditions.

However, it should be stressed that, in order for these "inducements" to work, other conditions (such as the existence of specific advantages) must be fulfilled.

(20) See Appendix I, pp.84-85, for a detailed discussion of the compilation of this variable.

Furthermore, it seems that political stability and general current and expected future economic conditions in the prospective host country are decisive factors influencing the decision to invest in that country.

The available empirical evidence shows that in some cases foreign government incentives have had a minor influence on the decision of multinationals(21), while in other studies researchers have found that such incentives have had a short-run effect on the decision to invest abroad.

Given the ambiguity of the empirical evidence on this issue, no variable was included in the set of regressors to account for government inducements.

8. The "Multinational Fad" Hypothesis

This hypothesis suggests that firms tend to follow the behaviour adopted by other firms in the same industry: firms imitate their rivals in different policies, following the "standards and norms" established in the industry (22). Therefore, investment abroad by some firms could induce further such investment by rival firms, thus giving rise to a "bandwagon effect" (or "fad"). The empirical evidence on

(21) L.Krause and K.W.Daw, "Federal Tax Treatment of Foreign Income", Brookings Institute, 1964, pp.92-93.

(22) See A.Koutsoyiannis, Non-Price Decisions, The Firm in a Modern Context, Macmillan, U.K., 1982, p.322.

this hypothesis is inconclusive. Therefore, no attempt was made (in this paper) to measure the impact of such behaviour on FDI.

(ii) ADDITIONAL EXPLANATORY VARIABLES

9. US Exports to Canada

To test Vernon's product-cycle hypothesis against Horst's hypothesis (that FDI and exports are complementary activities for attaining a "target share" in the foreign market), we introduced in our model the share of U.S. exports to the Canadian market as a direct explanatory variable. This variable is denoted by the ratio $[E_{us} / (C+M)]$. (The measurement of this variable is explained in Appendix I, p.81).

If Vernon's hypothesis is "correct", the coefficient of this variable is expected to be negative. On the other hand, a positive sign would support Horst's hypothesis.

10. The "Expectations" Variable

We have introduced the profit rate of U.S. firms in Canada as an "expectational" variable. We hope that this

will allow us to test whether the "expected profitability" plays a significant role in the decision of U.S. firms to directly produce in Canada, versus the alternative activity of exporting to this country.

This variable will be denoted by " Π_{us} ". The sign of its coefficient is expected to be positive.

11. Lagged Variable (Y_{t-1})

Adopting Nerlove's distributed-lag model, we introduced in our model the lagged value of the endogenous variable (23), (24). This is an exogenous variable, since it is an already realized value of the dependent variable.

The coefficient of Y_{t-1} is expected to be positive, with a value smaller than unity.

12. Dummy Variable

Finally, a dichotomous dummy variable was introduced in our empirical model, to take into account any effect of the OPEC policies during the years 1973-74 and 1979-80. It is expected that this dummy variable will capture the impact of the "shocks" directly, thus making it possible to obtain

(23) J. Johnston, Econometric Methods, 3rd ed., 1982, McGraw-Hill, New Jersey, U.S.A., Chapter 9.

(24) A. Koutsoyiannis, Theory of econometrics, 2nd ed. 1975, Macmillan, U.K., Chapter 13, pp.310-312.

"better" estimates of the coefficients of the other regressors. This variable will be denoted by "DM" in the subsequent empirical work (25).

Given the method used in constructing the dummy variable, the sign of its coefficient is expected to be positive.

B. SPECIFICATION: THE FORM OF THE EMPIRICAL MODEL

From the discussion of section A (above) we derive the following set of regressors:

$X_1 = [E_{us}/(C+M)]_j$ = share of U.S. exports to the jth Canadian market (industry)

$X_2 = (R \ \& \ D)_j$ = Research & Development activity of U.S. firms in the jth U.S. industry

$X_3 = (W_c/W_{us})_j$ = relative wage rates in Canada and the U.S. (for the jth industry)

$X_4 = (P_{r,c}/P_{r,us})_j$ = relative costs of raw materials and energy in the jth industry

$X_5 = (\Pi_{us})_j$ = profit rate of U.S. affiliates in Canada (in the jth industry)

(25) The method adopted for the construction of the dummy variable is discussed in Appendix I of this paper (p.90).

$X_6 = (BTE)_j$ = a measure of barriers to entry in the jth Canadian industry

$X_7 = (Y_{t-1})_j$ = lagged value of the endogenous variable

$X_8 = (DM)_j$ = dummy variable

The endogenous variable is the share of U.S. subsidiaries in Canadian manufacturing industries (markets). In symbols:

$$Y_j = [SP_{us}/(C+M)]_j$$

where: $SP_{us,j}$ = U.S. subsidiary production (in the jth industry)

$(C+M)_j$ = size of the jth Canadian market (industry)

The measurement of the variables is discussed in Appendix I (pp.81-91).

In the absence of a priori criteria regarding the mathematical form of the relationship between the endogenous and the explanatory variables, we decided to use a simple linear form. Thus, the specified empirical model, for testing Vernon's "product-cycle" hypothesis is:

$$Y_j = b_0 + b_1 [E_{us}/(C+M)]_j + b_2 (R\&D)_j + b_3 (W_c / W_{us})_j + b_4 (P_{r,c} / P_{r,us})_j + b_5 (\Pi_{us})_j + b_6 (BTE)_j + b_7 (Y_{t-1})_j + b_8 (DM)_j + u_j$$

where: u is the usual random term of the relationship.

On a priori grounds we expect the following signs for the parameter estimates:

$$\begin{array}{ll} b_1 \leq 0 & b_5 > 0 \\ b_2 > 0 & b_6 > 0 \\ b_3 < 0 & 0 < b_7 < 1 \\ b_4 < 0 & b_8 > 0 \end{array}$$

In the next Part of this paper we present the results obtained from the estimation of the above model for twelve manufacturing industries of Canada.

PART III

EMPIRICAL RESULTS

A. THE SAMPLE

The specified model was estimated for the 12 manufacturing industries of Canada shown in table 1, using time series samples for the period 1969-81.

TABLE 1: Industries

SIC code #	INDUSTRY
264	Office Furniture
271	Pulp and Paper Mills
306	Hardware, Tool and Cuttlery
321	Aircraft and Parts
325	Motor Vehicle Parts and Accessories
335	Communications Equipment
373	Plastics and Synthetic Resins
374	Pharmaceuticals and Medicines
375	Paints and Varnishes
377	Toilet Preparations
3782	Industrial Chemicals (inorganic)
3932	Toys and Games

The choice of the industries was based on the three following criteria:

1) Product Homogeneity:

A rigorous test of Vernon's hypothesis requires "narrowly" defined industries, whose product may be considered homogeneous.

2) The importance of the U.S. subsidiary production in Canada:

We sought to include in our study industries in which the U.S. affiliates play an important role. Table 2 shows the mean values of the endogenous variable over the sample period. It is seen from this table that the mean share of the U.S. affiliates of the Canadian markets included in our study ranges from 25 percent (in the Communications Equipment Industry) to 70 percent (in the industry of Toilet Preparations).

3) Data availability:

For several industries, data were available only for some variables, thus making it impossible to include them in our study.

TABLE 2

SIC	INDUSTRIES	MEAN [$SP_{05} / (C+M)$]
264	Office Furniture	0.300
271	Pulp and Paper Mills	0.323
306	Hardware, Tool and Cuttlery	0.303
321	Aircraft and Parts	0.308
325	Motor Vehicle Parts and Accessories	0.308
335	Communications Equipment	0.250
373	Plastics and Synthetic Resins	0.426
374	Pharmaceuticals and Medicines	0.572
375	Paints and Varnishes	0.460
377	Toilet Preparations	0.707
3782	Industrial Chemicals (inorganic)	0.325
3932	Toys and Games	0.277

The time span of our study is the thirteen-year period 1969-1981, for which data were available for the chosen industries. Ideally a longer period would be required. However, the sample is considered adequate for our exploratory analysis.

The time series for the twelve industries covered by our study are included in Tables 1-12 of Appendix II (pp.92-116).

B. REGRESSION RESULTS OF THE SIMPLE MODEL

As a first step in our test, we estimated the following simple model, using the OLS method:

$$Y_{jt} = \left[SP_{us} / (C+M) \right]_{jt} = b_0 + b_1 \left[E_{us} / (C+M) \right]_{jt} + u_{jt}$$

Although misspecified, this "truncated" model is useful in our test, since it throws some light on the relationship between U.S. subsidiary production and U.S. exports to Canada. Recall that a negative sign would be consistent with Vernon's hypothesis, while a positive sign would provide evidence in support of Horst's alternative hypothesis.

The obtained results are shown in Table 3. It is seen from this Table that in 9 out of the 12 industries the coefficient estimate b appears with a negative sign.

Given the values of the Durbin-Watson \underline{d} statistic, we decided to re-estimate the above model using the Cochrane-Orcutt method. The results are shown in Table 4. Examination of this Table shows that autocorrelation has not been eliminated, although the \underline{d} statistic has improved. Furthermore, for one industry (Aircraft and Parts) b changed sign (from positive, in the OLS estimation, to negative, in the Cochrane-Orcutt transformation) and for another (Plastics and Synthetic Resins) b changed sign in the opposite direction (i.e. from negative, in the OLS estimation, to positive, in the Cochrane-Orcutt).

TABLE 3. OLS: $Y = f[E_{us}/(C+M)]$

INDUSTRY	\hat{b}_0	\hat{b}_1 $E_{us}/(C+M)$	R^2 (F)	DW d
Office Furniture	0.325 (32.29) ***	-0.461 (-2.48) ***	0.36 (6.19)	1.32
Pulp and Paper Mills	0.388 (8.96) ***	-2.566 (-1.54) **	0.178 (2.39)	0.81
Hardware, Tool and Cuttlery	0.375 (4.32) ***	-0.329 (-0.82) *	0.058 (0.67)	0.44
Aircraft and Parts	0.311 (2.29) **	0.005 (0.01)	0.000 (0.00)	0.31
Motor Vehicle Parts and Accessories	1.00 (8.84) ***	-1.13 (-6.13) ***	0.773 (37.59)	1.19
Communications Equipment	0.245 (4.84) ***	0.021 (0.11)	0.001 (0.014)	0.64
Plastics and Synthetic Resins	0.498 (7.69) ***	-0.195 (-1.127) *	0.103 (1.27)	0.79
Pharmaceuticals and Medicines	0.615 (8.35) ***	-0.458 (-0.45)	0.03 (0.34)	0.43
Paints and Varnishes	0.491 (45.87) ***	-0.375 (-2.85) ***	0.426 (8.16)	1.83
Toilet Preparations	0.744 (33.13)	-0.588 (-1.68) ***	0.204 (2.82) *	0.59
Industrial Chemicals (inorganic)	0.368 (3.08) ***	-0.203 (-0.35)	0.011 (0.12)	0.18
Toys and Games	0.257 (8.44) ***	0.115 (0.70) *	0.043 (0.49)	0.42

Notes: See footnote (26) on page 32

TABLE 4. Cochrane-Orcutt: $Y = f [E_{us}/(C+M)]$

INDUSTRIES	b	b Eus/(C+M)	R (F)	DW d
Office Furniture	0.320 (77.83) ***	-0.394 (-5.20) ***	0.428 (7.96)	1.39
Pulp and Paper Mills	0.348 (5.44) ***	-1.712 (-0.78) *	0.368 (6.40)	1.00
Hardware, Tool and Cuttlery	0.349 (4.72) ***	-0.233 (-0.71) *	0.624 (17.94)	0.96
Aircraft and Parts	0.405 (4.31) ***	-0.228 (-1.07) **	0.717 (27.86)	1.22
Motor Vehicle Parts and Accessories	0.600 (3.23) ***	-0.498 (-1.66) **	0.823 (50.93)	1.52
Communications Equipment	0.096 (1.43) *	0.506 (3.69) ***	0.703 (0.67)	0.70
Plastics and Synthetic Resins	0.392 (9.98) ***	0.084 (0.98) *	0.679 (34.26)	1.29
Pharmaceuticals and Medicines	0.702 (12.1) ***	-1.394 (-2.31) ***	0.655 (20.88)	1.00
Paints and Varnishes	0.491 (48.07) ***	-0.377 (-3.01) ***	0.428 (8.22)	1.77
Toilet Preparations	0.731 (20.74) ***	-0.336 (-0.66)	0.583 (15.37)	0.91
Industrial Chemicals (inorganic)	0.344 (6.97) ***	-0.072 (-0.40)	0.812 (47.51)	1.02
Toys and Games	0.268 (9.79) ***	0.055 (0.52)	0.567 (14.40)	0.87

Notes: See footnote (26) on page 32

In the Cochrane-Orcutt regressions the estimate \hat{b}_1 is significant at the 5 percent (or a higher) level in four cases, at the 0.10 or 0.15 level in two cases, and at the 0.20 or 0.25 level in three cases. In two cases \hat{b}_1 is not significant at any acceptable level, and in three cases \hat{b}_1 has a positive sign.

Overall, the results of the simplified model suggest that in most cases the share of subsidiary production in Canada is negatively related to the share of U.S. exports. This evidence supports the Vernon hypothesis.

However, the simple model does not include all the determinants of the share of subsidiary production. The omission of variables introduces a misspecification bias in the estimate of \hat{b}_1 .

To avoid this, we estimated various specifications, including subsets of regressors and observing how the value of the coefficients and their t ratios were affected. The

(26) Statistical significance: The numbers in brackets are t ratios.

*** significant at the 0.05 (or a higher) level of significance (one-tail tests)

** significant at the 0.10 or 0.15 level of significance (one-tail tests).

* significant at the 0.20 or 0.25 level of significance (one-tail tests).

C-O denotes regression results obtained by the Cochrane-Orcutt iterative procedure, with convergence at 0.001.

results of this "experimental" (27) approach are shown in Tables 5-23 and are evaluated for each industry separately.

(27) This is a variant of Frisch's confluence analysis.

C. RESULTS BY INDUSTRY

1. Office Furniture (SIC 264)

The reported findings (Tables 5 and 6) suggest that the share of U.S. exports to the Canadian market is an important explanatory variable of the share of U.S. subsidiary production. In all specifications \hat{b}_1 appears with a negative sign; furthermore, both its value and its standard error are stable.

A second important explanatory variable is the R & D expenditures of U.S. firms. Its coefficient appears with the expected a priori sign in all specifications. Its value and its standard error are fairly stable (with the exception of one specification that includes the profitability of the U.S. multinationals as an explanatory variable).

The lagged variable improves slightly the overall fit, but its significance is rather low.

The other variables, that we included in the set of regressors, do not seem to affect the share of U.S. subsidiary production. They rarely appear with the "correct" sign, and are, in general, insignificant. Multicollinearity may be the cause of the poor performance of these variables. (See Table 1 of Appendix III, p.118).

Autocorrelation seems to pose a problem in the estimated function. However, the re-estimation of the various specifications with the Cochrane-Orcutt method did not yield better results.

Taking into account the above considerations, we feel that the "best" results are obtained from the following OLS form:

$$\hat{Y} = \left[\frac{SP_{us}}{(C+M)} \right] = 0.132 - 0.398 \left[\frac{E_{us}}{(C+M)} \right] + 3.130(R\&D) + 0.610(Y_{t-1})$$

\underline{t}	(0.721)	(-2.19)	(2.00)	(1.02)
	*	***	***	**

$$R^2 = 0.570$$

$$d = 1.38$$

$$F = 4.04$$

The above results support Vernon's hypothesis that foreign direct investment is a necessary stage in the dynamic evolution of a new product.

Table 5. Office Furniture:OLS

REGRESSIONS	\hat{b}_0	\hat{b}_1 $E_{L_i}/C+H$	\hat{b}_2 R&D	\hat{b}_3 $W_{i,t}/W_{i,t-1}$	\hat{b}_4 $R_{i,t}/P_{i,t}$	\hat{b}_5 $\Pi_{i,t}$	\hat{b}_6 BTE	\hat{b}_7 $Y_{L,t}$	\hat{b}_8 DM	R^2 (F)	Δ	h
$Y_{L,t} = f(E_{L,t}/C+H)$	0.325 (32.29) ***	-0.461 (-2.48) ***								0.360 (6.19)	1.32	
$Y_{L,t} = f(E_{L,t}/C+H, R\&D)$	0.319 (33.52) ***	-0.469 (-2.80) ***	2.86 (1.86) ***							0.524 (5.52)	1.47	
$Y_{L,t} = f(E_{L,t}/(C+H), R\&D, Y_{L,t-1})$	0.132 (0.721) *	-0.398 (-2.19) ***	3.13 (2.00) ***					0.610 (1.02)		0.570 (4.04)	1.38	n.a.
$Y_{L,t} = f(E_{L,t}/(C+H), R\&D, P_{i,t}/P_{i,t-1}, Y_{L,t-1})$	0.112 (0.549)	-0.397 (-2.07) ***	3.60 (1.54) **	-0.003 (-0.28)				0.685 (1.00) **		0.570 (2.74)	1.48	
$Y_{L,t} = f(E_{L,t}/(C+H), R\&D, B_{i,t}/B_{i,t-1}, Y_{L,t-1})$	0.088 (0.41)	-0.393 (-2.07) ***	1.817 (1.80) **	-0.005 (-0.51)				0.773 (1.10) **		0.580 (2.85)	1.55	
$Y_{L,t} = f(E_{L,t}/(C+H), R\&D, \Pi_{i,t}, Y_{L,t-1})$	0.038 (0.20)	-0.193 (-0.83) *	4.180 (2.53) ***				0.143 (1.42) **	0.718 (1.25) **		0.660 (3.88)	1.74	
$Y_{L,t} = f(E_{L,t}/(C+H), R\&D, W_{i,t}/W_{i,t-1}, Y_{L,t-1})$	0.151 (0.62)	-0.39 (-2.07) ***	3.300 (1.58) **					0.551 (0.71) **		0.575 (2.70)	1.38	
$Y_{L,t} = f(E_{L,t}/(C+H), R\&D, P_{i,t}/P_{i,t-1}, Y_{L,t-1}, DM)$	0.095 (0.42)	-0.386 (-1.91) ***	3.69 (1.64) ***		-0.004 (-0.43)		0.743 (0.99)	0.743 (0.99)	0.007 (0.38)	0.596 (2.06)	1.47	
$Y_{L,t} = f(E_{L,t}/(C+H), R\&D, Y_{L,t-1}, DM)$	0.136 (0.71) *	-0.389 (-2.03) ***	3.060 (1.86) ***					0.592 (0.94) **	0.600 (0.45)	0.584 (2.81)	1.29	
$Y_{L,t} = f(E_{L,t}/(C+H), R\&D, W_{i,t}/W_{i,t-1}, Y_{L,t-1}, DM)$	0.159 (0.62)	-0.390 (-1.91) ***	3.26 (1.48) **	-0.002 (-0.14)				0.522 (0.63)	0.0008 (0.43)	0.586 (1.98)	1.30	
$Y_{L,t} = f(E_{L,t}/(C+H), R\&D, \Pi_{i,t}, Y_{L,t-1}, DM)$	-0.106 (-0.48)	-0.318 (-1.82) **	1.49 (0.88) *			0.485 (1.77)		1.25 (1.86)	0.0009 (0.53)	0.713 (3.49)	1.66	n.a.

Statistical significance:

- *** significant at the 0.05 (or a higher) level of significance (one-tail tests)
- ** significant at the 0.10 or the 0.15 level of significance (one-tail tests)
- * significant at the 0.20 or the 0.25 level of significance (one-tail tests)

Table 6. Office Furniture: Cochran-Orcutt

REGRESSIONS	\hat{b}_0	\hat{b}_1 $E_{xy}/C+M$	\hat{b}_2 $R\&D$	\hat{b}_3 W_c/W_{c-1}	\hat{b}_4 P_c/P_{c-1}	\hat{b}_5 Π_{c-1}	\hat{b}_6 BTE	\hat{b}_7 Y_{c-1}	\hat{b}_8 DM	R^2 (F)	d	h
$Y_c = f(E_{xy}/(C+M))$	0.320 (7.78) ***	-0.394 (-5.20) ***								0.428 (8.23)	1.39	
$Y_c = f(E_{xy}/(C+M), R\&D)$	0.320 (43.32) ***	-0.494 (-3.73) ***	2.827 (1.98) ***							0.505 (5.10)	1.36	
$Y_c = f(E_{xy}/(C+M), R\&D, Y_{c-1})$	0.170 (1.03) #	-0.431 (-2.72) ***	3.185 (2.09) ***					0.486 (0.91) #		0.591 (4.33)	1.22	n.a.
$Y_c = f(E_{xy}/(C+M), R\&D, P_c/P_{c-1}, Y_{c-1})$	0.135 (0.73) #	-0.427 (-2.70) ***	4.079 (1.81) ***		-0.005 (-0.54)			0.619 (1.00) #		0.612 (3.85)	1.27	
$Y_c = f(E_{xy}/(C+M), R\&D, P_c/P_{c-1}, \Pi_{c-1}, Y_{c-1})$	0.111 (0.58) #	-0.420 (-2.65) ***	4.078 (2.03) ***		-0.006 (-0.69)			0.703 (1.10) #		0.619 (3.19)	1.29	
$Y_c = f(E_{xy}/(C+M), R\&D, \Pi_{c-1}, Y_{c-1})$	0.059 (0.36) #	-0.209 (-1.03) #	4.538 (2.76) ***				0.134 (1.56) **	0.628 (1.33) ***		0.691 (4.47)	1.47	n.a.
$Y_c = f(E_{xy}/(C+M), R\&D, W_c/W_{c-1}, Y_{c-1})$	0.182 (0.85) #	-0.429 (-2.53) ***	3.319 (1.60) #		-0.001 (-0.10)			0.450 (0.65) #		0.591 (2.88)	1.22	
$Y_c = f(E_{xy}/(C+M), R\&D, P_c/P_{c-1}, \Pi_{c-1}, Y_{c-1}, DM)$	0.110 (0.538) #	-0.418 (-2.43) ***	4.068 (1.89) **		-0.006 (-0.64)			0.704 (1.02) #	0.0001 (0.08)	0.618 (2.26)	1.29	
$Y_c = f(E_{xy}/(C+M), R\&D, Y_{c-1}, DM)$	0.159 (0.87) #	-0.415 (-2.33) ***	3.142 (1.93) ***					0.522 (0.88) #	0.0004 (0.27)	0.588 (2.85)	1.23	n.a.
$Y_c = f(E_{xy}/(C+M), R\&D, W_c/W_{c-1}, Y_{c-1}, DM)$	0.177 (0.72) #	-0.411 (-2.13) ***	3.333 (1.50) **	-0.002 (-0.14)				0.467 (0.60) #	0.0005 (0.29)	0.589 (2.00)	1.24	
$Y_c = f(E_{xy}/(C+M), R\&D, \Pi_{c-1}, Y_{c-1}, DM)$	-0.101 (-0.46) #	-0.327 (-1.93) ***	1.523 (0.89) #			0.113 (1.77) **		1.240 (1.86) ***	0.0007 (0.43)	0.714 (3.49)	1.61	n.a.

Statistical significance: see note on page 36

2. Pulp and Paper Mills (SIC 271)

The results for this industry (Tables 7 and 8) are impaired by a pervasive pattern of multicollinearity. (See Table 2 of Appendix III, p.118). Of particular importance is the collinearity between the share of exports to the Canadian market $\left[E_{us}/(C+M) \right]$ and all other regressors. The simple r values are:

a) For R&D : -0.45

b) For W_c/W_{us} : 0.37

c) For $P_{rc}/P_{r,us}$: -0.46

d) For Π_c : 0.81

d) For CR : -0.67

e) For Π_{us} : 0.78

f) For Y_{t-1} : -0.52

The R&D variable as well as the lagged variable are also strongly correlated with several other regressors (as can be seen from Table 2 of Appendix III, p.118).

As a consequence, the values of the coefficients of all regressors are very unstable to specification. In

particular, the value of the coefficient of the lagged variable varies between 0.4 and 3.5 in various specifications.

Experimentation with various subsets proved unsuccessful. Examination of the results reveals that the coefficient of our main exogenous variable (U.S. share of exports in the Canadian market) appears with a negative sign in several specifications. The simple regression of Y on the U.S. share of exports in the Canadian market shows that this variable has small explanatory power, but its coefficient is negative and statistically significant at the 0.10 level, although the significance declines when the Cochrane-Orcutt method is used to "correct" for autocorrelation. The slight improvement in the d statistic, obtained by the Cochrane-Orcutt transformation, suggests that autocorrelation might be of a higher order or might be attributed to the omission of autocorrelated regressors (quasi-autocorrelation).

In view of the above considerations, the following form yields the "best" results:

Cochrane-Orcutt

$$\hat{Y} \equiv [SP_{us}/(C+M)] = 0.348 - 1.712 [E_{us}/(C+M)]$$

$$\underline{t} \quad (5.44) \quad (-0.78)$$

*** *

$$R^2 = 0.368$$

$$d = 1.00$$

F =6.4

(We note that the 4-firm concentration ratio is significant in one specification. However, the strong collinearity between the concentration ratio and the U.S. share of exports to the Canadian market renders it impossible to separately assess the impact of these regressors on the dependent variable).

3. Hardware Tool and Cuttlery (SIC 306)

The reported results for this industry (Tables 9 and 10) show that the share of U.S. exports to the Canadian market appears with a negative sign in the various specifications. The values of its coefficients and of its t ratio are unstable in the various specifications, reflecting collinearity of the explanatory variables.

The R & D variable does not seem to be an important explanatory variable of the U.S. subsidiary production. In fact, the simple correlation between the dependent variable and R & D is $r = 0.116$. In general, the t ratios of the coefficient of R & D were very low.

The lagged variable is statistically the most significant explanatory variable in this industry. The value of its coefficient and its t ratio are stable in the various specifications. The inclusion of this variable in the function increases considerably the multiple correlation coefficient and decreases the degree of autocorrelation.

The other variables that we included in the set of regressors did not improve the fit.

Autocorrelation seems to pose a problem in the estimated function. The re-estimation of the various specifications by the Cochrane-Orcutt method did not yield better results.

The above considerations lead us to suggest that the "best" results are obtained from the following OLS form:

$$\hat{Y} \equiv [SP_{Us}/(C+M)] = 0.132 - 0.275 [E_{Uj}/(C+M)] + 2.091(R\&D)$$

$$\underline{t} \quad (1.369) \quad (-0.973) \quad (0.25)$$

 ** *

$$+ 0.728 (Y_{t-1})$$

$$t \quad (3.623)$$

$$R^2 = 0.620$$

$$h = 2.74$$

$$F = 4.9$$

The above findings support Vernon's product-cycle hypothesis.

Table 9. Hardware, Tool and Cuttlery: OLS

REGRESSIONS	\hat{b}_0	\hat{b}_1 $E_{yt}/C+M$	\hat{b}_2 R&D	\hat{b}_3 W_c/M_{c3}	\hat{b}_4 $P_{c,c}/P_{c,45}$	\hat{b}_5 Π_{w}	\hat{b}_6 BTE	\hat{b}_7 Y_{t-1}	\hat{b}_8 DM	R^2 (F)	\hat{d}	h
$Y_t = f(E_{yt}/(C+M))$	0.375 (4.32) ***	-0.329 (-0.82) **								0.058 (0.67)	0.44	
$Y_t = f(E_{yt}/(C+M), R\&D)$	0.356 (3.19) ***	-0.316 (-0.75) *	3.58 (0.30)							0.066 (0.35)	0.42	
$Y_t = f(E_{yt}/(C+M), Y_{t-1})$	0.143 (1.70) **	-0.282 (-1.05) *						0.730 (3.82) ***		0.617 (8.07)	0.93	
$Y_t = f(E_{yt}/(C+M), R\&D, Y_{t-1})$	0.132 (1.36) **	-0.275 (-0.97) *	2.091 (0.25)					0.728 (3.62) ***		0.62 (4.9)	0.95	2.74

Table 10. Hardware, Tool and Cuttlery: Cochrane-Orcutt

REGRESSIONS	\hat{b}_0	\hat{b}_1 $E_{yt}/C+M$	\hat{b}_2 R&D	\hat{b}_3 W_c/M_{c3}	\hat{b}_4 $P_{c,c}/P_{c,45}$	\hat{b}_5 Π_{w}	\hat{b}_6 BTE	\hat{b}_7 Y_{t-1}	\hat{b}_8 DM	R^2 (F)	\hat{d}	h
$Y = f(E_{yt}/(C+M))$	0.349 (4.72) ***	-0.233 (-0.71) *								0.624 (18.25)	0.96	
$Y = f(E_{yt}/(C+M), R\&D)$	0.310 (3.31) ***	-0.168 (-0.48)	5.384 (0.67)							0.640 (8.88)	0.89	
$Y = f(E_{yt}/(C+M), Y_{t-1})$	0.179 (1.77) **	-0.191 (-0.66)						0.544 (2.34) ***		0.737 (14.01)	1.34	
$Y = f(E_{yt}/(C+M), R\&D, Y_{t-1})$	0.178 (1.62) **	-0.188 (0.62)	0.544 (0.07)					0.539 (2.13) ***		0.737 (8.40)	1.33	

Statistical significance: See note on page 36

4. Aircraft and Aircraft Parts (SIC 321)

The results for this industry (Table 14) provide weak support to Vernon's hypothesis. The coefficient of the export variable appears with a negative sign only in specifications where the lagged variable is introduced in the set of regressors. However, its statistical significance is very low.

Multicollinearity has impeded the assessment of the impact of other regressors on the dependent variable (See Table 4 of Appendix III, p.119).

The "best" results are obtained from the following specification:

$$\hat{Y} \equiv [SP_{v,t}/(C+M)] = 0.055 - 0.050 [E_{v,t}/(C+M)] + 0.859 (Y_{t-1})$$

<u>t</u>	(0.62)	(-0.27)	(5.21)
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$$R^2 = 0.730 \qquad d = 1.60$$

$$F = 13.54 \qquad h = 0.88$$

Given the value of the h statistic, we did not proceed with the Cochrane-Orcutt estimation method.

In summary, the negative sign of the coefficient of the export variable is consistent with Vernon's hypothesis. However, the low significance of this coefficient suggests

that conclusions regarding the two alternative hypotheses are only tentative.

Table 11. Aircraft and Parts: OLS

REGRESSIONS	\hat{b}_0	\hat{b}_1 E ₀₁ /C+M	\hat{b}_2 R&D	\hat{b}_3 W _e /W ₀₁	\hat{b}_4 P _{1c} /P ₀₁₅	\hat{b}_5 Π ₀₁	\hat{b}_6 BTE	\hat{b}_7 Y _{t-1}	\hat{b}_8 DM	R ² (F)	d	H
$Y_t = f(E_{01} / (C+M))$	0.311 (2.29) ***	0.005 (0.01)								0.000 (0.00)	0.31	
$Y_t = f(E_{01} / (C+M), Y_{t-1})$	0.055 (0.62)	-0.05 (-0.27)						0.859 (5.20) ***		0.730 (13.57)	1.60	0.88
$Y_t = f(E_{01} / (C+M), W_e / W_{01}, Y_{t-1})$	0.093 (0.51)	-0.059 (-0.28)		-0.05 (-0.24)				0.892 (4.02) ***		0.732 (8.21)	1.65	0.62

Statistical significance: See note on page 36

5. Motor Vehicle Parts and Accessories (SIC 325)

The results (Table 12) suggest that the share of U.S. exports to the Canadian market seem to be an important explanatory variable of the share of U.S. subsidiary production. The parameter \hat{b}_1 appears with a negative sign in all specifications, and both its value and standard error are stable. The value of the t ratios show that the coefficient of the export variable is significant at the 1 percent level.

The lagged variable improves the overall fit substantially. The t ratios of the coefficient of this variable are high, and its value is fairly stable in alternative specifications. These findings show, that the lagged variable is an important explanatory variable of the share of U.S. subsidiary production.

The coefficient of the dummy variable appears with the "correct" a priori sign and is significant at the 5 percent (or a higher) level. The inclusion of this variable in the function increases the overall significance of the regression.

The R & D variable is strongly collinear with the U.S. exports ($r = 0.694$), the lagged endogenous variable ($r = 0.547$), and the dummy variable ($r = -0.445$). Despite the high degree of multicollinearity, the coefficient of R & D

is statistically significant in several specifications.

The other variables do not seem to influence the U.S. subsidiary production in this industry.

We feel that the "best" explanation of the U.S. subsidiary production is obtained from the following OLS specification:

$$\hat{Y} \equiv [SP_{us}/(C+M)] = 0.313 \quad -0.551 \quad [E_{us}/(C+M)] + 1.48 \quad (R\&D)$$

<u>t</u>	(3.52)	(-5.15)	(2.71)
	***	***	***

	+0.851	(Y_{t-1})	+0.02	(DM)
<u>t</u>	(9.00)		(4.69)	
	***		***	

$$R^2 = 0.979$$

$$h = -0.62$$

$$F = 97.69$$

The value of Durbin's \hat{h} statistic shows that autocorrelation (of the first order) is not a source of error in the chosen function.

We conclude that the results of the "Motor Vehicle Parts and Accessories" industry provides evidence in support of Vernon's product-cycle hypothesis.

Table 12. Motor Vehicle Parts and Accessories: OLS

REGRESSIONS	\hat{b}_0	\hat{b}_1 E_{MVC+M}	\hat{b}_2 R&D	\hat{b}_3 W_a/W_{MVC}	\hat{b}_4 P_{IC}/P_{MVC}	\hat{b}_5 Π_{MVC}	\hat{b}_6 BTE	\hat{b}_7 Y_{IC-1}	\hat{b}_8 DM	R^2 (F)	d	h
$Y_0 = f(E_{MVC}/(C+H))$	1.00 (8.84) ***	-1.13 (-6.13) ***								0.773 (37.59)	1.19	
$Y_1 = f(E_{MVC}/(C+H), Y_{IC-1})$	0.551 (4.48) ***	-0.69 (-4.61) ***						0.583 (4.45) ***		0.924 (60.84)	1.87	
$Y_2 = f(E_{MVC}/(C+H), R\&D, Y_{IC-1})$	0.558 (4.25) ***	-0.72 (-3.88) ***	0.252 (0.28)					0.590 (4.23) ***		0.924 (36.86)	1.87	
$Y_3 = f(E_{MVC}/(C+H), Y_{IC-1}, DM)$	0.350 (3.05) ***	-0.47 (-3.47) ***						0.749 (6.61) ***	0.018 (2.95) ***	0.961 (101.40)	2.76	
$Y_4 = f(E_{MVC}/(C+H), R\&D, Y_{IC-1}, DM)$	0.313 (3.52) ***	-0.551 (-5.10) ***	1.48 (2.71) ***					0.851 (9.00) ***	0.020 (4.69) ***	0.979 (97.68)	2.32	-0.62
$Y_5 = f(E_{MVC}/(C+H), \Pi_{MVC}, Y_{IC-1}, DM)$	0.344 (3.06) ***	-0.550 (-3.69) ***				0.09 (1.17) **		0.832 (6.33) ***	0.020 (3.21) ***	0.960 (58.92)	2.25	0.55
$Y_6 = f(E_{MVC}/(C+H), R\&D, P_{IC}/P_{MVC}, Y_{IC-1}, DM)$	0.326 (4.15) ***	-0.557 (-5.85) ***	1.857 (3.54) ***		-0.068 (-1.82) ***			0.982 (8.93) ***	0.033 (5.11) ***	0.986 (101.4)	2.76	5.41
$Y_7 = f(E_{MVC}/(C+H), R\&D, \Pi_{IC-1}, Y_{IC-1}, DM)$	0.302 (2.61) ***	-0.555 (-4.73) ***	1.495 (2.54) ***				0.035 (0.16)	0.859 (7.56) ***	0.025 (3.62) ***	0.980 (68.64)	2.39	

Statistical significance: See note on page 36

6. Communications Equipment (SIC 335)

The results for this industry (Tables 13 and 14) provide weak support to Vernon's hypothesis. The coefficient of the export variable appears with a negative sign only when the lagged variable is introduced in the function, but its significance is low.

Multicollinearity between the various regressors is strong (See Table 6 of Appendix III, p.119). For example, the simple correlation coefficient between the export share, $E/(C+M)$, and the other variables are:

a) For R&D $r = -0.746$

b) For W_c/W_{us} $r = -0.641$

c) For $P_{R,c}/P_{R,us}$ $r = -0.42$

d) For Π_{us} $r = -0.41$

e) For CR $r = -0.38$

f) For BTE $r = 0.803$

This impaired the exploration of the impact of the individual regressors on the dependent variable. The Cochrane-Orcutt transformation (Table 14) does not seem to deal satisfactorily with autocorrelation. Thus, we consider that the "best" results are obtained from the following OLS specification:

$$\hat{Y} \equiv \left[\frac{SP_{us}}{C+M} \right] = 0.051 - 0.008 \left[\frac{E_{uv}}{C+M} \right] + 0.783 (Y_{t-1})$$

t (0.56) (-0.06) (2.39)

$$R^2 = 0.364 \qquad d = 1.18$$
$$F = 2.86$$

The negative sign of the coefficient of the export variable is consistent with Vernon's hypothesis. However, the low significance of this coefficient and of the F statistic suggest caution in the interpretation of the obtained results.

Table 13. Communications Equipment: OLS

REGRESSIONS	\hat{b}_0	\hat{b}_1	\hat{b}_2	\hat{b}_3	\hat{b}_4	\hat{b}_5	\hat{b}_6	\hat{b}_7	\hat{b}_8	\hat{b}_9	\hat{b}_{10}	\hat{b}_{11}	\hat{b}_{12}	\hat{b}_{13}	R^2 (F)	d	h
$Y_t = f(E_{t-1}/(C+H))$	0.245 (4.84) ***	0.021 (0.11)													0.001 (0.001)	0.64	
$Y_t = f(E_{t-1}/(C+H), Y_{t-1})$	0.051 (0.56)	-0.008 (-0.057)						0.783 (2.39) ***							0.364 (2.86)	1.18	n.a.
$Y_t = f(R\&D, CR, Y_{t-1}, DH)$	-0.152 (-1.01) *		0.105 (0.373)					0.845 (2.73) ***	0.259 (1.11) ***					0.03 (1.56) **	0.609 (3.11)	1.69	

Table 14. Communications Equipment: Cochrane-Orcutt

REGRESSIONS	\hat{b}_0	\hat{b}_1	\hat{b}_2	\hat{b}_3	\hat{b}_4	\hat{b}_5	\hat{b}_6	\hat{b}_7	\hat{b}_8	\hat{b}_9	\hat{b}_{10}	\hat{b}_{11}	\hat{b}_{12}	\hat{b}_{13}	R^2 (F)	d	h
$Y_t = f(E_{t-1}/(C+H))$	0.096 (1.43) ***	0.506 (3.69) ***													0.703 (0.67)	0.70	
$Y_t = f(E_{t-1}/(C+H), Y_{t-1})$	0.059 (0.80) *	0.468 (3.24) ***						0.204 (0.96) *							0.719 (12.79)	0.81	3.33
$Y_t = f(R\&D, CR, Y_{t-1}, DH)$	-0.129 (-0.79) *		0.120 (0.37)					0.194 (2.51) **	0.241 (0.93) *					0.029 (1.46) **	0.616 (3.20)	1.69	n.a.

Statistical significance: See note on page 36

7. Plastics and Synthetic Resins (SIC 373)

The results for this industry (Table 15) show that the coefficient of the share of U.S. exports to the Canadian market appears with a negative sign, thus providing evidence in support of Vernon's product-cycle hypothesis. However the value and the significance of the coefficient of the exports variable cannot be easily assessed due to multicollinearity (See Table 7 of Appendix III p.120).

The cost of labour and of raw materials appears to have an influence on the decision of U.S. firms to build plants in the Canadian market. The collinearity between the share of U.S. exports and the cost-of-raw-materials index is very strong ($r = -0.832$). This renders the value of the coefficient of the exports variable unstable. We decided, however, to retain both variables in the set of regressors to avoid misspecification bias.

The lagged variable is an important regressor, as evidenced by its high t ratio and the increase of the multiple correlation coefficient, when this variable is included in the function.

The other variables do not seem to influence the U.S. subsidiary production.

The "best" explanation of the U.S. subsidiary production in this industry is obtained from the following OLS form:

$$\hat{Y} \equiv \left[\frac{SP_{us}}{(C+M)} \right] = 0.172 - 0.253 \left[\frac{E_{us}}{(C+M)} \right] - 0.5(10)^{-7} (W_c/W_{us})$$

\underline{t}	(1.36)	(-1.25)	(-2.11)
	**	**	**

$$-0.21(10)^{-7} (P_{r,c}/P_{r,us}) + 0.881(Y_{t-1})$$

\underline{t}	(-0.41)	(5.25)

$R^2 = 0.866$ $h = -0.39$
 $F = 12.97$

Durbin's \underline{h} statistic shows that autocorrelation (of the first order) is not a source of error in the estimated function.

We conclude that the results of the "Plastics and Synthetic Resins" industry are consistent with Vernon's hypothesis.

Table 15. Plastics and Synthetic Resins: OLS

REGRESSIONS	\hat{b}_0	\hat{b}_1 E ₃₃ /C+M	\hat{b}_2 RED	\hat{b}_3 W _c /W ₀₃	\hat{b}_4 P _c /P ₀₃	\hat{b}_5 Π ₀₃	\hat{b}_6 BTE	\hat{b}_7 Y _{t-1}	\hat{b}_8 DM	R ² (F)	d	h
Y _c = f(E ₃₃ /C+M)	0.498 (7.69) ***	-0.195 (-1.12) **								0.103 (1.27)	0.79	
Y _b = f(E ₃₃ /C+M, W _c /W ₀₃ , P _c /P ₀₃)	0.729 (5.39) ***	-0.787 (-2.26) ***		-0.23, 10 ³ (-0.51)	-0.17, 10 ³ (-2.01) ***					0.404 (2.04)	0.61	
Y _c = f(E ₃₃ /C+M, W _c /W ₀₃ , Y _{t-1})	0.126 (2.12) ***	-0.176 (-2.27) ***		-0.46, 10 ³ (-2.19) ***				0.851 (6.92) **		0.863 (18.98)	2.10	0.21
Y _c = f(E ₃₃ /C+M, W _c /W ₀₃ , P _c /P ₀₃ , Y _{t-1})	0.172 (1.36) **	-0.253 (-1.25) **		-0.5, 10 ³ (-2.11) **	-0.21, 10 ³ (-0.41)			0.851 (5.25) ***		0.866 (12.97)	2.17	-0.39

Statistical significance: see note on page 36

8. Pharmaceuticals and Medicines (SIC 374)

The results for this industry (Tables 16 and 17) show that the coefficient of the share of U.S. exports to the Canadian market appears with a negative sign and is statistically significant in almost all specifications.

The coefficient of the lagged variable is stable in the various specifications and is statistically significant. In addition, the inclusion of this variable in the function increases the multiple correlation coefficient. Thus, the lagged variable is an important explanatory variable of the share of U.S. subsidiary production.

The R & D expenditures of U.S. firms seem to have some impact on the dependent variable. This, however, is difficult to assess, due to the high degree of multicollinearity that exists between R & D and other variables, such as the profitability of U.S. firms in the Canadian market, both BTE (barriers-to-entry) variables, and the lagged variable (See Table 8 of Appendix III, p.120).

Changes in the dependent variable seem to be best explained by the following OLS specification:

$$\hat{Y}_t \equiv \left[\frac{SP_{us}}{(C+M)} \right] = 0.247 - 0.903 \left[\frac{E_{us}}{(C+M)} \right] + 2.824(R \& D)$$

t (2.46) (-1.92) (1.60)

$$+ 0.556(Y_{t-1})$$

t (2.78)

$R^2 = 0.739$

$d = 1.15$

$F = 8.52$

$h = 2.20$

However, autocorrelation seems to be a source of error in the above form: Indeed, the h statistic takes a value ($h=2.20$) which does not allow us to reject the null hypothesis of no autocorrelation. Thus, we re-estimated the chosen function, using the Cochrane-Orcutt method. The obtained results are as follows:

$$\hat{Y}_t \equiv \left[\frac{SP_{us}}{(C+M)} \right] = 0.279 - 1.040 \left[\frac{E_{us}}{(C+M)} \right] + 3.321(R\&D)$$

t (2.32) (-1.99) (1.75)

$$+ 0.493(Y_{t-1})$$

t (2.54)

$R^2 = 0.780$

$h = 1.24$

$F = 10.63$

The above results support Vernon's product-cycle hypothesis.