A paper prepared for the

Un document préparé pour le

Economic Council of Canada

Conseil économique du Canada

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DISCUSSION PAPER NO. 247

Trade, Tariffs, Product Diversity and Length of Production Run in Canadian Manufacturing Industries: 1970-1979

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November 1983

RÉSUMÉ

L'industrie manufacturière canadienne a longtemps été confrontée à des problèmes d'échelle et de spécialisation : usines trop petites et séries de production trop courtes. Il en est résulté une baisse du revenu des Canadiens et de plus faibles niveaux de productivité qu'aux États-Unis, principal partenaire commercial du Canada.

La plupart des études ont traité jusqu'ici des difficultés attribuables à une échelle de production insuffisante, plutôt qu'à la spécialisation, parce qu'il existe des données sur la taille des usines ainsi qu'un critère - c'est-à-dire la plus petite usine capable de minimiser les coûts unitaires - qui sert à comparer les usines à ce point de vue. Les renseignements sur la diversité des produits et la longueur des séries de production sont, au contraire, beaucoup plus difficiles à obtenir. La plupart des chercheurs qui ont analysé ce sujet ont dû se fonder sur des données qualitatives obtenues par des interviews, ou bien supposer que la diversité, au niveau de l'industrie, était à peu près la même que pour les produits. Mais pour la présente étude, nous avons pu nous pencher directement sur la diversité des produits et la longueur des séries de production, en mesurant l'hétérogénéité des produits d'après des données réelles tirées du recensement des usines, dans le cadre d'une entente spéciale avec Statistique Canada qui nous a permis d'accéder aux données, tout en veillant à

nous faire respecter les dispositions de la Loi sur la statistique relatives à la confidentialité.

Nous avons mesuré la diversité des produits et la longueur des séries de production à l'usine, en partant du système de classification des produits industriels, où une industrie est définie par les produits qui lui sont attribués. Pour mesurer la diversité, nous avons retenu deux niveaux de cette classification, l'un étant de deux à trois fois plus détaillé que l'autre. Le système plus détaillé divise le secteur manufacturier en 6 126 produits, comparativement à 167 industries à code de quatre chiffres.

Au cours de la période commençant en 1974, (première année où est devenu disponible le profil de production des usines selon la diversité de leur produits) jusqu'en 1979, nous avons assisté à une augmentation sensible de la longueur moyenne des séries de production, mesurées en dollars constants de 1971 au niveau de l'usine et dans plus de 120 industries manufacturières canadiennes, tandis que la diversité des produits a diminué de plusieurs points de pourcentage à cause de la spécialisation accrue des usines. Ainsi, lorsque la production augmente, celles-ci ont tendance à se limiter aux catégories de produits existantes.

Nous avons, d'autre part, poussé un peu plus loin l'étude de la diversité au niveau de l'usine, en ajoutant à notre analyse des renseignements sur la propriété de l'usine, selon qu'elle appartenait à des intérêts canadiens, américains ou à d'autres intérêts étrangers. En 1974, les usines canadiennes du secteur manufacturier étaient nettement plus diversifiées que leurs homologues américaines dans presque toutes les catégories de tailles, mais, en 1979, la différence était moins marquée. Les constatations faites pour 1974 concordent avec celles de travaux antérieurs portant sur à peu près la même période. Cependant, lorqu'on tient compte du nombre de produits répertoriés pour chacune des 167 industries à code de quatre chiffres, ainsi que de la taille des usines d'un échantillon donné d'industries, ces constatations ne se vérifient plus. En fait, dans la plupart des cas, les usines sont plus spécialisés aux États-Unis qu'au Canada. Il semble donc que les résultats des travaux précédents s'expliquent par le fait que les entreprises américaines étaient relativement plus concentrées dans des industries fabriquant plus de produits, et que les entreprises canadiennes se regroupaient surtout dans des industries qui en produisaient moins, car plus grand est le nombre de produits, plus élevé est en général le degré de diversité.

Les techniques de régression nous ont permis d'évaluer l'importance de divers déterminants de la diversité des produits et de la durée des séries de production. Nous avons accordé une importance particulière aux effets du commerce et des tarifs douaniers. Dans les industries caractérisées par des tarifs élevés et par une forte concentration - c'est-à-dire celles où l'incidence des barrières commerciales est souvent jugée comme la plus marquée - les séries de production, pour telle taille donnée d'usine, étaient plus courtes et la diversité des produits plus grande qu'ailleurs dans le secteur manufacturier. Le degré de propriété étrangère, même élevé, n'amplifiait pas les effets des hauts tarifs et de la forte concentration.

Les exportations et les importations ont contribué en général à allonger les séries de production et à diminuer la diversité des produits, mais cette influence ne s'est faite sentir qu'au début des années 70. Les tarifs, sans la concentration industrielle, n'ont pas eu le même effet au début des années 70 que vers la fin, mais la baisse des tarifs, au cours de la décennie, a contribué à allonger les séries de production.

Somme toute, les résultats de notre étude indiquent que des tarifs élevés, ou une forte concentration industrielle, mènent en fait à une diversité "excessive" et contribuent à raccourcir les séries de production, tandis que la propriété étrangère a peu d'effets mesurables, soit en général soit dans les industries à forte concentration et à tarifs élevés. Ces résultats concordent avec ceux de nos travaux antérieurs sur le problème des échelles de production insuffisantes dans les industries manufacturières canadiennes. Les conclusions qui se dégagent de la présente étude, en ce qui touche la politique économique, semblent indiquer que pour atténuer les problèmes que posent au Canada les échelles de production et la spécialisation, il faudrait envisager une réduction des barrières commerciales multilatérales plutôt qu'une diminution ou limitation de la propriété étrangère.

ABSTRACT

Canada's manufacturing sector has long suffered from problems of scale and specialization -- plants that were too small and production runs that were too short. This has resulted in lower incomes for Canadians and lagging levels of productivity compared with the United States, Canada's largest trading partner.

Most research studies have concentrated on the scale rather than the specialization problem. This choice reflects the availability of data on plant sizes and a benchmark -- the smallest sized plant at which unit costs are minimized -- against which to compare such plants sizes. In contrast, data on product diversity and length of production run is much more difficult to obtain. Most studies investigating this subject have had to rely on qualitative evidence obtained through interviews or they have had to assume diversity at the industry level approximates diversity at the commodity level. For this study we were able to address the issue of product diversity and length of production run directly by measuring product hereogeneity based on actual "census plant" data under a special arrangement with Statistics Canada, whereby access to the data was permitted, but the confidentiality provisions of the Statistics Act were respected.

Product diversity and length of production run at the plant level were measured with the use of the industrial commodity

classification system, which defines an industry in terms of the products or commodities classified to that industry. Two levels of the industry classification were used to measure diversity, with one system being two to three times as detailed as the other. The more detailed classification system divides the manufacturing sector into 6,126 commodities, compared with 167 four-digit industries.

Over the period from 1974 (the first year for which the output profile of plants on a product basis is available) to 1979, the average length of production run, measured in 1971 constant dollars at the plant level, across more than 120 Canadian manufacturing industries, increased substantially, while product diversity declined by several percentage points as plants became more specialized. Hence, as output grows, plants tend to concentrate on their existing product lines.

The study of diversity at the plant level was taken a step further by the introduction of information regarding the country of control of the plant -- Canadian, U.S. and other foreign owned. In 1974 Canadian owned plants across the manufacturing sector as a whole were unequivocally more diversified than their similar sized U.S. counterparts in almost every size grouping, but by 1979 this was less pronounced. The finding for 1974 accords with previous work for approximately the same time period. However, when account of number of commodities classified to each of the 167 four-digit industries is taken as well as plant size, for a selected sample of industries, these findings are not replicated. Indeed, in the preponderance of cases U.S. plants are more specialist than Canadian. It would therefore appear that previous findings were the result of U.S. firms being relatively more concentrated in industries with more products and Canadian firms in industries with fewer products. For the greater number of products the greater is the level of diversity in general.

Regression techniques were employed to assess the importance of various determinants of product diversity and length of production run. Particular attention was paid to the influence of trade and tariffs. In industries characterized by high tariffs combined with high concentration - industries where the impact of trade barriers is often thought to be most pervasisve - production runs were shorter and product diversity greater, for a given sized plant, than elsewhere in the manufacturing sector. High foreign ownership did not add to the existing impact of high tariffs and high concentration.

Exports and imports usually resulted in increased length of production runs and less product diversity, but it was only in the early 1970s that this influence was significant. Tariffs without concentration did not have the same effect in the early 1970s as in the latter part of the decade, but nevertheless, falling tariffs over the period of the 1970s led to increased length of production run.

In sum, the results suggest high tariffs/high concentration do result in "excessive" diversity and shorter production runs, while foreign ownership has little measurable impact, either in genral or in high concentration/high tariff industries. As such, the overall policy conclusions to emerge suggest that those interested in ameliorating Canada's scale and specialization problems should look at reduced multilateral trade barriers rather than reducing or confining foreign ownership.

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Acknowledgements

The support and active cooperation of Statistics Canada and the efforts of J. McVey and J. Crysdale were essential for the creation of the extensive data base used in this and accompanying papers. Elizabeth Knopf conducted the computations with diligence and helped write Appendix A. Dawn Murphy provided efficient and prompt word processing.

1. INTRODUCTION

The problems of sub-optimal plant size, short production runs, the crowding of too many products into one plant, and their relationship to Canada's productivity gap with the U.S. have long been a subject of debate among Canadian economists and policy makers. In recent years it has become conventional wisdom that sub-optimal plant size is not as an important problem as short production runs (Royal Commission on Corporate Concentration, 1978, p. 45). This view stems from the evidence that, on average, Canadian plant sizes, though smaller than those of the corresponding U.S. industry, are not substantially or dramatically different.[1] In contrast, short production runs and excessive product diversity are frequently referred to by manufacturers as a major cause of lower productivity.

A major problem in the debate on the relative importance of sub-optimal plant size as opposed to inadequate production runs -- often referred to as plant and product specific economies of scale, respectively -- concerns the lack of good quantitative evidence with respect to product specific scale economies. Much of the evidence is based upon interviews and is largely qualitative in nature.[2] This is not to deny that product specific scale economies are not important, only that the case remains to be proved. It is almost as though product specific economies have recently gained attention because a thorough analysis of plant scale economies and the extent of Canadian sub-optimal plant scale has until now been lacking. Moreover casual analyses have suggested plant scale was not a major problem. An accompanying paper which attempts to fill this void (Baldwin and Gorecki, 1983b) indicates that plant scale in the Canadian manufacturing sector is much less than U.S. plant scale -- especially where concentrated industries are protected by high tariffs.

No matter what the relative importance of product as opposed to plant specific economies of scale, it is generally argued that Canadian production runs are too short and that if plant specialization could be increased then productivity would rise in Canada. One policy designed to increase production runs and thus raise productivity has been multilateral tariff reductions.[3] In the 1960's, this took place following the Kennedy Round of tariff negotiations. More recently the Tokyo Round was concluded, with tariff reductions to be phased in during the period 1980 to 1985. This report attempts to assess the impact of trade and tariff changes during the 1970's upon product diversity and length of production run in Canada's manufacturing sector.

The paper is divided into six major sections. In Section 2 the method of measurement of product diversity and length of production run is discussed. Estimates of product diversity and length of run are presented. The determinants of product diversity and length of production run are detailed in Section 3. Empirical estimates are the subject of the next two sections -- cross section and first differences. Finally, Section 6 contains a brief summary and conclusion.

2. PRODUCT DIVERSITY AND LENGTH OF PRODUCTION RUN

Measuring Product Diversity and Length of Production Run

Product Diversity Diversity can be measured at either the plant or the firm level. The contention that the Canadian productivity problem stems from production runs that are too short relates to production costs at the plant level. Therefore it is plant level diversity that shall provide the focus of this paper.

Various measures of plant level diversity have been used in studies of diversity. Each captures one or more of the following dimensions of diversity:

(i) the number of separate products that a plant produces, denoted by N;

(ii) the quantitative importance to the plant of each of the N products over which it allocates its output. A plant that produces ninety-nine per cent of its output in one product and one per cent in another is considered more specialized than a plant that divides its output equally between two products. The general form of an index of plant diversity that takes into account the distribution of output across products for plant j is

$$I_j = \sum_i w_i \, (q_i/Q_j) = \sum w_i s_i$$

where q_i = output of the ith product i = 1, ... n

Q_i = total output of plant j

w_i = the weighting factor chosen for the product

s_i = q_i/Q_i =the share of the ith product in the jth plant's output.

Two measures, the Herfindahl and Entropy indices, have been used to capture these dimensions.[4] The Herfindahl index is Σs_i^2 and the Entropy measure is $\Sigma s_i \ln (1/s_i)$;

(iii) the extent to which the products which the plant manufactures are "related" to one another. For example, products classified to 1011 (Slaughtering and Meat Processors) and 1012 (Poultry Processors) may be considered related in that both belong to the Food and Beverage Industry Sector, but would be considered "unrelated" to products of such non-food industries as 3651 (Petroleum Refining) and 3915 (Dental Laboratories). The primary product specialization ratio attempts to capture the extent to which products are related. It is defined as the value of shipments of products primary to the industry to which the plant is assigned expressed as a ratio of the total value of shipments of all products manufactured by the plant.

Each of the dimensions of product diversity described above can be measured by one or another of the indices mentioned. In some cases, attempts have been made to develop more complex measures that combine several of the dimensions, such as the concentric index.[5] However, it is not immediately obvious that such a combination is desirable. For none of the above mentioned dimensions are important in and by themselves. The choice of a measure depends upon the purpose for which it is to be used. This paper is ultimately interested in the effect of diversity on product cost. Thus the measure of diversity chosen should vary directly with a change in costs consequent upon a variation in the product mix. If the plant becomes less diversified -- reduces product lines with total plant output held constant or increases the production of the more important products with other product lines output held constant -- then unit costs are likely to decline. The measure of plant level diversity should capture this phenomenon.

In order to determine which of the two most commonly used measures of diversification (the Herfindahl and the Entropy) do capture this effect, a cost function must be specified. If the average cost of production of a product line (AC_i) is represented by:

$$AC_i = a_i + \frac{bi}{qi} + c_i q_i$$

where q_i = length of the production run, then, it can be shown that the average cost of a given level of output varies both with the number of products produced and with the Herfindahl measure of plant diversity. (Appendix B provides details). Since the above cost function captures commonly perceived "U" and "L" shaped-cost functions, the Herfindahl was chosen as the appropriate measure of plant diversity used in this study. This index is inversely related to diversity at the product level. If only one product is produced it takes on a value of 1. If n products are produced in equal proportions, it takes on the value 1/n. The inverse of the Herfindahl index provides a numbers equivalent measure (discussed below) of the number of products produced per plant. The Entropy measure does not capture either aspect as effectively and, therefore, was not used. Appendix B outlines the deficiencies of the Entropy measure. Finally, since at the plant level, most of the diversification is into related products,[6] we did not pursue additional indices that consider the extent to which plants specialize in related, as opposed to unrelated, products.

Length of Product Run Ultimately, of course, the diversity index is of interest because of what it tells us about the degree to which Canadian production runs are too short. Therefore this paper uses the industry plant diversity index to construct a proxy for the average length of production run per plant.

The Herfindahl index of product diversity can be expressed as a numbers equivalent -- the number of products among which a plant would have to spread its output equally in order to generate the observed H value.[7] The numbers equivalent, NE, is simply the reciprocal of the H index: 1/H. For example, if a plant has an H index of 0.50 then this is equivalent to allocating its output equally among two product runs -- 1/0.50 = 2. By the simple expedient of dividing the output of plant by NE, an indication of the length of production run may be gained.

An alternative approach is to measure length of production run as the output of the plant divided by N -- the average number of products classified to the industry. However, since we know that the size distribution of the N products of the plant is highly skewed (Gorecki, 1980b) such a measure of the length of production run is very sensitive to a small number of products which are relatively unimportant. The length of production run calculated using the NE does not suffer from this problem.

Product Level of Classification The meaningfulness of a diversity index depends not only on its theoretical underpinnings but also on the level of aggregation used to define products. The level of product classification used may have a significant impact on the results. On the one hand, the classification system should not be so aggregated that it misses significant cost changes. On the other hand, the classification system should not be so disaggregated that measured changes in diversity are not associated with cost changes. Previous analyses in Canada of plant diversity have had to make do with very aggregated data - defining separate products as those that fell in different 4-digit SIC industries. In this study, we are able to devise plant level diversity indices based on product counts within 4-digit industries.

The commodity classification system used here is the Industrial Commodity Classification (ICC).[8] The ICC is created specifically for use in conjunction with the SIC and refers to domestic production of commodities. The fineness of the commodity classification scheme depends upon two factors. The first is the willingness and ability of manufacturers to distinguish between products. The second is the inherent heterogeneity or homogeneity of the industry. For example, an industry such as Iron and Steel Mills (SIC 2910) has more ICC products (90 at the 5-digit level) than Breweries (SIC 1093, with 6 products at the 5-digit ICC level).

The ICC system uses mainly supply side criteria in defining a commodity, as does the Standard Industrial Classification system. From the point of view of studying the costliness of plant diversity, supply side criteria -- such as whether products are made from a similar raw material, or processed in the same plant -- are likely to be more relevant than the demand side considerations. For example, plastic and paper bags, or wood and metal window frames might be classified as one product using demand side criteria but two separate ones using supply side criteria since the technological processes and raw materials involved in producing each are quite different.

This study will use the 4- and 5-digit ICC to define plant level diversity within 4-digit SIC industries. An example of a 4-digit ICC is 3511 Newsprint paper; the corresponding 5-digit classifications are 35111, Newsprint paper, white, and 35112, Newsprint paper coloured. An indication of the number of ICC 4- and 5-digit products per 4-digit SIC industry can be gained by examining Table 1. Across the whole manufacturing sector there are 6126 5-digit ICC products and 2336 4-digit products. This compares with 167 4-digit SIC industries. On average the 5-digit ICC classification system is about two and one-half times as detailed as the 4-digit, depending upon the sample of industries selected from Table 1. Not surprisingly the table shows that the miscellaneous industries contain, on average, a much larger number of ICC products than for the remaining manufacturing industries. Finally, it might be noted, that there are five industries that contain no ICC products, at either the 4- or 5-digit level.[9] These five industries are to a large extent finishing operations or primarily custom work, thus making specification of standard well-defined products difficult. Since no measurement of diversity is available for such industries, they will be excluded henceforth.

Table 1

The Industrial Commodity Classification and Standard Industrial Classification Systems

Level of ICC Classification	Number of ICC's per 4-Digit Industry			
	Average	Standard Deviation	Minimum	Maximum
	For 167 Industries			
4-Digit	13.99	18.19	0	156.0
5-Digit	36.68	46.14	0	411.0
	For 167 Industries, Less Those With No ICC[a]			
4-Digit	14.42	18.30	1.00	156.0
5-Digit	37.82	46.39	1.00	411.0
	For 167 Industries, Less Miscellaneous[b]			
4-Digit	10.33	11.01	0.0	55.00
5-Digit	27.69	27.50	0.0	136.00
	For 167 Industries, Less Miscellaneous and Those With No ICC[c]			
4-Digit	10.71	11.02	1.00	55.00
5-Digit	28.71	27.48	1.00	136.00

a. "No ICC" means that no ICC products were classified to these industries. The sample was 162 industries.
b. Sample was 141 industries.
c. Sample was 136 industries.

Source: Statistics Canada. See Appendix A for details (Vol. 25).

Any industry study of diversity faces the problem that the fineness of the classification scheme used (in the case at hand the 4- or 5-digit ICC level) is not based on characteristics that reflect cost differences but is instead based on the ease of defining distinct products. In order to take this possibility into account, the number of products classified to each 4-digit SIC industry was calculated and, suitably transformed, used as an independent variable to normalize for the potential level of diversification.

For the Herfindahl index, this means that the lower limit of diversification is 1/N* where N* is the number of products classified to a particular industry. It should be noted that this is only a proximate lower bound on plant level product diversity since a plant classified to a particular industry may diversify into products primary to that industry and/or into the products classified to other industries. N* measures only the products primary to the industry. Nevertheless, as noted above, the primary product specialization ratio was on average sufficiently high at the 4-digit SIC level to suggest this was not a significant problem.

Product Diversity: 1974 and 1979

We have a rich array of data that can be drawn upon to present the extent of product diversity: the H index of diversification is available at the 4- and 5-digit ICC; for 1974[10] and 1979; for plants in various categories (e.g. by industry across the manufacturing sector), for foreign and domestically owned plants, and for plants by size. The only drawback of note is that the data is available only for "long-form" establishments, thus excluding "short-form" establishments, which are virtually without exception very small establishments. This latter group accounted for 4.1 per cent of manufacturing shipments in 1975.[11] Hence their omission should not seriously bias the results. However, one industry consisted entirely of short-form establishments and had, therefore, to be excluded.[12]

Table 2 presents product diversity by employment size group at the 4- and 5-digit ICC level, for 1974 and 1979.[13] The Herfindahl index at the 4-digit level of classification is denoted by HERF4D, and the 5-digit ICC level, by HERF5D. Plant size is used as a control variable because of the finding, elsewhere, that plant size is positively correlated with product diversity. This is confirmed here, with product diversity increasing rapidly for the first few size classes, then levelling off somewhat. Indeed, in some instances the trend may be reversed. The tables refer to all manufacturing establishments except those for which no product data is available.

Table 2 shows that over the period 1974 to 1979 product diversity decreased -- Canadian plants became more specialized. This

Table 2

The Level of Product Diversity of Plant[a], Grouped by Employment; 1974 and 1979

PLANT SIZE	NUMBER OF PLANTS		HERF4D		HERF5D	
Employment Group[b]	1974	1979	1974	1979	1974	1979
Number	Group Total		Group Average		Group Average	
0 - 50	9,683	7,951	0.7988	0.8083	0.7464	0.7555
51 - 100	2,318	2,567	0.7237	0.7461	0.6646	0.6873
101 - 200	1,637	1,862	0.7024	0.7102	0.6233	0.6355
201 - 300	582	718	0.6426	0.7072	0.5641	0.6184
301 - 400	306	337	0.6711	0.6788	0.5898	0.5919
401 - 500	165	210	0.6141	0.6521	0.5423	0.5963
501 - 1000	309	336	0.6049	0.6614	0.5295	0.5793
1001 - 2000	108	117	0.5962	0.6592	0.5327	0.5795
2001 - 3000	16	21	0.6070	0.5843	0.5029	0.5260
3001 and Up	19	19	0.4209	0.5426	0.3780	0.4555
Average all plants						
Weighted[c]	--- ---	---	0.6455	0.7578	0.5772	0.6768
Unweighted	--- ---	---	0.7601	0.7681	0.7015	0.7077

a. Refers to all longform manufacturing plants for which 4 and 5 digit ICC data available.
b. All wage and salaried employees. For 1974, 1970 employees are used.
c. By plant employees as defined in footnote b above.

Source: Statistics Canada. See Appendix A for details (Vol. 26).

inference holds for virtually all plant employment size categories and whether the level of the ICC used to measure product diversity is at the 4- or 5-digit level. The increase in specialization was more pronounced in the larger size categories, as can be inferred by the large increase in the Herfindahl index using the weighted compared to unweighted index. Finally and, not surprisingly, Table 2 shows that measured diversity is sensitive to the level of ICC -- the finer the level the greater the product diversity.

In Table 2 no correction is made for the number of products classified to a particular industry, denoted by N*. In other words, two equal sized plants in different industries could be diversified to quite different degrees because of differing values of N*. Equally, two plants of different sizes could have equal values of HERF4D because N* differs by industry. In order to investigate this issue further Table 2 was re-estimated for various values of N* at the 4-digit ICC (Table 3) and 5-digit ICC (Table 4). The selection criteria for N* was as follows: several industries had to have the selected value of N*; the sample industries had to have a sufficiently large number of establishments that a large number of observations were included in each employment group; and all miscellaneous industries were excluded.[14] The selected values of N* at the 4-digit ICC were 1, 7 and 27, at the 5-digit ICC level, 3, 5, 14, 25, 41 and 79.

Table 3

The Level of Product Diversity of Plant[a], Grouped by Employment and Number of 4-Digit ICC Products Per Industry (N*): 1974 and 1979

PLANT SIZE	N*=1[c], HERF4D		N*=7[d], HERF4D		N*=27[e], HERF4D	
Employment Group[b]	1974	1979	1974	1979	1974	1979
Number	Group Average[f]		Group Average[f]		Group Average[f]	
0 - 50	0.8657 (647)	0.8777 (605)	0.7847 (414)	0.8010 (307)	0.8343 (349)	0.8222 (319)
51 - 100	0.8267 (110)	0.8779 (99)	0.7909 (107)	0.8434 (138)	0.7545 (122)	0.7148 (106)
101 - 200	0.9037 (81)	0.8942 (87)	0.7400 (106)	0.7628 (107)	0.6467 (93)	0.6906 (75)
201 - 300	0.8475 (13)	0.8963 (25)	0.6911 (34)	0.7326 (45)	0.5628 (25)	0.7003 (39)
301 - 400	0.8602 (10)	0.8987 (7)	0.6675 (20)	0.7327 (24)	0.6428 (19)	0.6577 (22)
401 - 500	0.8966 (2)	0.9963 (1)	0.5396 (9)	0.6273 (13)	0.7071 (5)	0.8356 (10)
501 - 1000	-	0.8142 (3)	0.6168 (23)	0.6406 (21)	0.4570 (8)	0.5651 (8)
1001 - 2000	-	-	0.4190 (4)	0.3636 (3)	-	0.2735 (1)
2001 - 3000	-	-	0.3530 (1)	-	-	-
3001 and Up	-	-	0.6251 (3)	0.6216 (5)	-	-
Average all plants						
Weighted [g]	0.862 (45.2)	0.882 (51.8)	0.656 (126.8)	0.688 (150.3)	0.655 (79.2)	0.696 (91.7)
Unweighted	0.864 (45.2)	0.880 (51.8)	0.760 (126.8)	0.785 (150.3)	0.768 (79.2)	0.767 (91.7)

a. Refers to all longform manufacturing plants for which 4 digit ICC data available for industries selected.
b. All wage and salaried employees. For 1974, 1970 employees are used.
c. 11 industries fell into this category.
d. 7 industries fell into this category.
e. 3 industries fell into this category.
f. Figure in parenthesis indicate number of plants in each respective employment group. For the last two rows the figures in parenthesis are average plant size.
g. By plant employees as defined in footnote b above.

Source: Statistics Canada. See Appendix A for details (Box 1 and 2).

The results in Tables 4 and 5 show that for any given plant size employment size group the level of diversity varies by N*. At the 4-digit level, as N* increases for most size groups in the employment range 51-1000 employees, plant diversity increases, while for the 5-digit ICC although higher N* tends to be associated with greater product diversity it is not as pronounced as that using the 4-digit ICC. Hence, this confirms an earlier suggestion that account of N* should be taken in evaluating measured product diversity as well as plant size.

Tables 3 and 4 show quite distinct similarities with Table 2 suggesting that previous inferences drawn with respect to plant size and diversity are essentially correct. However differences do occur, especially at the 5-digit ICC level. Product diversity does not always increase with size before levelling off particularly for N*=1 at the 4-digit ICC level and N*=3 (1974, only) and N*=25 at the 5-digit ICC level. Nor does plant diversity always decline across all employment size groups particularly for N*=3, 14, 25 and 41 at the 5-digit ICC level. For some of these categories, diversity has a distinct "U" shape --first increasing then decreasing.[15] Furthermore at the 5-digit ICC level of product classification, product diversity does not always decline over time, particularly for N*=14 where neither the weighted or unweighted average increases. Reference to the average plant size does not appear to provide an explanation, although N*=14 is the only instance in which average plant size, falls, albeit

Table 4

The Level of Product Diversity of Plant[a], Grouped by Employment and Number of 5-Digit ICC Products Per Industry (N*): 1974 and 1979

PLANT SIZE	N*=3[c], HERF5D		N*=5[d], HERF5D		N*=14[e], HERF5D	
Employment Group[b]	1974	1979	1974	1979	1974	1979
Number	Group Average[i]		Group Average[i]		Group Average[i]	
0 - 50	0.8072 (55)	0.8994 (63)	0.8815 (159)	0.8899 (143)	0.8393 (92)	0.8188 (82)
51 - 100	0.7568 (27)	0.7883 (20)	0.8353 (37)	0.8540 (35)	0.6975 (20)	0.7381 (32)
101 - 200	0.9052 (22)	0.8547 (34)	0.7470 (19)	0.7892 (23)	0.7371 (20)	0.6136 (19)
201 - 300	0.9048 (3)	0.7746 (4)	0.8378 (10)	0.7738 (4)	0.7022 (5)	0.5959 (5)
301 - 400	-	0.5837 (1)	0.7830 (5)	0.6686 (3)	0.7630 (2)	-
401 - 500	-	-	0.3329 (2)	-	0.6092 (4)	0.4029 (2)
501 - 1000	-	-	0.5531 (2)	0.7164 (2)	0.4623 (2)	0.7056 (3)
1001 - 2000	-	-	0.4605 (1)	0.5342 (3)	-	0.3779 (2)
2001 - 3000	-	-	-	-	-	-
3001 and Up	-	-	-	-	-	-
Average all plants						
Weighted[j]	0.843 (66.5)	0.829 (72.3)	0.747 (68.2)	0.738 (75.5)	0.678 (95.7)	0.621 (95.3)
Unweighted	0.817 (66.5)	0.862 (72.3)	0.850 (68.2)	0.861 (75.5)	0.788 (95.7)	0.752 (95.3)

PLANT SIZE	N*=25[f], HERF5D		N*=41[g], HERF5D		N*=79[h], HERF5D	
Employment Group[b]	1974	1979	1974	1979	1974	1979
Number	Group Average[i]		Group Average[i]		Group Average[i]	
0 - 50	0.7226 (324)	0.7627 (295)	0.6450 (820)	0.6786 (686)	0.7651 (202)	0.7514 (156)
51 - 100	0.7434 (182)	0.7175 (173)	0.5985 (130)	0.5971 (155)	0.6928 (82)	0.6385 (79)
101 - 200	0.6533 (105)	0.6580 (98)	0.5332 (72)	0.5555 (87)	0.5703 (51)	0.6112 (37)
201 - 300	0.6588 (29)	0.5719 (34)	0.5493 (20)	0.6123 (22)	0.4864 (7)	0.6790 (16)
301 - 400	0.8108 (14)	0.8037 (20)	0.4073 (12)	0.5835 (12)	0.4907 (13)	0.5829 (11)
401 - 500	1.0000 (3)	0.8115 (9)	0.6110 (5)	0.4819 (8)	0.4757 (3)	0.8344 (3)
501 - 1000	0.8970 (14)	0.9060 (21)	0.6381 (8)	0.5873 (5)	0.5759 (4)	0.5854 (5)
1001 - 2000	0.9912 (6)	0.9969 (3)	0.3745 (1)	0.5244 (1)	-	-
2001 - 3000	0.6417 (2)	0.6047 (2)	-	-	-	-
3001 and Up	-	-	-	-	-	-
Average all plants						
Weighted[j]	0.764 (102.9)	0.754 (118.7)	0.567 (48.3)	0.599 (58.0)	0.591 (77.2)	0.643 (88.6)
Unweighted	0.724 (102.9)	0.732 (118.7)	0.627 (48.3)	0.650 (58.0)	0.702 (77.2)	0.693 (88.6)

a. Refers to all longform manufacturing plants for which 5 digit ICC data available for industries selected.
b. All wage and salaried employees. For 1974, 1970 employees are used.
c. 6 industries fell into this category.
d. 6 industries fell into this category.
e. 5 industries fell into this category.
f. 5 industries fell into this category.
g. 5 industries fell into this category.
h. 2 industries fell into this category.
i. Figure in parenthesis indicate number of plants in each respective employment group. For the last two rows the figures in parenthesis are average plant size.
j. By plant employees as defined in footnote b above.

Source: Statistics Canada. See Appendix A for details (Box 1 and 2).

marginally, from 95.7 to 95.3 wage and salary earners. Notwithstanding these differences with Table 2, the messages that emerge are similar to those previously observed: both plant size and N* should be considered in examining product diversity; and that over the period 1974-79 Canadian plants have tended to become more specialized.

Table 5 presents plant diversity at the level of the 2-digit industry. For each 4-digit industry, the weighted plant HERF4D and HERF5D is estimated. This number is then used to derive both the weighted and unweighted measures of product diversity at the 2-digit level, where the weights are employment per 4-digit industry. The number of 4-digit industries within each 2-digit industry is shown in parenthesis in Table 5. The table is calculated from 135 4-digit industries: all miscellaneous industries were excluded; so too were those industries where the number of ICC products were zero or the industry did not report product diversity data. The weighted, as well as unweighted average is included because of our earlier observation that product diversity and plant size tend to be positively associated.

The table also shows that on average Canadian plants reduced their degree of product diversity, becoming more specialized over time. This result holds across most of the 2-digit industries, exceptions being tobacco products, knitting mills, furniture and fixtures, printing and publishing, primary metal and non-metallic

Table 5

Level of Product Diversity of Plant, Grouped by 2-Digit Industry by 4 and 5 Digit ICC, 1974 and 1979

2-DIGIT INDUSTRY[a]	HERF4D[b]		HERF4D[b]		HERF5D[b]		HERF5D[b]	
	1974	1979	1974	1979	1974	1979	1974	1979
	Weighted Average[c]		Unweighted Average[c]		Weighted Average[c]		Unweighted Average[c]	
Food and Beverages (17)	0.6643	0.6812	0.7014	0.7196	0.5791	0.5864	0.5927	0.5971
Tobacco Products (2)	0.8791	0.8740	0.8876	0.8645	0.6758	0.6340	0.7597	0.7189
Rubber & Plastics (0)	-	-	-	-	-	-	-	-
Leather (4)	0.7355	0.7679	0.7314	0.7640	0.6750	0.7216	0.6681	0.7187
Textiles (14)	0.6140	0.6867	0.0268	0.6928	0.5285	0.5817	0.5560	0.6161
Knitting Mills (2)	0.7451	0.7194	0.7185	0.7163	0.6687	0.6052	0.6510	0.6049
Clothing (7)	0.6683	0.6944	0.7255	0.7643	0.5769	0.6082	0.6032	0.6291
Wood Industries (9)	0.7607	0.7895	0.8300	0.8461	0.5699	0.6151	0.7100	0.7392
Furniture & Fixtures (2)	0.8286	0.7225	0.8330	0.7465	0.5850	0.5592	0.6746	0.6363
Paper & Allied Ind. (5)	0.7340	0.7637	0.7969	0.8358	0.6773	0.7148	0.7587	0.7971
Printing & Publishing (3)	0.7360	0.7254	0.7703	0.7355	0.7191	0.7080	0.7575	0.7198
Primary Metal (6)	0.6585	0.5889	0.7401	0.7245	0.6057	0.5321	0.6430	0.6343
Metal Fabricating (9)	0.6518	0.7199	0.6568	0.7151	0.6153	0.6674	0.6047	0.6405
Machinery (3)	0.4929	0.6248	0.5512	0.6641	0.4536	0.5571	0.5095	0.5875
Transportation Equipment (9)	0.6059	0.6430	0.6539	0.6930	0.5556	0.5678	0.5768	0.5879
Electrical Products (8)	0.6217	0.6875	0.6359	0.6954	0.5342	0.6050	0.5059	0.6175
Non-Metallic Mineral Products (12)	0.8976	0.8769	0.8738	0.8649	0.8484	0.8077	0.7929	0.7599
Petroleum and Coal Products (2)	0.2903	0.3200	0.4972	0.5339	0.2897	0.3062	0.4943	0.5265
Chemical & Chemical Products (8)	0.5602	0.5690	0.6842	0.7067	0.4785	0.4829	0.6162	0.6366
Miscellaneous Manufacturing (13)	0.6703	0.6917	0.6849	0.7028	0.6272	0.6539	0.6237	0.6593
Weighted 2-Digit Industry average	0.6689	0.6916	0.7124	0.7393	0.5976	0.6149	0.6296	0.6531

a. Numbers in parenthesis refer to number of 4-digit industries within each 2-digit industry. The table refers to 135 of the 167 4-digit industries into which the manufacturing sector is divided.
b. See text for definition.
c. Averages estimated across all constituent 4-digit industries within a 2-digit industry. Weighted averages uses employment weights, where employment includes both wage and salary earners.

Source: Statistics Canada. See Appendix A for details. (Box 3).

mineral products. One possible explanation for the increase in product diversity in these industries is that they may have been characterized as having substantial increases in plant size. However, data on plant size does not support this as a plausible explanation.[16]

A potential difficulty with Table 5, like Table 2, is that no control was made for variations in N* both within and across a 2-digit industry. Rather than presenting tables analogous to Tables 3 and 4 we designed and defined the following index of relative product diversity:

$$RELDIV4D = (1-HERF4D)/(1-(1/N^*)).$$

This variable will vary between 1 where the plant has the maximum degree of product diversity (recalling an earlier notation, $q_i/Q_j = 1/N^*$ for all i for the jth plant, implying HERF4D=1/N*)[17] and 0 when the plant is not diversified at all (both q_i/Q_j and HERF4D equal unity). In other words, the denominator contains the maximum degree of diversity and the numerator the actual degree of diversification. The 5-digit ICC equivalent of RELDIV4D is estimated in an analogous manner.

Table 6 presents average values of RELDIV4D and RELDIV5D, both weighted and unweighted, by 2-digit industry, as well as the average values of N* at the 4-digit and 5-digit ICC level (N4D and

Table 6

Level of Relative Product Diversity of Plant, Grouped by 2-Digit Industry By 4 and 5-Digit ICC: 1974 and 1979

2-DIGIT INDUSTRY[a]	RELDIV4D[b]		RELDIV4D[b]		RELDIV5D[b]		RELDIV5D[b]		Number of Products[b]					
	1974	1979	1974	1979	1974	1979	1974	1979	4-Digit ICC			5-Digit ICC		
									Averages					
	Weighted Average[c]		Unweighted Average[c]		Weighted Average[c]		Unweighted Average[c]		Unweighted	Weighted[c]		Unweighted	Weighted[c]	
									-	1974	1979	-	1974	1979
Food and Beverages (17)	0.3632	0.3418	0.3302	0.3066	0.4353	0.4285	0.4259	0.4217	14.6	19.5	19.9	39.1	50.5	50.7
Tobacco Products (2)	0.1491	0.1549	0.1341	0.1601	0.3483	0.3931	0.2562	0.2991	7.0	5.7	5.6	23.5	17.2	16.7
Rubber & Plastics (0)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leather (4)	0.2978	0.2577	0.3528	0.3001	0.3354	0.2864	0.3600	0.3034	10.3	14.9	14.7	33.5	67.7	62.5
Textiles (14)	0.4541	0.3575	0.4571	0.3705	0.5018	0.4386	0.4979	0.4186	6.6	9.1	8.4	17.2	27.2	25.4
Knitting Mills (2)	0.3375	0.3502	0.3470	0.3510	0.3469	0.4115	0.3629	0.4117	9.5	6.9	9.2	29.5	24.9	28.9
Clothing (7)	0.3650	0.3350	0.2427	0.2031	0.4410	0.4077	0.4414	0.4097	6.9	9.9	10.1	20.7	29.9	30.3
Wood Industries (9)	0.2840	0.2486	0.2042	0.1911	0.4454	0.3990	0.3164	0.2859	3.8	5.8	5.7	16.1	32.4	32.3
Furniture & Fixtures (2)	0.2270	0.3552	0.2591	0.3806	0.4382	0.4674	0.3545	0.4017	5.0	6.6	6.7	16.5	22.7	23.2
Paper & Allied Ind. (5)	0.3044	0.2691	0.3163	0.2482	0.3380	0.2990	0.2897	0.2405	7.4	21.8	21.8	21.0	66.5	66.6
Printing & Publishing (3)	0.3056	0.3255	0.3052	0.3782	0.2933	0.3079	0.2663	0.3175	9.3	12.7	13.2	23.3	31.1	31.5
Primary Metal (6)	0.3688	0.4382	0.3114	0.3220	0.4070	0.4807	0.3884	0.3954	13.2	24.3	34.0	33.0	60.7	62.4
Metal Fabricating (9)	0.3643	0.2976	0.3866	0.3099	0.3737	0.3331	0.3969	0.3658	16.1	18.8	19.5	38.9	45.4	46.2
Machinery (3)	0.5319	0.3927	0.4774	0.3605	0.5543	0.4493	0.4993	0.4208	23.7	28.9	31.7	67.0	79.2	83.9
Transportation Equipment (9)	0.4370	0.3901	0.3775	0.3334	0.4628	0.4490	0.4479	0.4359	10.3	15.3	15.8	27.6	42.1	43.7
Electrical Products (8)	0.3955	0.3262	0.3878	0.3248	0.4731	0.4005	0.5054	0.3907	20.5	30.3	31.0	60.4	12.5	11.8
Non-Metallic Mineral Products (12)	0.0962	0.1045	0.1192	0.1291	0.1502	0.1907	0.2389	0.2785	4.7	4.9	4.7	11.3	87.0	90.2
Petroleum and Coal Products (2)	0.7572	0.7259	0.5929	0.5427	0.7394	0.7225	0.5875	0.5409	10.5	17.3	17.1	17.5	30.6	30.3
Chemical & Chemical Products (8)	0.4745	0.4792	0.3764	0.3499	0.5436	0.5364	0.4092	0.3845	10.1	18.6	18.6	28.6	43.0	44.1
Miscellaneous Manufacturing (13)	0.3587	0.3324	0.3496	0.3285	0.3855	0.3570	0.3916	0.3540	13.4	17.8	18.8	29.2	35.2	36.4
Weighted 2-Digit Industry Average	0.3635	0.3372	0.3288	0.2963	0.4149	0.3981	0.3975	0.3714	10.8	17.4	17.5	28.9	47.6	48.0

a. Numbers in parenthesis refer to number of 4-digit industries within each 2-digit industry. The table refers to 135 of the 167 4-digit industries into which the manufacturing sector is divided.
b. See text for definition.
c. Averages estimated across all constituent 4-digit industries within a 2-digit industry. Weighted averages uses employment weights, where employment includes both wage and salary earners.

Source: Statistics Canada. See Appendix A for details. (Box 3).

N5D respectively). The averages at the 2-digit level are based upon the constituent 4-digit SIC industries in the same manner as HERF4D and HERF5D in Table 5. Several points are worth noting about Table 6. First, as with Table 5 and with the same exceptions, plants tend to become more specialized at the 2-digit than the 4-digit industry level -- RELDIV4D and RELDIV5D tend to become smaller. Second, relative to the maximum degree of product diversity attainable, measured product diversity rarely exceeds half that attainable. Similar results can be inferred from Tables 3 and 4.[18] The value of RELDIV4D is, however, usually lower than RELDIV5D, suggesting that most plants diversify to a considerable extent in several 5-digit ICC products that are classified to a much smaller number of 4-digit ICC products. This in turn tends to support the view that firms in an industry make up different strategic groups. This strategic group literature[19] argues that within a given industry different groups of firms can survive by following different strategies. The data in Table 6 suggests that one such strategy might be specialization within the industry in a sub-set of the products classified to the industry. However, Table 6 refers to plants not firms so this interpretation is only tentative.

The discussion of product diversity suggests that both plant size and the number of products per industry are important factors that affect the product diversity. Increases in plant size and the number of products per industry results in greater product diversity. Hence in our regression analysis variables designed to capture these attributes will be introduced. Turning now to the actual measures of product diversity themselves, an important problem concerns the lack of a standard of comparison against which to measure observed diversity. One possible benchmark is the maximum degree of diversity. Using this we find that plant diversity is rarely anywhere close to the maximum degree and that over the period 1974 to 1979 measured product diversity declined. However, the finer the industry classification the more diversified the plant. Although a cost based standard of comparison is lacking, making comparisons difficult at a point in time, this is not so serious a problem over time (providing, of course, the standard does not change). Our comparisons show that Canadian plants tended to become more specialist over time. Given an earlier discussion linking diversity and a cost function this implies, other things equal, reduced cost and greater efficiency over the 1970's.

The Dependent Variable

The regression analysis is concerned with the inter-industry determinants of the degree of product diversity and length of production run.[20] In an earlier discussion we presented measures of diversity at the plant level. The 4-digit industry plant level product diversity index is just the weighted average of plant diversity indices, using plant sales as weights.

Table 7

Product Diversity and Length of Production Run, By 4-digit Industry, 1974 and 1979

YEAR	DEGREE OF PRODUCT DIVERSITY		SIZE OF PRODUCTION RUN		AVERAGE PLANT SIZE[a] (000's)	NUMBER OF INDUSTRIES
	HERF4D	HERF5D	PR4D	PR5D		
	Maximum Number of Industries Data Available[b]					
1974	0.701	0.623	3202.5	2856.2	5391.9	161
1979	0.731	0.650	4649.2	4047.2	7553.7	161
1979-1974	0.029	0.027	1446.7	1191.0	2161.8	161
	Excluding Miscellaneous Industries					
1974	0.712	0.630	3585.3	3197.1	5978.6	135
1979	0.739	0.653	5231.1	4541.7	8477.9	135
1979-1974	0.027	0.024	1645.8	1344.5	2499.3	135
	Industry Sample, Regression Analysis					
1974	.702	0.617	3407.2	2980.4	6073.4	119
1979	.729	0.644	5333.8	4603.3	8906.0	119
1979-1974	0.028	0.026	1926.7	1622.9	2832.6	119

a. Measured in 1971 constant dollars. For 1974 average plant size refers to 1970.
b. Excludes those industries for which no ICC products exist and one industry where none of the plants classified to the industry reported product diversity data.

Source: Statistics Canada. See Appendix A for details (Vol. 25).

Table 7 presents details of the average degree of product diversity, for various samples of 4-digit manufacturing industries, for 1974 and 1979. The numbers in Table 7 are simple unweighted averages of the industry indices. The average plant size, measured in constant 1971 dollars, is also included. Different samples of industries are reported to test whether the sample used in the regression analysis is different in some systematic way from the universe of all 167 4-digit industries. Since this does not appear to be the case, our discussion will be confined to the sample of industries used in the regression analysis.

Table 7 shows that, over the period 1974 to 1979, product diversity in Canadian industry has been reduced somewhat, a result consistent with our discussion above. The diversity indices, expressed in terms of numbers equivalent for the 119 industry sample is as follows:

	4-Digit	5-Digit
1974	1.539	1.779
1979	1.470	1.695

Although product diversity exhibited only small decreases, the length of production run, measured in terms of 1971 constant dollars, showed a substantial increase. This is mainly the result of an increase in average plant size. The elasticity of plant level product diversity with respect to increases in average plant size was much less than that of the length of production run.

The length of production run and product diversity levels are quite sensitive to the level of ICC classification used. Not surprisingly, in view of the results in Tables 3 to 6, product diversity is greater when measured at the 5- compared to the 4-digit ICC, while production runs are shorter. The increase in the number of ICC commodities or products between the 4- and 5-digit is of the magnitude of 2.8 to 3.0. However, the increase in product diversity and the reduction in product runs is much less. This is consistent with the plant allocating its output, to a considerable extent, across 5-digit ICC commodities within the same 4-digit ICC.

In summary, over the period 1974 to 1979 Canadian manufacturing plants have become larger and more specialist, and have longer production runs. We now turn our attention to the factor responsible for this pattern and, in particular, to the role of trade and tariff policies.

3. DETERMINANTS OF PRODUCT DIVERSITY AND LENGTH OF PRODUCTION RUN

Introduction

The factors that determine the degree of product diversity and length of production run can be divided into several categories. The first category includes those factors that shield the industry from competitive forces and thus permit "excessive" diversity. Such influences include tariffs, concentration and the level of imports. The second category includes those technological factors that limit or raise the level of product diversity. In this context the number of products per industry is likely to be particularly significant. The final category includes those factors that determine how the firm distributes its output among the plant it owns such that costs are minimized.

Plant Size and Multiplant Operations Two variables -- average plant size and the degree of multiplant operations -- have been previously found to be related to diversity (Caves, 1975 and Caves *et al*, 1980). In order to justify inclusion of average plant size, Caves relies upon the assumption that firms add products to take advantage of plant scale economies. In this approach the multiproduct firm is characterized as facing an important decision concerning the way in which its products are distributed among its plants. At one extreme the firm could decide to produce all its products in a single plant or it could choose to build a plant for each product. In considering the factors that influence the firm in locating along this spectrum, Caves et al (1980, p. 206) make the following assumptions about the cost of production:

1. Capacity costs for the physical plant and its supporting services are subject to scale economies, so that total costs of plant (per square foot of capacity, say) increase with size less than proportionally over a significant range.

2. Each line of output that could be produced in the plant incurs a fixed cost of production facilities that generally increases less than in proportion to the output capacity for the line.

3. Each line of output also involves short-run variable costs specific to the line that we shall assume independent of the scale of output up to a capacity constraint. (The exact behaviour of these costs does not affect the analysis).

4. Supervisory and related costs of coordination within the plant that depend on the scale of each output but also on the diversity of output, increasing as the output mix grows more complex.

With these assumptions, it is argued that the firm will build a series of single product specialized plants if all of the economies implied by (1), (2) and (3) can be realized in a single plant for each product. Such a production pattern thus saves the firm from the costs incurred under (4). However, the market available to a particular firm, because of downward sloping demand curves, may not be sufficient to realize all the scale economies implied by (1) to (3) for a single plant. In other words, excess capacity will exist in each of the single product plants of the firm. Under such conditions the firm may decide to combine the production of several products in the same plant. While this incurs some supervisory costs, these costs will be offset by the realization of some of the scale economies implied by (1) to (3). Supervisory costs entail frequent charges and set-up of product lines as well as assorted inventory problems.[21]

Caves et al (1980, p. 207) then concluded that, "large plants will typically be more diversified than small ones because some plants turn out diverse outputs as a result of this optimization process". This view then has larger firms somehow managing to sell more products, combining them together in one plant to exploit plant scale economies to grow even larger because of the cost advantage so created. There is, however, even in this view of the world, an offsetting effect. For, if a large firm is larger because it is more successful in selling more of each product, there is no presumption that its plants will be less specialized unless plant economies of scale are so important that they are not exhausted until the largest scale plants. Indeed, it seems reasonable to suggest that large firms have sufficiently long production runs that they can afford to begin "unbundling" their plants and decreasing the average diversity of their plants. However, all this simply suggests that diversity is likely to increase at first as plant size gets larger but that beyond a certain point, it will again decline. Evidence from Tables 3, 4 and 5 tend to confirm this non-linear effect, at least for some industries.

There is another reason that average size of plant and the number of plants per firm are likely to be related to diversity. They are both likely to be correlates of the degree of diversity chosen by the firm. If a firm with a given number of products and given size should decide to produce in only a small number of plants, and therefore in plants of larger average size, it is making a decision as to the plant diversity given the number of products being produced. Average size of plant should have a negative effect on diversity since, in the limit, a plant that is as large as the entire industry must necessarily produce the industry's entire range of products.

If average plant size is included as an independent variable in a regression equation explaining diversity, then the addition of the number of plants per firm essentially captures firm size effects. This is because the greater the number of plants per firm for a given plant size, the larger will be the average firm size. Now the larger is the firm, for a given size of plant, the more likely it is that every plant will be more specialized. In effect, the decision to build more plants is one that will depend on, amongst other things, the cost of having a diversified as opposed to a specialist plant. And when more plants are built, it is likely that the advantages of specialization outweigh the disadvantages of smaller plant size. Therefore, ceteris paribus, the multiplant variable should be positively correlated with specialization.[22] This argument must be tempered with the recognition that the multiplant nature of some industries will be severely affected by transportation cost considerations. In this case multiple plants are constructed not to take advantage of specialization but because of the regional nature of the Canadian market. Hopefully, however, inclusion of a binary variable characterising the industry as regional or otherwise will correct for this influence.

There is, however, a danger in using such correlates of diversity as average plant size and number of plants per firm. If there are a number of factors that jointly determine average plant size, number of plants per firm, and diversity, it would be desirable to use these variables to specify a set of equations that jointly determine each of the variables of interest. However to the extent that we are unsure of the specification of the complete model specification or of the availability of data, inclusion of such correlates offers a convenient way of proxying the missing variables. This is our reason for including both.

Another problem with such proxies still remains. If the proxy is closely related not just to missing variables but also to included ones, it may decrease the significance of individual parameter estimates because of multicollinearity. In particular, to the extent trade related variables determine average plant size, inclusion of the plant size variables may mask the effect of the trade variables. To test for this possibility, we estimated the relations with and without average plant size and number of plants per firm. The sign and significance of other variables did not vary much in either case, while both average plant size and number of plants per firm were highly significant, when included. Therefore our reported results include both average plant size and number of plants per firm.

In order to capture the notions of plant size and multiplant operations we define:

AVPLSZ	average plant size, defined in 1971 constant dollars, of plants that were classified to the industry. Size is measured in $000,000's.
AVPLSQ	average size (AVPLSZ) squared.

Two terms are introduced to capture average size. In our earlier investigation of the relationship between plant diversity and plant size we found that as plant size increased so too did the degree of product diversity. However, its effect, after initially increasing rapidly tended to stabilize or at least to grow much more slowly. Hence AVPLSZ should be negatively related to product diversity (and have a postitive coefficient in the regression) and AVPLSQ should be positively related (and have a negative coefficient).

Table 8

Regression Results of Plant Size, Ownership and Multiplant Operations on Plant Diversity for Each of 75 4-Digit Industries, 1970: A Summary

Independent Variable	Number of Regression Coefficients			
	Positive		Negative	
	Significant[a]	Insignificant	Significant[a]	Insignificant
TSH				
PHERF4D[b]	2	20	25	28
PHERF5D[b]	4	12	27	32
TSHSQ				
PHERF4D[b]	15	36	5	19
PHERF5D[b]	19	34	3	19
NOEST				
PHERF4D[b]	8	28	8	31
PHERF5D[b]	7	34	9	25
OCON				
PHERF4D[b]	2	30	5	19
PHERF5D[b]	1	30	6	17
OSCON				
PHERF4D[b]	11	37	3	22
PHERF5D[b]	8	38	2	25

a. At 0.10 level, using a one tailed test.

b. The corresponding dependent variable.

c. In some instances there are no observations for OCON and/or USCON. In these cases the regression equation is estimated without OCON and/or USCON. Hence summing across the row for these two variables need not sum to 75.

Source: Statistics Canada. See Appendix A for details. (Vol. 16)

The multiplant nature of an industry will be represented by the variable:

MPLNT — a dummy variable which takes the value 1 when the average number of plants per firm (PLNT) is greater than its mean, 0 otherwise.

The breakpoint for the dummy variable MPLNT was 1.295 in 1970 and 1.292 in 1979.[23] Although the multiplant variable is entered in binary form here use of a continuous variable defined as the number of plants per firm yielded very similar results. The multiplant variable should be negatively related to diversity and thus have a positive coefficient in the regression.

The justification for the inclusion of both average plant size and number of plants per firm resides in a priori views about individual firm behaviour within each industry. Therefore, a limited investigation was conducted into the relationship between plant size, multiplant operations and product diversity as well as length of production run within each industry. This exercise is useful in that it permits a detailed evaluation of the assumptions about plant size and multiple plants to be tested; it is more limited than the inter-industry analysis in that it does not take into account differences in industry characteristics that affect the level of diversification. For each industry the following relationship was estimated:

$$\left.\begin{matrix}\text{PHERF4D}\\\text{PHERF5D}\end{matrix}\right\} = f(\text{TSH, TSHSQ, NOEST, OCON, USCON})$$

Table 9

Regression Results of Plant Size, Ownership and Multiplant Operations on Length of Production Run for Each of 75 4-Digit Industries, 1970: A Summary

Independent Variable	Number of Regression Coefficients			
	Positive		Negative	
	Significant[a]	Insignificant	Significant[a]	Insignificant
TSH				
PPR4D[b]	71	3	-	1
PPR5D[b]	67	8	-	-
TSHSQ				
PPR4D[b]	18	14	32	11
PPR5D[b]	14	7	40	14
NOEST				
PPR4D[b]	11	28	10	26
PPR5D[b]	12	30	14	19
OCON				
PPR4D[b]	7	27	7	13
PPR5D[b]	4	25	7	18
OSCON				
PPR4D[b]	9	31	6	27
PPR5D[b]	9	34	3	27

a. At 0.10 level, using a one tailed test.

b. The corresponding dependent variable.

c. In some instances there are no observations for OCON and/or USCON. In these cases the regression equation is estimated without OCON and/or USCON. Hence summing across the row for these two variables need not sum to 75.

Source: Statistics Canada. See Appendix A for details. (Vol. 20)

where

PHERF4D =	plant level product diversity is measured using the 4-digit ICC and the Herfindahl index of product diversity.
PHERF5D =	plant level product diversity is measured using the 5-digit ICC and the Herfindahl index of product diversity.
TSH =	plant total shipments, measured in nominal dollars.
TSHSQ =	plant total shipments squared, measured in nominal dollars,
NOEST =	the number of establishments owned by the firm which owns the particular plant.
OCON =	plant owned by non-resident, non-U.S. interests = 1, 0 otherwise,
USCON =	plant owned by U.S. = 1, 0 otherwise.

(The last two variables relate to the ownership characteristics of the plant and will be discussed further below under "Foreign Ownership"). The regression equation is estimated for 1979 and 1970 (where PHERF4D refers to 1974, all other variables 1970) with the level of plant diversity measured at both the 4-digit (PHERF4D) and the 5-digit (PHERF5D) ICC level. These results are reported in Tables 8 and 10. The regression is also run using length of production run at the 4-digit (PPR4D) and 5-digit (PPR5D) ICC level.[24] The latter results are reported in Tables 9 and 11. The sample of industries excluded miscellaneous industries,[25] those with no ICC products or long-form establishments as well as those with only a relatively small number of observations.[26]

Table 10

Regression Results of Plant Size, Ownership and Multiplant Operations on Product Diversity for Each of 79 4-Digit Industries, 1979: A Summary

Independent Variable	Number of Regression Coefficients			
	Positive		Negative	
	Significant[a]	Insignificant	Significant[a]	Insignificant
TSH				
PHERF4D[b]	2	14	22	41
PHERF5D[b]	1	13	27	38
TSHSQ				
PHERF4D[b]	20	39	4	16
PHERF5D[b]	20	41	4	14
NOEST				
PHERF4D[b]	11	34	11	23
PHERF5D[b]	9	32	10	28
OCON				
PHERF4D[b]	3	38	7	16
PHERF5D[b]	4	37	4	19
OSCON				
PHERF4D[b]	10	36	8	18
PHERF5D[b]	11	34	6	21

a. At 0.10 level, using a one tailed test.

b. The corresponding dependent variable.

c. In some instances there are no observations for OCON and/or USCON. In these cases the regression equation is estimated without OCON and/or USCON. Hence summing across the row for these two variables need not sum to 79.

Source: Statistics Canada. See Appendix A for details. (Vol. 17)

The regression results show that plant diversity and length of production run both increase with plant size, with few if any significant instances in which a contrary relationship is indicated. However, as plant size rises the increase in plant diversity and length of production run tend to be less than proportional, particularly at the 5-digit ICC level for length of production run. In other words, plant diversity and length of production tend to level off or grow more slowly as plant size increases, consistent with our earlier results in Tables 3 and 4. Nevertheless, in a significant number of cases, length of production run actually increases more than proportionately suggesting some specialization is taking place in such instances. The number of establishments has an equivocal impact, a result we will return to when discussion of the inter-industry results takes place. In sum, therefore, we find considerable support that, within a given industry, plant size and product diversity as well as production run length are related in the hypothesized manner.

Previous researchers have not estimated relationships such as those in Tables 8 to 11, primarily because of data limitations. Nevertheless at the enterprise level Caves et al (1980, Table 8.3, p. 210) estimated the relationship between firm diversity and firm size, firm size squared and the number of plant per firm for 19 2-digit industries. Bearing in mind the differences in sample, industry and commodity classification, and variable definitions,[27] the results suggest the relationship reported here between plant

Table 11

Regression Results of Plant Size, Ownership and Multiplant Operations on Length of Production Run for Each of 79 4-Digit Industries, 1979: A Summary

Independent Variable	Number of Regression Coefficients			
	Positive		Negative	
	Significant[a]	Insignificant	Significant[a]	Insignificant
TSH				
PPR4D[b]	73	5	-	1
PPR5D[b]	73	5	1	-
TSHSQ				
PPR4D[b]	24	11	28	16
PPR5D[b]	17	13	35	14
NOEST				
PPR4D[b]	10	28	12	29
PPR5D[b]	9	26	12	32
OCON				
PPR4D[b]	6	27	11	20
PPR5D[b]	5	34	8	17
OSCON				
PPR4D[b]	11	33	5	23
PPR5D[b]	14	32	4	22

a. At 0.10 level, using a one tailed test.

b. The corresponding dependent variable.

c. In some instances there are no observations for OCON and/or USCON. In these cases the regression equation is estimated without OCON and/or USCON. Hence summing across the row for these two variables need not sum to 79.

Source: Statistics Canada. See Appendix A for details. (Vol. 19)

diversity and plant size is similar to that found by Caves between firm size and firm diversity; however, while Caves found the number of plants per firm has a strong impact increasing firm diversity, our results show this variable increases and decreases plant diversity in about the same number of cases. The two results are not incompatible. Where multiple plants lead to greater plant diversification, firm level diversity should also be higher. Where multiple plants lead to less plant diversity, firm level diversity can also be higher if plants essentially produce different products. Examination of which industries fit into these separate categories must await further study.

Opportunity to Diversify The measure of plant level diversification should depend on the potential number of products that might be produced. That is, if every product produced in the industry (N) is produced in each plant, and no products from other industries are produced, then the Herfindahl will be bounded below by 1/N. To the extent plant economies do not require such crowding, plant diversity will be reduced - that is, take on a value above 1/N. In order to take account of the opportunity to diversify, two variables are used when product diversity is the dependent variable:

R4D	the reciprocal of the number of 4-digit ICC products classified to a 4-digit SIC industry.
R5D	the reciprocal of the number of 5-digit ICC products classified to a 4-digit SIC industry.

Examination of Tables 3, 4, 14 and 15 suggests that there may be substantial non-linearity effects of R4D and R5D on product diversity. This suggests that perhaps R4D and R5D should be entered in the form log R4D and log R5D, respectively. Experimentation with both the log and non-log forms suggested the relationship was indeed non-linear. For example, if equation 1 of Table 20 is re-estimated with R4D instead of log R4D then the $\bar{R}^2$ falls from 0.4461 to 0.3377 with little change in the sign and significance of the other explanatory variables.

When length of production run is the dependent variable, the opportunity to diversify variable is:

AV4D	average plant size divided by the number of 4-digit ICC products classified to a 4-digit SIC industry.
AV5D	average plant size divided by the number of 5-digit ICC products classified to a 4-digit SIC industry.

Whereas Tables 3, 4, 14 and 15 reveal important non-linearities between the level of diversity (HERF4D, HERF5D) and the opportunity to diversify variable (R4D, R5D), they do not give the same indication of non-linearities for the relationship between product run length and plant size. If a proxy for average product run length (plant size multiplied by the diversity index) is plotted against plant size (employment) for similar values of N* (at the 5-digit ICC level), no obvious non-linearities arise. Therefore it was decided to use a linear formulation regressing average product run length on average plant size.

The same plots did reveal that the number of products did produce a different slope. Therefore a second variable (average plant size divided by potential number of products, N*) was added. This implies the slope of the relationship between product run length and average plant size is inversely related to the number of potential products. This form makes inherent sense since growth is more likely to come from the addition of new product lines when the number of potential products is higher.

It should be noted that the product count variable does not measure the complete universe of products that might be produced in all countries (something akin to the Standard International Trade Classification (SITC)). Instead it is derived from the number of products actually being produced in Canada. Thus the variable standardizes for the factors that determine whether more or less products are being produced in the industry. Inclusion of this opportunity to diversify variable has important implications for the way in which we approach the interpretation of the other explanatory variables. With the number of products produced in the industry included in the regression, part of the effect normally posited for some independant variables may already be captured.

For instance, it is often claimed that as markets get larger, this permits less popular product lines to be produced and therefore industry diversity to be increased. Similarly, the effect of tariffs is usually couched in somewhat the same terms. Higher tariffs permit the production of a product line that would otherwise be imported from abroad. In both situations this effect could potentially be caught by N4D and N5D -- the number of 4 and 5 digit ICC products. Thus the variables introduced to normalize for the number of product lines in an industry may capture some of the effect of market size or other variables that is usually posited to occur through total number of products produced. More importantly, to the extent this is so, other independent variables should measure the specialization effect that does not depend upon industry level diversity.

Caution, however, must be given even to this interpretation. In discusssions with officials at Statistics Canada, it was emphasized that the number of ICC products was likely to be primarily related to the factors outlined previously. While it was possible, they felt, to argue that N4D and N5D might be higher relative to similar numbers for U.S. industries where the relative Canadian market size was higher, or where tariffs were higher, their opinion was that this effect would be small in comparison to others. If this is the case, as the results of Appendix D suggest, N4D and N5D will only measure some exogenous technological opportunities to diversify variable and other independent variables will capture industry wide diversity considerations and at the same time the ability of plants to specialize.

Trade Variables Imports and exports are likely to influence the length of production run and product diversity. Where an industry exports or has a comparative advantage, it is to be expected that production runs will be longer and plants more specialized to reap product specific scale economies. Turning to the other side of the trade balance, imports are likely to have two different impacts, making it difficult to specify the a priori direction. On the one hand imports may spur Canadian firms to concentrate on longer production runs to meet or beat the competition. On the other hand, high imports may affect average plant size detrimentally -- a result suggested by Baldwin and Gorecki (1983a) -- and lead to "product packing" in order to offset the cost disadvantage of small plants. While average size plant already is included separately as an independent variable, imports may measure the size of the incentive facing domestic firms to minimize costs.

A number of different variables are used in the regression equations to capture the effects of trade:

EXP = the proportion of domestic production that is exported.

INTRA = ((XT+IM) - (absolute value (XT-IM))/(XT+IM)) where XT = exports and IMP = imports -- a variable often referred to as measuring intra-industry trade.

IMP = imports as a proportion of domestic disappearance, where the latter indicates domestic production minus exports plus imports.

CA = (exports minus imports divided by the sum of exports plus imports) +1 -- a variable often referred to as measuring comparative advantage.

INTRA will vary between 1 (imports = exports) and 0 (imports = 0, exports > 0, or exports = 0, imports > 0) while the addition of 1 in CA scales the variable so that it varies between 0 (imports > 0, exports = 0) and 2 (exports > 0, imports = 0).

Each of the four trade variables is included in order to capture a separate aspect of the way trade may affect product diversity. The use of IMP and EXP assume that it is imports and exports (normalized by domestic disappearance and production, respectively) per se that impact upon product diversity. The use of INTRA, which measures intra industry trade, essentially assumes that greater imports or exports have the same impact on efficiency, but also adds the assumption that greater two-way trade between two countries has a similar effect. Finally, the use of CA assumes comparative advantage, as measured by the relative size of imports and exports, is important. All the trade measures are expected to be negatively related to diversity and thus have positive coefficients in the explanations of product diversity -- except IMP whose sign is ambiguous.

Tariffs An important attribute of Canadian manufacturing industries that is postulated to affect diversity is the level of tariff protection. An extensive literature following Eastman and Stykolt (1967) has postulated the existence of inefficient plant scale and excessive product differentiation in response to tariff protection. Although the impact of foreign competition should be caught with the previously discussed trade variables, there may be a residual effect caught by the tariff variables.

The effect of tariffs on diversity must be related to its effect on efficiency. This effect can be found in the trade off postulated between plant economies and product agglomeration costs. Suppose that the trade-off established as optimal number of products per plant that is achievable (i.e., the industry is not at a corner solution where unexploited plant scale economies always offset product agglomeration costs). Just as the sign of imports cannot be assigned a priori, so too tariff rates can have a two-fold effect. Firms, behind a tariff wall, could choose not to add products to take advantage of plant scale economies. In this case, the inefficiency would result, if, for a given plant size, diversity were too small and the coefficient on the tariff variable should be positive. On the other hand, the firm that does not trade off plant economies against product agglomeration cost in an optimal way may tend to add too many products. In this case, for a given average plant size, diversity would be higher than otherwise and the tariff variable would have a negative coefficient. Of course, we should expect the latter result in those industries where adding another product line to a plant would decrease average costs. To the extent unexploited economies of scale exist generally, we should expect a negative relationship to be the case.

The above discussion presumes that the number of 4- and 5-digit ICC products per industry represent not just the technological product opportunities but the number of products chosen to be produced in Canada. If they do, however, represent just technological opportunities, the plant diversity index will be affected by changes in two variables brought about by higher tariffs. The first is the change in the number of products produced per firm. The second is the changes in the number of products produced per plant. The latter has already been covered in the above discussion. The former should respond positively to higher tariffs and therefore lead to greater diversity. In this case, the first affect may be sufficient to cause a negative coefficient on the tariff variable - especially if unexploited economies lead to product packing. Related work (Baldwin and Gorecki, 1983c) suggests product packing is an important phenomenon. Therefore we posit a negative coefficient on tariffs.

We use the effective tariff rate to measure protection:

ERP = effective tariff protection, defined to take into account export intensiveness and indirect taxes and subsidies as suggested by Wilkinson and Norrie (1975, pp. 5-20).

However, Eastman and Stykolt (1967) and Bloch (1974), suggest that the performance of an industry may not be inversely related to tariffs alone. Rather it may be only in industries with high tariffs and high concentration that tariffs have an adverse impact. In such industries the protection afforded the firm, combined with oligopolistic interdependence (implied by high concentration) and the weak Canadian competition law, result in a competitive environment that is not sufficient to force firms to adopt the optimal trade-off between size and product diversity. The consequence of this may either be higher profits or higher costs. The profit evidence presented by Bloch (1974, Table 3, p. 607), albeit based on a small sample of industries, is consistent with this line of reasoning in that it suggests it is the joint effect of tariffs and concentration that leads to higher profits. Thus ERP may have a greater effect on plant diversity in concentrated industries.

In order to capture the interdependence between tariffs and market structure the following variables were specified:

HVTRHCR a dummy variable which takes the value 1 when both concentration and effective tariff protection are greater than their respective means, 0 otherwise.

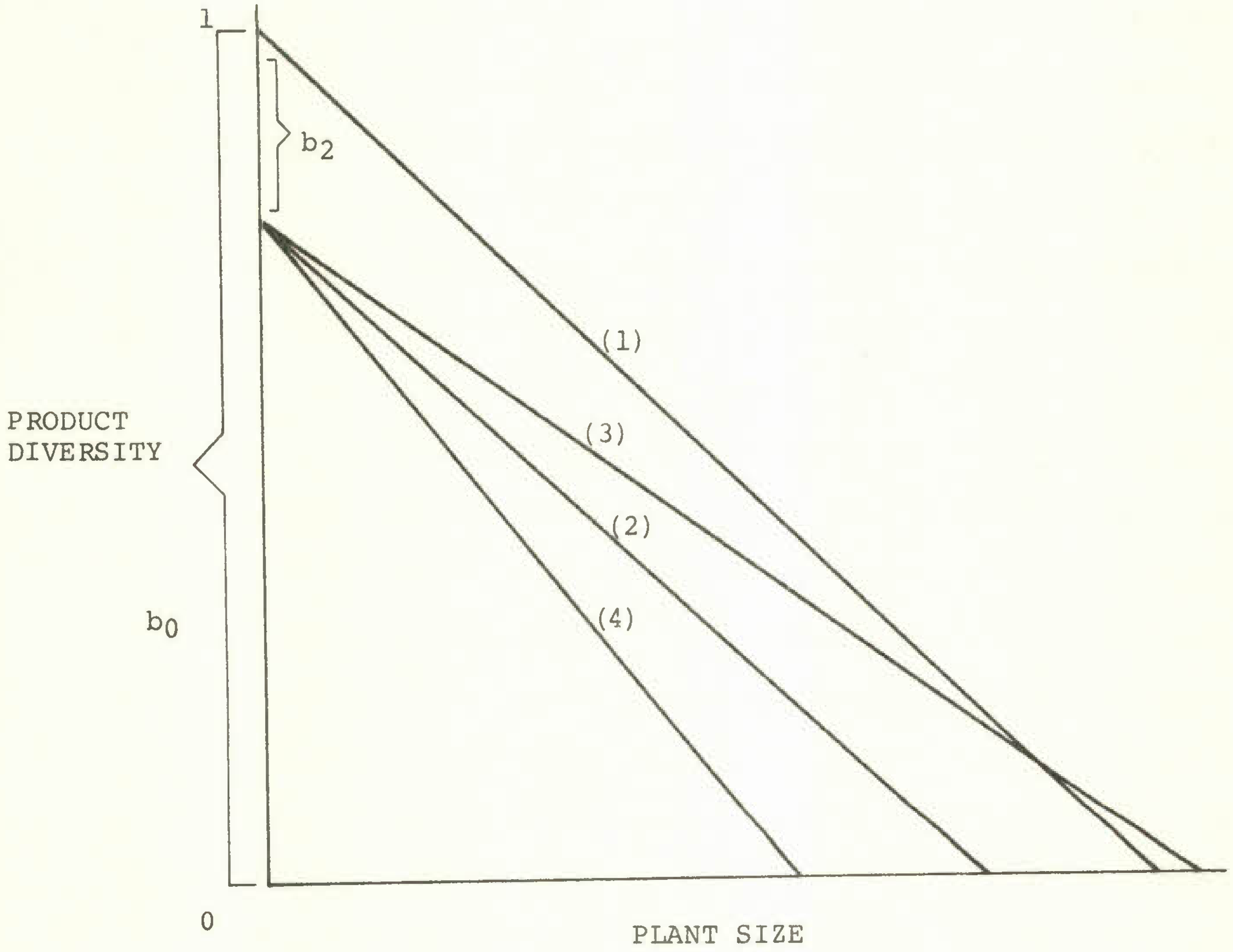
PLESTV HVTRHCR · AVPLSZ -- the average size of plant where both concentration and effective tariff protection are greater than their respective means.

If tariffs actually increased diversity in high concentration industries, HVTRHCR should have a negative sign. The term PLESTV is introduced to capture certain non-linearities in the tariff effect. If tariffs influence plant level diversity by affecting the rate at which products are added (or not subtracted) as plant size gets larger, then the coefficient on average plant size in high tariff/high concentration industries should differ from that attached to AVPLSZ. Since the coefficient on average plant size is hypothesized to be negative, our hypothesis is that it should be negative for the interaction term PLESTV if the effect of tariffs is to increase diversity, as suggested above.

The relationship between tariffs, concentration, plant size and product diversity can be illustrated with reference to Figure 1. The product diversity function that does not consider tariffs or concentration is represented by relation (1). It is expected to shift downward by the coefficient b_2 in highly concentrated industries where there are high tariffs. However, the slope of the relationship between product diversity and plant size is difficult to predict within high tariff/high concentration industries in relation to the slope where such conditions do not

FIGURE 1

TESTING THE EASTMAN/STYKOLT HYPOTHESIS:
PRODUCT DIVERSITY



(1) PRODUCT DIVERSITY = $b_o + b_1$ AVPLSZ

(2) PRODUCT DIVERSITY = $b_o + b_1$ AVPLSZ + b_2 HVTRHCR + b_3 PLESTV
where HVTRHCR = 1, $b_3 = 0$

(3) PRODUCT DIVERSITY = $b_o + b_1$ AVPLSZ + b_2 HVTRHCR + b_3 PLESTV
where HVTRHCR = 1, $b_3 < b_1$

(4) PRODUCT DIVERSITY = $b_o + b_1$ AVPLSZ + b_2 HVTRHCR + b_3 PLESTV
where HVTRHCR = 1, $b_3 > b_1$

Source: See text

obtain. In Figure 1 three possibilities are shown. In Case (3) at a certain plant size the impact of high tariffs/high concentration is nullified. In both the other cases -- (2) and (4) -- no matter what the size of plant, high tariffs and high concentration result in increased product diversity. We defer until the empirical section the issue of the actual relationship. An analogous figure can be presented for length of production run.

The mean values[28] used in estimating HVTRHCR were as follows:

	1970	1979
Concentration	0.539	0.529
Effective Tariff	0.138	0.124

The number of industries falling in the high tariff/high concentration categories were:[29]

	1970	1979
HVTRHCR = 1	19	22

Thus, approximately 16-18 per cent of the industry sample fell in the high tariff/high concentration category.

The mean and standard deviation of AVPLSZ were as follows for high concentration/high tariff industries.

	1970		1979	
	MEAN	S.D.	MEAN	S.D.
AVPLSZ for HVTRHCR = 1	8.905	11.193	11.711	16.419

The mean of AVPLSZ is greater in high tariff/high concentration industries than for the sample as a whole (see Table 7 for details). This is consistent with our earlier finding in the relative plant scale paper (Baldwin and Gorecki, 1983b) that in high tariff/high concentration industries MES was a substantial proportion of industry shipments. Hence, other things equal, plant size should be larger.

Product Differentiation Advertising may be regarded as the means by which firms obtain sufficient product line depth that they can combine products at the plant level to take advantage of plant level economies. Thus, for a given plant size, the firm has more likely reached that size through combining a large number of products, if advertising is high. We therefore define:

ADVDM The advertising sales ratio for consumer - non-durable goods industries, 0 otherwise.

This should be positively related to product diversity and therefore have a negative coefficient in the regression equation.

Foreign Ownership Foreign ownership is postulated to have two opposing effects on plant level diversity. On the one hand, there may be reason to suppose that foreign ownership will result in longer production runs and greater specialization. It is sometimes argued that foreign owned plants will attain minimum efficient size at a smaller size than domestic firms because the foreign owned firms can rely on some services provided by the parent corporation on a variable cost basis that would otherwise be fixed costs. If this is the case, the foreign firms will not be forced to add products at the same rate to take advantage of scale economies. In addition, it may be that a foreign firm, absent the tariff but with plant(s) in Canada, will have the choice of importing some items and manufacturing others. The domestic firm that hopes to attain the same scale economies in distribution and therefore needs the same range of products may have to produce all products in Canada - if there is some impediment to its purchasing part of its product line from abroad. Both of the above reasons suggest foreign ownership should increase plant specialization. High foreign ownership would be positively related to our diversity variable.

On the other hand, it has been argued that the ease of adding products may be greater for foreign firms. In the parlance adopted earlier, the product agglomeration costs are lower. In this case, foreign firms may find it easier to add products to obtain plant scale economies and industries where foreign ownership is high may have more diversified plants. If so, the coefficient on foreign ownership would be negative.

In order to capture the effect of foreign ownership, we define:

FOR   the proportion of industry shipments accounted for by foreign owned firms.

The sign of the coefficient of this variable is therefore uncertain.

There are those who suggest that since high foreign ownership esssentially occurs in oligopolistic industries where the tariff is high such industries replicate U.S. industry structures and produce inefficiently small plant. This is sometimes referred to as the miniature replica effect (Eastman and Stykolt, 1967, and English, 1964). In our case, it might be argued that in high tariff/high concentration industries, the interdependence effect is sufficiently enhanced by foreign ownership as to reduce the pressures for cost minimization. In that case we might expect to find the same effect hypothesized for high tariff/high concentration industries - that is, diversity of plants increasing at a faster rate than elsewhere as plant size increases. If this is the case, the industry tends to increase the number of products at a greater rate than cost minimization suggests is optimal - or it fails to branch into new plants when desirable.

In order to capture these two hypothesized effects, we specify;

HVTRCRF a dummy variable which takes the value of 1 when concentration, effective tariffs and foreign ownership are high, defined as greater than their respective means.

PLESTFV HVTRCRF · AVPLSZ -- average plant size where concentration, tariffs and foreign ownership are greater than their respective means.

Both HVTRCRF and PLESTFV are expected to have negative coefficients for the reasons outlined previously. The rationale underlying the expected relationship between HVTRCRF, PLESTV and product diversity and length of production run is analogous to that discussed above with respect to HVTRHCR and PLESTV.

The mean value used to define high foreign ownership is 0.44 of industry shipments in 1970 and 0.41 in 1979. The same cut-off points for high concentration and high tariffs are used as was the case with HVTRHCR. The number of industries falling into the high tariff/high concentration/high foreign ownership category are as follows:

	1970	1979
HVTRCRF = 1	12	11

Hence the addition of the constraint of high foreign ownership to high concentration and high tariffs reduces the number of industries by approximately one half.

The average and standard deviation of AVPLSZ in high concentration/high tariff/high foreign ownership industries are:

	1970		1979	
	MEAN	S.D.	MEAN	S.D.
AVPLSZ for HVTRCRF = 1	10.983	13.295	14.531	22.238

These means and standard deviations are higher than the corresponding set for the high tariff/high concentration industries and for the manufacturing sector as a whole. The larger AVPLSZ for HVTRCRF = 1 compared with HVTRHCR = 1 is consistent with our result (Baldwin and Gorecki, 1983b) that market size divided by MES (MESMSD) is smaller in the high tariff/high concentration/high foreign ownership industries than in just the high tariff/high concentration industries.

Table 12

The Level of Product Diversity of Plant[a], Grouped by Employment and Country of Control: 1974 and 1979

PLANT SIZE	HERF4D, 1974		HERF4D, 1979		HERF5D, 1974		HERF5D, 1979	
Employment Group[b]	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.
Number	Group Average[d]		Group Average[d]		Group Average[d]		Group Average[d]	
0 - 50	0.7982	0.8108	0.8031	0.8209	0.7441	0.7672	0.7485	0.7759
51 - 100	0.7239	0.7186	0.7445	0.7468	0.6655	0.6567	0.6872	0.6799
101 - 200	0.6953	0.6925	0.7035	0.7072	0.6197	0.6108	0.6304	0.6322
201 - 300	0.6517	0.6396	0.7186	0.7012	0.5786	0.5572	0.6273	0.6233
301 - 400	0.6828	0.6649	0.6925	0.6713	0.6120	0.5793	0.6018	0.5972
401 - 500	0.6196	0.5924	0.6469	0.6741	0.5472	0.5367	0.5889	0.6278
501 - 1000	0.6193	0.5878	0.6648	0.6581	0.5596	0.5133	0.5887	0.5726
1001 - 2000	0.6370	0.5810	0.6423	0.6584	0.5764	0.5232	0.5806	0.5663
2001 - 3000	0.7381	0.5548	0.6016	0.4543	0.5444	0.5518	0.5269	0.4224
3001 and Up	0.2793	0.5035	0.4090	0.6628	0.2463	0.4548	0.3162	0.5809
Average all plants								
Weighted[c]	0.663	0.620	0.686	0.666	0.598	0.555	0.627	0.590
Unweighted	0.764	0.757	0.788	0.769	0.708	0.689	0.730	0.701

a. Refers to all longform manufacturing plants for which 4 and 5 digit ICC data available.
b. All wage and salaried employees. For 1974, 1970 employees are used.
c. By plant employees as defined in footnote b above.
d. The number of plants classified to each size group, from smallest to largest is as follows:
Canada, 1974 - 8407, 1611, 931, 270, 141, 70, 129, 48, 7, 7;
U.S., 1974 - 944, 542, 537, 236, 138, 77, 140, 46, 6, 12;
Canada, 1979 - 6,668, 1884, 1146, 386, 176, 101, 154, 52, 11, 9;
U.S., 1979 - 879, 518, 539, 257, 125, 87, 150, 52, 7, 10.

Source: Statistics Canada. See Appendix A for details (Vol. 27).

Although the main emphasis in this paper is upon the influence of foreign ownership within an inter-industry framework it is possible to delve further into the influence of foreign ownership by the use of some descriptive statistics and reference to the regression results reported in Tables 8 to 11. The descriptive data is presented in Tables 12 through 16. These tables correspond to Tables 2 through 4, except that product diversity is presented by country of control, which is either U.S. or Canada. In other words, no reference is made to plants owned by non-U.S. foreign firms. Given the overwhelming importance of U.S. foreign investment this does not mark a serious omission.

Caves (1975, Table 5-1, p. 39) showed that for 1973-74 U.S. owned plants in Canada produced a more varied output of manufactured products than their Canadian counterparts in the same size category. This applied to all size groups.[30] Caves' indicator of product diversity was the number of different 4-digit products manufactured in the plant. The size categories in Tables 2 to 4 and 12 to 16 were designed to match those employed by Caves. His results are very similar to those reported in Table 12 for 1974 despite differences in data sources, level of product classification and the measure of product diversity. By 1979 however, at the 4-digit level U.S. plants were more specialist than Canadian plants in 5 out of 10 size categories at the 4-digit ICC level and 4 out of 10 at the 5-digit ICC level of commodity classification.

Table 13

The Level of Product Diversity of Plant[a], Grouped by Employment, Country of Control and Number of 4-Digit ICC Products per Industry (N*): 1974

PLANT SIZE	N* = 1[c], HERF4D		N* = 7[d], HERF4D		N* = 27[e], HERF4D	
Employment Group[b]	Canada	U.S.	Canada	U.S.	Canada	U.S.
Number	Group Average[f]		Group Average[f]		Group Average[f]	
0 - 50	0.8615 (557)	0.8554 (25)	0.7785 (381)	0.8959 (22)	0.8308 (278)	0.8738 (53)
51 - 100	0.8136 (76)	0.7992 (15)	0.7828 (69)	0.8223 (31)	0.7623 (93)	0.7791 (20)
101 - 200	0.9275 (33)	0.7702 (14)	0.7304 (65)	0.7786 (32)	0.6201 (57)	0.6762 (28)
201 - 300	0.8690 (5)	0.7431 (2)	0.6512 (22)	0.7937 (11)	0.5000 (16)	0.7049 (5)
301 - 400	0.8099 (5)	0.9253 (3)	0.6376 (13)	0.7267 (6)	0.6994 (11)	0.5741 (7)
401 - 500	-	0.7931 (1)	0.4902 (6)	0.6385 (3)	0.6863 (2)	0.7209 (3)
501 - 1000	-	-	0.5546 (16)	0.7925 (5)	0.2852 (3)	0.6173 (4)
1001 - 2000	-	-	0.4611 (3)	-	-	-
2001 - 3000	-	-	-	-	-	-
3001 and Up	-	-	-	0.6251 (3)	-	-
Average all plants						
Weighted[g]	--- ---	---	---	---	---	---
Unweighted	--- ---	---	---	---	---	---

a. Refers to all longform manufacturing plants for which 4 digit ICC data available for industries selected.
b. All wage and salaried employees. For 1974, 1970 employees are used.
c. 11 industries fell into this category.
d. 7 industries fell into this category.
e. 3 industries fell into this category.
f. Figure in parenthesis indicate number of plants in each respective employment group. For the last two rows the figures in parenthesis are average plant size.
g. By plant employees as defined in footnote b above.

Source: Statistics Canada. See Appendix A for details (Box 1 and 2).

Table 14

The Level of Product Diversity of Plant[a], Grouped by Employment, Country of Control and Number of 4-Digit ICC Products per Industry (N*): 1979

PLANT SIZE	N* = 1[c], HERF4D		N* = 7[d], HERF4D		N* = 27[e], HERF4D	
Employment Group[b]	Canada	U.S.	Canada	U.S.	Canada	U.S.
Number	Group Average[f]		Group Average[f]		Group Average[f]	
0 - 50	0.8664 (499)	0.9335 (29)	0.7912 (276)	0.8448 (17)	0.8214 (253)	0.8627 (53)
51 - 100	0.8625 (72)	0.9066 (11)	0.8314 (103)	0.8816 (30)	0.7030 (85)	0.7345 (18)
101 - 200	0.8523 (41)	0.8899 (14)	0.7315 (79)	0.8646 (20)	0.6707 (64)	0.8945 (8)
201 - 300	0.8811 (7)	0.9896 (5)	0.7028 (28)	0.7821 (15)	0.6673 (23)	0.7477 (10)
301 - 400	0.7889 (3)	0.9650 (3)	0.7940 (13)	0.6542 (10)	0.6063 (15)	0.9099 (5)
401 - 500	0.9963 (1)	-	0.5681 (7)	0.9807 (3)	0.9135 (7)	0.6405 (2)
501 - 1000	0.5338 (1)	0.9544 (2)	0.5654 (13)	0.7796 (6)	0.4999 (4)	0.6482 (3)
1001 - 2000	-	-	0.4375 (2)	-	0.2735 (1)	-
2001 - 3000	-	-	-	-	-	-
3001 and Up	-	-	0.5521 (3)	0.7258 (2)	-	-
Average all plants						
Weighted[g]	--- ---	---	---	---	---	---
Unweighted	--- ---	---	---	---	---	---

a. Refers to all longform manufacturing plants for which 4 digit ICC data available for industries selected.
b. All wage and salaried employees. For 1974, 1970 employees are used.
c. 14 industries fell into this category.
d. 7 industries fell into this category.
e. 3 industries fell into this category.
f. Figure in parenthesis indicate number of plants in each respective employment group. For the last two rows the figures in parenthesis are average plant size.
g. By plant employees as defined in footnote b above.

Source: Statistics Canada. See Appendix A for details (Box 1 and 2).

Hence, it would appear that U.S. plants were not uniformly more diversified than Canadian plants in 1979 as they were in 1974.

Caves result has been cited by a number of commentators (Daly, 1979, p. 49; Saunders, 1982, p. 473) as suggesting that U.S. plants are more diversified than Canadian plants. Strong conclusions have been drawn, in part, upon the basis of this sort of evidence. In particular it is seen as consistent with the miniature replica effect cited above.

There are a number of difficulties with this interpretation. First, over the period 1974 to 1979 Table 12 shows the result is much more ambiguous. Perhaps as a result of trade liberalization, U.S. plants were able to rationalize on a North American basis and reduce product diversity. Second, as noted above, in comparing product diversity between two plants one should normalize not only for the size of plant but also N*. Tables 13 to 16 attempt to do this for various values of N* using the criteria discussed above under "Plant Size and Multiplant Operations." These tables show that controlling for both N* and plant size, U.S. plants in both 1974 and 1979 are quite frequently more specialist not more diversified than their Canadian counterparts. Indeed, at the 4-digit ICC level it is only for N* = 1 (1974 only) and at the 5-digit ICC level at N* = 25 (both years), N* = 79 (1974 only), that U.S. plants are typically more diversified.[31] It would therefore appear that Caves' findings were the result of U.S.

Table 15

The Level of Product Diversity of Plant[a], Grouped by Employment, Country of Control and Number of 5-Digit ICC Products Per Industry (N*): 1974

PLANT SIZE	N*=3[c], HERF5D				N*=5[d], HERF5D				N*=14[e], HERF5D			
Employment Group[b]	Canada		U.S.		Canada		U.S.		Canada		U.S.	
Number	Group Average[i]				Group Average[i]				Group Average[i]			
0 - 50	0.7317	(21)	0.8447	(27)	0.8235	(78)	0.8896	(28)	0.8382	(77)	0.8682	(11)
51 - 100	0.5514	(8)	0.8073	(13)	0.7511	(13)	0.7655	(2)	0.6759	(11)	0.7240	(9)
101 - 200	0.8921	(7)	0.9152	(5)	0.7005	(5)	0.9194	(1)	0.7089	(10)	0.7934	(9)
201 - 300	0.9221	(1)	-		-		0.7401	(3)	0.3157	(2)	0.9358	(3)
301 - 400	-		-		-		-		-		1.0000	(1)
401 - 500	-		-		-		-		-		-	
501 - 1000	-		-		-		0.5531	(2)	-		-	
1001 - 2000	-		-		-		0.4605	(1)	0.6584	(1)	-	
2001 - 3000	-		-		-		-		-		-	
3001 and Up	-		-		-		-		-		-	
Average all plants												
Weighted[j]	-		-		-		-		-		-	
Unweighted	-		-		-		-		-		-	
PLANT SIZE	N*=25[f], HERF5D				N*=41[g], HERF5D				N*=79[h], HERF5D			
Employment Group[b]	Canada		U.S.		Canada		U.S.		Canada		U.S.	
Number	Group Average[i]				Group Average[i]				Group Average[i]			
0 - 50	0.7237	(316)	0.8826	(5)	0.6370	(789)	0.8590	(24)	0.7715	(142)	0.7578	(54)
51 - 100	0.7465	(161)	0.7307	(19)	0.5666	(111)	0.7809	(13)	0.6933	(61)	0.6876	(18)
101 - 200	0.6599	(87)	0.6375	(14)	0.5180	(60)	0.6807	(5)	0.4851	(26)	0.6454	(21)
201 - 300	0.6917	(23)	0.5328	(6)	0.5352	(15)	0.7194	(3)	0.5656	(2)	0.4547	(5)
301 - 400	0.7962	(13)	1.0000	(1)	0.2989	(7)	0.5592	(5)	0.3859	(5)	0.5639	(7)
401 - 500	1.0000	(3)	-		0.6110	(5)	-		0.4878	(1)	0.4697	(2)
501 - 1000	0.9071	(13)	-		0.6840	(5)	0.5617	(3)	0.1658	(1)	0.7125	(3)
1001 - 2000	0.9912	(6)	-		0.3745	(1)	-		-		-	
2001 - 3000	0.6417	(2)	-		-		-		-		-	
3001 and Up	-		-		-		-		-		-	
Average all plants												
Weighted[j]	-		-		-		-		-		-	
Unweighted	-		-		-		-		-		-	

a. Refers to all longform manufacturing plants for which 4 and 5 digit ICC data available.
b. All wage and salaried employees for 1974, 1970 employees are used.
c. 6 industries fell into this category.
d. 6 industries fell into this category.
e. 5 industries fell into this category.
f. 5 industries fell into this category.
g. 5 industries fell into this category.
h. 2 industries fell into this category.
i. Figure in parenthesis indicate number of plants in each respective employment group. For the last two rows the figures in parenthesis are average plant size.
j. By plant employees as defined in footnote b above.

Source: Statistics Canada. See Appendix A for details (Box 1 and 2).

Table 16

The Level of Product Diversity of Plant[a], Grouped by Employment, Country of Control and Number of 5-Digit ICC Products Per Industry (N*): 1979

PLANT SIZE	N*=3[c], HERF5D		N*=5[d], HERF5D		N*=14[e], HERF5D	
Employment Group[b]	Canada	U.S.	Canada	U.S.	Canada	U.S.
Number	Group Average[i]		Group Average[i]		Group Average[i]	
0 - 50	0.8944 (21)	0.9124 (23)	0.8542 (89)	0.9410 (31)	0.8154 (71)	0.8215 (4)
51 - 100	0.8556 (7)	0.8793 (6)	0.8373 (28)	0.8889 (5)	0.7401 (18)	0.7262 (11)
101 - 200	0.8023 (13)	0.8503 (6)	0.7445 (17)	0.8989 (5)	0.6030 (13)	0.6622 (5)
201 - 300	-	-	0.6984 (3)	-	0.4174 (2)	0.7142 (3)
301 - 400	0.5837 (1)	-	0.6686 (3)	-	-	-
401 - 500	-	-	-	-	0.2894 (1)	-
501 - 1000	-	-	-	0.7164 (2)	-	-
1001 - 2000	-	-	-	0.5342 (3)	-	0.5788 (1)
2001 - 3000	-	-	-	-	-	-
3001 and Up	-	-	-	-	-	-
Average all plants						
Weighted[j]	-	-	-	-	-	-
Unweighted	-	-	-	-	-	-

PLANT SIZE	N*=25[f], HERF5D		N*=41[g], HERF5D		N*=79[h], HERF5D	
Employment Group[b]	Canada	U.S.	Canada	U.S.	Canada	U.S.
Number	Group Average[i]		Group Average[i]		Group Average[i]	
0 - 50	0.7611 (287)	0.7330 (5)	0.6686 (654)	0.8430 (18)	0.7621 (99)	0.7773 (48)
51 - 100	0.7261 (153)	0.6874 (14)	0.5899 (141)	0.7080 (9)	0.6081 (60)	0.7150 (17)
101 - 200	0.6613 (83)	0.6053 (10)	0.5465 (68)	0.5733 (13)	0.6024 (28)	0.6355 (8)
201 - 300	0.5902 (24)	0.5209 (8)	0.6186 (20)	0.8914 (1)	0.8442 (3)	0.6408 (13)
301 - 400	0.8241 (17)	0.6882 (3)	0.5912 (10)	-	0.5036 (6)	0.7160 (4)
401 - 500	0.8115 (9)	-	0.4079 (7)	1.0000 (1)	1.0000 (1)	0.8221 (1)
501 - 1000	0.9067 (17)	1.0000 (3)	0.6065 (4)	0.5103 (1)	0.2666 (1)	0.6247 (3)
1001 - 2000	0.9969 (3)	-	-	0.5244 (1)	-	-
2001 - 3000	0.6047 (2)	-	-	-	-	-
3001 and Up	-	-	-	-	-	-
Average all plants						
Weighted[j]	-	-	-	-	-	-
Unweighted	-	-	-	-	-	-

a. Refers to all longform manufacturing plants for which 4 and 5 digit ICC data available.
b. All wage and salaried employees for 1974, 1970 employees are used.
c. 6 industries fell into this category.
d. 6 industries fell into this category.
e. 5 industries fell into this category.
f. 5 industries fell into this category.
g. 5 industries fell into this category.
h. 2 industries fell into this category.
i. Figure in parenthesis indicate number of plants in each respective employment group. For the last two rows the figures in parenthesis are average plant size.
j. By plant employees as defined in footnote b above.

Source: Statistics Canada. See Appendix A for details (Box 1 and 2).

firms being relatively more concentrated in industries with more products (higher N*) and Canadian firms in industries with fewer products. For the greater number of products, the greater is the level of diversificaiton generally (see Tables 3 and 4). Indeed, Tables 18 and 19 show foreign ownership and the number of products is positively correlated. Thus the greater diversification of foreign controlled firms previously reported is the result of aggregation bias.

This finding combined with that in Tables 8 to 11 -- that U.S. ownership of a plant more often than not increases production run length and reduces product diversity[32] -- suggests that the impact of U.S. foreign investment is ambiguous and the miniature replica effect is not general. To anticipate somewhat this is consistent with the finding in our inter-industry regression results that country of ownership has no statistically significant impact nor does high foreign ownership exacerbate the scale and specialization problems of high tariff/high concentration industries.

<u>Regional Industries</u> There are a number of reasons to postulate the length of production run and diversity may be affected by whether the industry is regional or national. Regional industries offer smaller markets and hence, the imperatives of plant economies will be greater. We should therefore expect greater plant diversity and a negative sign in the regression explaining

diversity. We use the following specification for regional industries.

REG a regional dummy variable taking on the value 1 when the industry is regional, 0 otherwise.

Plant Economies of Scale When plant scale economies are less important, there is less of a tendency to pack plants with products to take account of plant economies:

MESMSD the ratio of domestic disappearance (i.e., domestic production + imports -- exports) to minimum efficient sized plant (MES).

where the estimate of MES is drawn from U.S. data and fully described in Baldwin and Gorecki (1983b). Where this is larger, there will be less pressure to diversify to take advantage of scale economies and thus diversity should be less. Therefore we expect MESMSD to have a positive sign.

4. THE REGRESSION RESULTS: 1970 and 1979

Some Preliminaries

We have defined a relatively large number of independent variables that are determinants of the degree of product diversity and length of production run. In order to make the task of estimation and presentation manageable, we proceeded in the following manner.

The results concerning product diversity are presented first, and are followed by those concerning length of production run. In our discussion of the independent variables, we focus on the effects of groups of variables in order to develop more fully certain aspects of the determinants of product diversity and length of production run. Rather than estimate, present and discuss a regression equation including all of the independent variables, we concentrate on: average plant size, multiplant operations and opportunity to diversify; tariffs, concentration and foreign ownership; and, finally, the trade variables. In each instance we present only the most significant regression results and then summarize the remainder.

The independent variables, together with their means, standard deviations, and expected signs are presented in Table 17 for 119 industries, the maximum number of industries for which data is

Table 17

Means and Standard Deviations of Independent Variables Across 119 Canadian Manufacturing Industries: 1970 and 1979.

Variable	Mean	Standard Deviation	Variable	Mean	Standard Deviation	Expected Sign
AV4D70	0.797	1.265	AV4D79	1.125	2.133	n.a.
AVPLSZ70	6.073	18.482	AVPLSZ79	8.906	35.076	-
AVPLSQ70	375.602	3314.015	AVPLSQ79	1299.338	12,748.648	+
AV5D70	0.286	0.533	AV5D79	0.409	0.939	n.a.
LOG R4D	-1.949	1.045	LOG R4D	-1.949	1.045	+
LOG R5D	-2.978	0.989	LOG R5D	-2.978	0.989	+
PLESTV70	1.422	5.463	PLESTV79	2.165	8.296	-
REG	0.269	0.445	REG	0.269	0.445	-
ADVDM70	0.008	0.022	ADVDM79	0.006	0.017	-
PLESTFV0	1.108	5.245	PLESTFV9	1.343	7.731	-
HVTRCRF0	0.101	0.302	HVTRCRF9	0.092	0.291	-
EXP70	0.129	0.189	EXP79	0.156	0.196	+
INTRA70	0.410	0.301	INTRA79	0.398	0.294	+
FOR70	0.477	0.302	FOR79	0.444	0.293	?
IMP70	0.213	0.195	IMP79	0.255	0.223	?
CA70	0.665	0.573	CA79	0.681	0.592	+
ERP70	0.144	0.167	ERP79	0.127	0.353	-
MPLNT70	0.504	0.929	MPLNT79	0.540	0.931	+
HVTRHCR0	0.160	0.368	HVTRHCR9	0.185	0.390	-
MESMSD70	15.354	19.129	MESMSD79	18.516	21.585	+
CON70	0.563	0.218	CON79	0.556	0.220	+

a. The expected sign refers to product diversity as the dependent variable. Similar signs obtain if length of production run is the dependent variable, but AVPLSZ is now + and AVPLSQ -.

Source: Statistics Canada. See Appendix A for details. (Vol. 22A, Insert).

available for all of the variables. Earlier we defined an independent variable without reference to the year. If it is measured for 1970 the suffix 70 or 0 is added, while for 1979, 79 or 9 is added. In a number of instances, however, data for a year close to 1970 or 1979 had to be used. These are:

Variable	Actual Year Used
ERP79	1978
ADVDM79	1977
INTRA70	1971
EXP70	1971
IMP70	1971
CA70	1971
HERF4D70	1974
HERF5D70	1974
MESMSD70	1972
MESMSD79	1977
PR4D70	1974
PR5D70	1974

In the above cases, it is assumed that the missing value of a particular variable for 1970 and for 1979 is highly correlated with the actual value used. For the 1970 trade variables, we used the estimates of exports (XT) and imports (IM) from 1971, the earliest year for which data were tabulated on an industry basis. Finally, as noted above, the earliest available data for HERF4D, HERF5D, PR5D and PR4D were for the year 1974 not 1970, as was the case for most of the independent variables.

The independent variables are defined over the 119 industry sample, defined earlier. It, in turn, is derived from the universe of 167 4-digit Canadian manufacturing industries. In a small number of instances, data was not available at the 4-digit level but at a somewhat more aggregate level of industry classification, thus necessitating prorating or spreading. Effective tariffs and advertising variables were based on a 122 industry division of the manufacturing sector. The trade data (imports and exports used to derive INTRA, EXP, IMP, CA) needed some minor prorating for 21 4-digit industries. Appendix A provides details of the database.

Although miscellaneous industries have been excluded, it was recognized that a case may be made that some of the remaining industries might be too heterogeneous, or for some other reason might not fit the estimated relationship. Therefore, several additional regressions were run using different criterion for excluding "aberrant" observations (Appendix C provides full details). The only result of note of excluding outliers with product diversity as the dependent variable is to make the trade variables weakly significant in 1970 but not in 1979. For length of production run, outliers are more numerous, resulting in, once again, a marked increase in the significance of the trade variables in 1970 but not in 1979. However, the most important result of excluding outliers for length of production run is to affect the way in which the Eastman/Stykolt effect is felt. However, it still leaves most industries in the HVTRHCR=1 with shorter production runs than other industries characterized by

Table 18

Correlation Matrix Among Independent Variables Across 119 Canadian Manufacturing Industries: 1970

Variable	AV4D70	AVPLSZ70	AVPLSQ70	AV5D70	LOG R4D	LOG R5D	PLESTV70	REG	ADVDM70	PLESTFVO	HVTRCRFO	EXP70
AV4D70	1.000	0.657	0.565	0.927	0.297	0.258	0.286	-0.085	0.060	0.235	0.144	0.131
AVPLSZ70		1.000	0.946	0.790	-0.181	-0.160	0.230	-0.090	-0.015	0.227	0.089	0.273
AVPLSQ70			1.000	0.720	-0.120	-0.090	0.030	-0.055	-0.033	0.036	-0.009	0.242
AV5D70				1.000	0.169	0.227	0.317	-0.086	0.041	0.282	0.208	0.149
LOG R4D					1.000	0.922	-0.067	0.095	-0.112	-0.081	0.060	-0.199
LOG R5D						1.000	-0.041	0.112	-0.132	-0.052	0.106	-0.249
PLESTV70							1.000	0.068	0.160	0.948	0.589	-0.020
REG								1.000	0.127	0.066	-0.077	-0.148
ADVDM70									1.000	0.087	0.181	-0.115
PLESTFVO										1.000	0.633	-0.044
HVTRCRFO											1.000	-0.063
EXP70												1.000
INTRA70												
FOR70												
IMP70												
CA70												
ERP70												
MPLNT70												
HVTRHCRO												
MESMSD70												
CON70												

Variable	INTRA70	FOR70	IMP70	CA70	ERP70	MPLNT70	HVTRHCRO	MESMSD70	CON70
AV4D70	0.057	0.284	-0.041	0.313	0.065	0.419	0.186	-0.216	0.514
AVPLSZ70	0.155	0.230	0.120	0.159	-0.040	0.125	0.067	-0.128	0.314
AVPLSQ70	0.120	0.168	0.133	0.099	-0.113	-0.024	-0.023	-0.062	0.178
AV5D70	0.070	0.283	-0.030	0.299	0.056	0.362	0.230	-0.188	0.498
LOG R4D	-0.125	-0.107	-0.264	0.069	0.044	0.057	0.117	-0.099	0.099
LOG R5D	-0.161	-0.119	-0.268	0.040	0.007	0.082	0.169	-0.081	0.118
PLESTV70	-0.035	0.179	-0.142	0.178	0.465	0.470	0.600	-0.128	0.350
REG	0.037	-0.271	-0.355	0.051	-0.051	0.021	-0.057	0.361	-0.278
ADVDM70	0.006	0.160	-0.215	0.107	0.127	0.118	0.251	-0.048	0.064
PLESTFVO	-0.035	0.245	-0.132	0.143	0.419	0.337	0.487	-0.110	0.279
HVTRCRFO	-0.101	0.275	-0.163	0.170	0.468	0.241	0.768	-0.171	0.396
EXP70	0.248	0.209	0.504	0.469	-0.119	0.105	-0.071	-0.216	0.204
INTRA70	1.000	0.036	-0.017	0.390	-0.182	0.011	-0.065	0.022	0.002
FOR70		1.000	0.320	0.018	0.014	0.086	0.098	-0.358	0.437
IMP70			1.000	-0.308	-0.248	-0.172	-0.159	-0.356	0.212
CA70				1.000	0.132	0.390	0.161	0.032	0.211
ERP70					1.000	0.174	0.522	-0.071	0.113
MPLNT70						1.000	0.394	-0.122	0.509
HVTRHCRO							1.000	0.199	0.450
MESMSD70								1.000	-0.516
CON70									1.000

Source: Statistics Canada. See Appendix A for details. (Vol. 22A, Insert).

similar sized plants. This was confined to 1970, there being little impact in 1979 of excluding outliers.

The variables means presented in Table 17 change very little over time. As expected effective tariffs fall over time. Both imports and exports increase. Average plant size (AVPLSZ) increased substantially over the decade of the 1970's. (Recall that AVPLSZ is measured in 1971 constant dollars). Finally, as noted above, the average number of ICC 5-digit products is approximately triple the average number of 4-digit ICC products.

Tables 18 and 19 present the simple correlations among the independent variables for 1970 and 1979, respectively. Rather than discuss the correlations here, this will be left to the examination of the regression results below. During the discussion, we present the estimated coefficients along with the significance levels for each coefficient. These significance levels are the levels that would have to be adopted in order to reject the null hypothesis that the parameter is zero when a one-tailed test is used. In the following discussion, a variable is referred to as significant when the significance level is 10 per cent or less. Weakly significant variables are those between 10 and approximately 20 per cent. This standard was chosen because in each run all variables are usually included and exclusion of insignificant variables increased the significance levels substantially.

Table 19

Correlation Matrix Among Independent Variables Across 119 Canadian Manufacturing Industries: 1979

Variable	AV4D79	AVPLSZ79	AVPLSQ79	AV5D79	LOG R4D	LOG R5D	PLESTV79	REG	ADVDM79	PLESTFV9	HVTRCRF9	EXP79
AV4D79	1.000	0.730	0.663	0.945	0.239	0.215	0.254	-0.078	0.045	0.191	0.074	0.105
AVPLSZ79		1.000	0.970	0.857	-0.150	-0.125	0.186	-0.072	-0.016	0.183	0.051	0.169
AVPLSQ79			1.000	0.805	-0.112	-0.081	0.011	-0.053	-0.033	0.021	-0.016	0.132
AV5D79				1.000	0.118	0.169	0.286	-0.082	0.027	0.232	0.109	0.105
LOG R4D					1.000	0.922	-0.058	0.095	-0.113	-0.078	0.084	-0.239
LOG R5D						1.000	-0.019	0.112	-0.135	-0.041	0.115	-0.287
PLESTV79							1.000	0.064	0.108	0.915	0.478	-0.045
REG								1.000	0.132	0.094	-0.063	-0.198
ADVDM79									1.000	0.063	0.059	-0.137
PLESTFV9										1.000	0.547	-0.058
HVTRCRF9											1.000	-0.115
EXP79												1.000
INTRA79												
FOR79												
IMP79												
CA79												
ERP79												
MPLNT79												
HVTRHCR9												
MESMSD79												
CON79												

Variable	INTRA79	FOR79	IMP79	CA79	ERP79	MPLNT79	HVTRHCR9	MESMSD79	CON79
AV4D79	0.114	0.305	-0.097	0.335	0.004	0.445	0.160	-0.172	0.464
AVPLSZ79	0.192	0.233	0.040	0.148	-0.003	0.213	0.038	-0.102	0.254
AVPLSQ79	0.173	0.181	0.057	0.069	-0.045	0.106	-0.034	-0.051	0.156
AV5D79	0.119	0.286	-0.079	0.301	0.081	0.401	0.196	-0.151	0.436
LOG R4D	-0.182	- 0.100	-0.259	0.058	0.066	0.088	0.166	-0.110	0.145
LOG R5D	-0.198	- 0.111	-0.258	0.027	0.130	0.110	0.211	-0.092	0.178
PLESTV79	-0.060	0.169	-0.125	0.238	0.470	0.382	0.550	-0.144	0.276
REG	0.063	- 0.265	-0.378	0.080	0.064	-0.020	-0.094	0.328	-0.320
ADVDM79	-0.108	0.215	-0.204	0.153	0.024	0.114	0.108	-0.081	0.051
PLESTFV9	-0.095	0.249	-0.104	0.190	0.477	0.247	0.366	-0.105	0.162
HVTRCRF9	-0.187	0.313	-0.035	0.001	0.371	0.222	0.670	-0.180	0.295
EXP79	0.293	0.172	0.504	0.409	-0.230	0.078	-0.043	-0.228	0.168
INTRA79	1.000	0.058	-0.008	0.346	-0.111	0.060	-0.129	0.122	-0.024
FOR79		1.000	0.281	0.071	-0.050	0.093	0.071	-0.303	0.449
IMP79			1.000	-0.395	-0.067	-0.176	-0.088	-0.360	0.214
CA79				1.000	-0.093	0.383	0.141	0.031	0.195
ERP79					1.000	0.119	0.351	-0.014	-0.048
MPLNT79						1.000	0.444	-0.131	0.540
HVTRHCR9							1.000	-0.253	0.485
MESMSD79								1.000	-0.467
CON79									1.000

Source: Statistics Canada. See Appendix A for details. (Vol. 22).

During the course of our attempts to estimate the influence of average plant size and multiplant operations a problem arose because of the interrelationship between average plant size (AVPLSZ), multiplant operations (MPLNT) and scale economies (MESMSD). MESMSD is almost without exception positive (as predicted) but usually insignificant or weakly significant while AVPLSZ and MPLNT were typically significant when all three were included in the same regression equation (i.e., MESMSD was added to equations 1 and 4 of Tables 20 to 23). If AVPLSZ and MPLNT were removed from the equation MESMSD remained insignificant with length of production run as the dependent variable. However, such was not the case with product diversity as the dependent variable: MESMSD was significant in 1970 but either insignificant or weakly signficant in 1979. Hence it would appear plant size/market size is more appropriately represented by AVPLSZ and MPLNT rather than MESMSD. A further estimation problem developed since a correlation existed between PLESTV and PLESTFV (.705 in 1970 and .701 in 1979). Both in turn were highly correlated with HVTRCR (.78 or greater). To solve this problem PLESTV and PLESTFV are not included in the same regression equations.

A The Determinants of Plant Diversity

Average Plant Size, Multiplant Operations and Opportunity to Diversify

Tables 20 and 21 present the regression analysis for the determinants of product diversity for 1970 and 1979 with the Herfindahl index of product diversity measured at both the 4- and 5-digit ICC level. As expected average plant size (AVPLSZ) is negatively related to product diversity. In addition the rate of increase in product diversity slows as average plant size increases, as indicated by the positive coefficient attached to AVPLSQ. In industries where multiplant operations are prevalent (MPLNT = 1), plants are more specialist than where this is not the case. The opportunity to diversify, measured by log R4D and log R5D, is, as predicted, positively related to product diversity. The results are highly significant for both 1970 and 1979 and for product diversity at both the 4- and 5-digit ICC level of classification.

These results, at an inter-industry level, are broadly consistent with those reported earlier concerning the determinants of plant product diversity within industries. (Tables 8 and 10). In both instances product diversity increases with plant size but at a decreasing rate. However, differences do occur with respect to the multiplant variable, which is usually significant on an inter-industry basis but rarely on an intra-industry basis. One

Table 20

The Determinants of Product Diversity at the 4-Digit ICC, Across 119 Canadian Manufacturing Industries, 1970 and 1979

	1970						1979					
Equation #	(1)		(2)		(3)		(4)		(5)		(6)	
	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign
Constant	0.858	.0000	0.842	.0000	0.836	.0000	0.902	.0000	0.895	.0000	0.894	.0000
Trade and Tariffs												
ERP	0.094	.23	0.224	.01	0.188	.03	-0.059	.09	-0.024	.55	-0.037	.37
CA	0.035	.15	0.029	.22	0.034	.16	0.027	.26	0.024	.32	0.020	.42
IMP	0.070	.37	0.086	.27	0.053	.50	0.011	.87	0.013	.85	0.007	.91
Plant Size and Multiplant												
AVPLSZ	-0.008	.0009	-0.001	.05	-0.002	.03	-0.005	.003	-0.001	.10	-0.001	.09
AVPLSQ	0.00004	.007	-	-	-	-	0.00001	.007	-	-	-	-
MPLNT	0.040	.011	0.046	.004	0.032	.03	0.030	.05	0.027	.08	0.019	.20
Eastman/Stykolt												
PLESTV	-	-	-0.007	.04	-	-	-	-	-0.005	.02	-	-
PLESTFV	-	-	-	-	-0.005	.16	-	-	-	-	-0.004	.10
HVTRHCR	-	-	-0.076	.10	-	-	-	-	-0.013	.74	-	-
HVTRCRF	-	-	-	-	-0.099	.08	-	-	-	-	-0.010	.84
Other												
ADVDM	-0.964	.11	-0.571	.34	-0.857	.15	-1.820	.02	-1.658	.03	-1.803	.02
LOG R4D	0.088	.0000	0.097	.0000	0.095	.0000	0.092	.0000	0.097	.0000	0.097	.0000
REG	-0.020	.50	-0.007	.81	-0.008	.78	0.004	.89	0.012	.68	0.015	.61
FOR	-0.015	.74	-0.016	.73	0.016	.74	0.037	.43	0.035	.46	0.046	.37
$\overline{R}^2$	0.4461	.0000	0.4601	.0000	0.4547	.0000	0.4643	.0000	0.4578	.0000	0.4402	.0000

Note: For each variable the table presents its estimated regression coefficient (Coeff) and level of statistical significance (Sign). The tests of significance are one-tailed.

Source: Statistics Canada. See Appendix A for details. (Vol. 22A).

Table 21

The Determinants of Product Diversity at the 5-Digit ICC, Across 119 Canadian Manufacturing Industries, 1970 and 1979

Equation #	1970						1979					
	(1)		(2)		(3)		(4)		(5)		(6)	
	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign
Constant	0.839	.0000	0.846	.0000	0.834	.0000	0.872	.0000	0.875	.0000	0.873	.0000
Trade and Tariffs												
ERP	0.138	.09	0.283	.003	0.234	.01	-0.081	.03	-0.056	.19	-0.063	.15
CA	0.025	.33	0.020	.42	0.024	.33	0.128	.62	0.011	.68	0.008	.77
IMP	0.118	.16	0.142	.08	0.108	.19	0.056	.44	0.059	.41	0.054	.46
Plant Size and Multiplant												
AVPLSZ	-0.007	.005	-0.001	.12	-0.001	.08	-0.004	.02	-0.001	.06	-0.001	.07
AVPLSQ	0.00003	.02	-	-	-	-	0.00009	.06	-	-	-	-
MPLNT	0.036	.03	0.043	.01	0.029	.07	0.029	.08	0.026	.11	0.021	.18
Eastman/Stykolt												
PLESTV	-	-	-0.006	.06	-	-	-	-	-0.003	.11	-	-
PLESTFV	-	-	-	-	-0.005	.15	-	-	-	-	-0.003	.24
HVTRHCR	-	-	-0.088	.08	-	-	-	-	-0.0007	.85	-	-
HVTRCRF	-	-	-	-	-0.088	.14	-	-	-	-	-0.015	.79
Other												
ADVDM	-1.257	.05	-0.783	.22	-1.129	.07	-2.248	.006	-2.105	.011	-2.221	.007
LOG R5D	0.081	.0000	0.095	.0000	0.091	.0000	0.079	.0000	0.084	.0000	0.084	.0000
REG	0.014	.65	0.025	.42	0.026	.42	0.024	.44	0.030	.35	0.032	.32
FOR	-0.047	.33	-0.047	.32	-0.017	.74	0.021	.67	0.019	.71	0.030	.58
$\bar{R}^2$	0.3729	.0000	0.3991	.0000	0.3861	.0000	0.3579	.0000	0.3504	.0000	0.3424	.0000

Note: For each variable the table presents its estimated regression coefficient (Coeff) and level of statistical significance (Sign). The tests of significance are one-tailed.

Source: Statistics Canada. See Appendix A for details. (Vol. 22A).

explanation is that in the intra-industry regressions we were not able to correct for the regional character of the industry, but we do so in the inter-industry analysis thereby obtaining the hypothesized sign. Or it may be that MPLNT in the inter-industry regression is picking up some other industry specific variable.

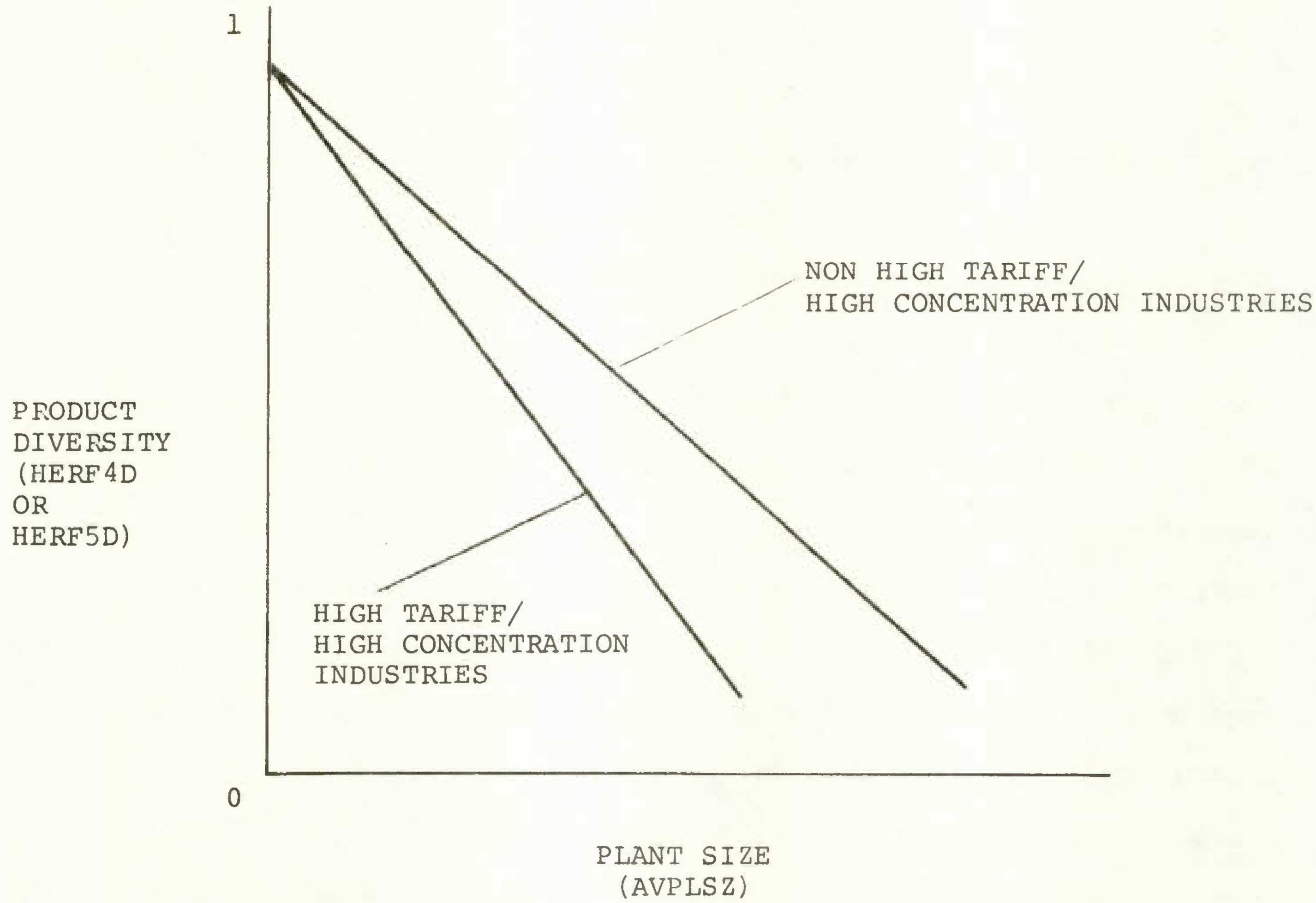
Concentration, Tariffs and Foreign Investment: Testing the Eastman/Stykolt Hypothesis

Equations 2, 3, 5 and 6 of Tables 20 and 21 present the results of regressions that test the Eastman/Stykolt hypothesis as it relates to product diversity. Because of the substantial collinearity between the terms representing high concentration/ high tariffs (HVTRHCR, PLESTV) and high concentration/high tariffs/high foreign ownership (HVTRCRF, PLESTFV), two estimated regressions are presented -- one regression equation with each set of interaction terms entered separately. In each regression equation only AVPLSZ and PLESTV or PLESTFV is included, the corresponding squared terms being omitted, due to the high degree of collinearity between each set.

The Eastman/Stykolt hypothesis is couched in terms of the combined influence of high tariffs and small market oligopoly behaviour. In the regression equations this is captured by PLESTV and HVTRHCR. The coefficient attached to PLESTV is always negative and statistically significant at the 4-digit ICC level and is still significant or weakly significant at the 5-digit ICC

FIGURE 2

PLANT SIZE, PRODUCT DIVERSITY, TARIFFS AND CONCENTRATION



level. Thus for a given plant size in high tariff/high concentration industries, product diversity will be substantially higher compared to similar sized plants elsewhere in the manufacturing sector. The intercept/shift parameter HVTRHCR is usually negative, as predicted, but only significant in 1970. Hence the relationship between plant size product diversity, high concentration and high tariffs is that represented by Figure 1 equation 4 for 1970, but in 1979 the relationship is that depicted in Figure 2. These results provide support for the Eastman/ Stykolt hypothesis with respect to product diversity and hence strengthen the results already derived for relative plant scale. (Baldwin and Gorecki, 1983b).

A comparison of equations 2 and 3 as well as 5 and 6 in Tables 20 and 21 permit us to draw inferences about whether high foreign ownership in high tariff/high concentration industries, exacerbates the product diversity problem. The coefficients and their significance for the high tariff/high concentration/high foreign ownership variant of the Eastman/Stykolt hypothesis are much the same as those reported for the high tariff/high concentration variant, but the level of significance, particularly 1979, is lower. These results suggest that high foreign ownership does not add to the existing impact of high tariffs and high concentration variables.

Tables 20 and 21 also permit us to test whether tariffs and foreign ownership have an impact outside high tariff/high concentration and high tariff/high concentration/high foreign ownership industries. In general FOR has no impact, either in 1979 or 1970, with product diversity measured at the 4- or 5-digit ICC level. This is consistent with the intra-industry relationships, as discussed above. However, such is not the case with respect to effective tariffs, ERP. In 1970 ERP had a positive impact that was, with one exception, significant; in 1979 ERP was negatively related to product diversity but it was not consistently significant. These results suggest the direction of the effect of tariffs has changed over the decade 1970-1979. In 1970, high tariffs were associated with less diversity, by 1979 with more diversity than average. This latter result accords more with traditional hypotheses.

The reason for the difference may be linked with the changing nature of tariff protection. It may have been that industries receiving protection did not require it, and they lost protection in 1966-1970. This explanation is supported by an examination of the correlation matrices in Tables 18 and 19. In 1970, the effective rate of tariff protection (ERP) was positively related to comparative advantage -- a surprising result. By 1979, the correlation was negative. Thus in 1970, ERP may be catching some of the export effect while in 1979, its effect is purged of this extraneous influence. It is also possible that the effect of tariffs is being felt in the number of products variables. In 1970, tariffs and the number of products are positively correlated, in 1979, the opposite is true. To the extent higher tariffs led to a larger number of products, the effect of tariffs may have been captured by the R4D and R5D variables in 1970.

Although not reported in tabular form, an attempt was made to see whether concentration had an impact outside high tariff/high concentration industries. This was accomplished by adding CON, the proportion of industry shipments accounted for by the largest four enterprises, to equations 2 and 5 of Tables 20 and 21. The expected impact of concentration is ambiguous: on the one hand, concentration is positively related to MPLNT (0.509 in 1970 and 0.540 in 1979) suggesting a positive relationship with product diversity but, on the other hand, concentration is positively related to plant size (.314 in 1970, .254 in 1979) suggesting a negative relationship with product diversity. However, despite this ambiguity as to predicted sign CON is usually (the only exception is for 1970 at the 4-digit ICC level) negative and statistically significant. However, in all of these instances AVPLSZ becomes either weakly significant or insignificant. Hence, one cannot disentangle the impact of CON from AVPLSZ.

Trade Effects

Tables 20 to 21 also permit us to draw inferences concerning the impact of IMP and CA upon product diversity. In general these variables are positive but statistically insignificant. The only exception is CA which is weakly significant at the 4-digit ICC level for 1970 and IMP which is significant or weakly significant in 1970 at the 5-digit ICC level. Experimentation with EXP and INTRA yielded no significant results: EXP was positive but insignificant while INTRA was negative in 1970, positive in 1979, but insignificant in both years. Hence trade had no direct impact upon product diversity, with the exception of some weak evidence for 1970 suggesting trade flows resulted in greater specialization. Indirect effects via average plant size do exist, as our previous investigations show. (Baldwin and Gorecki, 1983b).

Other Variables

Table 20 to 21 include variables that have not been discussed so far but a priori seem likely to be related to product diversity. ADVDM had, as expected, a significant negative relationship with product diversity in both 1970 and 1979 at both levels of the industrial commodity classification. The regional character of the industry did not affect industry plant level diversity.

B Length of Production Run

Tables 22 and 23 correspond exactly with Tables 20 and 21, respectively, except that the dependent variable is length of production run -- PR4D measured at the 4-digit level of the ICC, PR5D measured at the 5-digit level of the ICC. The same problems as mentioned above concerning MPLNT and MESMSD as well as PLESTV and PLESTFV also apply in considering length of production run. It should be noted that the dependant variables PR4D and PR5D and the opportunity to diversify variables AV4D and AV5D both contain average plant size (AVPLSZ) in the numerator. In addition AVPLSZ is included separately as an independent variable. As such the standard warning about about spurious regression results applies.

While the earlier descriptions of the hypothesized effects of the independent variables referred to the diversity index, the same effects can be expected with regards to the length of production run. If a variable is expected to increase diversity, it negatively affects the dependent variable HERF4D. But since average production run is just average plant size divided by numbers equivalent derived from HERF4D, the average production run will be decreased as well - providing that average plant size is not affected in a reverse fashion. In an earlier paper (Baldwin and Gorecki, 1983b), we examined the determinants of Canadian plant size relative to the U.S. A set of independent variables similar to those adopted here was used to explain sub-optimality

Table 22

The Determinants of Production Run Length at the 4-Digit ICC, Across 119 Canadian Manufacturing Industries, 1970 and 1979

	1970						1979					
Equation #	(1)		(2)		(3)		(4)		(5)		(6)	
	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign
Constant	-0.169	.68	-0.431	.30	-0.417	.32	0.827	.13	0.178	.73	0.877	.0000
Trade and Tariffs												
ERP	1.659	.06	3.506	.0007	2.966	.003	-2.907	.0000	-2.008	.0007	-2.087	.0006
CA	0.497	.07	0.425	.11	0.441	.10	-0.045	.91	0.059	.87	0.139	.70
IMP	1.462	.10	1.410	.10	1.262	.15	0.470	.65	0.404	.68	0.483	.62
Plant Size and Multiplant												
AVPLSZ	0.390	.0000	0.349	.0000	0.349	.0000	0.391	.0000	0.467	.0000	0.407	.0000
AVPLSQ	-0.0003	.06	-	-	-	-	0.0002	.01	-	-	-	-
MPLNT	0.138	.46	0.531	.006	0.414	.02	0.336	.17	0.248	.30	0.158	.48
Eastman/Stykolt												
PLESTV	-	-	-0.095	.008	-	-	-	-	-0.148	.0000	-	-
PLESTFV	-	-	-	-	-0.100	.0007	-	-	-	-	-0.154	.0000
HVTRHCR	-	-	-0.292	.56	-	-	-	-	1.194	.04	-	-
HVTRCRF	-	-	-	-	0.241	.70	-	-	-	-	1.828	.02
Other												
ADVDM	9.733	.14	11.020	.10	7.880	.23	15.444	.18	15.182	.16	13.678	.21
AV4D	0.931	.0000	0.900	.0000	0.889	.0000	0.918	.0000	0.889	.0000	0.877	.0000
REG	-0.674	.05	-0.583	.09	-0.543	.11	-0.798	.08	-0.421	.33	-0.374	.39
FOR	-0.580	.28	-0.217	.68	-0.067	.90	-0.094	.90	0.220	.76	0.113	.88
$\bar{R}^2$	0.9606	.0000	0.9625	.0000	0.9620	.0000	0.9876	.0000	0.9893	.0000	0.9892	.0000

Note: For each variable the table presents its estimated regression coefficient (Coeff) and level of statistical significance (Sign). The tests of significance are one-tailed.

Source: Statistics Canada. See Appendix A for details. (Vol. 23).

in plant size. The effect of these independent variables on plant size was such that whether we discuss diversity, or average plant size, these independent variables should be expected to have the same sign in the production run as in the diversity equation.

Average Plant Size, Multi Plant Operations and Opportunity to Diversify

Tables 22 and 23 accord with our expectations concerning the relationship between AVPLSZ and AVPLSQ and length of production run for 1970 and to a lesser extent for 1979. AVPLSZ is always statistically significant and positively related to length of production run, in both 1970 and 1979; AVPLSQ is negatively related and significant in 1970 but positive in 1979. However, the variable only has significance in the case of PR4D. Hence, larger plant sizes have longer production runs but while the rate of increase declines as plant size increases in the early 1970s, this is no longer the case in the late 1970's.

Whatever was constraining the maximum length of production run for large plants seems to have decreased by 1979. This is broadly consistent with the intra-industry regression results (Tables 9 and 11). Although the balance of the evidence suggested in 1970 that the rate of increase in length of production run with respect to plant size declined on an intra-industry basis, by 1979 the preponderance was much less.

Table 23

The Determinants of Production Run Length at the 5-Digit ICC, Across 119 Canadian Manufacturing Industries, 1970 and 1979

Equation #	1970						1979					
	(1)		(2)		(3)		(4)		(5)		(6)	
	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign
Constant	-0.288	.42	-0.556	.11	-0.581	.00	0.729	.13	0.338	.48	0.272	.57
Trade and Tariffs												
ERP	1.836	.02	3.568	.0001	3.226	.0001	-3.133	.0000	-2.524	.0000	-2.431	.0000
CA	0.520	.03	0.449	.05	0.470	.04	-0.038	.91	0.097	.77	0.156	.64
IMP	1.478	.05	1.448	.05	1.223	.09	0.242	.79	0.211	.81	0.216	.81
Plant Size and Multiplant												
AVPLSZ	0.344	.0000	0.321	.0000	0.322	.0000	0.361	.0000	0.380	.0000	0.381	.0000
AVPLSQ	-0.0002	.19	-	-	-	-	0.00004	.48	-	-	-	-
MPLNT	0.227	.17	0.553	.0006	0.453	.003	0.376	.09	0.395	.07	0.361	.08
Eastman/Stykolt												
PLESTV	-	-	-0.089	.003	-	-	-	-	-0.083	.002	-	-
PLESTFV	-	-	-	-	-0.096	.002	-	-	-	-	-0.096	.0009
HVTRHCR	-	-	-0.364	.40	-	-	-	-	0.697	.19	-	-
HVTRCRF	-	-	-	-	-0.073	.89	-	-	-	-	0.929	.18
Other												
ADVDM	4.087	.47	5.660	.31	2.587	.64	1.893	.85	1.239	.90	0.015	.999
AV5D	1.347	.002	1.329	.001	1.248	.002	1.678	.0001	1.624	.0001	1.598	.0001
REG	-0.428	.15	-0.330	.25	-0.294	.30	-0.523	.20	-0.330	.41	-0.288	.47
FOR	-0.212	.64	0.078	.86	0.323	.48	0.462	.49	0.760	.24	0.811	.24
$\bar{R}^2$	0.9638	.0000	0.9671	.0000	0.9672	.0000	0.9858	.0000	0.9868	.0000	0.9870	.0000

Note: For each variable the table presents its estimated regression coefficient (Coeff) and level of statistical significance (Sign). The tests of significance are one-tailed.

Source: Statistics Canada. See Appendix A for details. (Vol. 23).

The incidence of multiplant operations increases length of production run. This variable is typically more significant in 1970 than 1979 perhaps because it is more highly correlated with AV4D and AVPLSZ in 1979. The intra-industry results were more ambiguous on this point. The coefficient on the variable opportunity to diversify -- AV5D and AV4D -- is always highly statistically significant and positive.

The results of the diversity and the production run equation can be combined to shed light on the difference between small and large plants. The results from Tables 20 and 21 show that as plant size increases, so too does product diversity. However, the coefficients attached to AVPLZ in Tables 22 and 23 indicate that as plant size doubles the average length of production run increases by only 50 per cent[33], depending upon the level of ICC classification and year. This is roughly comparable to the evidence provided earlier in Tables 3 and 4 where N*, the number of products per industry, is held constant. There it is clear that as average plant size increases, so to does average length of production run. On the other hand, so does product diversity. If growth of plant size occurred only via the addition of products with shorter than the existing average production run, the coefficient on AVPLZ should be negative. Thus larger plant size is achieved not only by producing longer product lines of existing products but also by diversifying into new products.

Concentration, Tariffs and Foreign Investment: Testing the Eastman/Stykolt Hypothesis

The Eastman/Stykolt hypothesis finds considerable support: in high tariff/high concentration industries, although production run length increases with plant size, it does so at a much lower rate than for other manufacturing industries. In other words, for a given plant size in high tariff/high concentration industries, production run length is shorter than a similar sized plant located elsewhere in the manufacturing sector. This is consistent with our earlier result that plants in high tariff/high concentration industries, other things equal, were more diversified.

The shift paramenter HVTRHCR is negative and insignificant in 1970 but positive in 1979 and either significant (4-digit ICC) or weakly significant (5-digit ICC). Hence, in 1979 the positive coefficient in HVTRHCR serves to offset some of the impact of the coefficient PLESTV. Further analysis showed that the mean level of AVPLSZ was such that the positive impact of HVTRHCR had been largely eliminated but the underlying distribution of plant sizes was such that the Eastman/Stykolt impact led to shorter production runs in only 30 to 40 per cent of the industry in the high tariff/ high concentration category.[34] Hence, in 1979 we find support for the Eastman/Stykolt hypothesis with respect to production run length, but less than for 1970.

We also tested whether high foreign ownership changed the impact of high concentration and high tariffs. A comparison of equation 2 to 3 and 5 to 6 in Tables 22 and 23 indicated that the addition of the high foreign ownership constraint in the regression analysis results in a set of conclusions similar to those for the variant of the Eastman/Stykolt hypothesis with just high tariffs/ high concentration. The differences between the coefficients with and without foreign ownership are so small that little significance should be attached to them. Foreign ownership, therefore, exacerbates neither the diversity nor the production run problem associated with high tariffs in concentrated industries.

Tables 22 and 23 permit us to explore whether ERP, and FOR have an impact outside of high tariff/high concentration industries. FOR has essentially no impact. ERP has a significant positive impact in 1970 but a significant negative impact in 1979. This reversal in sign is like that found earlier for HERF4D and HERF5D. It might also be of interest to see whether CON exerts an independent influence outside high tariff/high concentration industries. Our earlier discussion concerning product diversity suggested that the impact of CON would, in general, be ambiguous. That discussion also applies, mutatis mutandis, to length of production run. To test this CON was added to equations 2 and 5 of Tables 22 to 23. In 1979 CON was highly insignificant while in 1970 positive and either significant (.08, PR4D) or weakly significant (.11 PR5D) in 1970. However, unlike the results recorded when product diversity was the dependent variable AVPLSZ retains its significance. Hence, there is only limited evidence that concentration exerts a posititive influence on length of production run, offsetting the impact in HVTHCR=1 industries.

Trade Effects

Our final set of variables are those connected with trade. Both CA and IMP result in longer production runs, although it is only in 1970 that a significant relationship is observed. The coefficient of EXP is positive but never highly significant.[35] INTRA is incorrectly signed but also never highly significant. Hence, the impact of trade is confined to the two variables CA and IMP, and then primarily to 1970.

Other Factors

Tables 22 and 23 include a number of other variables which are not discussed above, but were thought to be related to production run length. The advertising variable (ADVDM) is never significant. While advertising led to more plant level product diversity, it did not decrease the length of production run. Thus it must be said that advertising allowed firms to essentially expand by adding products without loss of product line economies. The regional variable is negative, but generally not very significant.

5. REGRESSION RESULTS: CHANGES IN THE 1970's

Introduction

In this section of the paper our primary focus is on the relationship between changes in product diversity, and the independent variables introduced and discussed above. A number of issues need to be resolved before regression analysis can be conducted. These are discussed in the next part of the paper.

Some Methodological Issues

In this section we discuss three issues. The first is the correct specification of the dependent variable -- percentage point change (i.e., HERF4D79-HERF4D70), percentage changes (i.e., (HERF4D79-HERF4D70)/(HERF4D70)), and closing the gap between actual relative plant scale and that attainable (i.e., (HERF4D79-HERF4D70)/(1/N*) -- and the independent variables -- levels, percentage point changes, percentage changes and interactions between levels and changes. The second issue is the appropriate specification of the relationship of the determinants of changes in product diversity. The third issue is the set of variables that should be included in the regression analysis.

The dependent variable employed here is the percentage point change in the level of product diversity over the period 1970 to 1979. More formally we define:

HERF4DIF = HERF4D79-HERF4D70

HERF5DIF is defined in an exactly analogous manner. The dependent variable is specified in this form because of our desire to make this section comparable with the regression results reported above. Implicit in this view is that moving from a product diversity index of 0.50 to 0.40 is as important as a movement of from 1.00 to 0.90 over the same period. Since average product run length is just average plant size multiplied by the Herfindahl index, this is equivalent to saying we weight equally similar changes in product run length -- a not unreasonable approach.

The independent variables will be defined in an analogous manner to HERF4DIF, as the first difference of the 1979 and 1970 values. Several of the independent variables are defined in such a way that they experience no change over the period 1970 to 1979 -- REG, R4D, R5D -- and hence will not be included in the analysis of the determinants of changes in product diversity. In terms of notation the letters DIF or DF will replace the year to indicate the first difference. Hence, for example, IMP70 is replaced by IMPDIF.

The specification of the appropriate relationship for the determinants of changes in product diversity is straightforward in light of the estimating equations chosen for the previous regressions and the adoption of changes in the product diversity index as the dependent variable. The appropriate specification is:

$$HERF4DIF = b_0 + b_1 \Delta X$$

where ΔX is a vector of first differences of the variables that were previously found to be significant at .10 or greater. The earlier results did show a certain non-linearity -- at least with respect to the Eastman/Stykolt hypothesis. Therefore, it is postulated that the effect of changes in some independent variables -- plant size, tariffs, foreign ownership and concentration -- will depend upon whether the industry initially fell into that subset where the Eastman/Stykolt effect was most relevant. Thus, the estimating equation becomes:

$$HERF4DIF = b_0 + b_1 \Delta X + b_2 H + b_3 \Delta Y \cdot H$$

where H is a dummy variable set equal to 1 when the industry falls in the high concentration/high tariff or high concentration/high tariff/high foreign ownership category in 1970 and ΔY is the subset, which is referred to above, of the ΔX variables.

The independent variables selected for the regression analysis were those that were significant in either 1970 or 1979 (with either product diversity or length of production run as the dependent variable) and exhibited a change between these years. The first differences of variables previously included in our analysis are shown in Table 24 together with their means, standard deviations and expected signs. The remaining variables in Table 24 require more explanation.

The testing of the Eastman/Stykolt hypothesis in the first difference form requires the creation of several new variables. First, a group of variables are introduced to reflect the previous finding that the effect of plant size depended upon whether an industry was protected by high tariffs and was highly concentrated:

PLESTFVDF = HVTRCRFO · AVPLSZDF -- plant size change for high effective tariffs/high foreign ownership/ high concentration industries.

PLESTVDF = HVTRHCRO · AVPLSZDF -- plant size change for high effective tariff/high concentration industries.

Table 24 shows that in all cases, on average, AVPLSZ increased over the time period 1970 to 1979. If we confine our attention to high tariff/high concentration/high foreign ownership industries

Table 24

Means and Standard Deviations of Independent Variables Across 119 Canadian Manufacturing Industries Used in Analysis of Changes in Product Diversity and Length of Production Run 1970-1979.

VARIABLE	MEAN	STD DEV	EXPECTED SIGN[a]
ADVDMDF	-.002	0.005	-
IMPDIF	.043	0.079	-
CADIF	.016	0.289	+
EHCFDF	-.010	0.405	-
EHCDF	-.012	0.407	-
FORHCVDF	.000	0.036	+
CONFCVDF	-.000	0.028	?
CONHCVDF	.000	0.032	?
ERPDIF	-0.017	0.410	-
AVPLSZDF	2.833	17.027	-
PLESTVDF	0.591	2.999	-
PLESTFVDF	0.511	2.959	-
AV4DIF	0.328	0.943	+
AV5DIF	0.123	0.431	+
PLNTDIF	0.002	0.144	+

a. The expected sign refers to changes in product diversity as the dependent variable. Similar signs obtain if changes in length of production run is the dependent variable, but APLSZDF is now + not -.

Source Statistics Canada. See Appendix A for details (Vol. 30).

(i.e., HVTRCRFO = HVTRHCRO = 1) then the mean value of AVPLSZDF is as follows (with standard deviation in parenthesis):

Category	Mean Value of AVPLSZDF
high tariff/high concentration	3.703 (6.835)
high tariff/high concentration/ high foreign ownership	5.067 (8.290)

The values are much larger than for the 119 industry sample (Table 24). This is not surprising since we know from our earlier discussion that AVPLSZ is larger in HVTRHCRO = HVTRCRFO = 1 industries and assuming fairly constant growth rates across industries, then this is likely to result in a larger absolute increase in AVPLSZ in such industries than for the 119 sample treated as a whole. A negative relationship is expected to be found between AVPLSZ in high tariff/high concentration industries and the dependent variable.

Changes in effective tariffs in industries characterized by both high tariffs and high concentration or high concentration/high foreign ownership may have a different impact than where such conditions do not occur. Hence, we define, EHCFDF = ERPDIF · HVTRCRFO -- effective tariff rate change for high effective tariff/high concentration/high foreign ownership industries.

EHCDF = ERPDIF · HVTRHCRO -- effective tariff rate change for high effective tariff/high concentration industries.

Table 24 shows such industries experienced declines in tariffs in the decade of the 1970's. If we confine our attention solely to the high tariff/high concentration/high foreign ownership industries, (rather than the mean of this variable calculated across all industries as in Table 24) then the mean of ERPDIF is as follows (with standard deviation in parenthesis):

Mean Value for Tariff Changes

Category	
high tariff/high concentration	-.076 (1.039)
high tariff/high concentration/ high foreign ownership	-.104 (1.327)

Since the average value of ERPDIF across the 119 industry sample was -.017 it can be seen that these industries experienced substantially higher declines in tariffs. In general we would expect a negative relationship between changes in tariffs in the high tariff/high concentration/high foreign ownership industries and in HERF4D.

The cross-section results previously presented also suggested that foreign ownership had little influence outside industries characterized by both high foreign ownership and high tariffs/high concentration. Hence we define:

> FORHCVDF = FORDIF · HVTRCRFO -- foreign ownership changes in high effective tariff/high concentration/high foreign ownership industries.

As Table 24 shows, such industries experienced little change in the share of foreign ownership during the 1970's, while the average value of FORDIF across the 119 industry sample declined slightly -.033. If we confine our attention only to those industries characterized by high concentration/high foreign ownership/high tariffs, then FORDIF is on average .003 (.119) where the standard deviation is in parenthesis. In view of our earlier results it is difficult to predict the sign of the relationship between FORHCVDF and HERF4DIF.

Finally, our earlier results suggested that concentration had little impact on product diversity, or it was difficult to disentangle the impact of CON and AVPLSZ. However, when high concentration was combined with high tariffs or high tariff/high foreign ownership, the relationship was negative. In order to capture this we introduce:

CONFCVDF = CONDIF · HVTRCRFO -- change in concentration in high concentration/high foreign ownership/high effective tariff industries.

CONHCVDF = CONDIF · HVTRHCRO -- change in concentration in high concentration/high effective tariff industries.

As noted above, it is difficult to predict the relationships between product diversity and concentration. Table 24 shows that concentration in such industries changes very little. Indeed, if we confine our attention to such industries, the average value of CONDIF (with the standard deviation in parenthesis) is as follows:

Mean Value for Concentration Change

Category	
high tariff/high concentration	.001 (.082)
high tariffs/high concentration/ high foreign ownership	-.004 (.092)

The only other variable included in Table 24 that requires an explanation is PLNTDIF -- the difference in the number of plants operated per unconsolidated enterprise. It is difficult to design an appropriate first difference variable taking into account changes in the degree of multiplantness, using MPLNT, a zero one variable, as the basis. As noted above whether MPLNT or PLNT, the number of plants per firm, is used in the regression results presented in Tables 20 to 23, the outcome was much the same. Hence, PLNTDIF is used instead of MPLNTDIF.

So far our attention has been confined to considering changes to product diversity. Much the same discussion applies, mutatis mutandis, to the case where the dependent variable is the change in length of production run. The dependent variable is defined in an analogous manner to HERF4DIF:

PR4DIF = PR4D79-PR4D70

also: PR5DIF = PR5D79-PR5D70

The only new independent variable that was not used in the diversity equation is changes in AV4D or AV5D. As shown in Table 24 both of these variables increase during the 1970's, but substantially less than AVPLSZDF. It is expected that these variables will have a positive relationship with changes in the length of production run.

Regression Results

Table 25 presents the correlation matrix among the explanatory variables, while the regression results are included in Table 26. As will be immediately apparent from the latter table no regression results are presented with either HERF4DIF or HERF5DIF as the dependent variable. This reflects the fact that when all the

Table 25

Correlation Matrix Among Independent Variables Across 119 Canadian Manufacturing Industries: 1979-1970

	IMPDIF	CADIF	AVP4D	AVP5D	EHCDF	CONFCVDF	FORHCVDF	EHCFDF	PLESTFVDF	AVPLSZDF	PLESTVDF
IMPDIF	1.000	-0.182	-0.295	-0.273	0.001	0.194	0.060	0.001	-0.111	-0.224	-0.119
CADIF		1.000	0.107	0.076	0.136	-0.333	-0.188	0.138	0.325	0.009	0.329
AVP4D			1.000	0.964	-0.041	-0.049	0.007	-0.037	0.173	0.812	0.198
AVP5D				1.000	0.021	-0.077	-0.049	0.023	0.187	0.915	0.204
EHCDF					1.000	-0.069	-0.397	0.999	0.006	0.005	0.005
CONFCVDF						1.000	0.412	-0.069	-0.357	-0.060	-0.352
FORHCVDF							1.000	-0.398	-0.132	-0.024	-0.131
EHCFDF								1.000	0.006	0.005	0.006
PLESTFVDF									1.000	0.150	0.983
AVPLSZDF										1.000	0.150
PLESTVDF											1.000
ADVDMDF											
CONHCVDF											
ERPDIF											
HVTRHCRO											
HVTRCRFO											
PLNTDIF											

	AVPLSZDF	PLESTVDF	ADVDMDF	CONHCVDF	ERPDIF	HVTRHCRO	HVTRCRFO	PLNTDIF
IMPDIF	-0.224	-0.119	0.027	0.154	-0.024	-0.028	-0.043	-0.020
CADIF	0.009	0.329	-0.082	-0.268	0.130	0.026	0.085	-0.093
AVP4D	0.812	0.198	-0.024	-0.004	-0.041	0.074	0.076	-0.034
AVP5D	0.915	0.204	-0.011	-0.038	0.020	0.087	0.101	0.001
EHCDF	0.005	0.005	0.023	-0.052	0.992	-0.069	-0.076	0.290
CONFCVDF	-0.060	-0.352	0.110	0.883	-0.069	-0.030	-0.039	0.220
FORHCVDF	-0.024	-0.131	-0.147	0.364	-0.394	0.022	0.029	0.047
EHCFDF	0.005	0.006	0.015	-0.061	0.992	-0.060	-0.078	0.299
PLESTFVDF	0.150	0.983	-0.028	-0.319	0.009	0.398	0.518	-2.281
AVPLSZDF	1.000	0.150	0.018	-0.047	0.001	0.022	0.044	0.071
PLESTVDF		1.000	-0.068	-0.266	0.008	0.454	0.502	-0.246
ADVDMDF			1.000	0.053	0.028	-0.242	-0.149	-0.091
CONHCVDF				1.000	-0.051	0.012	-0.040	0.228
ERPDIF					1.000	-0.063	-0.072	0.288
HVTRHCRO						1.000	0.768	-0.018
HVTRCRFO							1.000	-0.108
PLNTDIF								1.000

Source: Statistics Canada. See Appendix A for details. (Vol. 30).

relevant explanatory variables[36] are included in the regression equation the overall explanatory power of the regression equation was not statistically significant from zero. Nevertheless further investigation suggested that IMPDIF and, to a lesser extent AVPLSZDF were positively and signficantly associated with HERF4DIF and HERF5DIF.[37] The lack of concrete results may be accounted for by the small change in product diversity -- the mean value of HERF4DIF across the 119 industry sample was 0.028, HERF5DIF 0.026. The corresponding standard deviations were 0.068 and 0.082, respectively. Alternative formulations of the relationship yielded no major improvements.[38]

Turning our attention to the regression results in Table 26 (equations 2 and 4) we see that changes in the length of production run are positively associated with changes in plant size. However, in high tariff/high concentration industries increases in the length of production run are smaller than for a given sized increase in plant size elsewhere in the manufacturing sector (i.e., the coefficient attached to PLESTVDF is highly significant at both the 4- and 5-digit ICC level and negative). The coefficient attached to HVTRHCR, although positive is insignificant. These results are consistent with the cross-section results and confirm the importance of the Eastman/Stykolt effect.

A decline in tariffs (ERPDIF) resulted in an increase in the length of production run irrespective of whether the industry was

Table 26

The Determinants of Changes in the Length of Production Run at the 4- and 5-Digit ICC, Across 119 Canadian Manufacturing Industries: 1970-1979

	4-Digit ICC				5-Digit ICC			
Equation #	(1)		(2)		(3)		(4)	
	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign
Constant	-0.024	.79	-0.029	.75	0.086	.35	0.092	.33
Trade and Tariffs								
ERPDIF	-2.460	.05	-1.869	.16	-2.237	.09	-2.032	.14
CADIF	0.084	.75	0.074	.78	0.129	.64	0.140	.61
IMPDIF	1.544	.10	1.684	.07	1.123	.24	1.189	.22
Plant Size and Multiplant								
AVPLSZDF	0.611	.0001	0.608	.0001	0.454	.0001	0.454	.0001
PLNTDIF	-0.445	.41	-0.179	.74	1.192	.03	1.149	.04
Eastman/Stykolt								
PLESTVDF	-	-	-0.225	.0001	-	-	-0.126	.0001
CONHCVDF	-	-	2.865	.22	-	-	1.127	.64
EHCDF	-	-	1.035	.44	-	-	0.929	.51
HVTRHCR	-	-	0.232	.29	-	-	0.234	.31
PLESTFVDF	-0.236	.0001	-	-	-0.135	.0001	-	-
CONFCVDF	2.080	.49	-	-	2.605	.40	-	-
EHCFDF	1.771	.17	-	-	1.056	.43	-	-
FORHCVDF	2.897	.21	-	-	-2.839	.23	-	-
HVTRCRF	0.481	.08	-	-	0.465	.09	-	-
Other								
ADVDMDF	6.465	.66	-2.022	.89	14.341	.34	18.154	.23
AV4DIF	0.647	.0001	0.709	.0001	-	-	-	-
AV5DIF	-	-	-	-	1.856	.0001	1.893	.0001
$\bar{R}^2$	0.9959	.0001	0.9959	.0001	0.9929	.0001	.9926	.0001

Note: For each variable the table presents its estimated regression coefficient (Coeff) and level of statistical signficance (Sign). The tests of significance are one-tailed.

Source: Statistics Canada. See Appendix A for details (Vol. 30).

in the high tariff/high concentration category or not. However a problem of interpretation arose because of the high correlation between ERPDIF and EHCDF. Attempts to resolve this problem[39] increased the significance of ERPDIF but did not yield a uniform sign of any signifcance on EHCDF -- it is negative and significant for the 4-digit equation, but positive and insignificant for the 5-digit equation. Hence, during the seventies falling tariffs have led to longer production runs, with only limited evidence the impact was somewhat greater in high tariff/high concentration industries than elsewhere. This should be contrasted with our earlier finding (Baldwin and Gorecki, 1983b) that decreasing tariffs only affect changes in average plant scale relative to the U.S. plant size in high tariffs/high concentration industries.

Changes in comparative advantage had a positive but insignificant impact upon length of production run changes, but IMPDIF was positive and, at least at the 4-digit ICC level, significant. Hence, increasing imports decreased diversity and increased the length of production run. In our earlier paper (Baldwin and Gorecki, 1983b) increases in IMPDIF resulted in a decline in larger Canadian plants relative to the size of larger U.S. plants. The results, taken together, suggest that Canadian plants, when facing import competition, become smaller and carve specialist niches in the market place, rather than add even more products to offset the loss in plant scale economies resulting from declining sales in their primary product lines.

Of the remaining variables AV4DIF and AV5DIF are both, as predicted, positive and significant. PLNTDIF is insignificant with HERF4DIF as the dependent variable, but positive and significant with HERF5DIF as the dependent variable. Such a difference is consistent with the cross section results (Tables 22 and 23), since MPLNT is nearly always significant and positive in Table 23, but only for two equations for 1970 in Table 22. Finally ADMDMDF is positive but insignificant.

Equations 1 and 3 of Table 23 introduce the high tariff/high concentration/high foreign ownership variant of the Eastman/Stykolt hypothesis. The results are essentially the same as those in equations 2 and 4, respectively, with two exceptions: ERPDIF is now statistically significant rather than just weakly significant;[40] and HVTRCRF is significant unlike HVTRHCR. This latter result deserves some comment. The positive coefficient in HVTRCRF goes some way to offsetting the negative impact of the coefficient on PLESTFVDF. On average, however, this is not the case for the twelve industries in the high tariff/high concentration/high foreign ownership category. Nevertheless the underlying distribution of plant size differences over the 1970's means that only one-third of the industries actually had shorter production runs than for similar sized increases in plant size elsewhere in the manufacturing sector. Hence, high foreign ownership appears to ameliorate somewhat the impact of high tariffs/high concentration.

In sum, the regression for the determinants of changes in the length of production run over the 1970's are broadly consistent with, and hence strengthen, the cross section regression analysis in Tables 22 and 23. The importance of plant size and the Eastman/ Stykolt effect are confirmed, although the effect of foreign ownership in high tariff/high concentration industries lessens the Eastman/Stykolt effect. Tariff rate reductions over the 1970's lead to increased production run length.

6 SUMMARY AND CONCLUSION

Coming to grips with product diversity and length of production run, often considered to be the most important cause of Canada's scale and specialization problems, is a particularly difficult task. Questions have to be answered concerning the most appropriate index for measuring product diversity and production runs as well as the product classification system. These are not questions that are easy to answer. While the index of diversity used here and the consequent length of production run have some grounding in commonly accepted underlying cost functions of a plant, the classification system for defining the number of products produced may not adequately differentiate between products with important associated cost differences. However, we have used two quite detailed levels of commodity classification. This provides a test of the sensitivity of the results since they prove robust under the alternate specifications.

An examinination of product diversity and the length of production run at the plant level -- where the scale and specialization problem is considered to be most acute -- requires that we take into account both plant size and the maximum number of products across which a plant can allocate its output -- denoted by N*. This latter number is approximated by the number of products classified to the primary industry of the plant.

The evidence suggests that over the period 1974 to 1979 that the average Canadian plant became more specialized and increased its average length of production run. Nevertheless the level of product diversity fell well short of the maximum attainable. The increase in the specialization index was quite small compared with the substantial increase in length of production run. Hence, as average plant size increased -- measured in 1971 constant dollars -- plants raised the output of their existing set of products, with some increase in specialization.

Our study of diversity at the plant level was taken a step further by the introduction of information on the country of control of the plant -- Canadian, U.S. and other foreign owned. If plants are grouped only on the basis of plant sze, in 1974 Canadian owned plants across the manufacturing sector as a whole were unequivocally more diversified than their similar sized U.S. counterparts in almost every size grouping, but by 1979 this was less pronounced. The finding for 1974 accords with Caves result for approximately the same time period. However, when account of N* as well as plant size is taken, these findings are not replicated. Indeed, in the preponderance of cases, U.S. plants are more specialist than Canadian. It would therefore appear that Caves' findings were the result of U.S. firms being relatively more concentrated in industries with more products and Canadian firms in industries with fewer products. For the greater number of products the greater is the level of diversity in general and this is probably the reason that earlier studies found Canadian plants more specialized than U.S. plants.

Regression techniques were employed to assess the importance of various determinants of product diversity and length of production run. Such techniques were utilized within two frameworks. First, an attempt was made to assess intra industry determinants. Regression equations were estimated for each industry with a limited number of independent variables -- plant size, plant size squared, a multiplant variable and some plant ownership characteristics. Second, product diversity was assessed on an inter-industry basis, with the aforementioned variables plus a number of others, all at the industry level. In general, the intra- and inter-industry regression results were broadly consistent with one another. The major exception was the multiplant variable, which had an ambiguous impact on an intra-industry basis but was usually positive and significant on an inter-industry basis.

Our attempt to explain product diversity and length of production run provides numerous insights into the process of diversification and specialization. Plant size was positively associated with product diversity and length of production run. In 1970 as the plant got larger, the increase in diversity and length of production run slowed, as presumably scale economies became exhausted and the advantage of additional products disappeared. However, by 1979 there was some evidence that the rate of increase of production run did not decline with plant size. Furthermore, multiplant operations were associated with specialization in the inter-industry analysis. Hence, where demand and cost conditions warranted, firms were building an extra plant to produce a specialist output, rather than crowding all of the firm's output into a single plant.

Attempts were made to separate the influence of market size from plant size upon product diversity and length of production run. These attempts were not successful. The variable used for this purpose was the size of the Canadian market deflated by an estimate of MES. Nevertheless our earlier research (Baldwin and Gorecki, 1983b) showed that larger market size resulted in larger average plant size relative to MES. Thus market size results indirectly in increased specialization and longer production runs.

In high tariff/high concentration industries production runs are shorter and product diversity greater, for a given sized plant, than where such conditions do not obtain. This evidence is supportive of the Eastman/Stykolt view that high concentration and high tariffs adversely impact upon Canada's scale and specialization problems. High foreign ownership does not add to the existing impact of high tariffs and high concentration.

Outside high tariff/high concentration/high foreign ownership industries, foreign ownership per se had no impact on product diversity and length of production run while greater concentration resulted in increased specialization and lengthening of production runs. However, in the case of product diversity it was not possible to disentangle the impact of plant size and concentration. Effective tariffs outside high tariff/high concentration/ high foreign ownership industries resulted in increased diversity (reduced length of production) in 1979, but decreased product diversity and increasing length of production run in 1970. The relationship between tariffs and product diversity and length of production run accords with traditional views for 1979 but not 1970. This result may be linked to the changing nature of tariff protection, which in 1970 was, surprisingly, positively related to comparative advantage, but by 1979 was negatively related. Thus in 1970 effective protection may have been catching some of the impact of comparative advantage.

Trade variables often had a significant impact upon product diversity and length of production run in 1970 but not 1979. In industries where imports were significant and/or Canada had a comparative advantage, specialization was greater and product runs longer. In our research on relative plant scale, (Baldwin and Gorecki, 1983b) comparative advantage had a positive effect on relative plant scale and imports a negative effect. Hence it would appear that the impact of imports is to lead to small specialist plants rather than highly diversified inefficiently small operations. Why this influence should have disappeared by 1979 needs further study.

An attempt was made to model the determinants of changes in product diversity and length of production run during the 1970's. The results for length of production run are broadly consistent with and hence strengthen the cross-section results summarized here. The importance of plant size and the Eastman/Stykolt effect are confirmed, although the effect of foreign ownership in high tariff/high concentration/high foreign ownership industries lessens the impact of high tariffs/high concentration. Tariff rate reductions over the 1970s lead to increased length of production run at the 4-digit ICC level. Increases in imports raise length of production run, but changes in comparative advantage had no measurable impact. Only increasing imports (positive impact) and average plant size (also positive impact) had any impact upon changes in product diversity, perhaps reflecting the small movement in this variable over the 1970s.

The tariff results, both in this and our accompanying papers, deserve further comment. In our investigation of relative plant scale (Baldwin and Gorecki, 1983b), we also found that the tariff rate alone did not have the expected sign in 1970 but that it did in 1979. The results then of the two analyses are compatible. In 1970, tariffs increased plant scale but also decreased diversity.

In 1979, they had the hypothesized effect of negatively affecting plant scale and increasing diversity. This result, along with the confirmation of the Eastman/Stykolt effect found in both cases, shows that modeling the effects of the tariff is a complex exercise. The effects of high tariffs depends upon other factors. The accompanying two papers clearly show that one of these factors is the existence of imperfect markets -- or markets where concentration is high. But the shift in sign of the general tariff effect in both studies -- with the Eastman/Stykolt effect held constant -- suggests there are still factors other than imperfect markets that determine whether tariff rates affect plant scale and plant diversity.

Part of the difficulty of isolating the tariff effect is a statistical one that partially relates to the fact that tariffs are probably not exogenously determined. If the variance of tariff rates across industries is entirely unrelated to other variables, then the effect of this variable would not be confused with that of others. But the literature on the political economy of tariff rates suggest this is not the case. In an accompanying study, we have examined the determinants of tariff protection and have discovered not only a high degree of correlation with other variables in our equations, but more importantly a significant change over the 1970's as the changes of the Kennedy Round were gradually implemented.

Of particular interest in the analysis done of tariffs and tariff changes was our finding that tariffs were negatively related in a significant way to the disadvantage small firms suffered relative to large firms in 1970 but not in 1979 - where the disadvantage was measured as relative value added per worker of small to large firms. Thus, in 1970, tariffs were higher where cost pressures would not have been forcing smaller firms to become larger. There were, therefore, in 1970 a number of high tariff industries where the Eastman/Stykolt effect should not have been felt; however, by 1979, this was no longer the case. As such, it is not surprising to find that in 1970, tariffs generally did not exert a negative effect on plant scale but that they did in 1979. Equally, it is where the cost pressures for relatively larger scale plant are operable that the pressures for greater diversification are greatest. Thus it is to be expected that if the relative plant scale effect was not found in 1970, the diversification effect would also not surface - but that if the former occurred by 1979, so would the latter. In this sense then, the results from the two papers are consistent.

In addition, our analysis revealed that tariffs in 1970 were positively related to the importance of multi-establishment enterprises but that this relationship was no longer significant in 1979. As the results of the diversity equations presented in Tables 20 and 21 indicate, the multiplant nature of an industry tends to be strongly associated with greater plant specialization.

Therefore, it is perhaps not surprising that effective tariffs caught some of this effect in 1970 but that by 1979 when effective tariffs were no longer significantly associated with the multiplant variable used in the tariff study, effective tariffs had the expected effect of increasing, not decreasing, diversity.

It may, therefore, be concluded that much of the earlier concern with plant scale as opposed to diversity was not misplaced. For the diversity problem is not separate from, but is closely related to, the scale problem. It is the scale variables that are the primary determinant of diversity. Trade and tariff variables are felt indirectly through the scale variables. This conclusion is, however, subject to the caveat expressed earlier about the interpretation attached to the number of products variables (R4D and R5D) used to standardize each industry for potential diversity. Should these variables not reflect technical factors but be influenced by tariffs, then diversity could be directly influenced by trade variables in a way that these results do not reveal. Notwithstanding this, our results are relatively powerful in the area of the Eastman/Stykolt effect. Our results suggest high tariffs/high concentration do result in "excessive" diversity and shorter production runs, while foreign ownership has little measurable impact, either in general or in high concentration/high tariff industries.

Appendix A

Data Base: Sources and Definitions

The study of product diversity and length of production run draws upon a special data base assembled at Statistics Canada which brings together many series from different parts of the organization. Several features should be noted of the resultant data base. First, several of the series are unpublished and available for only a limited number of years. Second, the data base consisted of all observations for a given variable, no matter whether the particular observation is confidential within the meaning of the Statistics Act or not. For example, if there were only two firms in an industry, Statistics Canada would not publish concentration ratios for such industries. (However, as noted in the text, although the authors had access to such a data base all the material presented in this discussion paper was vetted carefully for confidentiality disclosure).

The Statistics Canada data are based upon the 1970 4-digit SIC, which divides the manufacturing sector into 167 industries. However, in a number of instances, series were provided at a more aggregative level of classification. Two systems were used. First, data series derived from input-output tables used a classification system that divided the manufacturing sector into 122 industries. Second, in a number of instances, such as the

R&D statistics, the 3-digit level of classification, which divides the manufacturing sector into 112 industries, was used. Typically all the 4-digit constituent industries of a given input/output or 3-digit industry are assumed to have an equal value for the data series provided, which are typically ratios. Exceptions are noted in the text. Table A-1 provides the three levels of industry classification and a concordance.

The remainder of the appendix consists of a detailed description and definition of the variables used in the paper. Since, in many instances, the series are not published we refer to the unit or division within Statistics Canada from where the data was derived. Unless otherwise stated the variable is defined at the 4-digit level of classification and is available for 1970 and 1979.

ADVDM — is the advertising/sales ratio for consumer non-durable goods industries, 0 otherwise. The advertising/sales ratio was provided by the Structural Analysis Division of Statistics Canada, from the Input/Output tables (i.e., the industry classification used in Col. (3) in Table A-2). The underlying data for the ratio on advertising have been collected at the company[1] level by a 1974 Survey. If the company produced output in only one industry then the advertising expenditures were attributed to that industry, otherwise, they were split among the various industries in which the company produced. Modification of this ratio, from information provided by CALURA (Corporation and Labour Union Returns Act) and Business Finance Data, were applied to other years. Data were available for ADVDM for 1975 rather than 1970.

AV4D — average plant size (AVPLSZ) divided by the number of 4-digit ICC products classified to a 4-digit SIC industry. This variable is defined for 162 of the 167 industries. See AVPLSZ and N4D for further details.

AV5D — average plant size (AVPLSZ) divided by the number of 5-digit ICC products classified to a 4-digit SIC industry. This variable is defined for 162 of the 167 industries. See AVPLSZ and N5D for details.

AVPLSZ — average plant size, defined in 1971 constant dollars, is value of industry shipments divided by the number of plants classified to the industry. Industry shipments is measured for total activity (see VS) and the price index is gross output (see GPINX). Industry shipments and number of plants per industry are taken from the Manufacturing and Primary Industries Division.

AVPLSQ — is simply AVPLSZ squared. See AVPLSZ for details.

CA — is one plus (exports minus imports divided by the sum of exports plus imports). The import and export data was provided by the External Trade Division, Trade of Canada, Statistics Canada. The import data is collected by Canadian Customs. The Custom's values are identical to the selling prices for most transactions, with exceptions occuring for transactions among company affiliates where adjustments are made such that the Custom's value may exceed company transfer prices. Imports are measured free on board (f.o.b.) which is the price as exported from the home base and does not include transportation costs. Some imports from the U.S., however, are purchased on a delivered basis and their prices will reflect an allowance for transportation. Exports are recorded at the values declared on export documents which reflects the actual selling price (and in the case of non-arm's length transactions at the transfer price used for company accounting purposes). Most exports are valued at the place in Canada where they are loaded onto a carrier for export.

The trade data are collected at the commodity level and were aggregated to the 4-digit SIC (industry) classification by the External Trade Division. Typically a commodity is allocated completely to the industry to which it is primary.

A number of approximations or adjustments had to be made to the data supplied by External trade. First, in a number of cases, the data for a given 4-digit SIC was not presented in the raw data supplied. This required different sorts of approximations, depending on the nature of the "missing" data. For the 21 industries concerned the details are as follows:

SIC	APPROXIMATION	SIC	APPROXIMATION
1831	A	3241	C
1832	A	3242	C
1871	B	3243	C
1872	B	3511	C
1880	B	3512	C
2391	A	3541	B
2392	A	3542	B
2611	B	3549	B
2619	B	3791	C
3031	C	3799	C
3039	C		

A = Prorating 3-digit trade data to 4-digit level on basis of 4-digit industry sales (e.g., data supplied for 1830, which when used was to generate observations for 1831 and 1832).

B = Data provided at 3-digit level and for some of constituent 4-digit industries. The 3-digit trade is prorated in the same way as A (e.g., data was provided for 1870 and 1871. The 1870 data was then prorated to 1871 and 1872).

C = Same as B except data were provided for all of constituent 4-digit industries, within a 3-digit industry. In other words the residual that could not be allocated to particular 4-digit industries is prorated from the 3-digit industry as in A.

In the case of approximation C (9 of 21) the prorating was often minor because it is only the unallocated residual at the 3-digit level which is a problem. In other words, apart from 4 type A approximations and 8 type B, which may be somewhat crude, the data set should be a close match at the 4-digit.

Second, for one industry exports exceeded domestic production by such a margin (180 per per cent in 1971) to suggest that the classification of export commodities to that 4-digit industry was incorrect. Further investigation suggested one commodity should be relocated. This was confirmed in conversations with responsible persons within Statistics Canada.

The import and export data were available for 1971 rather than 1970. In estimating IMP and EXP the 1971 data was converted to 1970 dollars using the gross output price index. See GPINX for further details.

CON is the proportion of industry shipments accounted for by the four largest enterprises. This was provided by the Manufacturing and Primary Industries Division.

ERP is the effective tariff in an industry. The variable was estimated by the Structural Analysis Division from input/output data (i.e., industry classification used in col. (3) in Table A-2) and 1978 is the latest year for which the variable is available. The variable is calculated to take into account exports, indirect taxes and subsidies in an industry. It was estimated using the Wilkinson and Norrie (1975) definition of effective tariff protection. More specifically the basic equation is:

$$G_j = \frac{V_j' - V_j}{V_j'}$$

where V_j' is the value-added/unit of output under protection and V_j is the value-added/unit of output after protection has been removed.

The equation estimated was:

$$\frac{\left(1-\sum_{i=1}^{n} a_{ij}\right) - \left(\frac{1+b_j t_j}{1+t_j}\right) - \left(\sum_{i=1}^{n-2} \frac{a_{ij}}{1+ti}\right)}{1 - \sum_{i=1}^{n} a_{ij}}$$

where: a_{ij} (the input coefficient) is the value of the ith input into the jth industry as a proportion of the value of the jth industry's output, at protected prices; t_i is the nominal tariff rate of the commodity; t_j is the nominal tariff rate of the jth industry; and b_j is the proportion of industry output exported.

To account for the impact of indirect taxes and subsidies the input coefficients from the input/output tables are summed from 1 to n-2. In the Wilkinson and Norrie study the tobacco and alcohol industries were excluded because import duties and excise taxes could not be separated. The data used here excluded all excise taxes and hence these industries are included.

In the input/output tables imports are defined to be the producers values which excludes costs, insurance, freight and import duties at the Canadian border. Because imports are measured f.o.b. it was necessary for the effective rate of protection to calculate estimates of transportation and insurance charges. Exports are valued at producer prices and all values in the input/output tables are measured at current prices. The producer price is the selling price at the boundary of the producing establishment excluding taxes.

EXP — is the proportion of domestic production (i.e., VS) that is exported. See CA for further details.

FOR — is the proportion of industry shipments (i.e., VS) accounted for by foreign owned enterprises. An enterprise is defined as foreign controlled if there is effective foreign control, although the percentage of stock owned by a foreign corporation may be less than 50 per cent. The data was supplied by Multinational Enterprise Division.

GPINX — The Gross Output Price Index for an industry was provided by the Industry Product Division of Statistics Canada and is estimated from the data provided in the Census of Manufacturers from shipments of commodities from an industry and from the industry selling price index that is available for most commodities. The commodities without a selling price index are grouped with 'similar' commodities to provide an estimated price index. The Gross Output Price Index is computed for the majority of the industries at the 4-digit level.

HERF4D — The Herfinadahl index of <u>plant</u> diversity can be defined as

$$PHERF4D = \sum_{i=1}^{N} Si^2$$

where Si is the proportion of the plant's shipments classified to the Nth 4-digit ICC commodity. For the <u>industry</u>, HERF4D, consists of

$$HERF4D = \sum_{j=1}^{m} Rj, PHERF4D_j,$$

where m is the number of plants in the industry and Rj is the jth plant's share of total industry shipments. In other words, HERF4D is simply the weighted average of plant diversity using shipments as weights. In the text, however, HERF4D is sometimes used to refer to PHERF4D. The context makes it clear when this is the case. HERF4D and PHERF4D are available for 1974, in a machine readable form, not 1970. Although machine readable product data is available for 1972 and 1973, Statistics Canada personnel stated that 1974 was the first year that the data could be considered dependable. (In Economic Council of Canada, 1983, p. 123, it is incorrectly stated that 1973, not 1974, data was used in measuring product diversity).

HERF (and PHERF) are available for only "long-form" establishments (i.e., those that account for about 96 per cent of shipments in the manufacturing sector, Statistics Canada, 1979, p. 10) and those industries which have ICC products classified to them (those industries which have no ICC products classified to them are, to a large extent, finishing operations or primarily custom work, thus making specification of standard well defined products difficult). This led to the exclusion of six industries. Data was derived in the Manufacturing and Primary Industry Division. See N4D for further details.

HERF5D — Defined analogously to HERF4D except for the 5-digit ICC. See N5D for further details.

HVTRHCRF — is a dummy variable that is equal to one when concentration (CON), effective tariff protection (ERP) and foreign ownership (FOR) are high (where these variables are greater than their respective means), 0 otherwise. See CON and ERP for further details.

HVTRHCR — is a dummy variable which is equal to one when both concentration (CON) and effective tariff protection (ERP) are greater than their respective means and 0 otherwise. (See CON and ERP).

IMP — is imports as a proportion of domestic disappearance, where the latter is domestic production (i.e., VS) minus exports plus imports. See CA for discussion of source of export and import data.

VINTRA — ((XT + IM) - absolute value (XT - IM))/(XT + IM). See CA for discussion of source of XT and IM.

MESMSD — is the ratio of domestic disappearance to USMES. Domestic disappearance is calculated as the total activity value of shipments (i.e., VS) plus total imports minus total exports. Statistics Canada (1979, pp.38-39) suggests total activity is most appropriate when comparing Canada (the numerator) with the U.S. (the denominator) census data. Note that the denominator is defined for 1972 and

1977, rather than 1970 and 1979. See USMES and VS for further details.

MPLNT — a dummy variable which takes on the value 1 when the average number of plants per unconsolidated enterprise (PLNT) is greater than the mean across 141 of the 167 manufacturing industries (i.e., excluding the miscellaneous industries). Data from the Manufacturing and Primary Industries Division. See PLNT for further details.

N* — See N4D and N5D.

N4D — the number of 4-digit ICC (Industrial Commodity Classification) commodities per 4-digit SIC (Standard Industrial Classification) industry. Note that N* is also used to represent N4D. Five industries had no 4-digit ICC commodities classified to them. As noted under HERF4D this is a reflection of the particular type of industry concerned -- finishing operations and custom work. Section 2 of the text under "Product Level Classificaiton" discusses the ICC in further detail. See Statistics Canada (1973) for further details.

N5D — The same discussion applies as that above concerning N4D except that N5D is at the 5-digit ICC level.

N5DUS — The number of 5-digit products per industry using the product counts from the corresponding U.S. industry or industries. The U.S./Canada industry concordance is presented in Baldwin and Gorecki (1983b, Table A-1, pp. 107-120) while U.S. Department of Commerce (1978) provides details of the U.S. system of product classification.

N7DUS — The same discussion applies as that above concerning N5DUS except that N7DUS is at the 7-digit level of classification.

PHERF4D — This is defined in HERF4D. Note that when the regression results concerning the determinants of PHERF4D are presented in Tables 8 and 10 the corresponding set of independent variables are defined in the text and will not be repeated here. TSH, TSHSQ and NOEST are from the Manufacturing and

	Primary Industries Division while OCON and USCON are from the Multinational Enterprise Division.
PHERF5D	This is defined in HERF5D. The same comments made under PHERF4D, mutatis mutandis, apply to PHERF5D.
PLESTFV	HVTRCRF•AVPLSZ. See HVTRCRF and AVPLSZ for further details.
PLESTV	HVTRHCR•AVPLSZ. See HVTRCRF and AVPLSZ for further details.
PLNT	the total number of unconsolidated enterprises classified to an industry divided by the number of plants classified to an industry. Data from Manufacturing and Primary Industries Division.
PPR4D	Plant shipments (TSH) divided by PHERF4D. Like PHERF4D, PPR4D is a variable defined for the plant rather than the industry. See PHERF4D for details.
PPR5D	Plant shipments (TSH) divided by PHERF5D. Like PHERF5D, PPR5D is a variable defined for the plant rather than the industry. See PHERF5D for details.
PR4D	AVPLSZ•HERF4D. See AVPLSZ and HERF4D for details.
PR5D	AVPLSZ•HERF5D. See AVPLSZ and HERF5D for details.
R4D	1/N4D. See N4D for details.
R5D	1/N5D. See N5D for details.
R5DUS	1/N5DUS. See N5DUS for details.
R7DUS	1/N7DUS. See N7DUS for details.
REG	is a regional dummy taking on a value of 1 when the industry was classified regional and 0 otherwise. The industries were classified as regional using Department of Consumer and Corporate Affairs (1971) concentration study with a small number of additions.

RELDIV4D (1-HERF4D)/(1-(1/N4D)). See HERF4D and N4D for details.

RELDIV5D (1-HERF5D)/(1-(1/N5D)). See HERF5D and N5D for details.

USMES is the average shipments of the largest U.S. plants which account for the top 50 per cent of industry shipments. It is based upon U.S. census data for 1972 and 1977, supplied by R. Caves of Harvard University. Conversion to Canadian currency was via the average noon spot rates for 1972 and 1977 as published by the Bank of Canada, while the price index used to convert these data to 1970 and 1979 respectively was GPINX. See GPINX and Baldwin and Gorecki (1983b, Appendix A, pp. 96-126) for further details.

VS is total activity value of shipments which encompasses manufacturing and non-manufacturing activities. It is the net selling values at the reporting establishments and excludes discounts, returns, allowances, sales taxes, excise duties and transportation charges by common carriers. The unsold portion at year end of consignment shipments in Canada is treated as inventory and not as shipments, but all shipments to foreign countries for which the form B13 "Customs Export Entry" has been completed are treated as shipments. Resale is included in the total value of shipments and is classified as non-manufacturing activity. The data is taken from the Manufacturing and Primary Industries Division.

FOOTNOTES TO APPENDIX A

1 A company "is the legal entity" whereas an enterprise is "a company or a family of companies which as a result of common ownership, are controlled or managed by the same interests." (Statistics Canada, 1979, pp. 16 and 17 respectively). An unconsolidated enterprise refers to an enterprises' activities within a particular industry, while the consolidated enterprise refers to all of the enterprises' activities, no matter where they are located.

Table A-1

Concordance Between 4-digit Standard Industrial Classification, 3-digit SIC and Input/Output Classification.

4-DIGIT S.I.C. CODE (1970)	Manufacturing Industries	INPUT/ OUTPUT	3-DIGIT S.I.C.
(1)	(2)	(3)	(4)
	1 - FOOD AND BEVERAGE INDUSTRIES		
1011	Slaughtering and meat processors	016	101
1012	Poultry processors	017	101
1020	Fish Products industry	019	102
1031	Fruit and Vegetable canners and preservers	020	103
1032	Frozen fruit and vegetable processors	020	103
104	Dairy products industry	018	104
105	Flour and breakfast cereal products industry	022	105
106	Feed industry	021	106
1071	Biscuit manufacturers	023	107
1072	Bakery Products	024	107
1081	Confectionary manufacturers	025	108
1082	Cane and beet sugar processors	026	108
1083	Vegetable oil mills	027	108
1089	Miscellaneous food processors, n.e.s.	028	108
1091	Soft drink manufacturers	029	109
1092	Distilleries	030	109
1093	Breweries	031	109
1094	Wineries	032	109
	2 - TOBACCO PRODUCTS INDUSTRIES		
151	Leaf tobacco processors	033	151
153	Tobacco products manufacturers	034	153
	3 - RUBBER AND PLASTICS PRODUCTS INDUSTRIES		
162	Rubber products industries	036	162
1623a	Tire and tube manufacturers	036	162
1624a	Rubber footwear manufacturers	035	162
1629a	Miscellaneous rubber products manufacturers	037	162
165	Plastics fabricating industry, n.e.s.	038	165
	4 - LEATHER INDUSTRIES		
172	Leather tanneries	039	172
174	Shoe factories	040	174
175	Leather glove factories	041	175
1792	Boot and shoe findings manufacturers	042	179
1799	Miscellaneous leather products manufacturers	042	179

5 - TEXTILE INDUSTRIES

181	Cotton yarn and cloth mills	043	181
182	Wool yarn and cloth mills	044	182
1831	Fibre and filament yarn manufacturers	045	183
1832	Throwster, spun yarn & cloth mills	045	183
184	Cordage and twine industry	048	184
1851	Fibre processing mills	046	185
1852	Pressed and punched felt mills	050	185
186	Carpet, mat and rug industry	051	186
1871	Cotton & jute bags manufacturers	054	187
1872	Canvas products manufacturers	053	187
188	Automobile fabric accessories industry	055	188
1891	Thread mills	047	189
1892	Narrow fabric mills	049	189
1893	Embroidery, pleating & hemstitching manufacturers	055	189
1894	Textile dyeing and finishing plants	052	189
1899	Miscellaneous textile industries, n.e.s.	055	189

6 - KNITTING MILLS

231	Hosiery mills	056	231
2391	Knitted fabric manufacturers	057	239
2392	Other knitting mills	057	239

7 - CLOTHING INDUSTRIES

2431	Men's clothing factories	058	243
2432	Men's clothing contractors	058	243
2441	Women's clothing factories	058	244
2442	Women's clothing contractors	058	244
245	Children's clothing industry	058	245
246	Fur goods industry	058	246
248	Foundation garment industry	058	248
2491	Fabric glove manufacturers	058	249
2492	Hat and cap industry	058	249
2499	Miscellaneous clothing industries, n.e.s.	058	249

8 - WOOD INDUSTRIES

2511	Shingle mills	059	251
2513	Sawmills and planing mills	059	251
252	Veneer and plywood mills	060	252
2541	Sash, door & other millwork plants, n.e.s.	061	254
2542b	Hardwood flooring plants	061	254
2543	Manufacturers of pre-fabricated buildings (woodframe construction)	061	254
256	Wooden box factories	062	256
258	Coffin and casket industry	063	258
2591	Wood preservation industry	064	259
2592	Wood handles and turning industry	064	259
2593	Manufacturers of particle board	064	259
2599	Miscellaneous wood industries, n.e.s.	064	259

9 - FURNITURE AND FIXTURE INDUSTRIES

2611	Furniture re-upholstery & repair shops	065	261
2619	Household furniture manufacturers, n.e.s.	065	261
264	Office furniture manufacturers	066	264
266	Miscellaneous furniture & fixtures manufacturers	067	266
268	Electric lamp and shade manufacturers	068	268

10 - PAPER AND ALLIED INDUSTRIES

271	Pulp and paper mills	069	271
272	Asphalt roofing manufacturers	070	272
2731	Folding carton & set-up box manufacturers	071	273
2732	Corrugated box manufacturers	071	273
2733	Paper & plastic bag manufacturers	071	273
274	Miscellaneous paper converters	072	274

11 - PRINTING, PUBLISHING AND ALLIED INDUSTRIES

286	Commercial printing	073	286
287	Platemaking, typesetting & trade bindery industry	074	287
288	Publishing only	073	288
289	Publishing & printing	073	289

12 - PRIMARY METAL INDUSTRIES

291	Iron & steel mills	075	291
292	Steel pipe & tube mills	076	292
294	Iron foundries	077	294
295	Smelting & refining	078	295
296	Aluminum roll, casting and extruding	080	296
297	Copper & copper alloy rolling, casting and extruding	081	297
298	Metal rolling, casting & extruding, n.e.s.	082	298

13 - METAL FABRICATING INDUSTRIES (EXCEPT MACHINERY AND TRANSPORTATION EQUIPMENT INDUSTRIES)

301	Boiler and plate works	083	301
302	Fabricated structural metal industry	084	302
3031	Metal door and window manufacturers	085	303
3039	Ornamental & architectural metal industry, n.e.s.	085	303
3041	Metal coating industry	086	304
3042	Metal stamping & pressing industry	086	304
305	Wire & wire products manufacturers	087	305
306	Hardware, tool & cutlery manufacturers	088	306
307	Heating equipment manufacturers	089	307
308	Machine shops	090	308
309	Miscellaneous metal fabricating industries	091	309

14 - MACHINERY INDUSTRIES (EXCEPT ELECTRICAL MACHINERY)

311	Agricultural implement industry	092	311
315	Miscellaneous machinery & equipment manufacturers	093	315
316	Commercial refrigeration & air conditioning equipment manufacturers	094	316
318	Office & store machinery manufacturers	095	318

15 - TRANSPORTATION EQUIPMENT INDUSTRIES

321	Aircraft & aircraft parts manufacturers	096	321
323	Motor vehicle manufacturers	097	323
3241	Truck body manufacturers	098	324
3242	Non-commercial trailer manufacturers	098	324
3243	Commercial trailer manufacturers	098	324
325	Motor vehicle parts & accessories manufacturers	099	325
326	Railroad rolling stock industry	100	326
327	Shipbuilding & repair	101	327
328	Boatbuilding & repair	102	328
329	Miscellaneous vehicle manufacturers	102	329

16 - ELECTRICAL PRODUCTS INDUSTRIES

331	Manufacturers of small electrical appliances	103	331
332	Manufacturers of major appliances (electric & non-electric)	104	332
333	Manufacturers of lighting fixtures	110	333
334	Manufacturers of household radio and television receivers	105	334
335	Communications equipment manufacturers	106	335
336	Manufacturers of electrical industrial equipment	107	336
338	Manufacturers of electric wire & cable	108	338
3391	Battery manufacturers	109	339
3399	Manufacturers of miscellaneous electrical products, n.e.s.	110	339

17 - NON-METALLIC MINERAL PRODUCTS INDUSTRIES

3511	Clay products manufacturers (from domestic clays)	115	351
3512	Clay products manufacturers (from imported clays)	115	351
352	Cement manufacturers	111	352
353	Stone products manufacturers	117	353
3541	Concrete pipe manufacturers	113	354
3542	Manufacturers of structural concrete products	113	354
3549	Concrete products, n.e.s.	113	354
355	Ready-mix concrete manufacturers	114	355
3561	Glass manufacturers	119	356

3562	Glass products manufacturers	119	356
357	Abrasives manufacturers	120	357
358	Lime manufacturers	112	358
3591	Refractories manufacturers	116	359
3599	Miscellaneous non-metallic mineral products industries, n.e.s.	118	359
	18 - PETROLEUM AND COAL PRODUCTS INDUSTRIES		
3651	Petroleum refining	121	365
3652	Manufacturers of lubricating oils & greases	121	365
369	Miscellaneous petroleum & coal products industries	122	369
	19 - CHEMICAL AND CHEMICAL PRODUCTS INDUSTRIES		
372	Manufacturers of mixed fertilizers	123	372
373	Manufacturers of plastics & synthetic resins	124	373
374	Manufacturers of pharmaceuticals & medicines	125	374
375	Paint & varnish manufacturers	126	375
376	Manufacturers of soap & cleaning compounds	127	376
377	Manufacturers of toilet preparations	128	377
3781	Manufacturers of pigments & dry colours	129	378
3782	Manufacturers of industrial chemicals (inorganic), n.e.s.	129	378
3783	Manufacturers of industrial chemicals (organic), n.e.s.	129	378
3791	Manufacturers of printing inks	130	379
3799	Miscellaneous chemical industries, n.e.s.	130	379
	20 - MISCELLANEOUS MANUFACTURING INDUSTRIES		
3911	Instrument & related products manufacturers	131	391
3912	Clock & watch manufacturers	131	391
3913	Orthepáedic & surgical appliance manufacturers	131	391
3914	Ophthalmic goods manufacturers	131	391
3915	Dental laboratories	131	391
392	Jewellry & silverware industry	132	392
3931	Sporting goods manufacturers	134	393
3932	Toys & games manufacturers	134	393
397	Signs & display industry	136	397
3991	Broom, brush & mop manufacturers	133	399
3992	Button, buckle & fastener manufacturers	137	399
3993	Floor tile, linoleum & coated fabrics manufacturers	135	399
3994	Sound recording & musical instrument manufacturers	137	399
3995c	Stamp & stencil (rubber & metal) manufacturers	137	399
3996	Pen & pencil manufacturers	137	399
3997c	Typewriter supplies manufacturers	137	399

3998	Fur dressing & dyeing	137	399
3999	Other miscellaneous manufacturing industries	137	399
167	Totals[g,h]	122	112

a) These three 4-digit industries are grouped into 162.

b) Included with 2541.

c) Included with 3999.

g) Net of duplicated codes

h) Takes into account footnotes a to c.

Source: Statistic Canada.

Appendix B

Product Diversity Indices and Cost Functions

Introduction

Applied studies in industrial organization often must use proxies that only roughly approximate the variable that is desireable. For example, most estimates (Loyns, 1980 excluded) of minimum efficient scale of plant start by presuming that a particular size class provides an estimate of the most efficient plants. Both survivor and cut-off (the average size of the smallest number of the largest plants accounting for 50 per cent of industry output) estimates make such an assumption. There are other cases where a variable has been used that lacks theoretical justification. Concentration ratios are meant to capture the effect of structure on performance but until recently (Cowling and Waterson, 1978), little effort was devoted to devising the appropriate variable for this purpose.

Product diversity indices suffer from much the same problem as the concentration index. They have been constructed generally for general purposes -- to characterize the diversification process -- and they may not be adequate for specific purposes. In particular, they may not capture our a priori notion as to how increased product diversity leads to higher plant costs.

Since ultimately we are interested in devising a variable that captures the effect of product line economies on productivity, it is important to consider how each of two commonly used measures does this. These measures are:

(i) The Herfindahl Index $\equiv \Sigma w_i^2 \equiv \Sigma(\frac{P_i}{P})^2$

where P_i is the value of the i'th products sales and P is equal to total plant (establishment) sales.

(ii) The Entropy Measure of Diversification $\equiv \Sigma w_i \ln\frac{1}{w_i}$

Whether we are interested in capturing how an industry has increased productivity or whether it has been more successful in competing with imports, we must examine how diversity affects the costs of the plant. Since we are interested in explaining cross-sectional differences in productivity and costs, some standardization for differences in output levels is required. This is normally done by considering differences in average cost levels. Therefore, in what follows, we examine the implicit average cost function and its relationship to diversity that is required to justify the use of the Herfindahl and Entropy measures.

The Herfindahl Index of Product Diversity

Suppose it is postulated that plant average costs (AC) are a linear function of the Herfindahl index (it being understood that there are a number of other terms that are omitted)

1) $AC = a + b\Sigma w_i^2$

where $b < 0$

Now $w_i = q_i/Q$

where q_i is the length of the ith product line

Q is the total output of the plant $= \Sigma q_i$

and $AC = \Sigma c_i \cdot w_i$

where c_i is the average cost of the ith product line.

$\therefore \Sigma c_i w_i = a + b \, \Sigma \, w_i^2$

and

2) $c_i = a + b\, w_i$ and $\dfrac{\partial c_i}{\partial w_i} = b$

Now assume that all N products produced are of equal size

$\therefore w_i = 1/N$ and thus

3) $c_i = a + b \dfrac{1}{N}$

4) $TC = AC.Q = aQ + bQ/N$

and $\dfrac{\partial TC}{\partial N} = \dfrac{-b.Q}{N^2}$

<u>The Entropy Measure of Product Diversity</u>

Starting with the same assumptions, let plant average costs

5) $AC = e + f\Sigma w_i \ln \dfrac{1}{w_i}$ where $f > 0$

then $c_i = e + f.\ln \dfrac{1}{w_i}$ is the ith product line's average cost.

6) $c_i = e - f.\ln w_i$

Then $\dfrac{\partial c_i}{\partial w_i} = -f \dfrac{1}{w_i}$

Once again assume that all the production lines are of equal size.

$$w_i = \frac{q_i}{Q} = \frac{1}{N}$$

Then

7) $c_i = e + f.\ln N$

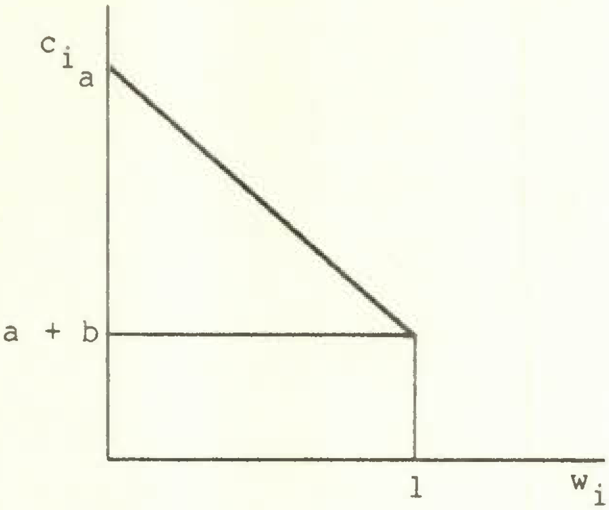
and

8) $TC = AC.Q = Q(e+f \ln N) = eQ + f.Q.\ln N.$

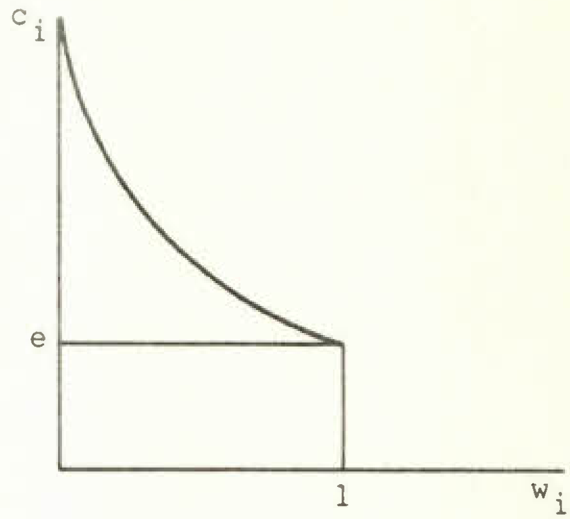
Then $\dfrac{\partial TC}{\partial N} = \dfrac{fQ}{N}$

In order to compare the two measures it is useful to plot the two cost curves. First look at the average individual product cost curves. Figure 3 represents the implied Herfindahl relationship; Figure 4 the Entropy measure.

(Figure 3)



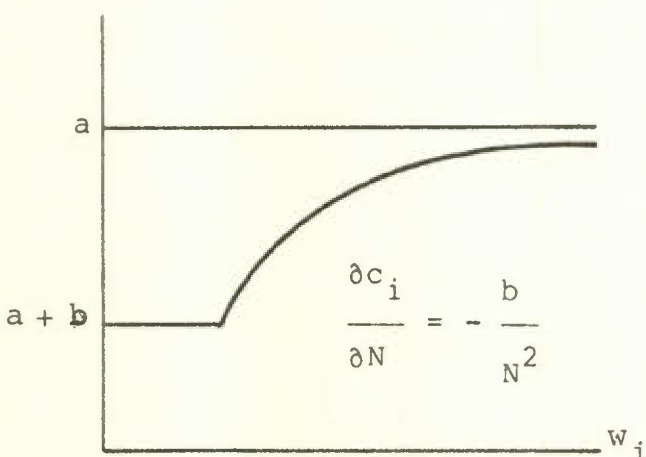
(Figure 4)



Thus the average cost goes up in both instances as the number of products increases (as w_i decreases from 1). However, as w_i decreases, the absolute value of the slope continually increases for the Entropy measure but is constant for the Herfindahl.

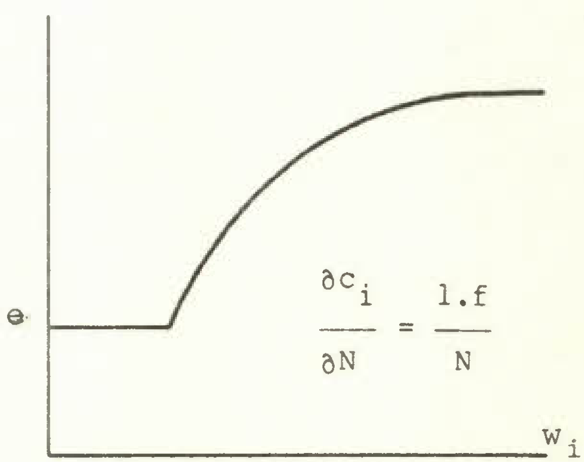
The relationship between average cost per product line and number of products is graphed below in Figure 5 for the Herfindahl index and Figure 6 for the Entropy index.

(Figure 5)



c_i = a+b [1/N], b<0

(Figure 6)



c_i = e+f.ln N, f>0

These charts show that as the number of products is increased, the average cost increases for both indices, but the curvature is greater for the Herfindahl than for the Entropy measure (ceteris paribus).

An evaluation of whether the Herfindahl or the Entropy measure is more appropriate must consider whether the above relationships accord with our a priori notions as to the effect of increasing diversity on costs of production. For that we need to proceed by reversing the process we have been following. We need to specify the cost function and ask which diversity measure falls out. Suppose we adopt a quadratic cost function for each product line i of N products produced.

9) $$TC_i = d_i + a_i q_i + b_i q_i^2$$

and

10) $$c_i = \frac{d_i}{q_i} + a_i + b_i q_i$$

This function can take on a standard U or L shape, or a straight line depending upon which coefficients are found to be significant. Let $q_i = w_i Q$ and drop the subscripts i on d, a and b. Then average costs for the plant are

11) $AC = \Sigma c_i w_i = \frac{Nd}{Q} + a + b\ Q\Sigma w_i^{\ 2}$

or

12) $TC = Nd + aQ + bQ^2\ \Sigma w_i^{\ 2}$

Let all production runs be the same length i.e., $w_i = 1/N$

Then

13) $TC = Nd + aQ + bQ^2\ \frac{1}{N}$

Then $\frac{\partial TC}{\partial N} = d - \frac{bQ^2}{N}$

This is essentially the same as the partial derivative of TC with respect to N that was derived from the Herfindahl. Put somewhat differently, equation 11 tells us that if we are ready to assume a quadratic cost curve, two terms should be used in any cross-section analysis that tries to relate average costs to diversity; the first $\frac{N}{Q}$ or $\frac{1}{Q\Sigma w_i^{\ 2}}$ for equal length production runs and the second, the inverse $Q\Sigma w_i^{\ 2}$.

In contrast, the entropy measure can be derived from a cost curve that yields an L shaped average cost curve for each product line

14) $c_i = a_i - b_i \ln q_i$

Then $c_i w_i = a_i w_i - b_i\, w_i \ln q_i$

Dropping the subscripts on a and b

15) $AC = \Sigma c_i w_i = \Sigma(aw_i - bw_i \ln q_i)$

$$= a - b\Sigma w_i \ln q_i$$

$$= a - b\Sigma w_i \ln Q - b\Sigma w_i \ln w_i$$

$$= a - b \ln Q + b\Sigma w_i \ln \frac{1}{w_i}$$

Thus if one is willing to postulate on the L shaped cost curve, then the entropy measure alone would be the appropriate one to use. Of course, in equation 14 above, a term with $\ln q_i^{\,2}$ could be added to allow for the possibiltiy of a U shaped average cost curve - but doing so does not yield another term that is easily reduced to a function of the entropy measure.

Another cost curve that generates the entropy is the following,

Let 16) $TC_i = gq_i^{h_i}$

Then

17) $C_i = gq_i^{h_i - 1}$ where C_i = average cost

$\ln C_i = k_i + (h_i - 1) \ln q_i$

Multiplying by w_i gives

18) $w_i \ln C_i = w_i k_i + (h_i - 1) w_i \ln q_i$

Substituting $q_i = w_i Q$, and dropping subscripts on k_i, h_i

19) $w_i \ln C_i = w_i k + (h-1) w_i \ln w_i + (h-1) w_i \ln Q$

Summing

20) $\Sigma w_i \ln C_i = k + (h-1) \ln Q - (h-1) \Sigma w_i \ln \frac{1}{w_i}$

But the left hand side of equation 20 is just the weighted geometric mean.

Summary and Conclusion

Contrary to the situation faced with other variables in the industrial organization literature, there is no need to proceed without a theoretical framework. Unfortunately the preceeding analysis only moves the problem from one level to another. The choice of an appropriate product diversity index requires a decision on the appropriate cost function. Nevertheless, confronted with the choice of using one of the cost functions suggested, we are of the opinion that the quadratic offers the greatest flexibility since it allows the average cost function to take on both U and L shapes - depending upon the significance of estimated parameters. Therefore we have chosen the Herfindahl measure of product diversity.

Appendix C

The Impact of Outliers

As noted in the text, (Section 4) some industries were omitted that were classified as miscellaneous. It is recognized that a case may be made that some of the remaining industries might have been too heterogenous for a meaningful analysis or for some other reason did not fit the estimated relationships well, and hence should have been omitted. Therefore two additonal regressions were run using different criteria for excluding "aberrant" observations. In the first case, (Method 1) all observations whose standardized error was greater than 4 were removed. In the second case, (Method 2) all observations whose standardized error was greater than 2 were removed.

Equations 2 and 4 of Table C-1 re-estimate two of the equations (2, 5) presented in Table 20. By comparing these equations with 1 and 3, estimated for the full 119 industry sample, the impact of removing "aberrant" industries can be seen. (In no instance was a standarized error of greater than 4 recorded when product diversity was the dependent variable). Virtually all of the results in equations 1 and 3 carry over into equations 2 and 4, respectively. The only difference worthy of note is that the trade variables become weakly significant in 1970. Hence, to all intents and purposes, with product diversity as the dependent variable,

Table C-1

Determinants of Product Diversity at the 4-Digit ICC,
Across 119 Canadian Manufacturing Industries:
The Impact of "Aberrant" Observations

	1970				1979			
			Method 2[a]				Method 2[a]	
Equation #	(1)		(2)		(3)		(4)	
	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign
Constant	0.842	.0000	0.853	.0000	0.895	.0000	0.912	.0000
Trade and Tariffs								
ERP	0.224	.01	0.209	.02	-0.024	.55	-0.034	.36
CA	0.029	.22	0.032	.16	0.024	.32	-0.001	.97
IMP	0.086	.27	0.107	.16	0.013	.85	-0.005	.94
Plant Size and Multiplant								
AVPLSZ	-0.001	.05	-0.002	.04	-0.001	.10	-0.001	.08
MPLNT	0.046	.004	0.046	.003	0.027	.08	0.035	.02
Eastman/Stykolt								
PLESTV	-0.007	.04	-0.006	.05	-0.005	.02	-0.006	.004
HVTRHCR	-0.076	.10	-0.076	.09	-0.013	.74	0.017	.66
Other								
ADVDM	-0.571	.34	-0.463	.42	-1.658	.03	-2.243	.003
LOG R4D	0.097	.0000	0.100	.0000	0.097	.0000	0.091	.0000
REG	-0.007	.81	-0.010	.74	0.012	.68	0.014	.61
FOR	-0.016	.73	-0.038	.39	0.035	.46	0.020	.66
$\bar{R}^2$	0.4601	.0000	0.4940	.0000	0.4578	.0000	0.5127	.0000
N[b]	119		117		119		118	

a. Method 2, all observations with a standardized residual greater than 2 omitted.

b. Number of industries in regression run.

Source: Statistics Canada. See Appendix A for details. (Vol. 29).

outliers are small in number and do not appreciably alter the inferences drawn for the full sample.

Table C-2 presents the same exercise with length of production run as the dependent variable. (For 1970 there were no standardized residuals greater than 4). Little change occurs for 1979 if aberrant industries are excluded, although ADVDM is no longer even weakly signficant and changes sign. However, for 1970 the impact of outliers is more apparent: IMP and CA are much more significant; REG now becomes insignificant; and finally, PLESTV changes sign (but is still significant) while HVTRHCR is now significant. The analysis of the impact of the Eastman/Stykolt effect embodied in equation 2 of Table C-2 can be extended using the approach, mutatis mutandis, outlined in footnote 34. The issue revolves around whether AVPLSZ in HVTRHCR=1 was small enough (to the left of the point, at which the impact of HVTRHCR offsets PLESTV, referred to as the crossover point) to suffer shorter production runs than a similar sized plant located elsewhere in the manufacturing sector. In other words, did the negative impact of HVTRHCR outweigh the positive impact of PLESTV. The data indicate for 1970 the crossover point is AVPLSZ=5.7 that 11 of the 17 HVTRHCRO=1 industries in equation 2 of Table C-2 had an AVPLSZ of less than 5.7, and that the mean level of AVPLSZ for HVTRHCRO=1 was 5.9. Hence, the Eastman/Stykolt effect is substantial in 1970 despite the change in PLESTV and HVRHCR. In sum, for length of production run as the dependent variable, the major impact of

Table C-2

The Determinants of Production Run Length at the 4-Digit ICC, Across 119 Canadian Manufacturing Industries: The Impact of "Aberrant" Industries

	1970				1979					
			Method 2[b]				Method 1[a]		Method 2[b]	
Equation #	(1)		(2)		(3)		(4)		(5)	
	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign
Constant	-0.431	.30	-0.447	.02	0.178	.73	0.064	.88	-0.046	.85
Trade and Tariffs										
ERP	3.506	.0007	2.303	.0000	-2.008	.0007	-1.938	.0000	-1.445	.0000
CA	0.425	.11	0.294	.02	0.059	.87	0.061	.83	0.159	.34
IMP	1.410	.10	1.070	.005	0.404	.68	0.680	.37	0.380	.38
Plant Size and Multiplant										
AVPLSZ	0.349	.0000	0.353	.0000	0.467	.0000	0.472	.0000	0.471	.0000
MPLNT	0.531	.006	0.235	.01	0.248	.30	0.225	.24	0.095	.41
Eastman/Stykolt										
PLESTV	-0.095	.008	0.107	.002	-0.148	.0000	-0.177	.0000	-0.075	.002
HVTRHCR	-0.292	.56	-0.614	.01	1.194	.04	1.346	.003	0.626	.04
Other										
ADVDM	11.020	.10	1.417	.63	15.182	.16	2.218	.80	-1.483	.77
AV4D	0.900	.0000	0.670	.0000	0.889	.0000	0.752	.0000	0.808	.0000
REG	-0.583	.09	-0.044	.77	-0.421	.33	-0.063	.85	0.005	.98
FOR	-0.217	.68	0.261	.27	0.220	.76	0.248	.65	0.453	.17
$\bar{R}^2$	0.9625	.0000	0.9924	.0000	0.9893	.0000	0.9935	.0000	0.9978	.0000
N[b]	119		110		119		117		112	

a. Method 1, all observations with a standardized residual greater than 4 omitted.

b. Method 2, all observations with a standardized residual greater than 2 omitted.

b. Number of industries in regression run.

Source: Statistics Canada. See Appendix A for details. (Vol. 29).

outliers is to strengthen the effect of the trade variables in 1970 and weaken the Eastman/Stykolt effect: nevertheless the Eastman/Stykolt effect remains and is stronger in 1970 than 1979, as suggested in the text.

Appendix D

Product Diversity and Number of Products per Industry

Introduction

One of the potential problems outlined in the text is that the number of 4- and 5-digit ICC products (N4D and N5D, respectively) may be endogenous. One way of throwing some light upon this question is to examine the number of 5- and 7-digit products (N5DUS and N7DUS, respectively) generated by the U.S. product classification system per 4-digit Canadian SIC industry. The implicit assumption, of course, is that N5DUS and N7DUS are truly exogenous.

A Comparison of Product Counts by Industry

A comparison of the means, standard deviations, minimum, maximum and number of products per industry is as follows: (In all instances the data refer to the sample of 119 industries used in the product diversity regression results reported above.)

Product Count Measure	Mean	Standard Deviation	Minimum	Maximum
N4D	11.387	11.271	1.000	55.000
N5D	30.328	28.289	2.000	136.000
N5DUS	6.647	6.171	1.000	30.000
N7DUS	30.420	31.297	1.000	194.000

Correlation Matrix

	N4D	N5D	N5DUS	N7DUS
N4D	1.000	0.932	0.671	0.636
N5D		1.000	0.679	0.623
N5DUS			1.000	0.740
N7DUS				1.000

Several points emerge from these data. First, on average, the number of products per industry is quite comparable using N5D and N7DUS, but N4D has twice as many products per industry as N5DUS. Second, correlations are higher, especially for Canada, between product counts developed by each country's statistical agency (i.e., N5D, N4D and N5DUS, N7DUS). Third, correlations between the N5D and N7DUS as well as N4D and N5DUS are quite high, but well short of unity. Hence, U.S. and Canadian product counts do bear some resemblance to one another.

Substituting U.S. for Canadian Product Counts

Tables D-1 and D-2 present the standard product diversity equations included in the text of the paper (equations 1 and 3) but, in addition, equations with R5DUS replacing R4D and R7DUS replacing R5D. (R5DUS = log(1/N5DUS) and R7DUS is defined analogously). The major differences between equations 1 and 2 as well as 3 and 4 of Tables D-1 and D-2 may be summarized as follows: the $\bar{R}^2$ falls considerably; ERP falls in significance, particularly in Table D-2, but nevertheless ERP does still change sign over the 1970s and is significant or weakly significant in 1970, but not in 1979; and, finally, ADVDM is consistently significant and negative as predicted. On the other hand, the importance of AVPLSZ, the opportunity to diversify (R5DUS and R7DUS), the Eastman/Stykolt effect (PLESTV), multiplant operations are all affirmed. Overall, then there is not a great deal of change.

Determinants of N4D and N5D

The final stage in examining the issue of the meaning of N4D and N5D involves estimating the determinants of N4D and N5D using trade, tariff and market size variables as well as N5DUS and N7DUS. The results are as follows:

Regression Results

	1970		1979	
	N4D	N5D	N4D	N5D
Constant	2.619 (.25)	7.225 (.22)	1.621 (.48)	8.325 (.17)
N5DUS	1.240 (.0000)	- -	1.201 (.0000)	- -
N7DUS	- -	0.584 (.0000)	- -	0.545 (.0000)
MESMSD	-0.053 (.27)	-0.125 (.34)	-0.027 (.53)	-0.046 (.69)
IMP	5.936 (.22)	17.154 (.17)	7.000 (.10)	20.202 (.07)
CA	0.567 (.69)	2.930 (.43)	1.653 (.26)	4.059 (.29)
ERP	1.875 (.73)	25.928 (.08)	0.267 (.91)	-1.262 (.84)
HVTRHCR	-3.518 (.17)	-13.116 (.05)	-3.599 (.11)	-8.043 (.18)
$\bar{R}^2$	0.4553 (.0000)	0.4021 (.0000)	0.4588 (.0000)	0.3968 (.0000)

Note: For each variable the table presents its estimated regression coefficient (Coeff) and level of statistical significance (Sign). The tests of significance are one-tailed.

Source: Statistics Canada. See Appendix A for details. (Vol. 22B).

Apart from N5DUS and N7DUS no other variable is consistently significant at .10 or better; MESMSD is always insignificant and wrongly signed -- negative, implying larger markets have fewer

Table D-1

The Determinants of Product Diversity at the 4-Digit ICC, Across 119 Canadian Manufacturing Industries, 1970 and 1979

	1970				1979			
Equation #	(1)		(2)		(3)		(4)	
	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign
Constant	0.842	.0000	0.778	.0000	0.895	.0000	0.829	.0000
Trade and Tariffs								
ERP	0.224	.01	0.186	.07	-0.024	.55	-0.014	.76
CA	0.029	.22	0.028	.30	0.024	.32	0.018	.51
IMP	0.086	.27	0.026	.76	0.013	.85	-0.083	.28
Plant Size and Multiplant								
AVPLSZ	-0.001	.05	-0.002	.01	-0.001	.10	-0.001	.02
MPLNT	0.046	.004	0.051	.006	0.027	.08	0.034	.06
Eastman/Stykolt								
PLESTV	-0.007	.04	-0.008	.03	-0.005	.02	-0.006	.01
HVTRHCR	-0.076	.10	-0.050	.35	-0.013	.74	0.009	.85
Other								
ADVDM	-0.571	.34	-1.453	.03	-1.658	.03	-2.699	.002
LOG R4D	0.097	.0000	-	-	0.097	.0000	-	-
REG	-0.007	.81	0.004	.91	0.012	.68	0.023	.51
FOR	-0.016	.73	0.019	.71	0.035	.46	0.058	.29
LOG R5DUS	-	-	0.072	.0000	-	-	0.068	.0001
$\bar{R}^2$	0.4601	.0000	0.2832	.0000	0.4578	.0000	0.2704	.0000

Note For each variable the table presents its estimated regression coefficient (Coeff) and level of statistical significance (Sign). The tests of significance are one-tailed.

Source: Statistics Canada. See Appendix A for details. (Vol. 22B).

Table D-2

The Determinants of Product Diversity at the 5-Digit ICC, Across 119 Canadian Manufacturing Industries, 1970 and 1979

	1970				1979			
Equation #	(1)		(2)		(3)		(4)	
	Coeff	Sign	Coeff	Sign	Coeff	Sign	Coeff	Sign
Constant	0.846	.0000	0.702	.0000	0.875	.0000	0.735	.0000
Trade and Tariffs								
ERP	0.283	.003	0.169	.12	-0.056	.19	-0.039	.41
CA	0.020	.42	0.014	.63	0.011	.68	0.004	.90
IMP	0.142	.08	0.033	.72	0.059	.41	-0.019	.81
Plant Size and Multiplant								
AVPLSZ	-0.001	.12	-0.002	.04	-0.001	.06	-0.001	.04
MPLNT	0.043	.01	0.051	.01	0.026	.11	0.033	.08
Eastman/Stykolt								
PLESTV	-0.006	.06	-0.008	.04	-0.003	.11	-0.005	.04
HVTRHCR	-0.088	.08	-0.030	.60	-0.0007	.85	0.030	.52
Other								
ADVDM	-0.783	.22	-1.320	.07	-2.105	.01	-2.631	.004
LOG R5D	0.095	.0000	-	-	0.084	.0000	-	-
REG	0.025	.42	0.052	.15	0.030	.35	0.056	.11
FOR	-0.047	.32	-0.017	.76	0.019	.71	0.043	.44
LOG R7DUS	-	-	0.041	.004	-	-	0.037	.008
$\bar{R}^2$	0.3991	.0000	0.2026	.0000	0.3504	.0000	0.1938	.0003

Note For each variable the table presents its estimated regression coefficient (Coeff) and level of statistical significance (Sign). The tests of significance are one-tailed.

Source: Statistics Canada. See Appendix A for details. (Vol. 22B).

product classifications per industry; IMP is positive but significant only in 1979 suggesting, perhaps, that imports are different in nature to Canadian goods, forcing Canadians to produce the same or similar products, thus raising the number of ICC products per industry; CA is always highly insignificant; ERP is significant on only one occasion, but is usually positive as predicted; and, finally, HVTRHCR is negative but significant on only one occasion. The negative sign is not to be expected since, presumably, in such industries there is great pressure to fill out product lines because of lack of imported goods, hence raising N4D and N5D. In sum, there is not a lot of evidence to suggest that N4D and N5D should be treated as endogenous.

Notes

1 See Baldwin and Gorecki (1983b) and Gorecki (1978, pp. 10-17) for a discussion of these issues.

2 Studies which fall into this category are Daly et al (1968) and Scherer et al (1975). Exceptions to this are Caves (1975), Caves et al (1980), and Gorecki (1978, 1980a). All have shortcomings. Caves, in both pieces, relies on a somewhat arbitrary assumption concerning the size distribution of the products a plant produces (Gorecki, 1980b) while Gorecki, although not suffering from this shortcoming, is confined to the food processing sector. Gorecki confines his attention to the determinants of enterprise diversification while Caves includes both enterprise and establishment.

3 See, for example, Economic Council of Canada (1967, p. 168).

4 See Caves (1975, pp. 21-25), Gorecki (1974, 1978) and Jacquemin and Berry (1979) for a discussion of these measures.

5 See Caves (1975, pp. 21-25) for a discussion of this index.

6 The average primary product specialisation ratio was approximately 0.90 in 1974 and 1979 for the 119 industry regression sample used below. A ratio of 0.90 indicates that only 10 per cent of products produced belonged to an industry other than the one in which the plant was classified.

7 See Stigler (1968, pp. 29-38) for a discussion.

8 For details see Statistics Canada (1973, 1979, pp. 46-64). The details in the paragraph are based on conversations with Statistics Canada personnel. By way of contrast with our study Caves et al (1980) used the 4-digit U.S. Standard Industrial Classification to define product diversity. This divides the manufacturing sector into 451 industries, which although much more detailed than the Canadian 4-digit SIC, falls well short of the ICC level of detail.

9 These are 1894, 2432, 2442, 2611, 3915. See Appendix A for industry name.

10 1974 is the earliest year for which this data is available at the plant level in a machine readable form and considered dependable by Statistics Canada personnel.

11 See Statistics Canada (1979, p.10) for further details. Short form establishments do not report commodity data.

12 Industry 3998.

13 The size grouping follow Caves (1975, Table 5-1, p. 39).

14 It is assumed that each miscellaneous industry consists of a series of separate industries. Hence, one cannot compare a properly defined industry with the same value of N* as a miscellaneous industry and claim to be controlling for the number of products classified to an industry.

15 For those industries where N* is low, the diversity index is substantially influenced by inter-industry diversification. Therefore the results for N*=1 (at the 4-digit ICC level) and N*=3 (at the 5-digit ICC level) suggest that greater size does not lead to greater inter-industry diversification at the plant level.

16 The unweighted 4-digit industry average plant size was estimated for all such industries classified to a given 2-digit industry. In the case of the 6 2-digit industries cited in the text average plant size rose in 2 industries and declined in 4. The average 2-digit industry plant size fell marginally 125.6 to 123.6 employees.

17 This is not, strictly speaking, correct, for a plant may diversify outside of its primary industry. Table 3 indicates this is the case for N*=1 at the 4-digit ICC level.

18 In both of these tables diversity and size are allowed to vary but N* is held constant for various values of N*. For a given N* the maximum degree of product diversity, subject to the caveat in footnote 17 above, is 1/N*. As can be seen by comparing 1/N* with actual HERF4D and HERF5D, even for the largest size groups, the maximum degree of diversity is not reached.

19 See, for example, Porter (1979).

20 Some results will be reported below, however which are estimated across all plants in a given industry.

21 See Caves et al (1980, pp. 206-207) for further details.

22 For additional discussion see Scherer et al (1975, pp. 355-381) on optimal unbalanced specialisation in a multiplant framework.

23 The cut-off points are derived using the sample of 141 industries -- i.e., the universe of 167 manufacturing industries less the miscellaneous categories.

24 More specifically, PPR4D = TSH/(1/PHERF4D) and similarly for PPR5D

25 See footnote 14 above for the reason we omitted miscellaneous industries.

26 These regression equations had 20 degrees of freedom or less.

27 On Caves et al (1980), see footnotes 2 and 8 above. Caves uses employment as the size dimension rather than shipments, and estimates relationships at the 2-digit rather than 4-digit SIC level. See Caves et al (1980, pp. 207-210) for further details.

28 As noted in footnote 23, the 141 industry sample is used for this purpose. Table 17 provides the variable means for the 119 industry sample used in the regression analysis.

29 The number of high tariff/high concentration industries is taken from the sample of 119 industries for which regression analysis is undertaken below.

30 It should be noted, however, that for the size group 0 to 50 employees, Caves had no observations for Canadian plants.

31 The criteria for selection of the industries included in Tables 12 to 16, as noted above, did not include foreign ownership. In 1979 the percentage of industry shipments controlled by foreigners at the 5 digit ICC level was as follows: 62, 37, 41, 26, 13 and 40 for N* = 3....79 respectively; and, at the 4-digit ICC level, 43, 37, 38 for N* = 1...27 respectively. (These percentages are simply the unweighted average percentage of industry shipments accounted for by foreign firms in each of the industries with the given N*). Most of the average values are below the 50 per cent figure that characterizes the manufacturing sector as a whole, suggesting the sample may be biased toward predominately Canadian controlled industries. Nevertheless, in one instance (N* = 3 at the 5-digit ICC level) where foreign ownership is substantially greater than 50 per cent saw U.S. plants are more specialist than Canadian. On the other hand, U.S. plants were more diversified in that instance where foreign ownership was relatively unimportant (N* = 25 at the 5-digit ICC level). Hence, the percentage of foreign ownership may not be that important in this context. This will be studied at greater length later.

32 It should be noted that at the enterprise level Caves et al (1980, Table 8.3, p. 210) found that foreign ownership, within a 2-digit industry, increased product diversity though the relationship was not significant.

33 The elasticity depends upon the value of N*. Using the mean value of this variable (at the 4-digit ICC level), average product run goes up by 43 per cent and 55 per cent of an increase in average plant size in 1970 and 1979, respectively (using equations 2 and 5 in Table 22).

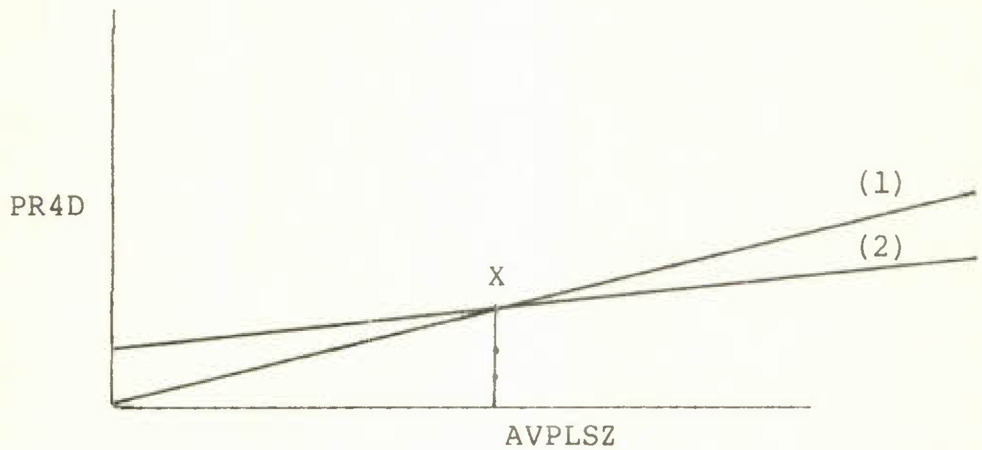
34 The relationship between plant size, tariffs, concentration and length of production run in situations where HVTRHCR=0 can be characterized as

(1) PR4D = d_0 AVPLSZ

in situations where HVTRHCR=1,

(2) PR4D = d_0 AVPLSZ + d_1 HVTRHCR + d_2 PLESTV.

These two relationships can be graphed thus:



Point X is the crossover point, determined by the ratio d_1/d_2. Plant sizes less than d_1/d_2 will have production runs that are longer in high tariff/high concentration industries than elsewhere, while the converse applies to plant sizes greater than d_1/d_2. Using the relationships in Tables 22 and 23, together with the raw data, we can estimate the number of industries to the right of X, which can be tabulated as follows:

Category	Mean Value of AVPLSZ for Category	Crossover AVPLSZ	Number of Industries to the Right of the crossover point to total number of Industries in Category
(1)	(2)	(3)	(4)
PR4DT, HVTRHCR9=1	11.7	8.1	8/22
PR5DT, HVTRHCR9=1	11.7	8.4	8/22
PR4DT, HVTRCRF9=1	14.5	11.9	3/11
PR5DT, HVTRCRF9=1	14.5	9.7	3/11

Hence, although, on average, the mean value of AVPLSZ (column 2) is substantially above the crossover point (column 3) the distribution of the underlying industries (column 4) suggests the

Eastman/Stykolt effect is confined to between 30 and 40 per cent of those industries classified as HVTRCRF9=1 or HVTRHCR9=1. However, in the case of PR5D the coefficient attached to HVTRHCR and HVTRCRF is only weakly significant.

35 In 1970 EXP is usually at least weakly significant while in 1979 the level of significance drops but at the 5-digit level remains weakly or nearly weakly significant.

36 As noted above the criteria for inclusion was that the explanatory variables had to be signficant at at least 0.10 in the cross sector regression results with HERF4D or HERF5D as the dependent variable. Using this criteria the independent variables were as follows: ADMDMDF, IMPDIF, EHCFDF, EHCDF, FORHCVDF, CONFCVDF, CONHCVDF, ERPDIF, AVPLSZDF, PLESTVDF, PLESTFVDF, PLNTDIF. The estimated regression equations corresponded to those presented in Table 26.

37 A stepwise regression procedure was applied to the four regression equations mentioned in footnote 37. In all instances IMPDIF was signficant at .05 or less. At the 4-digit ICC (HERF4DIF dependent variable) AVPLSZDF was also significant, at .09. The $\bar{R}^2$ when both variables were included was 0.07 which was signficant at .01.

38 An attempt was made to estimate the determinants of changes in HERF4D and HERF5D, with both dependent and independent variables measured as percentage changes (e.g. (HERF4D79-HERF4D70)/ HERF4D70). In those instances where the denominator was 0 the variable was assigned an arbitrary value of 0. The $\bar{R}^2$ of the equations corresponding to these in footnote 36, but in percentage change form, were not significantly different from zero.

39 The same problem arose in Baldwin and Gorecki (1983b, footnote 31, pp. 138-139). One method of resolving the problem was to remove three industries (1510, 3651, 3652) which lowers the correlation between ERPDIF and EHCDF from 0.992 to 0.516. If this is done then ERPDIF becomes marginally more significant (0.12 in equation 2 of Table 26 and 0.13 in equation 4), while EHCDF becomes negative and significant at 0.05 in equation 2 but in equation 4 is positive and not significant (0.22).

40 If the exercise described in the previous footnote is repeated for equations 1 and 3 of Table 26 then the signficance of ERPDLF changes only in equation 3 (to 0.08), but EHCFDF is negative in equation 1 (but insignificant) and positive in equation 3 (and also insignificant).

41 We use the methodology developed in footnote 34 except that attention is now confined to the case of first differences. The corresponding set of results is as follows:

Category	Mean Value of APLSZDF for Category	Crossover AVPLSZDF	Number of Industries to the right of the Crossover Point to Total Number of Industries in Category
(1)	(2)	(3)	(4)
PR4DIF HVTRCRFO = 1	5.067	2.038	4/12
PR5DIF HVTRCRFO = 1	5.067	3.444	4/12

Hence, although, on average, the mean value of APLSZDF (column 2) is substantially above the crossover point (column 3), the distribution of the underlying industries (column 4) suggests the Eastman/Stykolt effect is confined to approximately one-third of those industries for which HVTRCRFO = 1.

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