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THE USE OF LINEAR DISCRIMINANT FUNCTION IN PROFITABILITY ANALYSIS OF THE SMIS

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ABSTRACT

In this paper, an attempt is made to use the Linear Discriminant Function to study and identify those Small and Medium Industries (SMIs) which are operating profitably and those which are not. Some of the pertinent variables used are level of technology of the production process (as measured by capital-labour ratio or capital intensity, (K/L), labour productivity ratio (V/L) and capital productivity (K/V) as measured by fixed capital per value added. A comparison is also made between their sub-sectors. It is hoped that such approach can provide useful quantitative information to government agencies, decision makers from financial institutions and industrialists to identify the weaknesses and problems faced by the SMIs.

1.0 INTRODUCTION

The small and medium scale industries (SMIs) play a pivotal role in supporting and complementing the large and multi-national corporations (MNCs) in the industrial sector and they account for 80% of the manufacturing establishments in the country. However, they only contribute to one third of the value-added in the manufacturing sector. In order to help Malaysia in its industrialisation process to realize Vision 2020, the SMIs are expected to contribute significantly in terms of value added and labour absorption in the manufacturing sector to the level of 40 per cent and 50 per cent respectively within the next decade from the current position of 20 per cent and 30 per cent respectively[1]. Their small size coupled with inadequate capital, managerial, marketing and production capability as well as low utilization of modern technology, have resulted in the lack of inter-industry linkages, poor quality products and delays in delivery.[2]

The Government has outlined many physical and fiscal policies to help the SMIs to upgrade their managerial and technological and entrepreneurial know-how and the development of indigenous technology. In spite of all

[1] Government of Malaysia, The Second Outline Perspective Plan 1991-2000, p. 133.
[2] Government of Malaysia, Sixth Malaysia Plan 1991-1995, p. 143.

these programmes, many SMIs are still operating in the red and not able to maintain the required level of productivity and competitiveness. Hence there is a need to identify the variables and their relationships which contribute to the profitable operation of the SMIs. In this paper, a linear discriminating model is introduced to discriminate between those SMIs which are operating profitably and those which are not. It is hoped that such a model will enable decision makers from the financial sectors, government bodies and the industrialists not only to discriminate the contributing factors but also to pinpoint the weaknesses of the SMIs.

2.0 DEFINITION OF SMALL AND MEDIUM SCALE INDUSTRIES

There is no standard or legal definition of Small and Medium Industries in Malaysia as a whole and different agencies adopt different definitions based on their specific programmes and specific objectives. Two definitions commonly adopted are based on existing paid-up capital and employment size. In this paper, the size of the establishments is classified according to the number of workers employed. Those establishments with less than 50 workers are considered small; those with 50 to 199 workers are classified as medium whereas those with 200 and above are regarded as large industries.

2.1 PROBLEMS OF SMALL AND MEDIUM SCALE INDUSTRIES

In order to operate profitably, the SMIs need to restructure their industries from low value-added, labour intensive products to high value-added, skill and capital-intensive activities. However, apart from such structural changes, the SMIs have to contend with problems such as low educational level of the entrepreneurs, low level of technology, lack of finance and assistance, absence of export culture, lack of quality control and lack of linkage with large or multi-national corporations.[3]

2.2 INDICATORS OF PERFORMANCES OF THE SMIs

The commonly used indicators of the performances of the SMIs are:

(a) capital-labour ratio or capital intensity (K/L) as measured by fixed capital per worker. This ratio is commonly used to infer the level of technology used or the extent of automation in the industry or its sub-sector or at the firm level depending on how the data are aggregated.

[3] Ambrin Buang, The Malaysian Economy In Transition, Kuala Lumpur: Institut Tadbiran Awam Negara, Malaysia, (1990) pp. 128-130.

For instance, at the firm level, if it has invested heavily on capital equipment, the K/L ratio will be high. Conversely, for labour intensive type of industry, the K/L ratio will be low.

(b) labour productivity (V/L) as measured by value added per worker. Value added is defined as the incremental value of goods due to transformation or production. This takes into account the cost of raw materials or components at all stages of production. The general formula used is:

Value added = Gross sales/receipts from services provided - Cost of raw materials or components used in the production process.

Note that the component of receipts from services rendered is included because some establishments such as welding shops or newspaper publishing firms which are classified as manufacturing establishments according to the Malaysian Industrial Classification (1972), do not exclusively manufacture products but also perform services such as repairing or advertising.

The V/L ratio is related to the K/L ratio in the equation:

$$V/L = (V/K) \times (K/L)$$

(c) capital productivity (K/V) as measured by fixed capital per value added. This is the measure of the contribution of physical capital.

2.3 PROFILES OF THE SMIs IN TERMS OF (K/L), (V/L) AND (K/V)

In this paper, the aggregation of factor intensity at industry and establishment levels is based on data collected during the 1989-90 Study of the SMIs in Sarawak. Out of the 620 manufacturing establishments interviewed, 543 responded to the question whether they registered any profit before tax during the 1988 financial year.

The ratios of V/L, K/L and K/V by employment size and number of establishments of the SMIs in Sarawak are shown in Table 1.

In terms of labour productivity, the mean value added per labour for all the establishments is RM26,489 compared to RM24,665 for Peninsula Malaysia according to the 1989 Yearbook of Statistics. However, the Large Industries (LIs) have a significantly lower mean value added per worker of RM18,641. The lower labour productivity of these establishments could be due to the low level of technology employed in their production process. In fact, according to the 1989-90 Study of the SMIs in Sarawak, only 19% of the LIs are either fully mechanised or using more sophisticated technology. Perhaps this also accounts for the fact that the average K/L ratio for the LIs is RM16,134, a relatively low figure in comparison with the national figure of RM68,392 for the Large Industries. Another possible reason which accounts for the low value added of the Large Industries is that most of them have to import their intermediate and capital goods and capital equipment as the local SMIs which can supply the intermediate or capital goods are either non-existent or not able to satisfy the demand in terms of quantity and quality.

TABLE 1

RATIOS OF V/L, K/L AND K/V BY NUMBER OF INDUSTRY AND EMPLOYMENT SIZE OF SMIs IN SARAWAK

Industry Size	Employment Size	Number of Industry	V/L (RM'000)	K/L (RM'000)	K/V
TINY	1-9	214	29.255	43.374	1.47
SMALL	10-49	288	28.605	27.470	0.96
MEDIUM	50-199	87	29.455	24.714	0.84
LARGE	200 & ABOVE	21	18.641	16.134	0.87
NOT APPLICABLE		10	-	-	-
OVERALL		620	26.489	32.266	1.19

Source: Report on the Study of SMIs in Sarawak, 1990

In terms of efficiency with respect to capital productivity, the LIs have a value of 0.87 which is only slightly less than that of the medium sized establishments or MIs which have a value of 0.84. With a capital efficiency of 1.47, the Tiny Industries (TIs) seem to be the least efficient. This is followed by the Small Industries (SIs) which have a capital efficiency of 0.96. This confirms the general belief that the TIs and SIs are not efficient because they cannot take advantage of the economy of scale in their production processes.

The K/L and V/L ratios are also used in the Cobb-Douglas production function to study the total factor productivity and the elasticity of substitution of labour for capital. It has the form:

$$V/L = A \times (K/L)^{a}$$

where A is the estimated parameter that reflects the total productivity of the technique and the elasticity of value added with respect to capital.

In the study, the overall factors input of the aggregate of the industrial establishments yields the following Cobb-Douglas production function:-

$$V/L = 10.70 \times (K/L)^{0.204}$$

The averages of the K/L and V/L ratios are RM32,560 and RM23,820 respectively. According to the 1986 Industrial Survey, the corresponding average values for the K/L and V/L ratios are RM37,880 and RM21,250 respectively. The lower K/L ratio is probably due to the fact that the petroleum refinery and LNG plant in Sarawak are excluded in the survey.

The Cobb-Douglas production function shows that the total factor productivity $A=10.70$ while the elasticity of value added is $a = 0.204$. The low value of the elasticity of value added implies that an increase in capital (in the form of higher technology) only results in a small increase in labour productivity. Hence, this application further highlights the importance of these ratios.

3.0 METHODOLOGY

In order to classify the establishments of the SMIs into two distinct groups: one with profit and the other group without profit, linear discriminant functions are computed on the basis of one or more quantitative variables. A parametric method based on multivariate normal distribution theory is used with the assumption that the distribution within each group is multivariate normal.

In this paper, an attempt is made to determine the extent the three ratios, i.e. (K/L), (V/L) and (K/V) can be used to discriminate between those establishments which are operating profitably and those which are not. Initially, the choice of these three ratios is done after a Step-wise discriminant analysis. This technique is used to find a subset of quantitative variables that best reveals the differences among those establishments which registered profits before tax and those which did not. It should be noted that the model selected by the Step-wise discriminant analysis is not necessarily the best possible model with the best measure of discriminating power. However, if the Step-wise discriminant analysis is used carefully, in combination with knowledge of the data used and careful cross-validation, it can be considered as a valuable aid in selecting a discriminating model.

After the initial selection of the three ratios by Step-wise discriminant analysis, a Canonical discriminant analysis is performed on the three variables (i.e. the three ratios K/L, V/L and K/V). The Canonical discriminant analysis computes squared Mahalanobis distances, and does both univariate and multivariate one-way analyses of variance. Canonical discriminant analysis is a dimension-reduction technique related to principal component analysis and canonical correlation. Given a classification variable, in this case profitability (indicated by with or without profit) and several quantitative variables (i.e. the three ratios), the Canonical discriminant analysis derives canonical variables (linear combination of the quantitative variables that has the highest possible multiple correlation with the groups) that summarise between-class variation in much the same way that principal components summarise total variation.[4] The coefficients of the linear correlation are the canonical coefficients or canonical weights. These coefficients themselves will yield information about the relative importance of each quantitative variable insofar as discrimination between groups with profit versus without profit is concerned.

To discriminate between those SMIs which registered profit before tax and those which did not register profit before tax, the following equations for D_1^* (profit before tax) and D_2^* (no profit before tax) are used where:

$$D_1^* = a_1\,(K/L)_1 + a_2\,(V/L)_1 + a_3\,(K/V)_1$$

$$D_2^* = a_1\,(K/L)_2 + a_2\,(V/L)_2 + a_3\,(K/V)_2$$

where a_i = canonical weights or coefficients

$(K/L)_1$, $(V/L)_1$, $(K/V)_1$ = the mean of the respective ratios in the group of establishments with profit

$(K/L)_2$, $(V/L)_2$, $(K/V)_2$ = the mean of the respective ratios in the group of establishments without profit

The linear discriminant function outlined above is an attempt to take the three dimensional space and collapse the 'object' points onto a single (discriminant) axis. The axis was found by computing a set of weights that maximize separation between the two groups relative to their within-group variability. This is done for the following aggregation of establishments according to sector and sub-sector as well as establishment size as tabulated in Table 2.

Lastly, the performance of the linear discriminant function is evaluated by estimating error rates, that is the percentages or probabilities of misclassification.

[4] SAS Institute Inc., SAS/STAT User' s Guide, Release 6.03 Edition, Cary, NC:SAS Institute Inc., 1988, pp.173-175.

Relevant procedures in the SAS statistical package were used to generate the linear discriminant functions for the overall aggregation of the industries as well as the sub-sector of Food & Beverage and Wood & Wood Products according to the establishment size. These functions are used to classify the overall establishments as well as the industrial sub-sector of Food & Beverage and Wood & Wood Products into two groups according to their profitability.

TABLE 2

NUMBER OF ESTABLISHMENTS WITH AND WITHOUT PROFIT BEFORE TAX BY SECTOR AND ESTABLISHMENT SIZE

Sector	Industry Size	No. Of Establishments With Profit	No. Of Establishments Without Profit	Total
OVERALL	SMALL	328	121	449
	MEDIUM	65	11	76
	LARGE	12	6	18
	TOTAL	405	138	543
FOOD & BEVERAGE	SMALL	70	30	100
	MEDIUM	11	1	12
	LARGE	2	2	4
	TOTAL	83	33	116
WOOD & WOOD PRODUCTS	SMALL	74	17	91
	MEDIUM	32	6	38
	LARGE	8	3	11
	TOTAL	114	26	140

4.0 FINDINGS

The results of the linear discriminant functions with their respective canonical variables and coefficients as described by the following models are summarized in Table 3 according to level of aggregations:

$$D_1^* = a_1\,(K/L)_1 + a_2\,(V/L)_1 + a_3\,(K/V)_1$$

$$D_2^* = a_1\,(K/L)_2 + a_2\,(V/L)_2 + a_3\,(K/V)_2$$

TABLE 3

VALUES OF CANONICAL VARIABLES AND COEFFICIENTS OF LINEAR DISCRIMINANT FUNCTIONS BY LEVEL OF AGGREGATION

Sector	Industry Size	a_1	a_2	a_3	D_1^*	D_2^*
OVERALL	SMALL	-0.0000002358	-0.000002258	0.047885	-0.0924	0.2505
	MEDIUM	0.0000033059	0.0000302138	0.020741	0.05185	-0.3064
	LARGE	-0.000016757	0.000079509	-1.22771	0.63810	-1.2762
	TOTAL	0.0000001852	-0.000005286	0.042904	-0.0672	0.1972
FOOD & BEVERAGE	SMALL	0.000009487	-0.0000064532	0.025383	-0.1290	0.30097
	MEDIUM	-0.000069703	0.000084408	3.5541428	0.13046	-1.4351
	LARGE	-0.000396530	0.000137156	5.0561233	0.86603	-0.8660
	TOTAL	0.0000034701	-0.0000072049	0.0322782	-0.1173	0.30779
WOOD & WOOD PRODUCTS	SMALL	0.0000133608	0.0000046495	0.056442	-0.1287	0.56034
	MEDIUM	-0.0000293534	0.0000433421	0.0136423	0.10874	-0.5800
	LARGE	-0.000116911	0.000053836	4.5767759	-0.8022	2.1391
	TOTAL	0.0000232696	-0.0000083887	-0.0081808	-0.10224	0.44830

Table 4 shows the summary of the performance of the linear discriminant functions in the correct classification of those establishments which registered profit before tax. On the whole, the linear discriminant functions manage to classify correctly 331 or 81.728% of the establishments which are making profit before tax. In terms of employment size, the function scores the success rate of 90.552% for the small scale industries and 83.3% for the large scale industries. However, the function only succeeds in classifying 63.087% of the medium scale industries.

The pattern seems to be quite similar for the Food & Beverage as well as the Wood & Wood Products sub-sector. The only exception is that for the Food & Beverage sub-sector, none of the large scale establishments which are making profit is classified correctly by the discriminant function. These findings tally with the fact that the canonical correlations of the three variables (K/L, V/L and K/V) for the small and large scale industries are significantly different from zero.

TABLE 4

NUMBER AND PERCENTAGES OF CORRECT CLASSIFICATION BY THE FUNCTION OF THE ESTABLISHMENTS WHICH REGISTERED PROFIT BEFORE TAX BY SECTOR AND ESTABLISHMENT SIZE

SECTOR	ESTABLISHMENT SIZE		
	Large	Medium	Small
Overall	10 (83.30%)	24 (63.09%)	297 (90.55%)
Food & Beverage	0 (0.00%)	6 (54.55%)	57 (81.43%)
Wood & Wood Products	8 (100.00%)	16 (50.00%)	64 (86.49%)

TABLE 5

NUMBER AND PERCENTAGES OF CORRECT CLASSIFICATION BY THE FUNCTION OF THE ESTABLISHMENTS WHICH DID NOT REGISTER PROFIT BEFORE TAX BY SECTOR AND ESTABLISHMENT SIZE

SECTOR	ESTABLISHMENT SIZE		
	Large	**Medium**	**Small**
Overall	4 (66.67%)	8 (72.75%)	19 (15.70%)
Food & Beverage	0 (0.00%)	0 (0.00%)	10 (33.33%)
Wood & Wood Products	2 (66.67%)	4 (66.67%)	4 (25.53%)

Table 5 shows that of the overall establishments which were not making profit, 43.03% were correctly classified by the discriminant function. The discriminant function successfully classified 72.75% of the medium scale establishments while only 15.70% of the small scale establishments were correctly classified. However, for the large and medium scale establishments of the Food & Beverage sub-sector, the discriminant function could not discriminate very well those establishments which were not making profit before tax. On the other hand, for the Wood & Wood Products sub-sector, the discriminant function successfully classified 66.67% of the large and medium scale establishments while only 23.53% of the small scale establishments were classified correctly.

On the whole, the discriminant function performs better in classifying the small scale establishments which registered profit before tax than the corresponding function which classifies the establishments which did not register profit before tax.

5.0 CONCLUSION

Apart from the Ministry of Industry and International Trade, there are more than 26 public agencies providing assistance to small and medium scale industries, not to mention banks and financial institutions. Although the ultimate profitability of the SMIs depends on a host of other factors such as domestic market performance and competitiveness, the linear discriminant function can be used as a useful quantitative input to decision makers from government agencies, financial agencies and entrepreneurs to monitor the performance as measured by profitability of the SMIs.

Currently, the government is moving towards the direction of creating a regional data base on all the industrial sectors in collaboration with the United Nations Centre for Regional Development. There is a plan to create a Business Information Support System (BISS) for small and medium scale enterprises at the regional level. When such a system is available, it is hoped that more vigorous studies of the SMIs be carried out so that models can be developed to monitor the growth and development of the SMIs which play a pivotal role in the industrialization process of Malaysia.

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