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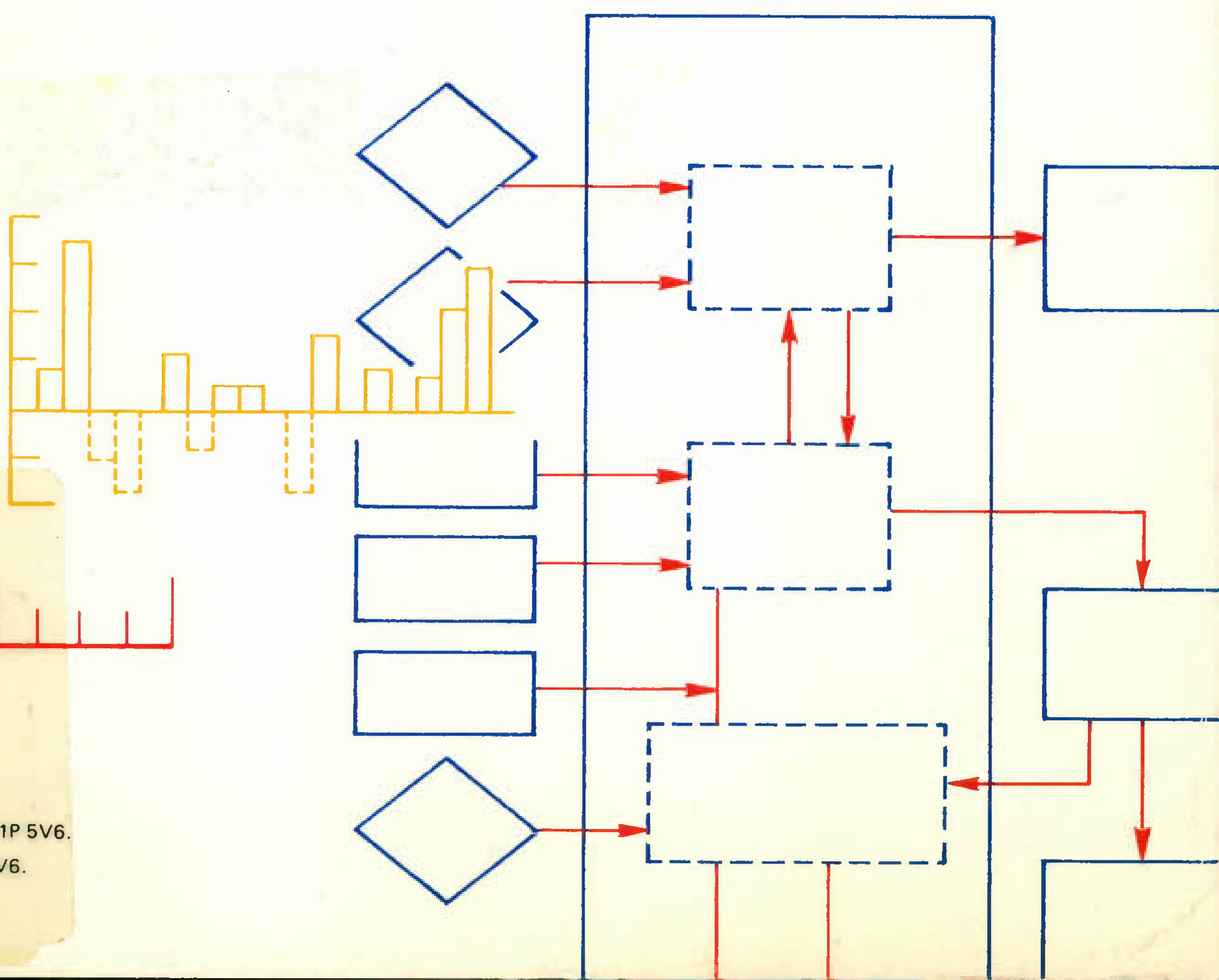

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DISCUSSION PAPER NO. 237

The Relationship Between Plant Scale and Product Diversity in Canadian Manufacturing Industries

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RÉSUMÉ

Les différences de productivité observées entre les secteurs manufacturiers canadien et américain sont souvent attribuées à la plus petite échelle des usines canadiennes et à leur trop grande diversité de produits par rapport à la taille du marché canadien. Il existe cependant peu d'études traitant de l'existence ou de l'importance de ces phénomènes. Pour parer à l'insuffisance des données, la plupart de celles qui ont été réalisées portent sur seulement quelques industries, et des prédictions ou des observations qualitatives remplacent les données manquantes. La présente étude, effectuée à partir d'une importante base de données au niveau de désagrégation à quatre chiffres de la Classification des activités économiques au Canada, fait partie d'une série d'ouvrages dans lesquels on tente d'examiner les faiblesses des industries manufacturières canadiennes et de déterminer dans quelle mesure leur sous-optimalité peut être attribuée aux barrières tarifaires.

Dans d'autres ouvrages, nous avons examiné dans quelle mesure la sous-optimalité des usines est reliée aux barrières commerciales. Nous avons cherché également à déterminer dans quelle mesure les restrictions commerciales influent sur la diversité au niveau de l'usine. Dans le présent document, nous analysons la relation entre ces deux résultats. Il existe une relation entre la diversité des produits et l'importance des économies d'échelle

d'une usine, car plus les économies d'échelle sont importantes, plus on sera tenté de multiplier les produits de l'usine afin de tirer parti de ces économies. Par ailleurs, plus le nombre de produits est élevé, plus la taille de l'usine sera grande, du moins en attendant qu'une nouvelle expansion ait lieu (telle la création d'une nouvelle usine). Ainsi, l'importance de la diversité peut être examinée indirectement en comparant la taille moyenne des usines canadiennes et américaines oeuvrant dans des industries comparables, au stade où elles prennent de l'expansion.

Prenant cette démarche indirecte pour mesurer les effets de la diversité, les auteurs du présent document constatent que, là où la diversité est élevée, la taille des usines canadiennes est, en moyenne, considérable par rapport à celle des usines américaines au moment où les entreprises prennent de l'expansion. Ils constatent en outre que les droits douaniers ont le même effet. Cette conclusion vient appuyer l'opinion selon laquelle les tarifs douaniers conduisent eux aussi à une plus grande diversité. Alors que, comme l'indiquaient des recherches antérieures, les tarifs douaniers peuvent avoir pour conséquence de réduire la taille des grandes usines canadiennes par rapport aux grandes usines américaines, ils peuvent également accroître la taille moyenne des usines canadiennes par rapport à celle des usines américaines au stade où les entreprises établissent une seconde usine. Ainsi faut-il conclure que les tarifs douaniers ont un double effet complexe sur la taille relative des usines.

Il importe de souligner que les restrictions commerciales s'avèrent coûteuses, que l'on considère l'un ou l'autre des deux effets mentionnés ci-dessus. Le fait que les restrictions commerciales conduisent à un agrandissement de la taille des usines par rapport au point où les entreprises prennent de l'expansion est attribué à la diversité des produits. Bien que des économies puissent être réalisées en multipliant le nombre de produits, en ce sens qu'on évite la construction de nouvelles usines, ceci est accompli au coût d'une "diversité excessive". Le coût de la petitesse des marchés est réduit, mais non entièrement éliminé, par une plus grande diversité. Dans la comparaison au sujet des usines de grande taille, la constatation que les usines canadiennes sont plus petites que les usines américaines correspondantes lorsque les tarifs douaniers et la concentration sont élevés et que cette différence disparaît lorsque les tarifs sont abaissés indique que des économies d'échelle demeurent inexploitées. On peut donc conclure que les restrictions commerciales sont préjudiciables à l'efficacité du secteur manufacturier canadien, que nous prenions les petites ou les grandes usines comme base de comparaison.

ABSTRACT

Productivity differences between the Canadian and U.S. manufacturing sectors are commonly attributed to smaller Canadian plant scale and levels of product diversity that are too large for the size of the Canadian market. However, there are few studies that indicate the extent to which these phenomena either exist or are important. Because of data unavailability, most of those that have been done have either been concentrated in only a few industries, have had to predict the values of missing observations or have relied on qualitative evidence. This study, using an extensive data base at the Canadian four-digit SIC level, is one of a series that explore the existence of sub-optimality in Canadian manufacturing industries and the extent to which trade barriers are responsible for sub-optimality.

In other papers we have examined the extent to which sub-optimal plant scale was related to trade barriers. We also investigated the degree to which diversity at the plant level was affected by trade restrictions. In this paper, we examine the relationship between the two. Product diversity and the importance of plant scale economies are connected since the more important are plant scale economies, the greater will be the incentive to add products to a plant to take advantage of these economies. In turn, the greater is the number of products produced, the larger will be the size of the plant

before branching (second plant creation) occurs. Thus the importance of diversity can be indirectly examined by comparing the plant size at which U.S. firms, on average, branch relative to the average size of Canadian plants in the comparable industry.

Using this indirect approach to measure the effects of diversity, this paper finds that where diversity is high, Canadian plant sizes, on average, are larger, relative to size of plant at which U.S. firms branch. In addition, tariffs are found to have the same effect. This finding supports the contention that tariffs also result in higher diversity. While our earlier research found that tariffs may reduce the size of large Canadian plants relative to large U.S. plants, they also increase the average size of Canadian plants relative to the point at which small U.S. firms establish second plants. The conclusion is that tariffs have a complex two-fold effect on relative plant scale.

It should be emphasized that trade restrictions are costly no matter which of the two above-mentioned effects is examined. The fact that trade restrictions lead to higher plant scale relative to the branching estimate is attributed to product diversity. While plant economies may have been exploited by "product packing", this is accomplished at the cost of "excessive diversity". The cost of small markets is reduced by higher diversity but not eliminated. In the large plant comparison, the finding that Canadian plants are smaller than U.S. plants where tariffs and concentration are high and that this difference falls when tariffs are lowered is indicative of unexploited economies of scale. Therefore, it may be concluded that trade restrictions affect the efficiency of the Canadian manufacturing sector -- whether we use small or large plants as our basis for comparison.

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ACKNOWLEDGEMENTS

The support and active co-operation 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.

1. INTRODUCTION

Productivity differences between the Canadian and U.S. manufacturing sectors are commonly attributed to smaller Canadian plant scale and levels of product diversity that are too large for the size of the Canadian market. However, there are few studies that indicate the extent to which these phenomona either exist or are important.[1] Because of data unavailability, most of those that have been done have either been concentrated in only a few industries,[2] have had to predict the values of missing observations[3] or have relied on qualitative evidence.[4] This study, using an extensive data base at the Canadian four digit SIC level, is one of a series[5] that explore the existence of sub-optimality in Canadian manufacturing industries and the extent to which trade barriers are responsible for sub-optimality.

In other papers we have examined the extent to which sub-optimal plant scale was related to trade barriers. We also investigated the degree to which diversity at the plant level was affected by trade restrictions. In this paper, we examine the relationship between the two. Product diversity and the importance of plant scale economies are connected since the the more important are plant scale economies, the greater will be the incentive to add products to a plant to take advantage of these economies. In turn, the greater are the number of products produced, the larger will be the size of the plant before branching (second plant creation) occurs. Thus the importance of diversity can be indirectly examined by comparing the size at which Canadian firms on average branch relative to comparable U.S. firms.

Using this indirect approach to measure the effects of diversity, this paper finds that where diversity is high, Canadian firms branch later than U.S. firms. In addition, tariffs are found to have the same effect. This finding supports the contention that tariffs also result in higher diversity. While tariffs may reduce the size of large Canadian plants relative to large U.S. plants (Baldwin and Gorecki 1983C), they increase the average size of Canadian plants relative to the point at which small U.S. firms establish second plants. The conclusion is that tariffs have a complex two-fold effect on relative plant scale.

2. METHODOLOGY

The link between plant scale and diversity arises from two sets of assumptions. The first has to do with plant cost functions. The second relates to the effects of diversity on distribution costs and the elasticity of demand faced by each product line.

If the costs of production at the plant level exhibit economies for total output, and economies within each product line, but diseconomies of product agglomeration -- that is, supervisory or coordination costs depend positively on the diversity of output -- then the production cost disadvantages of small size may be offset, at least over some size range, by increased plant diversity. That a firm may choose to combine a number of separate products in a plant in this way does, however, presume that 1) the firm faces a demand curve for its products that is so downward sloping that it would not conceive of replacing its diversified output with the same level of output in only one or a smaller number of products and 2) that diseconomies in distribution costs do not offset the economies gained on the production side.[6]

With these assumptions, it can be argued that some firms will be able to reduce the cost disadvantage associated with small scale by packing products into their plants. Thus plant size and diversity will be positively related. But this effect will be limited to those firms whose plants are smaller than MES -- the smallest size of plant at which unit costs are minimized. As plant size increases beyond MES, firms will branch or to create new plants that will be more specialized to avoid the extra costs of supervising diversified plants.[7]

The argument that average plant size and diversity should be positively correlated can be made more explicit by focusing on the branching decision of the firm. A firm can be assumed to consider branching when the distribution and other cost advantages arising from multiplant operations offset the production cost disadvantages. In figure 1, US1 is the long run average cost curve of operating one plant for a given level of product diversity. US2 is the long run average cost curve of operating two plants holding the number of products constant.[8] Dividing up output into two plants incurs a cost penalty for any output less than Q^*.[9] It is reasonable to presume that the branching decision will occur earlier the smaller is Q^* or S^* (since $Q^* = 2S^*$ by construction). Thus firms whose unit cost curve approaches the long run asymptote at a larger plant size will tend to branch later and generally have larger average plant sizes.

The effects of diversification can also be represented on figure 1. CAN1 is the average cost curve of a firm that differs from that of US1 only because it is more diversified -- it has more pro-

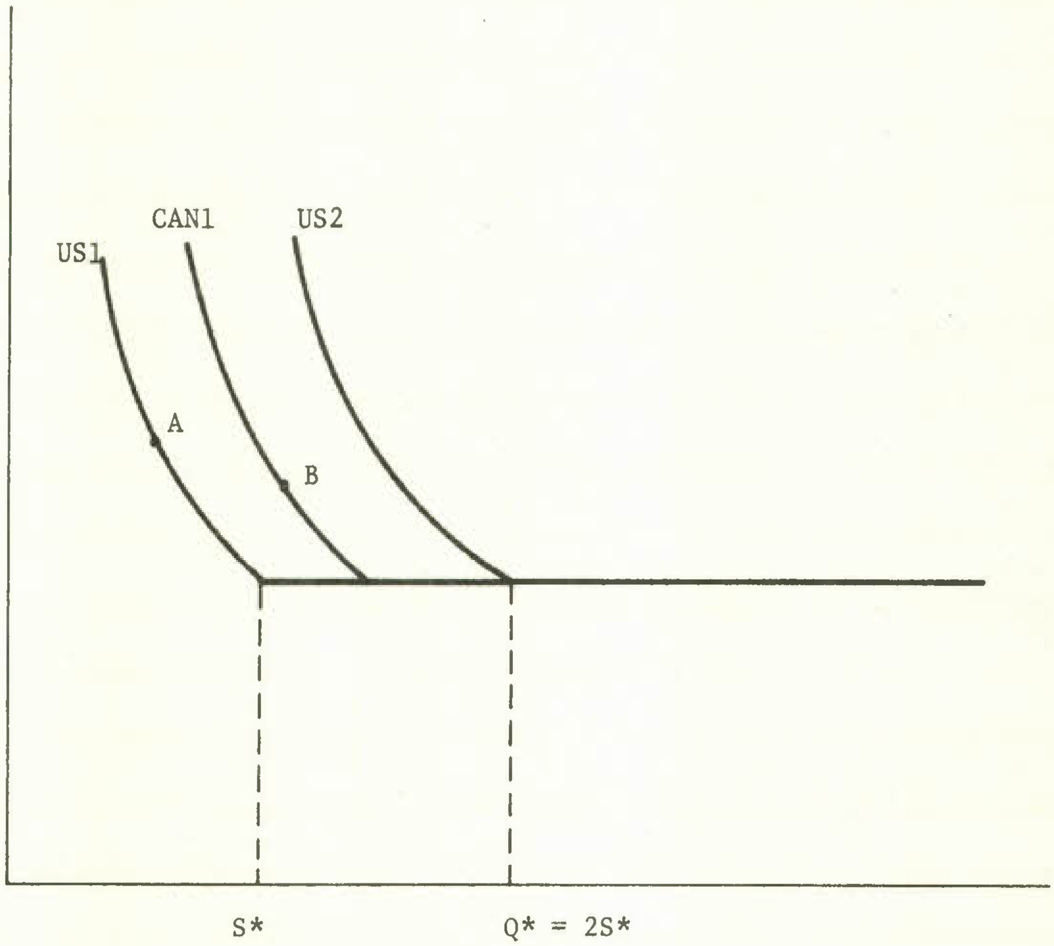

Figure 1

ducts in its single plant. Using the previous set of assumptions about the nature of the cost function, CAN1 will lie above US1 over small ranges of output but will approach the same asymptote to the right of S^*.[10] A firm may choose a point B on CAN1 to a point A on US1 even though this shifts the unit cost curve to the right because the unit cost at the former is lower than the latter.

The choice of B over A is a result of a larger optimization process that involves choice of number of products per firm. In turn, this depends upon economies of scale considerations in the marketing and distribution side. However, for small firms, there is a strong presumption that plant economies are generally great and that firm level product economies rather than diseconomies probably exist. Both then suggest Canadian small firms will indeed be on curves CAN1 rather than US1. But since CAN1 approaches the long run asymptote to the right of US1, diversified small firms will tend to branch somewhat later than those firms possessing single more specialized plants.

Firms that can operate with unit cost curves like US1 will be found in large markets where they can expect very long product runs for each product. In these markets, speciality products do not have to be tacked on to the production runs of the more popular brands and firms may exploit plant economies without having to incur the agglomeration costs that smaller markets suffer. Since the U.S. market is some ten times the size of the Canadian market, it is reasonable to presume that cost curves like US1 will dominate that market and curves like CAN1 the Canadian. Thus Canadian firms are likely to be more diversified and hence will have large average size plants than in the U.S. Thus, a comparison of the branching decisions of Canadian and

American firms should provide a means of evaluating the effects of diversity upon plant scale.

If the effect of diversity upon Canadian plant size is to be examined, the differences in the average size of the two markets must be taken into account. Since the U.S. market is so much larger than the Canadian, it is likely to have more large firms. This means that a simple comparison of average plant sizes in Canada and the United States is inappropriate. While Canadian firms are sufficiently small that the average plant size probably closely reflects the branching decision outlined above, this will not be the case for the U.S.

The branching size discussed above (call it A) is just the size at which, on average, firms move from possessing one to two plants. If this size (A) determines the incremental size required before additional plants are built and is constant across all size classes of firms, any firm of size S should have a number of plants M equal to S/A. Then the estimate A needed for standardization could be derived from any size class of firm as S/M.

However large and small firms do not act as if their branching points are the same. Larger firms have fewer plants than would be predicted using the branching point estimate derived from the smaller firms' branching estimate. Large firms are large not just because they have more plants but because their plants are larger.[11] What is needed, therefore, is an estimate of U.S. MES because it is that point that determines branching tendencies -- at least for relatively small firms such as those that populate the Canadian market.

MES can be measured in a number of different ways -- using the engineering technique, the statistical cost approach, the survivor technique, and the procedure that uses summary statistics derived from actual plant size distributions. Most cross-sectional studies rely on the latter approach because the first three do not yield enough observations. Various summary statistics have been suggested -- the mean plant size, the median, and the mean of the largest firms.

In an accompanying study, we used the measure used by Comanor and Wilson (1967) and subsequently by others, including Caves et al. (1980). It is the average size of the smallest number of the largest plants accounting for 50 per cent of industry size. We examined the determinants of the ratio of the size of the largest Canadian plants to this measure of MES. Other studies that have used this measure have argued that large firms can be assumed to be in a position to build plants of at least MES. These studies recognized that such plants will often be larger than MES, but postulated that their average size will be closely correlated with MES. Where this assumption has been tested by correlating large plant average size with more precise estimates of MES devised from individual industry case studies, it has not proven to be wrong.[12]

While the large plant scale estimate of MES may have been suitable for our study of relative plant scale, it is not the measure needed for this examination of the effects of diversity upon plant scale. The reason for this is that the effects of diversity should not be expected to be felt beyond MES. Once plant economies have been exploited, increasing the number of products per plant will not serve to reduce plant unit costs. Therefore, the effects of diversity on plant size should not be felt across the complete plant size distribution -- unless plant economies are not fully exploited by any plant no matter how large.

The large plant MES proxy is larger generally than the true MES and is therefore inappropriate for our purposes. It was quite acceptable when we were using Canadian large plant size in the numerator of our measure of relative plant scale. But this size plant is likely to be one where the diversification effects on plant scale are not very significant. Instead, since we use average Canadian plant size for the entire plant size distribution, we need a proxy for MES which, if it errors, does so on the low side. Such a measure should come from a group of firms that are on average similar to the majority of the Canadian sample in terms of size. It should also have a sensible interpretation.

The measure chosen is the size of firm at which, on average, U.S. firms first branch by building second plants. In each industry, firms are ranked by size and the average number of plants per firm is plotted against the size rankings. Thus if the smallest size class is used as a starting point, the U.S. reference point is obtained by moving up the ranking until that size of firm is reached at which branching may be inferred to be generally occurring. A more precise definition of this point is included in the next section.

This measure satisfies both of the specified criteria. By construction, it is derived from the smaller firms in the U.S. industry and thus should provide a reference point comparable to Canadian plants. Indeed the variable created by dividing Canadian average plant size by the branching point size is very close to one. Secondly, the U.S. reference point so estimated can be interpreted as an alternate way of estimating MES to those usually adopted. Since it uses the firm branching point, it will be referred to as the branching MES or BMES.

3. MEASURING THE BRANCHING POINT MES (BMES)

Lyons (1980) points out that the branching tendency of an industry can be used to provide an estimate of MES. This method is essentially a variant of the survivorship technique but instead of concentrating on the size class that distinguishes those firms who are increasing their percentage of sales from those who are in decline, it uses information on the size where firms begin to build a second plant to infer the level of MES plant.

Assume that the long run average cost curve of operating one plant and two plants are represented by US1 and US2 respectively in figure 1. MES output is at S* and US1 = US2 at Q* where Q* = 2S*. Each firm of a given size Q_j is assumed to have a probability of operating a single plant that depends upon the size of the difference between US1 and US2.

$$P(1/Q_j) = g_1(US1(Q_j) - US2(Q_j))$$

When the costs of operating one as opposed to two plants are equal (US1=US2), it is assumed that a firm is indifferent to operating one or two plants.

$$P(1/Q_j) = g_1(0) = .5$$

If the number of plants under consideration is restricted to 2, then the average number of plants that can be expected for any given firm size is

$$E(P/N)Q_j = P(1/Q_j)\ .1 + P(2/Q_j)\ .2$$

where $E(P/N)Q_j$ is the expected number of plants operated by firms of size Q_j.

$$\text{or}\quad E(P/N)Q_j = P(1/Q_j)\ .1 + (1 - P(1/Q_j)).2$$
$$= 2 - P(1/Q_j)$$

When US1 = US2, $P(1/Q_j) = .5$, thus the expected number of plants per firm at firm size twice MES is

$$E(P/N)Q_j = 2 - .5 = 1.5.$$

Thus, if the size of firm where, on average, 1.5 plants are operated by each firm is calculated (Q_j*), an estimate of MES can be derived as Q_j*/2. (Since from figure 1, 2 MES = Q_j*.)

The U.S. estimate of BMES was calculated from the U.S. Bureau of Census, Enterprise Statistics, 1972 and 1977.[13] The estimates may be found in Appendix A. BMES is calculated as half the size (measured in terms of employees) of that firm which has on average 1.5 plants per firm. This value is calculated by taking a linear interpolation of the means of the size classes that bracket the desired value of 1.5 plants per firm. When the largest size class has less than 1.5 plants per firm, it is this category that is chosen as being equal to twice that of MES. If there is more than one size of firm at which the number of plants per firm equals 1.5 (that is, the number of plants per firm is not monotonically increasing with size class), the smallest size class where 1.5 plants per firm is first reached is used. Of the 115 estimates of MES that were calculated, 4 in 1972 and 9 in 1977 fell into the first category and 8 in 1972 and 6 in 1977 fell into the second. Therefore, generally, this methodology required little subjective interpretation -- an advantage that it possesses compared to the traditional survivor technique.

In order to compare Canadian average plant size to U.S. BMES, the U.S. and the Canadian data were matched via a specially constructed concordance. The Canadian Department of Industry, Trade and Commerce (1971) has constructed a concordance between Canadian and American four digit industry Census of Manufacturers classifications. However, the U.S. data on MES came not from the U.S. Census of Manufactures but from the U.S. Bureau of the Census, Enterprise Statistics. The level of aggregation in the Enterprise Statistics is greater than for the four digit level of the Census of Manufactures. Therefore, a special concordance was constructed using the information contained in Enterprise Statistics linking the categories contained therein to the U.S. four digit SIC level and the Department of Industry, Trade and Commerce concordance between Canada and the United States at the four digit level.

The concordance so created is presented in Appendix Table B-1. Such an exercise rarely provides exact matches of industries across countries. While 157 out of 167 four digit SIC Canadian industries can be matched to individual U.S. four digit SIC industries or groups thereof, the concordance between Canada and the United States that uses the more aggregated Enterprise Statistics matches only 68 industries. Generally the level of aggregation was somewhere between the three and four digit SIC level. Not all matchings were regarded as equally good. Therefore, we separated the concordance into those which we felt were reasonably good (A) -- some 33 industries; those which were not quite as good (B) -- another 20 industries --; and the remainder (C) -- another 15. Table B-2 includes our evaluation of the category into which each of the matching industries fell.

The estimate of BMES was derived in terms of number of total employees since data were available on this basis for both 1972 and 1977. Data on number of plants per firm across value added size classes were available for only one of the two years and therefore value added could not be used. Since various U.S. enterprise industry categories and Canadian four digit SIC census of manufacturing industries had to be combined for purposes of comparison, a weighting system had to be adopted. The weights used were the relative size of employment in each of the subcategories. They are reported in Appendix Table B-2.

Using the estimate of U.S. BMES and the Canada-U.S. industry concordance, the degree to which Canadian plants are suboptimal is measured by

RELBRNCH The ratio of Canadian average plant size to the U.S. branching MES estimate. Both numerator and denominator are measured in terms of wage and salary earners.

The measure is calculated for the early and for the late nineteen seventies. For the early seventies (RELBRNCH70), the Canadian estimate is from 1970, the U.S. estimate from 1972. For the late seventies (RELBRNCH79), the Canadian average is from 1979, the U.S. estimate from 1977. The mean for the ratio in the first case was 0.97; in the second, it was 1.11 -- when calculated across group A.[14] Thus Canadian average plant size was not greatly different from the U.S. BMES.[15]

4. THE MODEL

The dependent variable, RELBRNCH, should be influenced by two sets of variables. First, there are those that determine the central tendency of the distribution of plant sizes. Second, there are those that determine the extent to which the distribution of plant sizes is skewed or has a large variance.

The central tendency of plant size distributions can best be described with the aid of figure 2. This figure demonstrates that the size of a plant that minimizes costs depends not only on production economies but also on distribution costs. In figure 2, APC is average production costs, ADC is average distribution costs and ATC, average total costs is the sum of APC plus ADC. APC is drawn with a familiar U shape and has a minimum at MES. ADC is increasing in Q because it is assumed that greater output levels must serve less dense or less enthusiastic markets and therefore incur higher average distribution costs (which could be interpreted to include both transportation and advertising expenditures). The optimal size plant -- what can be referred to as minimal optimal size (MOS) is found at Q^* and depends

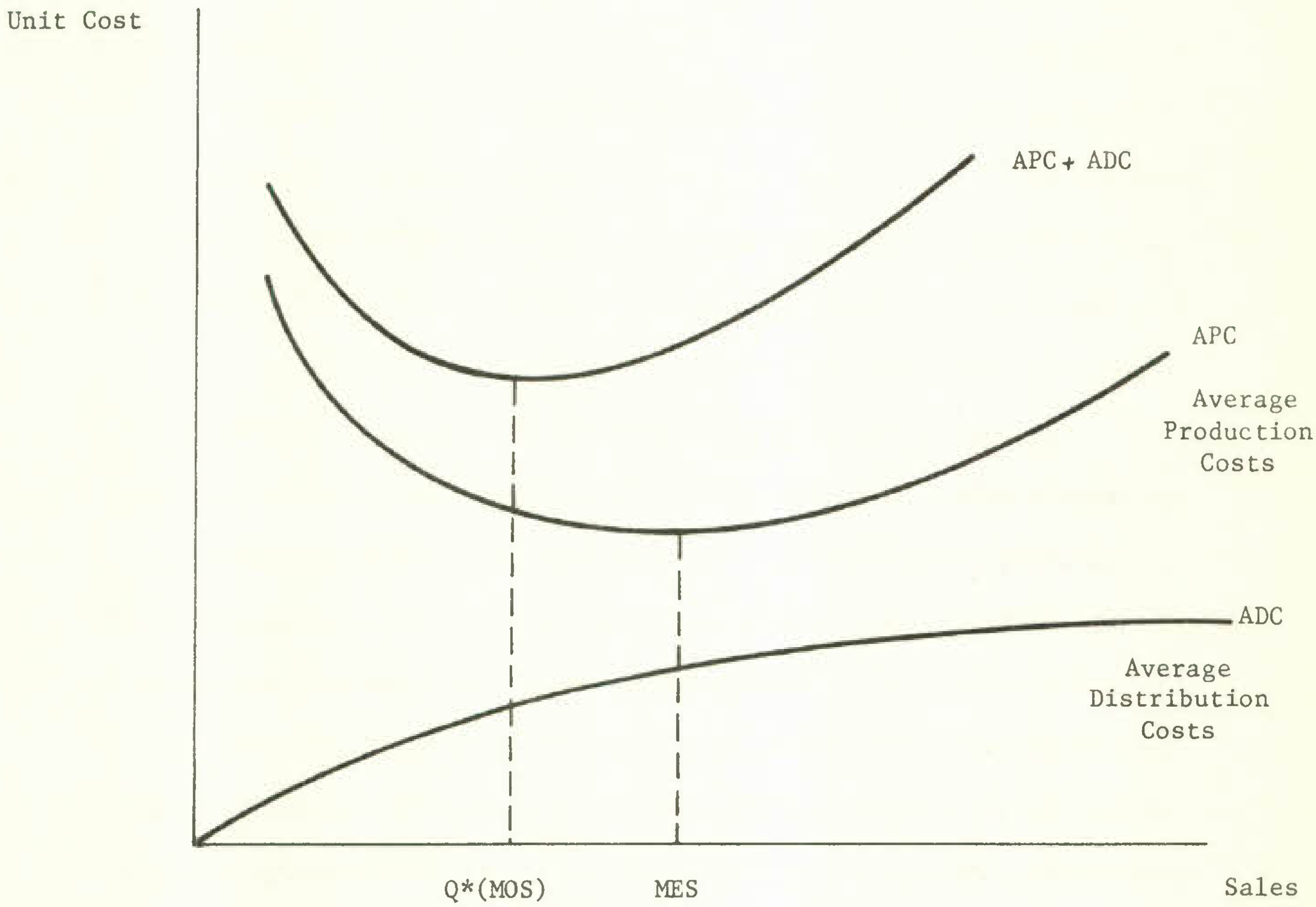
Unit Cost
APC + ADC
APC
Average
Production
Costs
ADC
Average
Distribution
Costs
Q*(MOS)
MES
Sales

Figure 2

not only on the curvature of APC but also of ADC. The steeper the ADC curve, the greater will be the amount by which the MOS falls below that size of plant that would just minimize plant average production costs (MES).

The factors that determine the size of Q^* can be broken into two sets. First there are those that influence the slope of the ADC curve in figure 2. The greater is the rate at which distribution costs increase the lower will be the average size of Canadian plants relative to American. Distribution costs will rise less steeply where markets are denser and where advertising tends not to be important. Second there are those variables that shift the cost curve APC in Canada to the right compared to the U.S. A primary factor that determines the position of the unit cost curve and therefore the point at which branching is likely to occur is the average level of product diversity at the plant level. If each product line is associated with its own fixed costs, the greater the number of products, the greater will be the plant fixed costs and the further to the right will be MES and therefore Q^* in figure 2. Other factors that influence the level of fixed costs will have the same effects.

The average size of plant depends not just on the variables that determine Q^* in figure 2 but also on the extent to which the distribution of plant sizes is concentrated at Q^*. If there are factors that truncate the bottom tail of the distribution (such as capital barriers), then the distribution will be skewed to the right and RELBRNCH will be larger. On the other hand, if some industries permit small less efficient firms to exist side by side with larger firms, the distribution of plant size in these industries will be skewed to the left relative to most industries and RELBRNCH will be smaller.

Each of the variables used to capture the effects described above will now be discussed in turn.

Size of Industry

The size of the industry is expected to have a positive effect on RELBRNCH. The larger is the market, the greater will be the density that can be expected since more plants of MES can be fitted into the market. The greater the density, the lower will be the slope of ADC in figure 1.[16] The size variable is

SIZE The number of wage and salary earners in the industry divided by the U.S. branching estimate of MES also defined in terms of number of wage and salary earners.

Concentration

In addition to SIZE, concentration might be expected to have a positive influence on average plant size. The effects of concentration and economies of scale cannot always be separated because of the manner in which the latter is calculated. With market size deflated by MES held constant, higher concentration is achieved either by greater multiplant operations or greater than MES plants. Both factors should have a positive effect on RELBRNCH. First, the effect of greater than MES plants is clearly positive. Secondly, the greater the degree of multi-plant operations, the smaller will be the market radius served by each plant. The slope of the unit transport curve is a positive function of the radius of each sub-market (Scherer et al., 1975, pp. 23-4). Thus a multi-plant operation may be presumed to have a unit transport cost curve that has a lower slope. Therefore multiplant operations also should have a positive effect on RELBRNCH.

In order to separate out the economies of scale effect from the concentration ratio, the following variable was defined.

RESCON The reciprocal of the difference between the four firm concentration ratio and four times MES divided by sales (where MES is the average size of those largest U.S. plants that account for the top 50 per cent of employment).[17]

This variable captures the residual effect of those determinants of concentration other than the size of the minimum efficient sized plant. It was calculated as the reciprocal in order to define it in units that are similar to those used for SIZE. Because it bears an inverse relationship to concentration, its expected sign will be negative.

Market Segmentation

Any factors that lead to market segmentation can be regarded as increasing the slope of the distribution costs curve ADC in figure 1. Advertising intensive industries can be regarded as those where information costs and therefore market penetration costs increase steeply with increases in output. To catch this effect, advertising intensity is included

AD The advertising sales ratio multiplied by a dummy variable that takes a value of 1 for all consumer non-durable goods industries.

The use of the dummy variable for non-consumer goods industries builds on the earlier work by Porter (1974) that found a difference in barriers created by advertising in non-convenience as opposed to convenience industries.

Research and development intensive industries may also be characterized as industries with considerable market segmentation and therefore a tendency for steeply sloped distribution costs. Therefore a research and development variable was defined as:

RD The ratio of research and development personnel to all wage and salary earners.

The effect of market segmentation should cause both variables to have negative coefficients.

Market segmentation may lead to rapidly increasing market penetration costs but at the same time be associated with product diversity. Markets that are segmented may also be those characterized by a large number of products. However, where potential product diversity is high, plants may offset diseconomies from large size by product packing. This in turn increases the average size at which branching occurs. Thus the diversity effects of both advertising and research and development may offset the market segmentation effects. As a result it is difficult a priori to sign the coefficients attached to these variables.

Product Diversity

As argued above, product diversity is expected to have a positive effect on RELBRNCH. The first variable used to capture diversity is

DIV The herfindahl index of industry plant level diversity. This index is calculated as the weighted average of plant herfindahl indices. The weights were the sales of individual plants to total industry sales. The plant level indices are just the sum of the square of the proportion of sales of each product. The level of product aggregation employed at the plant level is the four digit Industrial Commodity Classification (ICC).

This variable[18] is more accurate than those previously used. Previous attempts have had to guess at the distribution of sales across product classes and have been limited to a product classification scheme defined only at the four digit SIC level.[19] Nevertheless our measure may not capture the notion of product line diversity entirely since the four digit ICC product classification level may not be satisfactory. Because product diversity is likely to be so important, a second variable -- the extent of inward and outward bound industry diversity[20] -- was used since it was thought to be closely related to aspects of product level diversity at the plant level that are not captured by DIV.

Inward and outward bound industry diversity measures the extent to which production in an industry comes from plants that belong to firms that have production in other industries. Outward bound diversity is measured as the percentage of industry sales accounted for by plants owned by multi-industry firms that are assigned to the industry on the basis of the majority of their sales. Inward bound diversity is defined as the percentage of industry sales accounted for by plants that are owned by multi-industry firms that are assigned to a different industry on the basis of the majority of their sales. The variable actually used here is

INDIV The percentage of shipments in an industry that comes from plants that are owned by multi-industry enterprises.

This measure is intended to capture the extent to which diversity affects the costs of product agglomeration at the plant level. The index DIV catches the extent to which a plant produces more ICC products irrespective of whether those products are primary or secondary to the industry. Thus, DIV does not measure the extent to which product diversity occurs within an industry as opposed to across industries.

A plant may be assigned to an industry even though it produces some products that are classified to another industry as long as the majority of its shipments are in the industry in question. Therefore the same value of DIV may occur in an industry where nothing but products in that industry are produced; or when products in that industry and others are being combined.

When the latter occurs, products are being combined in the same plant that are less compatible in the production process. This is because of the supply side or technical criteria used in defining both SIC industries and ICC products. The less related are products, the greater are the coordination costs of product agglomeration likely to be. In figure 1, US1 is shifted to the right by higher product coordination costs and the average size at which branching occurs will be larger.

Higher inward and outward bound diversification at the industry level is associated with higher levels of inter-industry product diversification at the plant level (Caves et al., 1980, p. 201). In effect, when a greater proportion of shipments in an industry come from plants that are owned by multi-industry enterprises, plants are more likely to combine products from different industries. It is, therefore, postulated that the greater is the degree of inward and outward bound diversification (INDIV), the greater will be the coordination costs associated with any level of plant diversity (DIV). Thus INDIV should have a positive coefficient.

Trade Variables

There is a long standing tradition that the level of trade will have an effect upon the degree of specialization in an industry. Recently a number of theoretic models have been formulated to catch the interaction between the degree of product variety and the extent of trade.[21] Generally, it is argued that protected markets will be characterized by greater diversity at the plant level. Higher tariffs lead to more products being produced per industry. They may also lead to more products per plant -- depending upon the nature of cost complementarities across product lines and the degree of competition in the industry.

Whether tariff reductions will always result in increased specialization is unclear. For example, if unbalanced specialization (see Scherer et al. (1975), ch. 8) is sensible -- because of large economies in one product line and unimportant product line economies elsewhere -- it is possible that a movement to freer trade between Canada and the U.S. will see the U.S. plants concentrate on these high economy product lines and Canadian plants continue to produce a range of products whose transportation costs are relatively high. In this case trade liberalization might be assumed to have little effect on diversity.

Since, Scherer (1975) found little evidence of such unbalanced specialization, it can be argued that, on balance, protected markets should be characterized by higher plant diversity. And, of course, the greater the diversity, the later will be the branching decision. To catch this trade influence on RELBRNCH, two variables were used

ERP The effective rate of tariff protection.

IMP The ratio of the level of imports to domestic disappearance.

The sign on the tariff variable is expected to be positive. The sign on the import variable is expected to be negative.

In addition, a variable was used to catch Canada's ability to compete in world markets. This variable was

CA The comparative advantage, defined as exports minus imports, divided by the sum of exports plus imports.

Where an industry is able to compete in world markets, it is unlikely to rely upon diversity to bring down its unit costs. As such its branching point and therefore average plant size relative to the U.S. BMES will be lower. Therefore, the comparative advantage variable is expected to have a negative sign.

Foreign Ownership

Foreign ownership can be postulated to have two effects on RELBRNCH. First, foreign firms' plants may not have the same level of fixed costs associated with plant operations as domestically-owned firms. The foreign-owned subsidiary may be able to call upon engineering expertise or other management skills from its parent that effectively reduces its level of fixed costs compared to a domestic firm. As such foreign ownership would have a negative effect on the dependent variable.

On the other hand, there is evidence to suggest that foreign subsidiaries' plants of a given scale are more diversified than those belonging to Canadian domestic companies (Caves, 1975, ch. 5). Caves explains this by arguing that the same advantages referred to above also affect the incremental cost of adding product lines. Thus the foreign owned subsidiary will sometimes diversify where the domestic firm would not find it profitable. This would cause foreign ownership to have a positive effect on RELBRNCH.

The foreign ownership variable is defined as

FOR — The proportion of sales of an industry that are accounted for by foreign controlled firms as of 1970.

Because of the offsetting effects outlined above, its effect cannot be signed a priori.

Size Distribution Effects

In addition to the variables that affect the central tendency of the plant size distribution, several variables that were expected to influence the shape of the distribution were included. The first is meant to proxy the slope of the average cost curve. It is

CDR1 — The ratio of value added per manhour of the smallest plants accounting for 50 per cent of industry employment divided by value added per manhour for the largest plants accounting for 50 per cent of industry employment, all multiplied by a dummy variable set equal to one where market size divided by MES is less than its median and 0 otherwise.

This variable (CDR1) only operates in small markets and captures the degree to which the value added per manhour of small plants is less than that of large plants. A previous study by the authors (Baldwin and Gorecki, 1983c) determined that the ratio of value added per manhour of small to large firms only measures the cost disadvantage incurred by small firms in markets that are small relative to MES. In large markets, there is room for numerous efficient sized plants and competition will be stronger, forcing price toward long run average cost. This reduces the importance of the fringe that otherwise might have located itself on the negatively sloped section of the average cost curve. Thus, where most plants are located along a flat portion of the cost curve, the cost disadvantage ratio is relatively meaningless as an estimate of the slope of the cost curve below MES.

Since CDR1 is inversely related to the cost disadvantage ratio, then to the extent that the cost disadvantage of small firms is positively related to the diversification incentive, CDR1 should have a negative effect on RELBRNCH. However, it must be recognized that the variable CDR1 may be small where, because of a lack of competition, small firms with a cost disadvantage are not eliminated from the market. In this case, CDR1 might have a positive though probably insignificant coefficient.

In a previous paper (Baldwin and Gorecki, 1983c), we found CDR1 was negatively related to relative Canadian-American plant size when only large plants were compared in the two countries. Thus, steeply sloped cost curves caused those firms that managed to get larger to approach more closely their American counterparts. This accords with the expectations outlined above since, in the case of large firms, the small firm effect should not be felt. In contrast, the small firm effect should be felt in this analysis since plant size is being measured as the average of the entire distribution. It is, therefore, more likely that the two opposite signed effects will cancel one another out. Therefore the expected sign of CDR1 is ambiguous.

This simply recognizes that the curves drawn in figure 1 determine central tendencies for firms and plant sizes. In any industry, a distribution of plant sizes exist. In effect then CDR1 is a proxy for the degree to which the distribution of plant sizes is skewed because small firms are missing. With this interpretation in mind, we also defined a variable

CVAR The coefficient of variation of the net margins/sales ratio for 1970. Net margin is total activity value added less wages and salaries.

This variable captures the extent to which the dispersion of profitability is large and skewed because of the existence of small firms -- if the existence of the latter leads to lower profits generally. Thus, this variable should catch the same effect that CDR1 partially captures. Its sign is expected to be negative.

The final variable that is used to capture the cost disadvantage that small firms might face is the capital/labour ratio.

CAPLAB The ratio of the gross value of capital to the number of wage and salary earners.

While not all industries with large capital investments must necessarily have a component of capital that is fixed, the variable is meant to capture this general tendency. Its effect on RELBRNCH should be positive.

The Eastman-Stykolt Effect

In two previous papers, the degree of plant suboptimality was found to be a function not just of concentration, but also of tariff levels. It was the interaction of the two -- both high tariffs and high concentration -- that led to Canadian large plants being smaller than their American counterparts and to a greater percentage of the Canadian industry having suboptimal scale plant. In order to capture this interdependence between tariffs and market structure, the following variables were specified.

HVTRHCR	A dummy variable which takes the value of 1 when both concentration and effective tariff protection are greater than their respective means, 0 otherwise.
EAST	The variable SIZE multiplied by HVTRHCR.

The variable HVTRHCR, like both the concentration and tariff variable, is expected to have a positive coefficient. On the other hand, EAST is expected to have a negative coefficient; for the larger the market, the less should be the joint affect of tariffs and concentration on the tendency to pack more products into a plant in order to take advantage of plant level economies.[22]

5. THE DATA BASE

The data for Canadian average plant size and Canadian industry characteristics were drawn from the universe of 167 four digit Canadian manufacturing industries. Contrary to other recent studies, this study did not have to rely upon only those industries for which published data was available. As a result of an arrangement with Statistics Canada, a complete but confidential data base was used for this study. Therefore estimating missing observations was not a major problem. However, in a small number of instances, data was not available at the four digit level but only at a somewhat more aggregative level of industry classification. This necessitated some prorating or spreading of the data. Effective tariffs were based on a 122 industry division of the manufacturing sector. Research and development statistics were available only at the three digit level, which divides the manufacturing sector into 112 industries. Finally, the trade data needed some minor prorating for 21 of the four digit industries. An appendix is available on request that details the data base and its sources.

6. THE REGRESSION RESULTS

The regression was estimated both for the early and the late nineteen seventies using the two dependent variables -- RELBRNCH70 and RELBRNCH79 respectively. It was estimated just for the best two matchings (Group A and Group A plus B). The results for Group A are reported in Table I. Not all of the independent variables specified above are included in the reported regression equations. Those excluded proved to be insignificant. The results for Group A and B together are similar to those for Group A and are therefore relegated to Appendix C. Table I presents the estimated coefficients, their standard errors and the significance of each coefficient for Group A.

TABLE 1

The Determinants of the Ratio of Canadian Average Plant Size to the U.S. Branching Estimate of MES for 33 Canadian Manufacturing Industries

VARIABLE	1970 COEFF.	1970 S.E.	1970 SIGNIF.	1979 COEFF.	1979 S.E.	1979 SIGNIF.
INDIV	0.03	0.01	0.001	0.03	0.01	0.001
RESCON	-0.02	0.01	0.28	0.39	1.54	0.80
IMP	-0.82	1.04	0.44	-0.34	0.30	0.26
ERP	1.81	0.82	0.03	2.03	0.39	0.00
SIZE	0.005	0.002	0.002	0.005	0.001	0.000
DIV	-0.14	0.07	0.05	-0.82	0.54	0.14
CA	-0.55	0.39	0.17	-0.24	0.27	0.39
CDR1	0.35	0.62	0.57	0.71	0.46	0.14
FOR	-0.89	0.69	0.21	-0.54	0.54	0.33
R^2	.66			.78		
F (9,23)	8.116			14.3		
RELBRNCH Mean	.97			1.11		

These significance levels are the levels that would have to be adopted in order to reject the null hypotheses that the parameter is zero when a one-tailed test is used. The correlation matrix for each of the regressions is reported in Appendix D.

The regression results reported in Table I for both years are remarkably similar. The dominant variable is market size (SIZE) with its positive coefficient. Residual concentration (RESCON) has the expected negative sign in 1970 but changes sign in 1979 and is not significant in either year. Thus it is the interaction between market size and plant economies (as is caught by SIZE) rather than the multiplant nature of large firms (that is caught by RESCON) that significantly affects average Canadian plant size relative to BMES.

The two variables that are meant to capture the effect of diversity (DIV and INDIV) have the right signs and are generally significant. The greater the plant diversity (the smaller DIV) the greater the average plant size. The greater the inward and outward bound industry diversity (INDIV), the larger the average plant size. Of interest is the greater significance of the inward and outward bound diversification measure. It is cross industry diversification that leads to the most significant impact on RELBRNCH. Diversity therefore leads to greater average plant size relative to BMES.

The trade variables have the predicted sign though only tariff rates (ERP) were significant. Tariffs (ERP) had a positive and significant coefficient as they should, since they tend to increase the diversity of Canadian plant.[23]

Foreign ownership (FOR) has a negative but insignificant coefficient in each of the two regressions. This suggests that the greater tendency for foreign firms to diversify that has been observed (Caves, 1975) is offset by the lower fixed costs that were postulated to accompany subsidiary operation.

The variables that were meant to capture the Eastman/Skykolt effect are not reported in Table I. HVTRHCR was positive, EAST was negative but both were generally insignificant when included with either tariffs or concentration -- because of the high degree of collinearity between ERP and HVTRHCR and between SIZE and EAST. When the HVTRHCR variable was included but ERP excluded, HVTRHCR was positive and significant but the explanatory power of the equation was less than when ERP alone was included. It may therefore be concluded that the tariff effect on RELBRNCH is a general one and not confined to only high tariff, high concentration industries.[24]

Both measures that are meant to capture the rate of decline in the average cost curve are not significant when included with all other variables.[25] Indeed the capital/labour ratio (CAPLAB) is not even reported in Table I because it is so insignificant. The cost disadvantage ratio (CDR1) has a positive not a negative sign -- thereby indicating it is catching plant size dispersion rather than the pressure to exploit significant plant economies.

The problem with CAPLAB and the cost disadvantage ratio (CDR1) is that both are highly collinear with other variables. The removal of inward and outward bound industry diversity makes CDR1 significant. CAPLAB likewise becomes quite significant but only after everything but industry size and industry diversification are removed.

Several other variables that were defined previously were tried but not reported. While research and development (RD), and advertising (AD) each had their expected negative sign, neither was significant. The coefficient of variation of margins variable (CVAR) had the expected negative sign but was not significant.

7. IMPLICATIONS

Productivity problems in Canada have often been attributed to excessive product line diversity at the plant level as well as to suboptimal plant scale. All too infrequently, little recognition is given to the relationship between the two. For the cost of suboptimal plant scale may be offset somewhat by increased product level diversity. Moreover, there have been few attempts to measure the relationship between the two.

This paper has measured the relationship by testing the extent to which the extent of sub-optimal scale is related to plant level diversity. It uses a recently proposed measure of MES -- the branching point estimate -- to overcome several traditional problems with the usual MES estimates. The results show the importance of diversity. Both the direct and indirect measures of product diversity have the effect expected. Where diversity is high or where it may be inferred to be high, Canadian plants on average were large compared to the U.S. branching estimate of MES. It may, therefore, be concluded that there are both substantial benefits and costs of diversity. The benefits, of course, relate to the gains in plant scale obtained. The costs may be inferred from the effect of diversity on the ratio of average plant scale relative to the branching estimate. Canadian average plant size would not have increased relative to the branching estimate if diversity did not make it more costly to establish new plants.

This paper has also shed light on a different aspect of the sub-optimal plant scale literature. In an earlier paper, we used a different measure of plant suboptimality -- relative plant scale defined as the ratio of Canadian average large plant size to U.S. large plant size (RELSIZ). This paper has used the ratio of Canadian average plant size to the U.S. branching estimate of MES (BMES) -- (RELBRNCH).

Examination of the relationships shown to influence the two suboptimal variables -- RELSIZ and RELBRNCH -- reveals dramatic differences. While some of the same variables were found to be significant in each, generally the direction of their effect was not. Tariffs combined with high concentration had a significant negative effect on RELSIZ while tariffs alone had a significant positive effect on RELBRNCH. Comparative advantage had a significant positive effect on the former but was not significant in the RELBRNCH regression. Concentration had a significant positive effect on the former, but an insignificant negative effect on the latter. Foreign ownership was insignificant in both regressions. The cost disadvantage ratio had a significant negative effect on the first but generally, an insignificant positive effect on the second.

The results differ because the two measures of suboptimality capture different phenomena. RELBRNCH, the ratio used in this paper, captures the extent to which Canadian plants are large or small relative to the size at which branching first occurs. RELSIZ, the measure used in the earlier paper, captures the extent to which Canadian large plant size differs from U.S. large plant size. The difference between the two results cannot be attributed to the numerator used. While the measure of Canadian plant size relates to the total sample in one paper and only large plants in the other paper, the two measures are highly correlated (Baldwin and Gorecki, 1983c). The difference in the results must be attributed to the different U.S. MES measures used.

The two U.S. measures are related. The branching estimate of MES is essentially just the size at which on average smaller firms move from possessing one to two plants. As previously indicated, if this was the incremental size at which larger firms always created a new plant, large firm average plant size would just equal BMES. However, while the two measures are related, they are not identical. Large and small firms do not act as if their branching points are the same. Larger firms have fewer plants than would be predicted using BMES. Large firms are large not just because they have more plants but because their plants are larger.

Thus the two suboptimal plant measures use information about average plant size taken from different parts of the distribution of plant and firm size. As such, they might be expected to yield different results. In particular, a comparison of Canadian plant size to that found in U.S. markets must keep in mind the fact that the size of markets in the two countries is not the same and that the diversity of plants is not the same. This makes comparisons of plant scale complicated.

Canadian market size is smaller than that of the U.S. For nonexporting industries, small market size should mean that plants are somewhat smaller but at the same time more diversified to take advantage of plant economies. Thus when considering plants that are generally in the same lower size range in the two countries, Canadian plants should be more diversified than their American counterparts. This should not be the case in the larger size ranges because plant economies of scale are more likely to be exhausted and there is less need to add product lines to obtain such economies.[26]

There are, however, several other related factors at work. The Canadian market, being smaller than the American, will not support the production of as wide a range of products. Specialized goods will not be produced in Canada, but instead will be imported from the United States. With fewer products being produced than in the large U.S. market, the typical Canadian enterprise should be less diversified than its U.S. counterpart "unless small size in the national market somehow shrinks the enterprise population more than proportionately" (Caves et al., 1980, p. 207).

There is also evidence that the size of firm is positively related to the diversity of plants. Large firms tend to be larger because they produce more products (Caves et al., (1980), p. 208). Our work also indicates large firms not only produce more products but that they do so by producing more per plant -- or that diversity is greater where average size per plant is greater. (Baldwin and Gorecki, 1983b) These results support the notion that different sized firms may coexist using different strategies. (Caves and Porter, 1977, Newman, 1978, Caves and Pugel, 1980, Porter, 1979) Small firms tend to be relatively specialized, while larger firms less so. Large firms offset any diseconomies of diversity at the plant level with economies at the firm level from full product line distribution.

These considerations suggest that because of the small size of the Canadian market, the branching point MES will characterize those firms most closely resembling the average Canadian firm in size. Indeed, the fact that RELBRNCH takes a value close to one confirms this supposition. It is therefore RELBRNCH that should capture the diversity effects related to trade barriers. The results of both our earlier study and this investigation show that higher tariffs lead to greater product diversity and thus generally to larger average plant size relative to the U.S. BMES.

In contrast, a comparison of large average plant size in Canada to the United States utilizes firms and plants that differ substantially both in terms of size and diversity of products. The ratio of large Canadian plant size to large American plant size essentially captures the extent to which Canadian large firms are smaller than U.S. large firms. In this instance, higher tariffs in concentrated industries lead to smaller large plant size relative to the U.S. standard.

Neither measure of suboptimality is superior to the other. This is not just because the actual measurement of MES is difficult and it is not clear which of these contains the closer approximation to the MES. It is because the strategic group approach suggests that different size classes of firms can coexist with one another. This has led some to ask what factors permit a wide diversity of firm sizes to exist side by side. Our analyses allow us to ask how external factors -- such as trade restrictions -- affect different strategic groups. As such each of our measures yields information about different size groupings.

In the discussion about the effects of trade protection, apparently conflicting claims have sometimes been made. Some have noted that tariffs should have a deleterious effect on plant size -- that they lead to excessive entry in oligopolistic industries.[27] Others have noted that the effects of diversity can offset the cost penalty of small markets thereby suggesting that small firms in small markets may have somewhat larger plants than small firms in large markets where product specialization is greater.[28] Our results have shown that both results occur and suggest a reason for the simultaneous existence of both. The effect then of trade restrictions differs across the size distribution of firms.

Finally, it should be emphasized that trade restrictions are costly no matter which of the two above mentioned effects is examined. The fact that trade restrictions lead to higher plant scale relative to the branching estimate is attributed to product diversity. While plant economies may have been exploited by "product packing", this is accomplished at the cost of "excessive diversity". The cost of small markets is reduced by higher diversity but not eliminated. In the large plant comparison, the finding that Canadian plants are smaller than U.S. plants where tariffs and concentration are high and that this difference falls when tariffs are lowered is indicative of unexploited economies of scale. Therefore, it maybe concluded that trade restrictions affect the efficiency of the Canadian manufacturing sector -- whether we use small or large firms as our basis for comparison.

APPENDIX A

Table A-1

Estimate of U.S. Branching MES (BMES), 1972, 1977

(No. Of Employees)

1972 Code	Manufacturing Industries	BMES 1972	BMES 1977
20A	Meat Packing Plt.	391.825	221.563
20B	Prepared Meat & Poultry Pr.	204.466	191.476
20C	Fluid Milk Co.	93.603	79.383
20D	Dairy Pr. n.e.c.	50.019	57.727
20E	Canned Fruit & Veg. Co.	106.803	129.151
20F	Preserved Fruit & Veg. n.e.c.	202.384	73.043
20G	Mill Grain Pr.	51.990	36.896
20H	Bread & Cake & Related Pr.	116.071	115.506
20I	Cookies & Crackers Co.	200.285	158.088
20J	Sugar & Confectionery Pr.	194.712	115.404
20K	Fats & Oils	53.724	64.109
20L	Alcoholic Beverages	103.107	89.566
20M	Bottled Soft Drink & Flavorings	73.460	48.699
20N	Misc. Food & Kindred Pr.	85.593	88.289
21A	Tobacco Manufactures	145.554	187.500
22A	Weaving & Finishing Mills	126.467	125.585
22B	Hosiery	206.653	195.652
22C	Knitting Mills n.e.c.	517.857	239.130
22D	Floor Covering Mills	187.500	196.039
22E	Yarn & Thread Mills	166.071	154.841
22F	Textile Mill Pr. n.e.c.	113.216	97.547
23A	Men's & Boy's Suits & Coats	288.841	375.000
23B	" " Shirts & Nightwear	183.370	136.256
23C	" " Clothing n.e.c.	155.890	123.182
23D	Blouses & Dresses	122.369	150.954
23E	Women's & Misses' Suits & Coats	195.574	132.675
23F	" " Outerwear n.e.c.	198.253	134.283
23G	" & Children's Undergarments	142.715	119.844
23H	Children's Outerwear	155.401	111.975
23I	Apparel & Accessories n.e.c.	132.996	121.994
23J	Misc. Fabricated Textile Pr.	131.205	109.591
24A	Logging, Camps & Logging Contractors	187.500	116.071
24B	Sawmills & Planning Mills	125.619	117.620
24C	Millwork & Plywood	375.000	154.395
24D	Wood Building & Mobile Homes	104.603	102.806
24E	Wood Pr. n.e.c.	101.480	103.041
25A	Wood Household Furniture	446.551	292.114
25B	Upholstered Household Furniture	261.501	169.118
25C	Household Furniture n.e.c.	123.152	103.445
25D	Furniture & Fixtures n.e.c.	112.417	145.114

26A	Pulp, Paper & Board Mills	107.452	129.559
26B	Misc. Converted Paper Pr.	104.659	98.944
26C	Paperboard Container & Boxes	124.898	99.973
27A	Newspapers	137.265	77.920
27B	Periodicals	89.500	77.885
27C	Books	77.248	118.172
27D	Greeting Cards & Publishing n.e.c.	500.000	68.545
27E	Commercial Printing & Business Forms	106.820	98.665
27F	Bookbinding & Printing Services	156.661	113.348
28A	Industrial Chemicals & Synthetics	91.529	46.586
28B	Drugs	81.842	51.999
28C	Soap, Cleaners & Toilet Goods	74.444	92.515
28D	Paints & Allied Pr.	50.279	58.128
28E	Agriculture Chemicals	100.965	45.736
28F	Misc. Chemical Pr.	34.198	32.520
29A	Petroleum Refining	47.177	48.102
29B	Petroleum & Coal Pr.	91.474	31.322
30A	Rubber Pr.	198.778	123.999
30B	Misc. Plastic Pr.	107.592	101.429
31A	Footwear, Except Rubber	217.967	205.848
31B	Leather & Leather Pr. n.e.c.	133.737	132.721
32A	Glass Pr.	318.683	199.219
32B	Structural Clay Pr.	77.133	61.577
32C	Ready-Mixed Concrete	48.012	32.704
32D	Concrete & Gypsum Pr.	53.696	41.812
32E	Nonmetalic Mineral Pr.	132.675	93.534
33A	Blast Furnaces & Steel Mills	63.237	158.929
33B	Gray Iron Foundries	271.658	162.682
33C	Steel & Malleable Iron Foundries	875.000	333.972
33D	Primary Steel Pr. n.e.c.	85.285	67.163
33E	Nonferrous Metal, Except Foundries	142.271	86.029
33F	Nonferrous Foundries	375.000	210.814
34A	Metal Can & Shipping Containers	80.512	83.968
34B	Cutlery, Hand Tools & Hardware	154.755	166.269
34C	Plumbing & Heating, Except Electric	156.347	123.480
34D	Fabricated Structural Steel	141.570	208.185
34E	Metal Doors, Sash & Trim	87.500	98.214
34F	Structural Metal Pr. n.e.c.	108.765	122.771
34G	Screw Machine Pr. Bolts etc.	108.704	92.612
34H	Metal Forgings	281.250	187.500
34I	Metal Stampings	189.356	143.322
34J	Metal Services n.e.c.	95.452	105.398
34K	Ordnance & Accessories n.e.c.	875.000	87.500
34L	Fabricated Wire Pr.	105.517	102.298
34M	Fabricated Metal Pr. n.e.c.	160.044	267.903
35A	Engines & Turbines	87.500	87.500
35B	Farm & Garden Machinery	241.071	287.926
35C	Construction Machinery	109.369	204.545
35D	Mining & Materials Handling Equip.	76.210	60.768
35E	Machine Tools	172.264	105.317
35F	Metalworking Machinery n.e.c.	114.507	219.527
35G	Special Industrial Machinery	118.096	103.163
35H	Pumps & Compressors	91.387	87.500

35I	General Industrial Machinery n.e.c.	112.472	157.821
35J	Office & Computing Machines	382.692	377.134
35K	Refrigeration & Service Machinery	141.796	392.892
35L	Misc. Machinery, Except Electrical	133.621	143.563
36A	Household Appliances	254.550	191.973
36B	Elect. Lighting & Wiring Equipment	166.966	224.750
36C	Radio, TV, Communication Equipment	191.327	233.268
36D	Electronic Components & Accessories	165.366	201.817
36E	Electrical Machinery n.e.c.	142.794	129.899
37A	Motor Vehicles & Equipment	127.712	202.040
37B	Aircraft & Guided Missiles	187.500	92.763
37C	Aircraft Guided Missile Parts	145.775	187.500
37D	Ship & Boat Building & Repairing	257.813	267.241
37E	Transportation Equipment n.e.c.	375.000	101.995
38A	Scientific & Measuring Instruments	190.204	135.836
38B	Optical & Ophthalmic Goods	109.073	121.711
38C	Medical Instruments & Supplies	88.985	100.634
38D	Photographic Equipment & Supplies	159.480	71.053
38E	Watches, Clocks & Watchglass	187.500	375.000
39A	Jewelry, Silverware, & Plated Ware	131.083	109.026
39B	Toys & Sporting Goods	202.023	252.206
39C	Manufacturing Industries n.e.c.	119.849	129.808

Source: United States. Department of Census. Enterprise Statistics. 1972, 1977.

APPENDIX B

Table B-1

Concordance Between Canadian Census of Manufactures 4 digit SIC Classification and the U.S. 1972 Enterprise Classifications

Category	Matching Classifications		Title
1.	Can	1011	Slaughtering & Meat Processors
	Can	1012	Poultry Processors
	U.S.	20A	Meat Packing Plt.
	U.S.	20B	Prepared Meat & Poultry Pr.
2.	Can	1031	Fruit & Veg. Canners & Preservers
	Can	1032	Frozen Fruit & Veg. Processors
	U.S.	20E	Canned Fruit & Veg. Co.
	U.S.	20F	Preserved Fruit & Veg. n.e.c.
3.	Can	1040	Dairy Products
	U.S.	20C	Fluid Milk Co.
	U.S.	20D	Dairy Processors n.e.c.
4.	Can	1050	Flour & Breakfast Cereal Products
	Can	1060	Fried Industry
	U.S.	20G	Mill Grain Products
5.	Can	1071	Biscuit Manufacturers
	U.S.	20I	Cookies & Crackers
6.	Can	1072	Bakeries
	U.S.	20H	Bread & Cake & Related Products
7.	Can	1081	Confectionery
	Can	1082	Cane & Beet Sugar
	U.S.	20J	Sugar & Confectionery Products
8.	Can	1083	Veg. Oil Mills
	U.S.	20K	Fats & Oils
9.	Can	1091	Soft Drinks
	U.S.	20M	Bottled Soft Drinks & Flavouring

10.	Can	1092	Distilleries
	Can	1093	Breweries
	Can	1094	Wineries
	U.S.	20L	Alcoholic Beverages
11.	Can	1510	Leaf Tobacco
	Can	1530	Tobacco Products
	U.S.	21A	Tobacco Manufactures
12.	Can	1740	Shoe Factories
	U.S.	31A	Footwear, Except Rubber
13.	Can	1810	Cotton Yarn & Cloth Mills
	Can	1820	Wool Yarn & Cloth Mills
	Can	1832	Throwsters, Spun Yarn & Cloth Mills
	Can	1891	Thread Mills
	Can	1894	Textile Dyeing & Finishing Plants
	U.S.	22A	Weaving & Finishing Mills
	U.S.	22E	Yarn & Thread Mills
14.	Can	1840	Cordage & Twine
	Can	1851	Fibre Processing Mills
	Can	1852	Pressed & Punched Felt Mills
	Can	1892	Narrow Fabric Mills
	Can	1871	Cotton & Jute Bags
	Can	1872	Canvas Products
	Can	1893	Embroidery, Pleating & Hemstitching
	Can	1899	Misc. Textile Industries, n.e.c.
	Can	1831	Fibre & Filament Yarn Manufacturers
	U.S.	22F	Textile Mill Processors n.e.c.
	U.S.	23J	Misc. Fabricated Textile Processors
15.	Can	1860	Carpet, Mat, & Rug
	U.S.	22D	Floor Covering Mills
16.	Can	2310	Hosiery Mills
	U.S.	22B	Hosiery
17.	Can	2480	Foundation Garments
	Can	2460	Fur Goods
	Can	2491	Fabric Glove Manufacturers
	Can	2492	Hat & Cap Industry
	Can	2499	Miscellaneous Clothing Industries
	U.S.	23I	Apparel & Accessories n.e.c.

	U.S.	23G	Women's & Children's Undergarments
18.	Can	2450	Children's Clothing
	U.S.	23H	Children's Outerwear
19.	Can	2511	Shingle Mills
	Can	2520	Veneer & Plywood Mills
	Can	2513	Sawmills & Planing Mills
	Can	2541	Sash, Door & Other Millwork Plants, n.e.c.
	Can	2543	Pre-Fabricated Buildings
	U.S.	24B	Sawmills & Planing Mills
	U.S.	24C	Millwork & Plywood
	U.S.	24D	Wood Building & Mobile Homes
20.	Can	2710	Pulp & Paper Mills
	U.S.	26A	Pulp, Paper & Board Mills
21.	Can	2720	Asphalt Roofing
	Can	3652	Lubricating Oils & Greases
	Can	3690	Miscellaneous Petroleum & Coal Products
	U.S.	29B	Petroleum & Coal Products
22.	Can	2731	Folding, Carton & Set-Up Box
	Can	2732	Corrugated Boxes
	Can	2733	Paper & Plastic Bags
	Can	2740	Other Paper Converters
	U.S.	26B	Miscellaneous Converted Paper Products
	U.S.	26C	Paperboard, Container & Boxes
23.	Can	2880	Publishing
	U.S.	27A	Newspapers
24.	Can	2870	Platemaking, Typesetting & Trade Bindery
	U.S.	27F	Bookbinding & Printing Services
25.	Can	2860	Commercial Printing
	Can	2890	Publishing & Printing
	U.S.	27B	Periodicals
	U.S.	27C	Books
	U.S.	27D	Greeting Cards & Publishing, n.e.c.
	U.S.	27E	Commercial Printing & Business Forms
26.	Can	2910	Iron & Steel Mills
	Can	2920	Steel Pipe & Tube Mills
	Can	2940	Iron Foundaries

	Can	3050	Wire & Wire Products
	U.S.	33A	Blast Furnaces & Steel Mills
	U.S.	33B	Gray Iron Foundaries
	U.S.	33C	Steel & Malleable Iron Foundaries
	U.S.	33D	Primary Steel Products, n.e.c.
	U.S.	34G	Screw Machine Products, Bolts, etc.
	U.S.	34L	Fabricated Wire Products
27.	Can	2950	Smelting & Refining
	Can	2960	Aluminum Rolling, Casting, & Extruding
	Can	2970	Copper & Copper Alloy Rolling, Casting, & Extruding
	Can	2980	Metal Rolling, Casting, & Extruding, n.e.c.
	Can	3380	Electric Wire & Cable
	U.S.	33E	Nonferrous Metal, Except Foundries
	U.S.	33F	Nonferrous Founderies
28.	Can	3010	Boiler & Plate Works
	Can	3039	Ornamental & Architectural Metal, n.e.c.
	Can	3042	Metal Stamping & Pressing
	U.S.	34A	Metal Can & Shipping Containers
	U.S.	34F	Structural Metal Products, n.e.c.
	U.S.	34I	Metal Stampings
29.	Can	3020	Fabricated Structural Metal
	U.S.	34D	Fabricated Structural Steel
30.	Can	3031	Metal Door & Window
	U.S.	34E	Metal Doors, Sash, & Trim
31.	Can	3041	Metal Coating
	U.S.	34J	Metal Services, n.e.c.
32.	Can	3060	Hardware, Tool & Cutlery
	U.S.	34B	Cutlery, Hand Tools, & Hardware
33.	Can	3110	Agricultural Implements
	U.S.	35B	Farm & Garden Machinery
34.	Can	3160	Commercial Refrigeration & Air-Conditioning
	U.S.	35K	Refrigeration & Service Machinery
35.	Can	3180	Office & Store Machinery

	U.S.	35J	Office & Computing Machines
36.	Can	3230	Motor Vehicles
	Can	3241	Truck Body Manufacturers
	Can	3243	Commercial Trailer Manufacturers
	Can	3250	Motor Vehicle Parts & Accessories
	U.S.	35L	Misc. Machinery, Except Electrical
	U.S.	37A	Motor Vehicles & Equipment
37.	Can	3270	Shipbuilding & Repair
	Can	3280	Boatbuilding & Repair
	U.S.	37D	Ship & Boat Building & Repairing
38.	Can	3310	Small Electrical Appliances
	Can	3320	Major Appliances
	U.S.	36A	Household Appliances
39.	Can	3340	Household Radio & TV Receivers
	Can	3350	Communication Equipment
	U.S.	36C	Radio, TV, Communication Equipment
	U.S.	36D	Electronic Components & Accessories
40.	Can	3511	Clay Product Manufacturers (from domestic clays)
	Can	3591	Refractories
	U.S.	32B	Structural Clay Products
41.	Can	3550	Ready-Mix Concrete
	U.S.	32C	Ready-Mixed Concrete
42.	Can	3561	Glass Manufacturers
	Can	3562	Glass Products
	U.S.	32A	Glass Products
43.	Can	3651	Petroleum Refining
	U.S.	29A	Petroleum Refining
44.	Can	3740	Pharmaceuticals & Medicines
	U.S.	28B	Drugs
45.	Can	3750	Paint & Varnish
	U.S.	28D	Paints & Allied Products
46.	Can	3760	Soap & Cleaning Compounds

	Can	3770	Toilet Preparations
	U.S.	28C	Soap, Cleaners, & Toilet Goods
47.	Can	3912	Clock & Watch
	U.S.	38E	Watches, Clocks & Watchglass
48.	Can	3920	Jewellery & Silverware
	U.S.	39A	Jewellery, Silverware, & Plated Wire
49.	Can	3931	Sporting Goods
	Can	3932	Toys & Games
	U.S.	39B	Toys & Sporting Goods
50.	Can	1720	Leather Tanneries
	Can	1750	Leather Glove Factories
	Can	1792	Boot & Shoe Findings
	Can	1799	Luggage, Handbag, & Miscellaneous Leather Products
	U.S.	31B	Leather & Leather Products, n.e.c.
51.	Can	2391	Knitted Fabric Manufacturers
	Can	2392	Other Knitted Mills
	U.S.	22C	Knitting Mills, n.e.c.
52.	Can	2560	Wooden Box Factories
	Can	2591	Wood Preservation Industry
	Can	2592	Wood Handles & Turning Industry
	Can	2593	Manufacturers of Particle Board
	Can	2599	Miscellaneous Wood Industries
	U.S.	24E	Wood Products, n.e.c.
53.	Can	2619	Household Furniture
	U.S.	25A	Wood Household Furniture
	U.S.	25B	Upholstered Household Furniture
	U.S.	25C	Household Furniture, n.e.c.
54.	Can	1020	Fish Products
	Can	1089	Miscellaneous Food Processors
	U.S.	20N	Miscellaneous Food & Kindred Products
55.	Can	1620	Rubber Products
	U.S.	30A	Rubber Products
56.	Can	1650	Plastics Fabricating, n.e.c.

	U.S.	30B	Miscellaneous Plastic Products
57.	Can	2431	Men's Clothing Factories
	Can	2432	Men's Clothing Contractors
	U.S.	23A	Men's & Boy's Suits & Coats
	U.S.	23B	" " " Shirts & Nightwear
	U.S.	23C	" " " Clothing, n.e.c.
58.	Can	2441	Women's Clothing Factories
	Can	2442	Women's Clothing Contractors
	U.S.	23D	Women's & Misses' Blouses & Dresses
	U.S.	23E	" " " Suits & Coats
	U.S.	23F	" " " Outerwear, n.e.c.
59.	Can	2640	Office Furniture
	Can	2660	Miscellaneous Furniture & Fixtures
	U.S.	25D	Furniture & Fixtures, n.e.c.
60.	Can	3070	Heating Equipment
	Can	3090	Miscellaneous Metal Fabricating
	U.S.	34C	Plumbing & Heating, Except Electric
	U.S.	34H	Metal Forgings
	U.S.	34K	Ordinance & Accessories, n.e.c.
	U.S.	34M	Fabricated Metal Products, n.e.c.
61.	Can	3210	Aircraft & Aircraft Parts
	U.S.	37B	Aircraft & Guided Missiles
	U.S.	37C	Aircraft & Guided Missile Parts
62.	Can	3242	Non-Commercial Trailer Manufacturers
	Can	3260	Railway Rolling Stock
	Can	3290	Miscellaneous Vehicles
	U.S.	37E	Transportation Equipment, n.e.c.
63.	Can	2680	Electric Lamp & Shade
	Can	3330	Lighting Fixtures
	Can	3360	Electrical Industrial Equipment
	Can	3391	Battery Manufacturers
	Can	3399	Miscellaneous Electrical Products, n.e.c.
	U.S.	36B	Electrical Lighting & Wiring Equipment
	U.S.	36F	Electrical Machinery, n.e.c.
64.	Can	3512	Clay Product Manufacturers (from imported clays)
	Can	3520	Cement Manufacturers
	Can	3530	Stone Products

	Can	3570	Abrasives
	Can	3599	Miscellaneous Non-Metallic Mineral Products
	U.S.	32E	Non-Metallic Mineral Products
65.	Can	3541	Concrete Pipe Manufacturers
	Can	3542	Manufacturers of Structural Concrete Products
	Can	3549	Concrete Products Manufacturers, n.e.c.
	Can	3580	Lime Manufacturers
	U.S.	32D	Concrete & Gypsum Products
66.	Can	3720	Mixed Fertilizers
	Can	3730	Plastics & Synthetic Resins
	Can	3781	Manufacturers of Pigments & Dry Colours
	Can	3782	" " Industrial Chemicals (Inorganic, n.e.c.)
	Can	3783	" " " " (Organic, n.e.c.)
	Can	3791	" " Printing Inks
	Can	3799	Miscellaneous Chemicals Industries n.e.c.
	U.S.	28A	Industrial Chemicals & Synthetics
	U.S.	28E	Agriculture Chemicals
	U.S.	28F	Miscellaneous Chemical Products
67.	Can	3911	Instruments & Related Products
	Can	3913	Orthopaedic & Surgical Appliances
	Can	3914	Ophthalmic Goods
	Can	3915	Dental Laboratories
	U.S.	38A	Scientific & Measuring Instruments
	U.S.	38B	Optical & Ophthalmic Goods
	U.S.	38C	Medical Instruments & Supplies
	U.S.	38D	Photographic Equipment & Supplies
68.	Can	2580	Coffin & Casket
	Can	3970	Signs & Displays
	Can	3991	Broom, Brush, & Mop
	Can	3992	Button, Buckle, & Fastener
	Can	3993	Floor Tile, Linoleum & Coated Fabrics
	Can	3994	Sound Recording & Musical Instruments
	Can	3996	Pens & Pencils
	Can	3998	Fur Dressing & Dyeing
	Can	3999	Other Miscellaneous Manufacturing Industries
	U.S.	39C	Manufacturing Industries, n.e.c.

Source: 1) Canada. Department of Industry, Trade & Commerce. 1971 for concordance between Canadian and U.S. industries at the 4 digit SIC level.

2) United States: Bureau of the Census. Enterprise Statistics for concordance between U.S. 4 digit SIC classification and Enterprise Statistics classifications.

APPENDIX B

TABLE B-2

Weights Used For Concordance and Quality of Industry Matchings

Category No.	Canada 4 digit SIC Category	Canadian Weights 1970	Canadian Weights 1979	U.S. Enterprise Category	U.S. Weights 1972	U.S. Weights 1977	Quality of Matching
1	1011	.806	.772	20A	.512	.513	B
	1012	.194	.228	20B	.488	.469	
2	1031	.851	.760	20E	.382	.377	C
	1032	.149	.240	20F	.618	.623	
3	1040	1.000	1.000	20C	.670	.622	A
				20D	.330	.378	
4	1050	.351	.362	20G	1.000	1.000	B
	1060	.649	.638				
5	1071	1.000	1.000	20I	1.000	1.000	A
6	1072	1.000	1.000	20H	1.000	1.000	A
7	1081	.778	.764	20J	1.000	1.000	A
	1082	.222	.236				
8	1083	1.000	1.000	20K	1.000	1.000	C
9	1091	1.000	1.000	20M	1.000	1.000	A
10	1092	.363	.449	20L	1.000	1.000	B
	1093	.579	.168				
	1094	.058	.383				
11	1510	.151	.115	21A	1.000	1.000	A
	1530	.849	.885				
12	1740	1.000	1.000	31A	1.000	1.000	A
13	1810	.356	.304	22A	.712	.780	A
	1820	.190	.162	22E	.288	.220	
	1832	.346	.396				
	1891	.025	.028				
	1894	.083	.110				

14	1831	.314	.219				
	1840	.039	.023	22F	.345	.269	B
	1851	.037	.023	23J	.655	.731	
	1852	.016	.026				
	1871	.041	.029				
	1872	.088	.090				
	1892	.092	.080				
	1893	.061	.056				
	1899	.312	.454				
15	1860	1.000	1.000	22D	1.000	1.000	A
16	2310	1.000	1.000	22B	1.000	1.000	A
17	2460	.241	.278	23G	.567	.553	C
	2480	.459	.346	23I	.433	.447	
	2491	.052	.062				
	2492	.162	.133				
	2499	.086	.181				
18	2450	1.000	1.000	23H	1.000	1.000	A
19	2511	.019	.019	24B	.415	.436	B
	2513	.635	.658	24C	.387	.393	
	2520	.160	.131	24D	.198	.171	
	2541	.144	.145				
	2543	.042	.047				
20	2710	1.000	1.000	26A	1.000	1.000	A
21	2720	.553	.560	29B	1.000	1.000	A
	3652	.205	.265				
	3690	.242	.175				
22	2731	.201	.169	26B	.462	.516	A
	2732	.229	.280	26C	.538	.484	
	2733	.164	.160				
	2740	.406	.391				
23	2880	1.000	1.000	27A	1.000	1.000	A
24	2870	1.000	1.000	27F	1.000	1.000	B
25	2860	.542	.570	27B	.113	.106	B
	2890	.458	.430	27C	.156	.133	
				27D	.102	.098	
				27E	.629	.663	

26	2910	.602	.617	33A	.492	.578	A
	2920	.065	.067	33B	.145	.092	
	2940	.130	.110	33C	.084	.079	
	3050	.203	.206	33D	.114	.088	
				34G	.106	.108	
				34L	.059	.055	
27	2950	.620	.548	33E	.765	.739	B
	2960	.105	.128	33F	.235	.261	
	2970	.062	.062				
	2980	.068	.105				
	3380	.145	.157				
28	3010	.191	.207	34A	.151	.133	C
	3039	.163	.181	34F	.421	.540	
	3042	.646	.612	34I	.428	.327	
29	3020	1.000	1.000	34D	1.000	1.000	A
30	3031	1.000	1.000	34E	1.000	1.000	A
31	3041	1.000	1.000	34J	1.000	1.000	A
32	3060	1.000	1.000	34B	1.000	1.000	A
33	3110	1.000	1.000	35B	1.000	1.000	A
34	3160	1.000	1.000	35K	1.000	1.000	B
35	3180	1.000	1.000	35J	1.000	1.000	B
36	3230	.463	.443	35L	.186	.194	C
	3241	.041	.050	37A	.814	.806	
	3243	.024	.039				
	3250	.472	.468				
37	3270	.836	.810	37D	1.000	1.000	A
	3280	.164	.190				
38	3310	.331	.271	36A	1.000	1.000	A
	3320	.669	.729				
39	3340	.149	.070	36C	.627	.593	B
	3350	.851	.930	36D	.373	.407	
40	3511	.701	.663	32B	1.000	1.000	B
	3591	.299	.337				
41	3550	1.000	1.000	32C	1.000	1.000	A
42	3561	.730	.712	32A	1.000	1.000	A
	3562	.270	.288				

43	3651	1.000	1.000	29A	1.000	1.000	A
44	3740	1.000	1.000	28B	1.000	1.000	A
45	3750	1.000	1.000	28D	1.000	1.000	A
46	3760	.515	.508	28C	1.000	1.000	A
	3770	.485	.492				
47	3912	1.000	1.000	38E	1.000	1.000	A
48	3920	1.000	1.000	39A	1.000	1.000	B
49	3931	.587	.624	39B	1.000	1.000	B
	3932	.413	.376				
50	1720	.274	.240	31B	1.000	1.000	A
	1750	.139	.111				
	1792	.104	.163				
	1799	.483	.486				
51	2391	.209	.257	22C	1.000	1.000	C
	2392	.791	.743				
52	2560	.360	.346	24E	1.000	1.000	A
	2591	.157	.147				
	2592	.113	.083				
	2593	.091	.212				
	2599	.279	.212				
53	2619	1.000	1.000	25A	.423	.472	A
				25B	.290	.308	
				25C	.287	.220	
54	1020	.513	.552	20N	1.000	1.000	C
	1089	.487	.448				
55	1620	1.000	1.000	30A	1.000	1.000	B
56	1650	1.000	1.000	30B	1.000	1.000	B
57	2431	.824	.803	23A	.257	.209	C
	2432	.176	.197	23B	.233	.237	
				23C	.510	.554	
58	2441	.801	.733	23D	.638	.603	C
	2442	.199	.267	23E	.172	.190	
				23F	.190	.207	
59	2640	.276	.354	25D	1.000	1.000	B
	2660	.724	.646				
60	3070	.185	.197	34C	.155	.158	C
	3090	.815	.803	34H	.101	.123	
				34K	.276	.124	
				34M	.469	.595	

61	3210	1.000	1.000	37B	.585	.703	C
				37C	.415	.297	
62	3242	.280	.321	37E	1.000	1.000	C
	3260	.348	.544				
	3290	.372	.135				
63	2680	.032	.034	36B	.296	.200	C
	3330	.080	.069	36E	.704	.800	
	3360	.608	.566				
	3391	.060	.064				
	3399	.220	.267				
64	3512	.121	.089	32E	1.000	1.000	B
	3520	.243	.240				
	3530	.038	.060				
	3570	.160	.132				
	3599	.438	.479				
65	3541	.186	.206	32D	1.000	1.000	B
	3542	.226	.224				
	3549	.523	.484				
	3580	.065	.086				
66	3720	.029	.022	28A	.751	.822	C
	3730	.096	.119	28E	.091	.061	
	3781	.029	.031	28F	.158	.117	
	3782	.220	.266				
	3783	.272	.246				
	3791	.029	.034				
	3799	.325	.282				
67	3911	.656	.644	38A	.453	.434	B
	3913	.025	.027	38B	.107	.107	
	3914	.190	.151	38C	.216	.203	
	3915	.129	.178	38D	.224	.256	
68	2580	.053	.030	39C	1.000	1.000	C
	3970	.234	.260				
	3991	.096	.077				
	3992	.082	.059				
	3993	.157	.121				
	3994	.081	.105				
	3996	.047	.038				
	3998	.025	.039				
	3999	.225	.271				

Note: 1) Each category was assigned an ordinal ranking, A, B or C based on the authors' assessment of the precision of the matching
A - best matching
B - intermediate case
C - worst matching

2) The Canadian 4-digit classification uses the 1970 SIC definitions.
3) The U.S. Enterprise Codes are taken from the U.S. 1972 Enterprise Statistics.
4) The weights are calculated as the percentage of employees in the category and is taken from the Canadian Census of Manufactures for 1970 and 1979 and from the U.S. Census Enterprise Statistics for 1972 and 1977.

APPENDIX C

Table C-1

The Determinants of the Ratio of Canadian Average Plant Size to the U.S. Branching Estimate of MES, for 52 Canadian Manufacturing Industries, 1970 and 1979

VARIABLE	1970 COEFF.	1970 S.E.	1970 SIGNIF.	1979 COEFF.	1979 S.E.	1979 SIGNIF.
INDIV	0.017	0.007	0.03	0.02	0.007	0.002
RESCON	0.009	0.011	0.43	0.49	1.74	0.78
IMP	-0.55	0.90	0.55	-0.52	0.33	0.12
ERP	1.43	0.84	0.10	2.03	0.42	0.00
SIZE	0.004	0.001	0.001	0.003	0.001	0.002
DIV	-0.78	0.58	0.19	-0.81	0.60	0.19
CA	-0.17	0.27	0.53	-0.11	0.23	0.64
CDR1	1.10	0.49	0.03	1.05	0.39	0.01
FOR	0.13	0.51	0.80	-0.30	0.51	0.55
R^2	.50			.64		
F (9,43)	7.01			11.42		
Mean of RELBRNCH	.92			1.00		

APPENDIX D

TABLE D-1

Correlation Matrix for 1970

	INDIV	RESCON	IMP	ERP	SIZE	DIV	CA	FOR	CDR1
INDIV	1.000	0.209	-0.044	0.060	0.297	-0.150	0.396	0.613	0.379
RESCON	0.209	1.000	-0.382	-0.232	0.541	0.078	0.020	-0.078	-0.264
IMP	-0.044	-0.382	1.000	-0.226	-0.273	-0.258	-0.181	-0.104	0.392
ERP	0.060	-0.232	-0.226	1.000	-0.156	0.013	0.194	0.179	0.082
SIZE	0.297	0.541	-0.273	-0.156	1.000	-0.096	0.471	0.065	-0.285
DIV	-0.150	0.078	-0.258	0.013	-0.096	1.000	-0.008	-0.239	-0.107
CA	0.396	0.020	-0.181	0.194	0.471	-0.008	1.000	0.159	0.325
FOR	0.613	-0.078	-0.104	0.179	0.065	-0.239	0.159	1.000	0.112
CDR1	0.379	-0.264	0.392	0.082	-0.285	-0.107	0.325	0.112	1.000

TABLE D-2

Correlation Matrix for 1979

	INDIV	RESCON	IMP	ERP	SIZE	DIV	CA	FOR	DCR1
INDIV	1.000	-0.116	0.182	0.136	0.251	0.144	0.588	0.636	0.450
RESCON	-0.116	1.000	-0.021	0.049	-0.022	0.320	-0.112	-0.109	-0.267
IMP	0.182	-0.021	1.000	0.118	-0.145	-0.005	0.053	0.086	0.348
ERP	0.136	0.049	0.118	1.000	-0.028	-0.266	0.273	0.243	-0.118
SIZE	0.251	-0.022	-0.145	-0.028	1.000	-0.060	0.347	0.075	-0.316
DIV	0.144	0.320	-0.005	-0.266	-0.060	1.000	0.030	0.033	-0.006
CA	0.588	-0.112	0.053	0.273	0.347	0.030	1.000	0.423	0.333
FOR	0.636	-0.109	0.086	0.243	0.075	0.033	0.423	1.000	0.178
CDR1	0.450	-0.267	0.348	-0.118	-0.316	-0.006	0.333	0.178	1.000

FOOTNOTES

1. Plant scale has been examined by Bain (1966), Eastman and Stykolt (1967), Scherer et al. (1975), Gorecki (1976), Caves et al. (1980), Dickson (1979) and Gupta (1979); diversity has been studied by Caves (1975) and (1980), and Daly et al. (1968).

2. Bain (1966); Eastman and Stykolt (1967); Scherer et al. (1975).

3. Caves et al. (1980).

4. Daly et al. (1968).

5. Baldwin and Gorecki (1983a, b, c, d).

6. The reasonableness of the assumptions requires some attention. The first set, having to do with the plant cost curve, has been used profitably by others (Caves et al. 1980). The second set does not seem unreasonable. Others have argued (Royal Commission on Corporate Concentration, 1978) that firm level economies are not fully exploited at the point where plant level economies are exhausted.

7. This does not mean that plant level diversity will necessarily fall as plants get larger because another separate phenomenon is taking place. Large firms tend to be more diversified (Caves et al. 1980). Large firms also possess larger average size plants. Thus as plant sizes get larger, the actual level of plant diversity may continue to increase well beyond the MES point. But in this size range, diversity is not being used to increase plant size to exploit plant economies.

8. These assumptions -- plant fixed cost of d; product line fixed cost of a; constant marginal cost per product line of b -- yield a plant cost curve of

   $$TC = d + Na + bQ$$

   where $N \equiv$ number of products.

   Thus

   $$AC = b + \frac{aN+d}{Q}.$$

9. This presumes that the reduction in fixed costs associated with the product line Na is more than offset by the increase in d to 2d. More generally, if the optimal number of plants (M) for a given products (n) is chosen, increasing the number of plants above M will shift the firm average cost curve up as is shown in figure 1.

10. $$CAN1 = \frac{d+N_2a}{Q} + b.$$

$$US1 = \frac{d+N_1a}{Q} + b.$$

$CAN1 > US1$ if $Q<\infty$ and $N_2>N_1$.

11. See McVey (1972) for an article discussing average establishment size for large and small enterprises.

12. Masson and Shaanan (1982), p. 418, Scherer et al. (1975), pp. 182-183, and Weiss (1976), pp. 132-136.

13. The U.S. Enterprise Statistics contain data on number of plants per firm for both single industry and multi-industry firms. All plants belonging to single industry firms are located in the same industry as the firm; but plants belonging to multi-industry firms and assigned to the industry of the multi-industry firm may actually come from a different industry. Primary plants of multi-industry firms are those that are appropriately assigned to the industry in which the multi-industry firm is located; but secondary plants are from other industries. Unfortunately the Enterprise Statistics do not publish the number of primary plants per firm by size class -- only the total of primary and secondary plants. The multi-industry category is inadequate then because its use will tend to bias downward the MES estimates. Multi-industry firms will be listed as opening a second plant when that plant may be in another industry. To the extent that all size categories for multi-industry firms contain some firms that have diversified into other industries, the value of the plant per firm variables is shifted upwards for every size class and the size at which a firm first has on average 1.5 plants is biased downwards. Indeed, this appears in the data. MES calculated from multi-industry firms is smaller than for single industry firms. Thus, multi-industry firms were excluded and only single industry firms were used in calculating the branching estimate of MES.

14. The mean of RELBRNCH is .92 and 1.00 for the early and late seventies for groups A and B together. No importance can be attached to the growth in RELBRNCH since the years used in numerator and denominator of the two ratios should, in a growing economy, have led to an increase in the ratio.

15. This result is different from that reported in our previous work where large U.S. plant size is used as a proxy for MES and compared to Canadian large plant size. The average plant size for large Canadian plants was about 70 per cent of the average U.S. large plants.

16. See Scherer et al. (1975), pp. 23-24, and 88-89 for a more detailed discussion of the relationship between market density and the slope of ADC.

17. MES is here defined as the size of the larger plants and not BMES because otherwise RESCON would measure not only the residual effects other than plant size that determine concentration but also the effects that determine the difference between large firm plant size and BMES.

18. See the data appendix for a description of this variable. Baldwin and Gorecki (1983d)contains a more detailed description of the difference between the diversity measure used here and that used by Caves.

19. See Caves et al. (1980) and Gorecki (1980) for details.

20. It might be argued that outbound diversification rather than in-bound diversification would more closely approximate this phenomenon. An experiment with alternate formulations of the INDIV variable turned up no significant differences so the two industry level diversification measures were combined.

21. Snape (1977), Curtis (1983), Krugman (1980).

22. It may be that EAST will be picking up some of the general size affect represented by SIZE. Since collinearity between SIZE and EAST is very high, this possibility cannot be excluded.

23. Baldwin and Gorecki (1983d).

24. While the relative plant scale effect (Baldwin and Gorecki, 1983c) was indeed primarily a function of tariffs only in high concentration industries, this does not appear to be the case for the tariff effect on RELBRNCH.

25. Appendix Table C-1 shows CDR1 is significant for Groups A and B together.

26. Our evidence is broadly consistent with this. If diversity is included in the relative plant scale equations reported in Baldwin and Gorecki (1983c), it has a negative coefficient which is generally insignificant. Thus while the effect of diversification is felt across the size range, it is generally only significant in Canadian plant size as measured against U.S. BMES.

27. Eastman and Stykolt (1967), English (1964).

28. Caves et al. (1980).

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