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Working Paper No. 4

From Plants to Enterprises in the Analysis of Diversification: Implications of Different Assumptions

by

Paul K. Gorecki

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Abstract

This paper is concerned with a problem in aggregating the output diversity of the plants which are owned or controlled by an enterprise to estimate the size distribution of products for the enterpise. Previous studies have made differing assumptions in allocating the output of the plant across the N industries in which it produces. On the basis of the particular assumption made, indices of enterprise diversification are derived. Regression techniques are then applied to explain the interenterprise variance of diversification. Policy recommendations and conclusions are then often drawn. A problem arises because of the arbitrary nature of the assumption made about the N markets over which a plant allocates its output and the lack of any attempt to examine the sensitivity of the conclusions and empirical results to alternative assumptions.

The paucity of data on the size distribution of products at the plant level has been the main reason why previous studies have been forced to make arbitrary assumptions about the size distribution. The purpose of this paper is to examine the validity of these assumptions by using the actual size distributuion of products of a plant. Data for 890 plants and 155 enterprises in the Canadian food manufacturing sector is used to examine this question.

Three major findings emerge from this study. First, there appears to be no unique distribution which can be applied to the N products over which a plant allocates its output, which holds irrespective of the industry classification system used. However, despite this, two of the commonly used assumptions yield size distributions which are markedly less skewed than the actual distribution while the converse applied to the third assumption. This result is robust to the extent that it held for two quite different levels of industry classification. Secondly, application of the three distributions implies that statistics released by census authorities typically understate the degree of enterprise diversification while previous studies based on Fortune as well as Dun and Bradstreet data for larger enterprises have overstated the degree of enterprise diversification. Such differences are large and systematic. Thirdly, in terms of the determinants of diversification, considerable similarity is observed in that the major explanatory variable is enterprise size, irrespective of the assumption, but nevertheless differences did occur with respect to the overall explanatory power of the model and, to a lesser extent, the size of the co-efficient on the major explanatory variable. This suggests that future researchers should test the sensitivity of their results to the distribution used.

Résumé

Le présent document porte sur la difficulté de totaliser la production diversifiée des usines appartenant à une entreprise ou contrôlées par elle, pour évaluer la distribution des produits de cette entreprise. Des études précédentes ont émis diverses hypothèses en répartissant la production de l'usine sur les N industries auxquelles elle appartient. Une hypothèse en particulier permet d'établir l'indice de diversification de l'entreprise. On se sert alors de techniques de régression pour expliquer la variance de diversification entre les entreprises et, bien souvent, l'on en tire des recommandations de principe et des conclusions. Un problème surgit en raison du caractère arbitraire de l'hypothèse émise à propos du nombre N de marchés parmi lesquels une usine distribue sa production et de l'absence d'effort en vue de déterminer dans quelle mesure d'autres hypothèses pourraient influer sur les conclusions et les résultats empiriques.

La pauvreté des données sur l'étendue de la distribution des produits à l'usine explique pourquoi il a fallu, dans les études précédentes, émettre des hypothèses arbitraires sur le chiffre de distribution. Le présent document a pour objet d'étudier la validité de ces hypothèses en se fondant sur le chiffre réel de la distribution des produits d'une usine. Des données concernant 890 usines et 155 entreprises dans le secteur de la fabrication de produits alimentaires permettront d'étudier cette question.

Voici les trois principales conclusions de cette étude. Tout d'abord, il semble n'y avoir aucun mode de distribution unique qui puisse être appliqué aux N produits sur lesquels une usine répartit sa production, ce qui est valable indépendamment du système de classification de l'industrie utilisé. Toutefois, malgré cela, deux des hypothèses les plus courantes produisent des chiffres de distribution nettement moins dissymétriques que la distribution réelle, tandis que l'inverse s'applique à la troisième hypothèse. Le résultat est solide dans la mesure où il s'est maintenu pour deux niveaux très différents de classification de l'industrie. Deuxièmement, l'application des trois hypothèses de distribution signifie que les statistiques publiées par le bureau du recensement sous-estiment de façon caractéristique le degré de diversification des entreprises tandis que les études précédentes fondées sur les données de Fortune ainsi que de Dun et Bradstreet relatives aux plus grosses entreprises ont surestimé le degré de diversification des entreprises. De telles différences sont importantes et systématiques. Troisièmement, on a observé que les causes déterminantes de la diversification se ressemblent beaucoup, à savoir que la principale variable explicative est la taille de l'entreprise, indépendamment de l'hypothèse émise. Néanmoins, des différences se sont manifestées sur la plan de

la capacité explicative globale du modèle et, de façon moins prononcée, pour le coefficient de la principale variable explicative. Cela signifie qu'à l'avenir, les chercheurs devront évaluer dans quelle mesure leurs résultats cadrent avec le mode de distribution considéré.

Acknowledgements

I should particularly like to acknowledge my indebtedness to Richard St. George who collected the data upon which the study is based and answered my numerous queries. D. Khosla made extremely useful and instructive comments on an earlier version of the paper. Finally, capable research assistance has been provided by Denis Moreau and, initially, Michael Mullagh.

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FROM PLANTS TO ENTERPRISES IN THE ANALYSIS OF DIVERSIFICATION: IMPLICATIONS OF DIFFERENT ASSUMPTIONS

I INTRODUCTION

This paper is concerned with a problem in aggregating the output diversity of the plants which are owned or controlled by an enterprise to estimate the size distribution of products for the enterprise. Previous studies have made differing assumptions in allocating the output of the plant across the N industries in which it produces. On the basis of the particular assumption made, indices of enterprise diversification are derived. Regression techniques are then applied to explain the inter-enterprise variance of diversification. Policy recommendations and conclusions are then often drawn. A problem arises because of the arbitrary nature of the assumption made about the N markets over which a plant allocates its output and the lack of any attempt to examine the sensitivity of the conclusions and empirical results to alternative assumptions.

The paucity of data on the size distribution of products at the plant level has been the main reason why previous studies have been forced to made arbitrary assumptions about the size distribution. The purpose of this paper is to examine the validity of these assumptions by using the actual size distribution of products of a plant. The main focus of the paper is to evaluate the implications of each assumption for commonly used indices of

diversification at the plant and enterprise level and the difference in regression results between these various indices, depending on the assumption made.

The paper is divided into six sections including the introduction. Section II sets out the main assumptions which have been used in previous work concerning the size distribution of products at the plant level. The third section briefly describes the data base used in this paper and three commonly used indices of diversification. Section IV attempts to quantify the most appropriate statistical distribution for representing the size distribution of products produced in a plant by reference to a sample of 890 plants. The next two sections detail the sensitivity of the indices of enterprise diversification and the inter-enterprise determinants of diversification to the alternative assumptions, outlined in section II, which are made about the output diversity of the plant in order to derive the size distribution of products to the enterprise. Section VII contains a brief summary and some conclusions.

II ASSUMPTIONS MADE CONCERNING THE OUTPUT DIVERSITY OF A PLANT

Three assumptions have been made in the literature with respect to the size distribution of products produced in a plant, namely, primary, geometric and rectangular. Each of these will be discussed briefly below with an indication of the frequency with

which the assumption has been used.

Actual Distribution

Only one published source could be found which aggregated the actual size distribution of products of a plant to form the output profile of the enterprise across the N industries in which it produced output. The U.S. Federal Trade Commission (1972) made available the value of shipments, by product class, for the 1,000 largest U.S. manufacturing companies in 1950.[1] The actual establishment data was not published. Only limited use of this data source has been made since its publication.[2]

Primary Distribution

The primary distribution allocates the total output of each plant to the primary industry of the plant. The primary industry of the plant is that industry which accounts for the largest portion of the output of the plant. For example, if a plant has $233 thousand classified to market 1 and $112 thousand to market 2[3] and zero to all other markets, then the primary market of the plant is market 1. The primary distribution assumption is made by the census authorities in Canada, the U.K. and the U.S.A. in compiling their published statistics relating to diversification.[4] Many of the published studies in the U.S. and the U.K. have relied wholly or in large part upon such census based data.[5] As yet no study in Canada has appeared utilizing the available data. The census authorities have access to the complete output profile of a plant across the N industries in which it allocates its output, but chooses to make use of

only one piece of information: the identity of the primary industry. No reason is given by the census authorities for this procedure, although convience must clearly be a major consideration.

Rectangular Distribution

The rectangular distribution divides the output of the plan equally across the N industries in which the plant produces a non-zero output. In other words if a plant produces in N industries then 1/N is the proportion of its output allocated to each of the N industries. For example, given the information that plant A had a total output of $100 million distributed between markets 1 and 2, then application of the retangular distribution would yield an output profile of $50 million in each market. The rectangular distribution has been applied by Berry in his extensive analysis of diversification for the U.S. Berry's data base, Fortune Plant and Product Directory,[7] listed all the product classes in which a plant produced and the total output[8] of the plant. Since Berry had no information on the relative importance of the N markets in which a plant produced or even the identity of the primary market he had no *a priori* basis upon which to attach more weight to one market than another.[9] Hence, the rectangular distribution, which assigned an equal weight to all the N markets in which a plant produced, was the most practical solution.

Geometric Distribution

The general form of a geometric sequence is

$$a,\ ar,\ ar^2,\ ar^3 \ldots\ldots ar^{N-1}$$

where N is the number of items in the sequence, a is the starting point of the sequence (i.e. N=1) and r is the common ratio. For example, if r=2, a=1, then the geometric series is of the form 1, 2, 4, 8, 16 etc. There are an infinite number of geometric series depending upon the selected values of a and r. The sum of a geometric series, S, with N items, is found by applying the following formulae,

$$SN = \frac{a(1-r^N)}{1-r}$$

To form the geometric distribution, from a geometric sequence, which can then be applied generate the size distribution of products produced by a plant, the following procedure is used. Given the number of markets over which a plant distributes its output (i.e. N) the weight which is applied to the plant's i^{th} market is

$$Si/\sum_{i=1}^{N} Si$$

For example, if a=1, r=2, N=4 then the resulting distribution is 1/15, 2/15, 4/15 and 8/15. The geometric distribution can be applied when three pieces of information are known: the size of the plant; the identity and ranking of the industries on which the plant allocates its output. Such data is available from a Dun and Bradstreet source, Dun's Market Identifiers,[10] which refers to the plants of larger U.S. and Canadian enterprises.[11] Caves (1975, 1977a, 1977b) has used this data source, applying the geometric distribution, to produce the major contribution in the literature relating to diversification

in Canada.[12] The particular form of the geometric distribution selected by Caves has a=1 and r=2.[13] Caves made no attempt to justify this particular form of the geometric distribution.[14]

Given that a plant allocates its output among N different markets, application of the primary and rectangular distributions yield the minimum and maximum degree of diversification, respectively. The primary assumption is the limiting case as the output in N-1 markets tend to zero, the whole of the output of the plant being allocated to the Nth industry. In contrast the rectangular assumption allocates the output of the plant equally among the N industries in which the plant operates. The geometric distribution occupies an intermediate position.

III DATA SOURCE AND DIVERSITY INDICES

Nature of Sample

The study of diversification in this paper relates to both plants and enterprises, which are defined in terms of the plants they own or control. However, the data source used here is drawn from a study on the structure, conduct and performance of the Canadian food manufacturing sector.[15] The sample selection criteria referred to enterprises not plants. The original sample of enterprises was selected such that at least the leading four enterprises in each of 105 regional and national markets into which the food manufacturing

sector was divided were chosen. Data was collected on all the activities of the enterprise in the food manufacturing sector, not just the enterprise's activity in the market(s) in which it was among the leading four enterprises. No data was collected on plants, owned by these enterprises, which were primarily engaged in non-food activities. Available data from other sources indicates that the diversified enterprise is substantially larger than the specialist.[16] This suggests that the sample of enterprises selected for the food study is likely to be especially appropriate for an analysis of diversification. Unfortunately, little data could be obtained on the representativeness of the sample, since the size distribution of enterprises is not available. However, the sample of enterprises accounted for approximately 50 per cent of the value of shipments of food manufacturing sector.[16a]

This brief description reveals a number of possible limitations concerning the data base. First, it only refers to enterprises primarily engaged in the food manufacturing sector and hence generalisation to the manufacturing universe is difficult without additional information. Second, the non-food manufacturing plants of the sample of enterprises are excluded. However, the sample used here is restricted only to enterprises wholly or mainly in the food sector. Nevertheless presentation of the results in the succeeding sections can be justified because the findings are quite striking and unambiguous, the major study on diversification in Canada used a sample of food manufacturing enterprises in order to derive the most appropriate distribution for the manufacturing

sector as a whole[17] and, finally, given that no attempt has hitherto been made to test the implications of the alternative distributions detailed in Section II this paper at least provides a starting point.

Measures of Diversification

An enterprise or plant allocates its output among N markets. Let Pi represent the proportion of output in the ith market, where i represents the rank of the ith market such that $Pi > Pi+1$, for all i except N. Given such information, it is possible to derive a large number of indices of diversification. Attention will be confined here to three commonly used indices.[18] For ease of expression the discussion is framed in terms of the enterprise, since these indices have been applied almost exclusively to the enterprise. However, the general definition and properties of the indices also apply, mutatis mutandis, to plants.

The first index, D_1, attempts to take into account both the number of different markets in which an enterprise operates (N) and the relative importance of each market (Pi). D_1 can be defined as,

$$\sum_{i=1}^{N} Pi^2$$

The index will vary between 1 for a specialist enterprise (i.e. N=1) and 1/N* (where N=N*, Pi=1/N* for all i, and N* is the maximum the number of industries in the universe). If the enterprise allocates its output equally among N industries

$D_1=1/N$. This is referred to as the Numbers Equivalent. The D_1 index has been used extensively by those sources which make use of the geometric and rectangular assumptions. Most census authorities do not estimate D_1 in their published statistics. The exception is Canada.[19]

The second index, D_2, is defined as N-1. This index will vary between zero for specialist enterprises and N*-1 for enterprises which operate in all N* industries into which the universe is divided. This simple descriptive index has been used by the papers using the geometric and rectangular distribution.[20] Only U.K. census publications and, to a lesser extent, Canadian[21] permit an indication of the magnitude of D_2.

The third index is $D_3=1-P_1$, where P_1 is the market which accounts for the largest proportion of the output of the enterprise. D_3 will vary between when the enterprise is a specialist and (N*-1)/N* when the enterprise allocates its output equally among N* markets. Like D_1, D_3 has a Numbers Equivalent which can be defined as $1/(1-D_3)$. It shows the number of industries among which the enterprise must allocate its output equally in order to generate the observed value of D_3. D_3 is presented by census authorities[22] in the U.K., U.S. and Canada, while of these studies using the geometric and rectangular distribution only Caves (1977a, 1977b) uses D_3.[23]

IV THE APPROPRIATE DISTRIBUTION OF OUTPUT AT THE PLANT LEVEL

The sample of 890 plants for which data are available was first divided into categories based upon the number of industries, N, over which their output was allocated. An industry is defined at the 3-digit level of the Canadian Standard Industrial Classification System[24] which delimits eight separate industries in the food manufacturing sector.[25] The resulting frequency distribution is as follows:

N	Number of Plants	%
1	513	57.6
2	274	30.8
3	90	10.1
4	12	1.3
5	1	0.1
TOTAL	890	100.0

Not surprisingly a marked skewness characterizes the distribution with the frequency dropping sharply for higher values of N.

Table 1 presents, for plants allocating their output over 2, 3 and 4 industries,[26] the average values of P_1, P_2, P_3 and P_4 (i.e., actual distribution) together with what would be predicted by the application of the goemetric (r=2, a=1) and rectangular distributions. The primary distribution yields P_1=1.00 for all N. The table shows large and systematic differences in all instances between the actual and the predicted distributions. In particular actual P_1 is much greater than predicted P_1, especially for the

TABLE 1

The Output Diversity of a Plant at the 3-digit Level of Industry Classification

Distribution[a]	P_1	P_2	P_3	P_4
		N=2		
Actual Average[b]	0.87	0.13	-	-
Rectangular	0.50	0.50	-	-
Geometric[e]	0.67	0.33	-	-
		N=3		
Actual Average[c]	0.82	0.15	.03	-
Rectangular	0.33	0.33	0.33	-
Geometric[e]	0.57	0.29	0.14	-
		N=4		
Actual Average[d]	0.85	0.11	.03	.01
Rectangular	0.25	0.25	0.25	0.25
Geometric[e]	0.53	0.27	0.13	0.07

a. The Primary Distribution, for N-2, 3 or 4, yields P_1=1.00.

b. 274 plants.

c. 90 plants.

d. 12 plants.

e. The geometric series used r=2, a=1, which follows Caves (1975).

Source: See text.

rectangular distribution, while the converse applies to P_2, P_3, and P_4. In other words the actual distribution is much more skewed than the geometric and rectangular distributions would suggest. The most appropriate rule for generating the actual distribution in Table 1 is a geometric sequence with r=7, a=1. A comparison with observed or actual P_1, P_2, P_3 and P_4 with that predicted by this sequence is as follows:

P_i \ N=	2		3		4	
	Actual	Predicted	Actual	Predicted	Actual	Predicted
P_1	0.87	0.88	0.82	0.86	0.85	0.86
P_2	0.13	0.13	0.15	0.12	0.11	0.12
P_3	-	-	0.03	0.02	0.03	0.02
P_4	-	-	-	-	0.01	0.003

As can be seen there is a very close conformity between the actual and predicted distributions, irrespective of the number of industries over which the plant allocates output.

TABLE 2

THE IMPORTANCE OF THE PRIMARY INDUSTRY (P_1) OF THE PLANT, AT THE 5-6 DIGIT LEVEL OF INDUSTRY CLASSIFICATION

Distribution[a]	Number of Industries Over Which a Plant Allocates Output														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Actual Average	1.00	0.85	0.75	0.71	0.70	0.65	0.57	0.64	0.60	0.53	0.55	-	0.63	0.46	0.27
Rectangular	1.00	0.50	0.33	0.25	0.20	0.17	0.14	0.13	0.11	0.10	0.09	0.08	0.08	0.07	0.07
Geometric[b]	1.00	0.67	0.57	0.53	0.52	0.51	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Number of Plants[c]	278	235	136	80	36	38	21	20	5	8	4	0	2	1	2

a. The Primary Distribution for N = 1 to 15 yields $P_1 = 1.00$

b. The geometric sequence used r = 2, a = 1, which follows Caves (1975).

c. Only 886 of the 890 plants used in Table 1 are used because of problems with the data. These are outlined in Gorecki (1978, p.12) under Consolidated Returns.

Source: See text

Although the results in Table 1 are quite unambiguous their significance is difficult to assess because studies of diversification often use different, somewhat finer, levels of industry classification than the 3-digit. Table 2 attempts to overcome this difficulty by presenting details of a limited test at a much finer level of industry classification, which roughly corresponds to the U.S. 5 to 6-digit level. At this finer level the food manufacturing sector is divided into ninety-six industries or product markets.[27] The test presented is limited because only actual and predicted P_1 and not $P_{i=1}$ is included, for N=1 to 15.[28]

The results in Table 2 closely parallel those in Table 1 in some important respects: the size distribution of plants is highly skewed toward the lower values of N; the predicted value of P_1 using the rectangular distribution is always well below the actual P_1, for any N. A similar result holds for the particular form of the geometric distribution used here (i.e., r=2, a=1) except that the differences between actual and predicted P_1 are generally less, especially for the higher values of N.[29] However, most of the plants are concentrated in N=2-6, where the differences are still large. Although the

application of the geometric distribution r=7, a=1, considered the most appropriate form of the actual P_1, P_2, P_3 and P_4 in Table 1, does not yield the actual values P_1 in Table 2, nevertheless a distribution which generates a much more skewed distribution than either of those used in the table is needed to derive actual P_1 in Table 2.[30]

In sum, this section has shown that previous assumptions about the size distribution of the N industries over which a plant allocates output are likely to be quite misleading. This is a robust result, since it held for two quite different levels of industry classification. Second, the 3-digit level of industry classification a geometric sequence with r=7, a=1 seemed to provide the best approximation to the actual distribution. A somewhat less skewed distribution is probably appropriate at the 5 - 6 digit level of industry classification. Hence, the most appropriate distribution of a plant's output is likely to vary with the industry classification system used.

V SENSITIVITY OF INDICES OF ENTERPRISE DIVERSIFICATION

In order to derive the output of the enterprise in each of the N industries over which it operates, the output of each plant, owned by the enterprise, in the ith industry, is summed to form the output profile of the enterprise. From such a profile or size distribution D_1, D_2 and D_3 can be estimated for the enterprise. The object of this section is to test the sensitivity of measured enterprise diversification (i.e. D_1 to D_3) when the geometric, primary and rectangular distributions are applied to

generate the output profile of the plant and hence, the enterprise.

A priori it is not possible to predict how aggregation from the plant to the enterprise, using each of the three distributions mentioned in Section II, will affect D_1 and D_3. However, the value of D_2 derived from using either the rectangular or geometric distribution will be the same as the actual value of D_2, while the primary distribution assumption will yield a value of D_2 less than or equal to the actual value of D_2. In general, however, the issue of the affect of aggregation is empirical, not theoretical.

Caves has reported the results of an exercise to test the sensitivity of the output profile of the enterprise across the N industries over which it allocates output, to the assumptions made concerning the product size distribution at the plant level. The test reported by Caves was to compare,

> .... the output profiles for selected firms built up using the geometric-series assumption to control totals reported directly in other sources of information, such as companies' annual reports, and found the match at least as good as that yielded by other trial assumptions [i.e. rectangular and primary][31] ... (Caves, 1975, p.20, footnote 6).

In other words Caves' result implies that for quite different trial assumptions the output profile of the enterprise remained relatively unaffected. In evaluating the significance of this result the data source used here is particularly appropriate for two reasons. First, Caves finding was based upon a sample

TABLE 3

The Means & Standard Deviations[a] of D_1, D_2 and D_3 Under Different Assumptions for Various Samples of Enterprises in the Canadian Food Manufacturing Sector[b], 1970

Index of Diversification	DISTRIBUTION Actual	Primary	Rectangular	Geometric[e]
D_1				
Largest[c] 25	0.6490 (0.2105)	0.7087 (0.2265)	0.4737 (0.2486)***	0.5158** (0.2318)
Largest[c] 50	0.6853 (0.2226)	0.7446* (0.2292)	0.5222 (0.2467)***	0.5565*** (0.2322)
All Diversified[d]	0.6971 (0.2088)	0.8161 (0.2225)***	0.4794 (0.1701)***	0.5226*** (0.1526)
All Enterprises	0.7928 (0.2229)	0.8742 (0.2028)***	0.6440 (0.2805)***	0.6735*** (0.2580)
D_2				
Largest[c] 25	2.8400 (1.6753)	1.6000*** (1.4142)	Same as Actual by Definition	
Largest[c] 50	2.3200 (1.5836)	1.2400*** (1.2216)		
All Diversified	1.9906 (1.2149)	0.7640*** (1.0194)		
All Enterprises	1.3613 (1.3670)	0.5226*** (0.9141)		
D_3				
Largest[c] 25	0.2492 (0.1885)	0.2041 (0.1839)	0.4391*** (0.2498)	0.3484** (0.1878)
Largest[c] 50	0.2302 (0.1964)	0.1795* (0.1858)	0.4062*** (0.2459)	0.3305*** (0.1926)
All Diversified	0.2214 (0.1814)	0.1339*** (0.1776)	0.4703*** (0.1805)	0.3620*** (0.1422)
All Enterprises	0.1514 (0.1820)	0.0916*** (0.1594)	0.3217*** (0.2652)	0.2476*** (0.2057)

a. The standard deviation appears in parenthesis below the average.

b. At the 3-digit level of industry classification.

c. Measured in terms of value of factory shipments (sales).

d. Of the 155 enterprise sample 106 were diversified.

e. The geometric sequence used r = 2, a = 1, which follows Caves (1975).

*** Significant at .01 level
** " " .05 "
* " " .10 "

Note: The levels of statistical significance refer to the difference in means, reading across a row, between the actual mean and those generated by application of each of the three other distributions.

of only six enterprises,[32] whereas the sample size available here is 155. Second, the test reported by Caves had been carried out by Thomas Horst, in writing At Home Abroad (1974 p.60 fn.b) which referred to U.S. food manufacturing enterprises. Here the sample refers to Canadian food manufacturing enterprises.

Table 3 presents the means and standard deviations for the three measures of diversification discussed in Section III above and for four samples of enterprises. The studies using the geometric and rectangular distribution assumptions present results which refer to larger enterprises. For example, Berry's (1975) sample is drawn from the 500 largest U.S. corporations. Hence, in Table 3 data is presented for the 25 and 50 largest enterprises in the food manufacturing sector. On the other hand, the census authorities often present the average level of diversification for all diversified enterprises in a particular industry or group of industries. Table 3 includes this sample of enterprises as well as the complete sample of 155 enterprises.

The differences between the actual means of D_1 and D_3 and the means of these measures of diversification using the rectangular and geometric distributions are large, systematic, and statistically significantly different for the two samples of larger enterprises in Table 3.[33] The differences are systematic in that application of the rectangular and geometric distributions yield mean estimates of D_1 and D_3 which are bias upward, compared to the actual degree of diversification. (Remember D_1 is an inverse index). The bias is greater for the rectangular than the geometric distribution. For example, while the actual mean of D_3 for the largest 25 enterprises

is 0.2492 the corresponding rectangular and geometric means are 0.4391 and 0.3484, respectively. The differences are large in that the means of the actual and predicted D_1 and D_3 are of such a magnitude as to imply quite different inferences concerning the degree of diversification. For example, the actual mean of D_3 for the largest 25 enterprises records that 25 percent of output is classified to non-primary industries, whereas the corresponding number is the rectangular distribution is 44 percent.[34] Table 3 implies that the use of the primary distribution for the sample of all diversified enterprises yields a statistically significant systematic underestimate of the degree of diversification using D_1, D_2 or D_3. The downward bias is much greater for D_2 followed by D_3 and D_1, respectively. Hence, non-surprisingly, the primary distribution leads to a bias in the opposite direction to the rectangular and geometric distributions. This result holds irrespective of the sample of enterprises in Table 3.

In sum, the results presented here suggest that census reports typically understate the actual degree of diversification, while those studies which have used the rectangular and geometric distributions have overstated the degree of enterprise diversification. These differences in means have been large, statistically significantly different and systematic. Hence, Caves (1975) result, based on the earlier work of Horst (1974), that the output profiles of enterprises differed little whether the rectangular, primary or geometric distribution is used is not confirmed here, at least when measured in terms of D_1 or D_3.

VI THE DETERMINANTS OF DIVERSIFICATION: THE SENSITIVITY OF THE REGRESSION RESULTS

The purpose of this section is to examine the validity of previous regression analysis into the determinants of diversification which have relied on the geometric, rectangular or primary distribution in estimating the degree of enterprise diversification. Some commonly used determinants of diversification are introduced. These are then used as the independent variables while the dependent variable is either D_1, D_2 or D_3 estimated under the three aforementioned distributions.

Explanatory Variables and their Specification

The determinants of enterprise diversification can be divided into two categories: those variables which relate to the characteristics of the enterprise such as size and those which refer to the primary industry of the enterprise such as concentration and market growth. Discussion of those variables is to be found in Gorecki (1978, pp. 45-47, 72-74) so that the discussion presented here will be brief.

Two characteristics of the enterprise are introduced as likely determinants of enterprise diversity. Enterprise size is expected to be positively related to enterprise diversity. The larger the enterprise the more likely it is to carry a full-line of goods and be able to diversify into related industries within the food manufacturing sector. The nationality of an enterprise is likely to exert an unequivocal influence on

diversification. The foreign based enterprise may have less diversified output in Canada, because it is able to import items for which only limited Canadian market exists, from its foreign parent. Such an opportunity may not be available to the Canadian enterprise. On the other hand in some instances easy access by the foreign owned enterprise to the parent's research and development, advertising and production experience may result in diversification that would be prohibitively expensive for the Canadian enterprise. Alternatively foreign enterprise diversification may be primarily related to conditions in country of the parent enterprise, not Canada.

The characteristics of the primary industry of the enterprise which may influence the degree of enterprise diversification considered here are concentration, growth, the opportunity to diversify and regionalism. The greater the proportion of the industry output accounted for by the four largest enterprises the most costly and difficult it is likely to be for any of the enterprises in the industry to expand, because of oligopolistic interdependence. Instead diversification is likely to be a favoured form of growth. However, for a given level of concentration the faster the growth rate of the industry (i.e., demand curve shifting to the right) the more likely it is that the enterprise will invest in its primary industry rather than diversify. Hence a negative relationship may be expected between growth and diversification. In industries which are regional in nature, a priori, it is not possible to predict the

relationship with diversification. Finally, the degree of enterprise diversification is likely to negatively related to the scope for diversification within the primary 3-digit industry of the enterprise, which is represented by the number of product markets within such an industry.

The above variables are defined in the following manner:

Variable	Definition
Enterprise size	1970 Sales X 10^{-9}
Nation of Enterprise	1 = Foreign, 0 = Canadian
Concentration in Primary Industry	Output of the four largest Enterprises as a percentage of Industry Sales.
Growth in Primary Industry	(1970 Sales - 1965 Sales)/1965 Sales expressed as a percentage.
Regionalism of Primary Industry	0 = Regional Industry 1 = National "
Opportunity to Diversify within Primary Industry	Number of product markets within a 3-digit SIC industry.

The Regression Results

In presenting the empirical results for the determinants of enterprise diversification a question arose over the most appropriate sample. Berry (1975) Caves (1975, 1977a) and others have presented results for the larger enterprises in the manufacturing sector, while studies based on census data include both larger and small enterprises. However, studies based on census data are usually concerned with the determinants average levels of enterprise diversification, grouped by the primary

TABLE 4

SIMPLE CORRELATIONS BETWEEN ACTUAL MEASURES OF DIVERSIFICATION AND THOSE BASED UPON THREE DISTRIBUTIONS[a] FOR THE LARGEST[b] 50 ENTERPRISES IN THE CANADIAN FOOD MANUFACTURING SECTOR[c]: 1970

Index of Diversification	Distribution		
	Primary	Geometric	Rectangular
D_1	0.8486	0.7490	0.6698
D_2	0.7718	1.000[d]	1.000[d]
D_3	0.8502	0.7577	0.5314

Notes:

a. The Primary, Geometric and Rectangular distributions are discussed further in section II above.

b. Measured in terms of value of factory shipments (sales).

c. At the 3-digit level of Industry Classification.

d. Equal to unity by definition.

NOTE: All correlations are statistically significant at the .01 level.

Source: See text.

industry of the enterprise. Since the Ford manufacturing sector consists of only eight 3-digit industries the sensivity of such studies to the three distributions selected here cannot be explored. Hence, the regression results presented in Table 5 below refer to a sample of large enterprises - the 50 largest in the sample of 155.[35]

An important factor bearing upon the regression results is the correlation between the actual index of diversification and that derived by application of each of the three distributions. The relevant correlations for the 50 largest enterprises are presented in Table 4. The varying magnitude of the correlation coefficients suggest that the regression results for the primary distribution are likely to approximate those of the actual distribution to a much greater extent than either the geometric or (especially) the rectangular. This suggestion is confirmed below.

The regression results are presented in Table 5.[36] Three major inferences can be drawn concerning the similarities and differences with respect to the four distributions. First, irrespective of the index of diversification, the choice of index or distribution, the most consistently significant explanatory variable is enterprise size. Secondly, the overall explanatory power of the regression model differs systematically across D_1 and D_3 by type of distribution. The explained variance is much greater for the geometric and rectangular distributions than either the primary or actual. Further, the use of the F-test suggests that the explanatory power of regression equations 1, 2, 7 and 8 are not significant at the .10 level.

TABLE 5

Regression of Indices of Diversification Under Different Distributions[a] on Various Explanatory Variables for the Largest 50 Enterprises in the Canadian Food Manufacturing Sector[b]: 1970

Equation Number	Distribution	Intercept	Regional Dummy	Enterprise Size	Opportunity	Enterprise Nationality	Concentration	Growth	R^2	F Ratio
		EXPLANATORY VARIABLES								
		REGRESSION CO-EFFICIENTS AND t-VALUES[c] DIVERSIFICATION INDEX = D_1								
1	Actual	16.9287	-23.3443 (-1.41)	-0.1406 (-2.70)***	1.4266 (1.29)	-9.4477 (-1.50)	1.0825 (1.29)	0.7401 (1.54)*	.19933	1.78
2	Primary	16.1292	-22.1563 (-1.25)	-0.1025 (-1.84)**	1.6727 (1.42)*	-8.9486 (-1.33)	0.0846 (1.21)	0.7650 (1.12)	.13968	1.16
3	Geometric	62.9951	-10.4056 (-0.62)	-0.1587 (-3.06)***	0.7555 (0.69)	-7.4380 (-1.19)	0.1139 (0.14)	0.0176 (0.03)	.27823	2.76**
4	Rectangular	54.3058	-9.6769 (-0.54)	-0.1568 (-2.81)***	0.8235 (0.69)	-7.1358 (-1.06)	0.1117 (0.12)	0.1492 (0.23)	.24900	2.38**
		DIVERSIFICATION INDEX = D_2								
5	Actual	4.7764	1.1311 (1.10)	0.0138 (4.28)***	-0.1009 (-1.47)*	0.0919 (0.24)	-0.0457 (-0.88)	-0.0407 (-1.03)	.39605	4.70***
6	Primary	3.4977	0.8416 (1.12)	0.0125 (5.34)***	-0.0718 (-1.44)*	0.2356 (0.83)	-0.0433 (-1.15)	-0.0416 (-1.44)	.45784	6.05***
		DIVERSIFICATION INDEX = D_3								
7	Actual	55.8801	17.0440 (1.12)	0.1011 (2.12)**	-0.9119 (-0.90)	6.4018 (1.11)	-0.7007 (-0.91)	-0.5257 (-0.89)	.13284	1.10
8	Primary	56.4215	14.4611 (0.10)	0.0721 (1.59)*	-1.2408 (-1.29)	6.2303 (1.14)	-0.6859 (-0.94)	-0.5085 (-0.91)	.12568	1.03
9	Geometric	29.0569	10.6085 (0.75)	0.1004 (2.26)**	-0.5946 (-0.63)	7.5190 (1.40)	-0.0611 (-0.09)	-0.1295 (-0.23)	.21710	1.99*
10	Rectangular	22.1631	7.8389 (0.44)	0.1464 (2.59)***	-0.3995 (-0.33)	4.3488 (0.64)	0.1711 (0.19)	-0.0044 (-0.00)	.22834	2.12*

a. The primary, geometric, rectangular and actual distributions are explained in Section II.

b. As the 3-digit level of industry classification.

c. t-values in parenthesis, R^2 tested by F-test; all t-tests one tailed accept enterprise nationality and regional dummy.

*** Significant at .01 level

** " " .05 "

* " " .10 "

Source: See Text

For D_2 the primary distribution yields a slightly higher R^2 than the actual D_2. Thirdly, the explanatory variables regional dummy, enterprise nationality and concentration are never statistically significant at the .10 level. However, opportunity for primary D_1, D_2 and actual D_2 and growth for actual D_1 and primary D_2 are of the predicted sign and statistically significant at the .01 level only.

In view of the relative insignificance of most of the independent explanatory variables, with the noticeable exception of enterprise, the eight equations presented in Table 5 were re-estimated with enterprise size as the only independent or explanatory variable. The results are presented in Table 6. The explanatory power of the model differs systematically across D_1 and D_3 by type of distribution, as in Table 5. Again the F-statistic tends to be lower for the actual and primary distribution than the geometric and rectangular distribution. Finally, the coefficient on enterprise size is larger with the geometric and rectangular distribution than the primary or actual. These results genenerally support those in Table 5.

In sum, the results presented in Tables 5 and 6 suggest that those studies of larger enterprises which have used the geometric or rectangular distribution to generate D_1 or D_3 may have reported regression results that have a marked upward bias in the explained variance and, to a lesser extent, in the statistical significance of the primary explanatory variable - enterprise size. On the other hand the coefficient on the major explanatory variable did exhibit considerable stability between

TABLE 6

Regression of Indices of Diversification Under Different Distributions[a] on Enterprise Size for the Largest 50 Enterprises in the Canadian Food Manufacturing Sector[b]: 1970

Equation Number	Distribution	Explanatory Variables: Intercept	Size	R^2	F-Ratio
		REGRESSION CO-EFFICIENTS AND t-VALUES[c] DIVERSIFICATION INDEX = D_1			
1	Actual	77.227	-.134 (-2.727)***	.134	7.439***
2	Primary	81.229	-.104 (-1.998)**	.077	3.992*
3	Geometric	67.003	-.175 (-3.574)***	.210	12.774***
4	Rectangular	63.704	-.177 (-3.364)***	.191	11.317***
		DIVERSIFICATION INDEX = D_2			
5	Actual	1.337	.015 (4.958)***	.339	24.626***
6	Primary	.401	.013 (5.839)***	.415	34.036***
		DIVERSIFICATION INDEX = D_3			
7	Actual	16.744	.097 (2.178)**	.090	4.742**
8	Primary	12.798	.079 (1.867)**	.068	3.484*
9	Geometric	25.578	.115 (2.708)***	.133	7.334***
10	Rectangular	29.731	.167 (3.161)***	.172	9.993***

a. The primary, geometric, rectangular and actual distributions are explained in Section II.

b. As the 3-digit level of industry classification.

c. t-values in parenthesis, R^2 tested by F-test; all t-tests one tailed.

*** Significant at .01 level

** " " .05 "

* " " .10 "

Source: See text.

actual, geometric and rectangular D_1, but only actual and geometric D_3 not rectangular D_3, which was substantially higher. These findings suggest that some caution should be shown in placing heavy reliance on the results of Caves (1975, 1977a and 1977b) for Canada and Berry (1975) for the U.S.A.

VII SUMMARY AND CONCLUSION

The major objective of this paper has been to examine the implications of three commonly used assumptions about the size distribution of products at the plant level, when such data is then aggregated to permit the estimation of output diversity measures for the enterprise. The use of these assumptions reflects the paucity of data available to previous researchers. Data for a sample of 155 enterprises and 890 plants in the Canadian food manufacturing sector was used to investigate the issue.

Three major findings emerge from this study. First, there appears to be no unique distribution which can be applied to the N products over which a plant allocates its output, which holds irrespective of the industry classification system used. However, despite this, two of the commonly used assumptions yield size distributions which are markedly less skewed than the actual distribution while the converse applied to the third assumption. This result is robust to the extent that it held for two quite different levels of industry classification. Secondly, application of the three distributions implies that statistics

released by census authorities typically understate the degree of enterprise diversification while previous studies based on Fortune as well as Dun and Bradstreet data for larger enterprises have overstated the degree of enterprise diversification. Such differences are large and systematic. Thirdly, in terms of the determinants of diversification, considerable similarity is observed in that the major explanatory variable is enterprise size, irrespective of the assumption, but nevertheless differences did occur with respect to the overall explanatory power of the model and, to a lesser extent, the size of the co-efficient on the major explanatory variable. This suggests that future researchers should test the sensitivity of their results to the distribution used.

One policy implication is worth noting. If large corporate size is considered to be of concern in public policy, then it is important to know whether this primarily reflects the enterprise's large size in one industry which may be the result of monopoly power or whether it reflects activity spread across several industries which may result from diversification to reduce risk. For the 50 largest enterprises in the sample of 155 application of one assumption suggests that, on average, the enterprise allocates 82 percent of its output to one industry, while another assumption yields 59 percent. In the former instance policies aimed at large size would be framed in terms of the primary industry of the enterprise, while in the latter instance much more attention would be paid to the non-primary activities of the enterprise.

FOOTNOTES

1. This publication was based on an earlier study, the Federal Trade Commission (1957). Examination of this reference, particularly pp. 24-35, suggested that individual plant data was used.

2. The only reference that could be located which related primarily to diversification was Honeycutt and Zimmerman (1976).

3. The definition of product markets and industries will be discussed further below. At this stage these terms are used interchangeably.

4. For Canada, see McVey (1972) and Statistics Canada, (1977, Table 4, pp. 114-135: 1978, Table 4, pp. 182-197); the U.K., Board of Trade (1968-69, Part 132, Table 16, pp. 18-57) and for U.S. Bureau of the Census (1963, Part 1, Table 4-b).

5. For the U.K. see, for example, Amey (1964), Gorecki (1974, 1975), Hassid (1975), Utton (1977), while for the U.S. see Gort (1962), Rhoades (1973).

6. Berry wrote a number of articles which are brought together in Berry (1975). Markham (1973) uses Berry's data on diversification, while Hexter (1975, pp. 133-134) employs a slight variant of Berry's method.

7. This is fully discussed by Berry (1975, pp. 52-88) where appropriate references and sources are to be found.

8. Output is used as a convenient shorthand for the size dimension. Both Caves (see geometric distribution below) and Berry had to rely on plant employment which is likely to introduce a further source of bias if labour/output ratios differ. Census data used value of shipments (sales).

9. See Berry (1975, p. 66, footnote 9 and pp. 76-78).

10. See Caves (1975, p. 15; 1977a, p. 96). The data base is discussed in detail in Caves (1975, pp. 15-21).

11. The only limitation is that the data source lists the most important products produced by a plant up to a maximum of six. Since the level of industry classification is at the 3-digit level this shortcoming probably is not of great consequence.

12. See also Lemelin (1977) which was carried out as part of Caves' larger study.

13. See Caves (1975, p. 20). It has the additional property that the weights must always sum to unity.

14. An attempt was made, however, to justify this particular form of the geometric distribution versus two other non-geometric distributions. This is discussed in section IV below.

15. The sample was selected not for the purpose of an analysis of diversification but rather a study of structure-conduct performance relationships. The data was collected under the powers of section 47 of the Combines Investigation Act, R.S.C. Full details will be found in St. George (forthcoming, 1978).

16. See, for example, Consumer and Corporate Affairs (1971, Table 11-3, p. 16) and McVey (1972). Note both sources used the Primary Distribution in aggregating from plant to enterprise. As discussed below, this is likely to bias the number of diversified enterprises downward.

16a. The sample coverage for plants was higher, 65 per cent, since slightly different criteria were used for plants and enterprises. Full details may be found in Gorecki (1978, pp. 9-14).

17. Caves (1975, 1977a, 1977b). This is discussed in section IV below.

18. The following discussion of these measures is a much abbreviated version of Gorecki (1974a).

19. See McVey (1972) and Statistics Canada (1978).

20. Sometimes defined as N rather than N-1.

21. Canadian data available for enterprises irrespective of primary industry (i.e. P_1). (See Consumer and Corporate Affairs, 1971, Table 11-3, p. 16, and McVey, 1972).

22. The census publication often presents P_1 under the title of the Specialisation Ratio.

23. The only study based on actual data, Honeycutt and Zimmerman (1976) used all three indices, as well as several others.

24. See Domionion Bureau of Statistics (1970) for details of this Standard Industrial Classification System.

25. The eight industries were: 101, Meat and Poultry Products; 102, Fish Products; 103, Fruit and Vegetable Processing; 104, Dairy Products; 105, Flour and Breakfast Cereal

Products; 106, Feed; 107, Bakery Products; 108, Miscellaneous Food. This eight-fold classification follows the 1970 Canadian Standard Industrial Classification.

26. Data is not presented for N=5 since only one plant falls in this category and information cannot be released for confidentiality reasons.

27. For a list of these markets see St. George (forthcoming, 1978, Appendis B).

28. Limited resources meant that only actual P_1 not P_2, P_3, etc. were estimated.

29. However, for N=14, 15 predicted P_1 is greater than actual P_1.

30. A geometric series with r=3 to 4, a=1 provides a somewhat rough approximation of actual Pi in Table 2.

31. See Horst (1974, p. 60, footnote b).

32. In a letter to the author from R. Caves dated Nov. 17, 1976.

33. A similar finding also holds for the other two samples but as pointed out above the relevant comparisons are for the largest enterprises.

34. On the evidence presented in Table 3 the primary distribution yields much closer estimates of D_1 and D_3 than the geometric or rectangular distribution for the larger enterprises. However, the primary distribution has typically not been applied to samples of larger enterprises.

35. In Gorecki (1978) results are presented for the full sample of 155 enterprises. The question of the influence of the nationality of the enterprise is dealt with by estimating separate regression equations for the 101 domestic and 54 foreign enterprises. Here this approach is not used because the resulting sample sizes are considered too small when the total sample is the 50 largest enterprises.

36. The simple correlation coefficients between the independent variables are always less than 0.32 with the exception of that between concentration and opportunity which is, -0.61. See Gorecki (1978, pp. 63-64) for a discussion of this coefficient.

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