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Costs of Production and Labour Productivity: 1978 and 1983 Malaysian Vintage Technology

Zakariah Ab. Rashid

ABSTRAK

Dengan menggunakan jadual "input-output" 1978 dan 1983 bagi Malaysia, kajian ini cuba menentukan perbezaan kos pengeluaran yang disebabkan oleh perubahan struktur kos. Indeks-indeks harga bagi harga pengeluar dan harga import dan bagi kadar upah dibina, melibatkan pemindahan klasifikasi barangan dan dagangan apabila klasifikasi input-output digunakan. Kajian ini menganggarkan kos pengeluaran sektoral bagi setiap vintage dan paras kos ini mengukur perubahan teknologi dan perlapukan. Ia juga menganggar jumlah buruh yang diperlukan bagi setiap vintage. Adalah didapati bahawa vintage lama (baru) mempunyai kos pengeluaran yang lebih tinggi (rendah) dan memerlukan lebih banyak (sedikit) buruh.

ABSTRACT

By using the 1978 and 1983 Malaysian input-output tables, the paper attempts to determine differences in costs of production caused by changing price structure. Appropriate price indices for producer and import prices and wage rates are formulated involving cost-transformation of product and trade classifications when input-output classification is adopted. The paper estimates sectoral costs of production (including labour) for each vintage and their levels measure technological change and obsolescence. It also estimates total labour requirements for each vintage. It was found that older (younger) vintage has higher (lower) costs of production and requires more (less) labour.

INTRODUCTION

Technical change either embodied in the new plants and machinery or disembodied in the organisation of works (Solow 1967; Brown 1967; You 1976; Mchugh & Lane 1987) may be resulted from the emergence of successive best-practice technique (Salter 1960)[1], and caused exogenously by changes in the state of knowledge or endogenously by changes in relative prices (Ahmad 1966). In a given moment of time with a current price structure, there is a spectrum of techniques in use ranging from the best-practice technique which yields the maximum surplus to the marginal technique waiting to be discarded.

Changes in the relative prices on the old techniques inevitably affect their viability through increase in costs of production which are partly made up of costs of domestic materials, imported inputs and labour. The younger techniques may, therefore, have relatively lower costs of production than those of the older ones. The main objective of this paper is to show the above phenomenon in terms of the costs of production (domestic materials, imported inputs and labour) and labour requirements differential for the two different average vintage technologies (1978 and 1983) occurring in the Malaysian economy.

THE MODEL

An introduction of new techniques causes adjustments to take place in the stock of capital (Britto 1971; Boddy & Gort 1973) which may be associated to certain amount of labour requirements depending on the profile of the stock. The current best-practice technique is associated with the lowest labour requirements, conversely the outmode techniques use more labour. This implies that period-to-period changes in best-practice techniques allow an absolute saving of labour, and the average labour requirement of the industry as a whole is the weighted average of the labour requirement of all techniques in the capital stock.

In a given period of time, new plants are constructed and outmoded plants are discarded. The process of constructing modern plants and scrapping outmoded plants is a continuous one. In Figure 1 the current price of best-practice plants constructed in the current period, (P_n) is composed of operating costs, AB, and capital costs (including normal profits), BC, This price defines the oldest plants that can remain in operation, that is, the plants built in period n-t whose operating costs, ED, are almost equal to price.

Competition between the old and new plants to be used in production on these terms is effective in two ways: first, by a direct

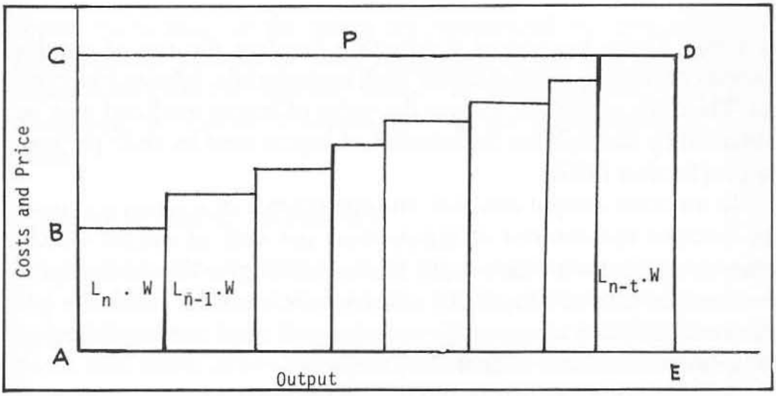

FIGURE 1: Co-existence between Old and New Techniques

comparison of operating and total costs in the case of deliberate replacement, and secondly by the price movements of the industry. These price movements are determined by total costs of best-practice plants and impose upon the industry the condition that the delay in the use of new techniques cannot exceed that which leads to operating costs per unit of output greater than price.

The extent of co-existence between old and new techniques, therefore, depends upon relative factors prices. The difference between the operating costs of the current best-practice plant (L_n.w) and those on the margin of obsolescence (L_n-t.w) is equal to surplus per unit of output, BC, or the gross trading margin in relation to the former.

The range of requirements of current factors per unit of output is a function of best-practice standards of fixed factors per unit of output, and the relative prices of current and fixed factors. The costs of new capital equipment is the barrier to the immediate general use of new techniques, and higher operating costs are the price paid for retaining outmoded method. A change in relative price alters the balance of co-existence among techniques and sets a new standard in the savings of current factors necessary for profitable replacement.

COSTS OF PROCUDTION OF VINTAGE TECHNOLOGIES

Based on the above theoretical framework, we may compare costs of production and labour requirements for different average technologies. Every process of production involves the use of combinations of factors of production such as materials, labour and capital. The costs of production are the value of inputs used and may be obtained by multiplying the amount of inputs used by their per unit prices (Rashid 1989).

In an input-output analysis, the coefficients of a structural matrix describe the amount of inputs used per unit of output which, when multiplied with their input prices, would give the costs of production per unit of output. In other words, in order to obtain per unit costs for each sector of the economy, we need as many prices as the number of sectors indicated by the tables.

In this way costs of production, therefore, equal to the sum of the products of its input coefficients and its respective per unit prices. For sector j, for example, the costs of production can be represented by:

$$\sum_j a_{ij} P_j \tag{1}$$

where a_{ij} and P_j are respectively the column vector of sector j input coefficients and the producer prices of the respective input for the total on n sectors.

THE TOTAL COSTS

This paper has identified three components of total costs: domestic materials, imported inputs, and labour. The structure of each of the first two inputs is represented by their respective input coefficient matrices, namely the structural and the imported inputs matrices. Since labour is not normally aggregated by sectors the structure of labour used in production is represented by its labour coefficient vector. Their respective prices are the producer prices, the import prices and the wage rate (Mathur 1977).

Based on the above formulation, the total cost of production of sector j output would then be expressed as

$$\sum_j P_j a_{ij} + w_j L_j + \sum_j^m P_j^m a_{ij} + r \sum_j b_{ij} \tag{2}$$

where a_{ij}, L_j, $^m a_{ij}$, and b_{ij} are the domestic input, labour, imported inputs, coefficients; and P_j, w_j, and $^m p_j$ are their respective per unit prices. Nota that, all the prices are represented by their respective prive vectors. Because of some limitations in the way the producer prices were provided and the manner in which the model has been developed, all prices of inputs have to be re-expressed in index form.

COSTS OF DOMESTIC MATERIALS

Let us generalise the derivation of the costs of domestic materials, and imported inputs. Let A be the matrix of input coefficients of each of the above costs items. Let us also suppose that P be the matrix of time series prices. The per unit costs of each of the sector of the economy may then be represented by

$$P'A \tag{3}$$

where $A = [a_{ij}]$, $i,j = 1, \ldots, n$.

The A matrix is an n^{th} order matrix (commonly known as a square matrix), $n = 40$ for input-output table 1978 and 1983 respectively[2]. The elements a_{ij} being the input coefficient, represents the amount of output of sector i used by sector j in order to produce one unit for sector j output.

The matrix P, on the other hand, is a rectangular matrix of order n X t, $t = 9$ or 4 with respect to each of the respective tables. Multiplying the input coefficient, a_{ij}, by the price of sector j would give the value of output of sector i purchased by sector j for each unit of sector j output. Summing column-wise the value of each of the n inputs for each unit of sector j output purchased by the sector would give the total costs of producing of one unit of sector j output. By transposing the matrix P, the costs of sector j per unit of its output in year t could be expressed as:

$$\textstyle\sum_j^t P_j a_{ij} \tag{4}$$

The elements of the P'A matrix will show the annual costs of production for each of the n sectors.

COSTS OF IMPORTED INPUTS

The element ${}^m a_{ij}$, being the import coefficient, represents the amount of imported output of sector i purchased by sector j in order to produce one unit sector j output[3]; when multiplied by the import price of sector j would give the value of imported output of sector i purchased by sector j for each unit of sector j output. Therefore, the total cost of imported inputs in year t when producing one unit of sector j output is the column sum of all the value of the imported inputs for each unit of sector j output, that is,

$$\sum_{j}^{m} P_j m_{a_{ij}} \tag{5}$$

COSTS OF LABOUR

The cost of labour input is dealt with separately because the labour coefficient, unlike the rest of the two cost items, is represented as a vector (because labour cannot be distinguished by sectors). l_j is the labour coefficient, representing the amount of salaries and wages paid to produce one unit of sector j output; when multiplied by the sector wage rate in year t, ${}^{t}w_j$, will gives the value of labour used in order to produce one unit of the value of labour used in order to produce one unit of the sector's output, or simply called labour costs

$$ {}^{t}w_j l_j \tag{6}$$

In matrix notation, the annual costs of labour for each of the n sectors for the whole of the period can be obtained by pre-multiplying the diagonal matrix of the labour coefficient by the matrix of indices of wage rate, that is:

$$L.W \tag{7}$$

where L = diagonal $[l_{ii}]$
and $W = [w_{ij}]$

As far as the model goes, the total per unit costs of production of each sector of the economy is determined by three different constants and variables. The constants are all the input coefficients – domestic materials, labour and imported inputs; whereas the variables are the indices of prices of inputs. Since all the three pairs of constants and variables are observable, the total per unit costs of production can easily be determined.

THE DATA

In this paper, the published producer price indices at two-digit level for the domestic production and import classified by SIC and SITC have been reclassified according to that of input-output. Unless those in SIC are unavailable, we use those classified in SITC (because the former has a closer resemblance than the latter to the input-output classification). Indices for the non-manufacturing industries are compiled from other independent sources[4]. In cases where more than one price indices (SIC or SITC) correspond to a particular sector in the input-output table, a simple average of them will represent that industry's index. Ideally, we would prefer to use a weighted average index (Lespeyres), if gross outputs of the respective industries for 1978 and 1983 base years are given. Paucity of such data has stopped us from doing so. A few indices, therefore, are our own estimates. These indices will represent the input prices of domestic production and of imports.

In estimating the wage rates for various industries, we would prefer to use earnings figures to represent wage rates. Due to the unavailability of such information, price of labour is now defined as the ratio of salary and wages to the number of employees in an establishment. These prices are given in value term which have to converted to indices and based to 1978 and 1983 before they can be applied to the model.

In estimating salary and wages for input-output sector, the Industrial Survey does not include all establishments in the manufacturing industries. A cut-off based on paid full-time employment for each individual industries is considered reasonable for the purpose of the study. The study thus uses salary and wages reported by the survey as the salary and wages of the economy, sector-wise.

RESULTS AND DISCUSSIONS

The results of our preliminary findings show that at the end of 1987, generally, manufacturers had to pay one and one third times the 1978 prices of domestic materials and imported inputs and double the price of labour. Among manufacturing industries which have experienced the highest rate of increase in domestic prices are beverages, tobacco, paper print, glass, cemot and other non-metallic industries. Fishing industry, in particular, has experienced the most rapid increase in its producer prices. The rise in producer prices in general is higher that that of import prices but lower than that of the wage rate for the same time period.

Figure 2 dan Figure 3 show the annual average change in prices and costs of domestic material, labour and imported inputs for the manufacturing sector. Wage rate has increased more than one and one-half times faster than producer and imported input prices. Among the industries which have experienced a rapid increase in the wage rate are other agriculture, oil palm, livestock, beverages and tobacco.

TABLE 1. Sectoral Average Change in Input Prices for Selected Periods

Input prices	1978-87	1983-87
Producer Price Index	1.3022	1.0122
Wage rate	2.1239	1.2097
Imported Input Prices	1.3006	1.0491

Source: Computed from the model

Tables 1 summarises the changes in wage rate, producer and import prices over the selected periods.

The movements in the input prices are expected to show corresponding movements in the costs of production because the latter is derived from the former through an input-output relationship, the coefficients of which are fixed. The precise pattern of the movements, however, will depend fundamentally on the changing input structure that may be taken place during the two periods. This can be examined by looking at the changing input structure of each industry by comparing the structural and import coefficient matrices and labour coefficient vector of 1978 to those of 1983.

In spite of the fact that wage rate constitutes the highest rate of increase in all the per unit input prices, labour costs do not represent the largest proportion of the total costs. And since domestic materials represent the largest amount of input used in the production for each Ringgit worth of output produced, domestic costs take the largest proportion (Figure 3).

Using the expressions for calculating costs of production described above Figure 4 and Figure 5 show the results which compare

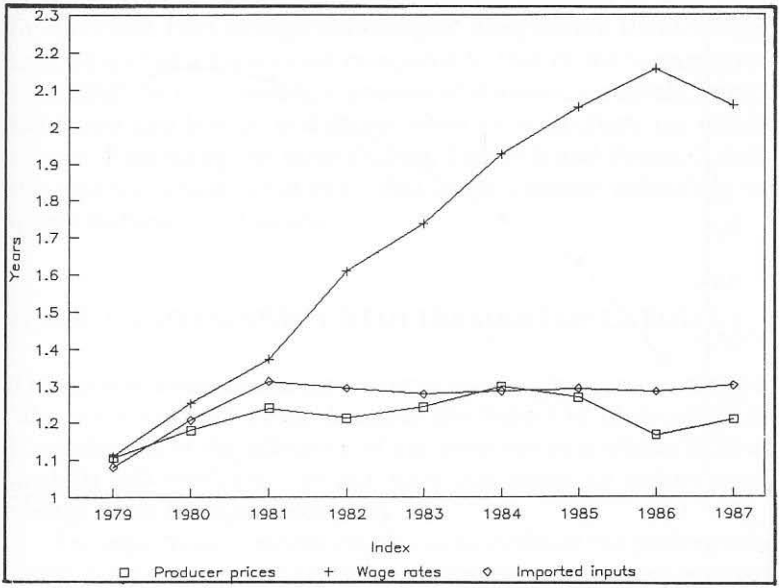

FIGURE 2: Changes in Input Prices for Manufacturing Sector

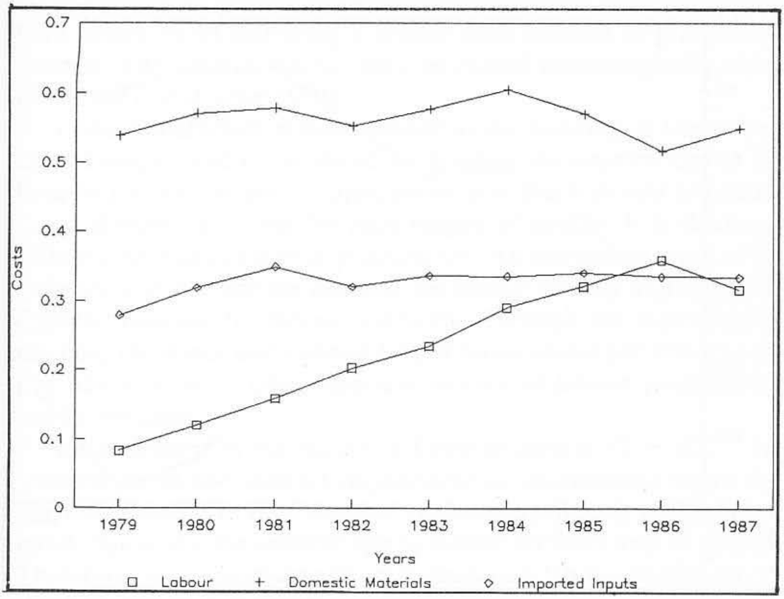

FIGURE 3: Changes in Components of Costs for Manufacturing Sector

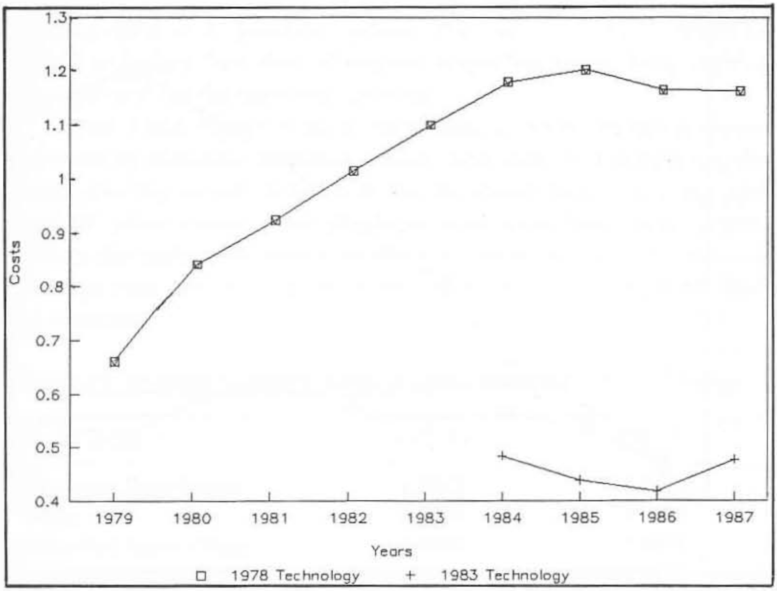

FIGURE 4: Index of Total Costs of the Whole Economy

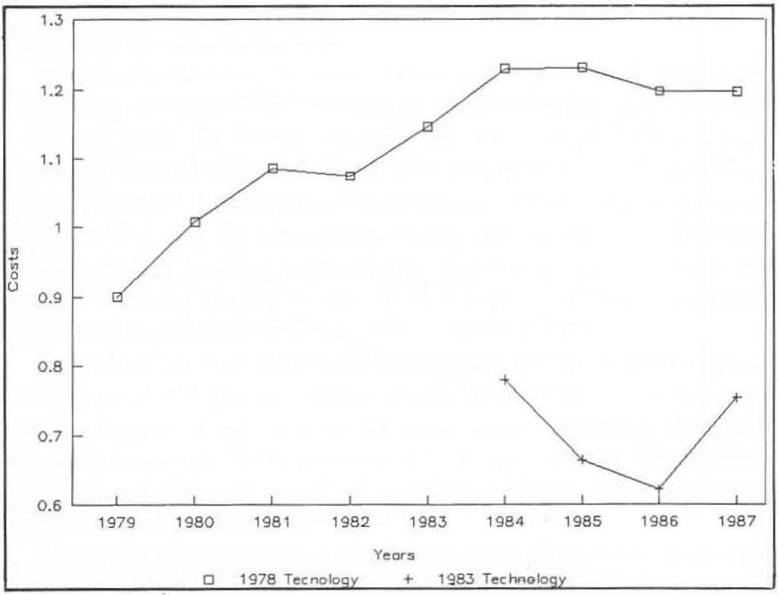

FIGURE 5: Index of Total Costs of the Manufacturing Sector

the whole economy and the manufacturing's indices of total costs for 1978 and 1983 vintage technologies. They set out that the older technology has a higher cost compared to that of the younger one, indicating the latter uses less amount of domestic materials, imported inputs and labour, and enjoys lower price structure per unit of output. Expressing the same finding, Figure 6 and Figure 7 show the case for labour input only, that is the younger technology requires less amount of labour.[5]

DIRECT AND INDIRECT REQUIREMENT OF LABOUR

This section analyses changes in input-output structures in terms of labour requirement which describes the impact of observed structural changes of the efficiency of the economy as a whole. Such an analysis will fit nicely into our main discussion on technological change of the Malaysian economy.

The input-output model enables us to evaluate the performance of the economy in terms of the amount of primary factors required, particularly labour, to deliver a given bill of final demand. An economy capable of producing a given final demand with less labour than others, or of delivering a greater final demand of given composition with a given labour, may be judged technologically superior to the first (Carter 1970).

Labour coefficient may be defined as the quantity of labour per unit of output and is calculated by dividing the amount due to labour by its total output. It, thus, shows how much should be contributed directly to labour for each ringgit of output. It is the most widely used index of labour productivity. An increase in input of an industry will increase the demand for labour directly and other industries' demand for labour indirectly. Through the input-output relation, the direct and indirect labour requirement per unit of output which shows a comprehensive picture of labour productivity can be obtained.

Each element in the matrix of Leontief inverse, $(I - A)^{-1}$, represents direct and indirect requirement of intermediate inputs for one unit increase in final demand. Labour coefficient, on the other hand, represents the amount due to labour for each unit of output. Therefore, pre-multiplying the row vector of labour coefficient by the Leontief inverse yields the direct and indirect labour require-

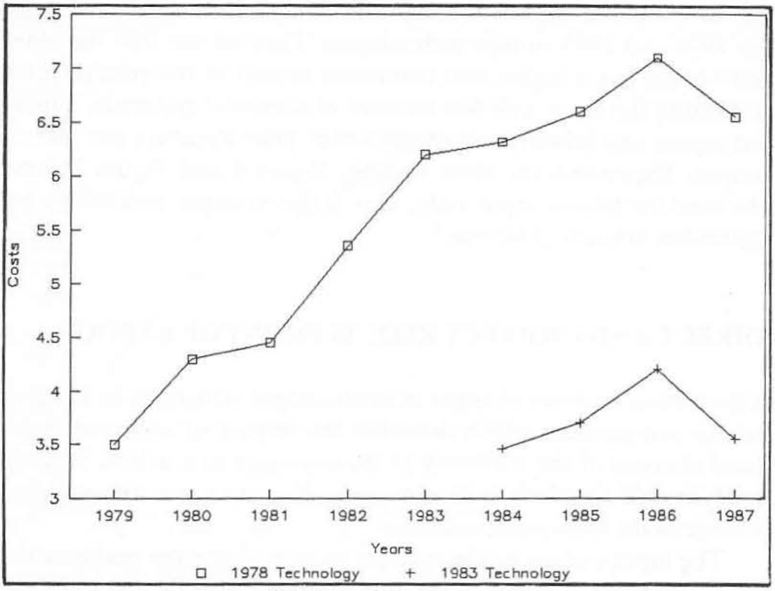

FIGURE 6: Index of Labour Costs of The Whole Economy

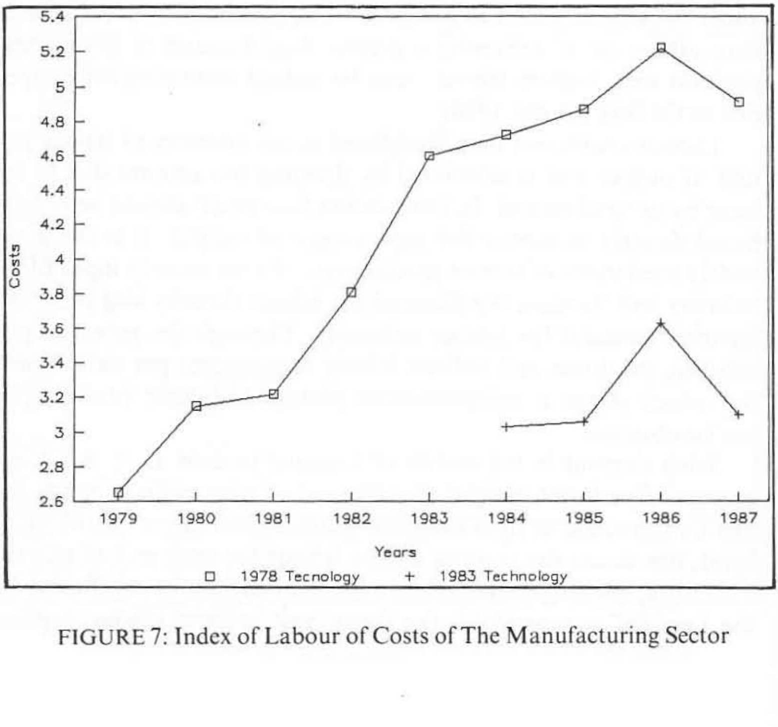

FIGURE 7: Index of Labour of Costs of The Manufacturing Sector

ment per unit of output.

Now, we can distinguish two concepts of labour productivity. First, direct labour, 1^t, measures labour inputs required per unit of output of a sector in year t. Secondly, we may also, given a complete structural description of the economy, derive the total (direct and indirect) labour content of structural deliveries to final demand, that is:

$$1^{*t} = 1^t (I - A)^{-1}$$

A_{ij} : element in the Leontief inverse is the direct and indirect increase in output of sector i for each increase in final output of sector j.

$1_i A_{ij}$: direct and indirect labour to produce one unit of sector j output.

where 1^{*t} is a vector of man-years required to deliver a unit of labour of each sector's product to final demand, with the technology of year t prevailing in all sectors. Changes in 1^t measure changes in the overall labour requirement of an economy in delivering various kind of final output. Such changes are the net result of changes in direct and indirect labour coefficient of many sectors and of shifting division of labour among sectors. Concurrent analysis of changes in direct and in total labour requirement for particular output gives some notion of the importance of shifting industrial specialisation in the changing productivity picture.

Table 2 shows the direct and total labour requirements per unit of output for each of the vintage technology. Column (1) and column (2) of the table compare the direct and indirect labour coefficients for 1978 and 1983 average technologies. Except for a few cases, the columns show that the coefficients of 1983 technology are generally smaller than those of 1978 average technology. As labour coefficient is the reciprocal of index of labour productivity, the difference in the two paired coefficients indicates an increase in labour productivity over the period.

Expressing the similar conclusion, comparing column (3) with column (5) and column (4) with column (6), the table also shows the direct and indirect requirement of labour per $ million of 1978 final demand is larger than that of 1983 final demand, either by

TABLE 2. Total Labour Requiment per $ Million of 1978 and 1983 Final Demand

Industrial sectors	Direct and indirect labour coefficients		Direct and indirect requirement per $ million of: 1978 final demand using technology of		Direct and indirect requirement per $ million of: 1983 final demand using technology of	
	1978 (1)	1983 (2)	1978 (3)	1983 (4)	1978 (5)	1983 (6)
1 Oth Agric	0.013861	0.017460	23985634.91	22450822.46	3704176.15	34671460.49
2 Rubber Pln	0.029446	0.021940	52091850.76	33470829.19	56307272.06	36179384.26
3 Oil Palm	0.080428	0.113734	83740603.01	105673615.58	103825009.38	131018451.45
4 Livestock	0.091133	0.090395	70839903.82	69058304.14	145871128.28	142202518.61
5 Forestry	0.23397	0.053095	38946942.88	61926055.94	73156980.82	116320382.34
6 Fishing	0.019820	0.074642	37321733.22	103527052.62	36925481.26	102427886.16
7 Petrol Min	0.078839	0.059670	226770783.26	144413196.67	582626204.59	371030656.86
8 Dairy Prod	0.088254	0.063941	123817205.82	84797166.46	249418193.25	170815969.48
9 Veg Fruit	0.089937	0.078361	64308202.21	52825933.60	60673820.92	49840473.30
10 Oil Fats	0.080710	0.131420	326814114.59	666604993.81	634238947.40	1293661536.43
11 Grain Mill	0.035340	0.043991	40387266.00	40052536.21	43430229.29	43070279.42
12 Baker Corf.	0.107032	0.99530	52994152.15	42692519.95	95654340.07	77059914.27
13 Oth Food	0.062200	0.070195	45313461.40	43503284.39	68995086.98	66238879.08
14 Animal Feed	0.049586	0.46977	2626365.06	2821117.78	5804094.48	6234485.22
15 Beverages	0.121872	0.113224	46074148.65	36122354.85	90766164.44	71161110.87
16 Tabacco	0.076781	0.053788	57128794.71	32106260.05	99826682.85	56102381.57

17 Textiles	0.155569	0.165489	137170489.76	131443545.99	188670472.57	180793376.05
18 Wearing Apl	0.143354	0.157460	94427447.36	74110306.11	169245254.59	132830209.61
19 Sawwill	0.159923	0.157376	248969782.73	222073207.77	322183660.70	287377681.88
20 Furn Fixt	0.232397	0.197528	42711800.69	31831772.95	77605980.52	57837316.89
21 Paper Prrnt	0.202442	0.174644	28492038.12	21547438.69	93701935.84	70863190.23
22 Ind Chem	0.072140	0.042286	5228007.79	2557351.63	99681379.30	48760512.28
23 Paints Etc	0.119068	0.097284	−258642.43	−179710.18	4152396.18	2885171.81
24 Oth Chem Prod	0.150518	0.151217	57767215.15	50523660.31	8759185.21	76608026.36
25 Petrol Prd	0.030157	0.023999	35498582.14	25276507.96	112951296.68	80426151.60
26 Rubber Pro	0.057526	0.048296	143317089.71	99326192.22	188237550.37	130458406.24
27 Rubber Prd	0.164224	0.155444	76755637.07	60851262.85	140197399.15	111147390.76
28 Plastic Prod	0.133709	0.121055	23328940.85	17678795.47	60866898.43	46125259.41
29 Glass Prod	0.105034	0.074039	86582265.87	5238513.88	25707088.44	15553569.47
30 Cement	0.211225	0.163279	−15480115.80	−1036918.63	15453468.07	10351308.36
31 Non Metallic	0.153088	0.331990	2348453.70	4006963.83	14018985.59	23919384.93
32 Basic Metalli	0.061510	0.063715	264025031.63	204018789.23	200202508.79	154701518.99
33 Oth Metallic	0.161943	0.152203	33296360.71	28179462.52	79460276.85	67249027.99
34 Non Elec Mach	0.140156	0.131250	47604112.43	36766680.99	110792625.96	85569857.89
35 Elect Mach	0.120243	0.105442	285152081.11	208884116.84	812935962.64	595504721.37
36 Motor Veh	0.051970	0.045599	65400512.98	54789347.31	165050878.97	138271544.37
37 Oth Transp	0.111717	0.055592	27964752.58	13484134.76	85749765.24	41347098.89
38 Or Mfg Prod	0.161215	0.161458	50431970.87	35276574.84	91511619.27	64011309.29
39 Constuction	0.530260	0.193446	2744704400.42	1043169171.37	7234595676.81	2749624759.67
40 Other Service	0.111585	0.012871	2534485968.15	398663021.02	4986688127.24	784383176.19

Source: Input-output tables 1978 and 1983 using 1978 or 1983 average technology. The demand for final output has increased over the period, but the ratios of sum of column (3) to that of column (4) and sum of column (5) to that of column (6) respectively are 3.82 and 2.034, showing that more labour is required if using 1978 technology compared to if using 1983 technology, to meet either 1978 or 1983 final demand. The table also sets out that in order to satisfy the final demand of either year, the economy uses less amount of labour if average technology of 1983 is used compared to if 1983 average technology is being used.

CONCLUSIONS

The paper compares the costs of production and labour productivity of 1978 and 1983 Malaysian vintage technologies. Since it uses input-output analysis as its basic framework, the study takes into account the inter-industry transactions in calculating the costs of production and the amount of labour required and for each vintage. The result sets out that both costs of production and labour requirement for new vintage is less than those of the older one, supporting the vintage hypothesis. By allowing annual price charges, the costs of production of both vintages can be compared from the year the vintages were put in operation until the year 1987.

The paper also found that despite of the faster growth of wage rate compared to those of imported inputs and producer's prices, costs of domestic materials still represent the largest component of the total costs. However, cost of labour which increases rapidly (due to the rapid increase in the wage rate) may represent the major cause of rapidly increasing production costs and obsolesence (Rashid 1989) in the economy's vintage technologies. The increasing labour cost may lead to switching of techniques which are more capital intensive and results in higher labour productivitiy in a developing country like Malaysia (Pickett et al. 1972).

NOTES

[1] The best-practice technique is a technique of production that gives the highest surplus, given the current price structures. The terminology was first introduced in Salter (1960).

[2] We have aggregated the 60 × 60 put-output table for domestic production for both 1978 and 1983 to 40 × 40 dimension. Except for the service

sectors which are aggregated into a single service sector due to the difficulties in estimating ecah of the individual sector's price index, the rest of the sectors remains intact. In order to maintain comparability between the two tables, the 1983 transaction table is deflatd to 1978 prices the producer price incides for various sectors as the deflators.

[3] The dimension for import matrix is the same as A matrix (see 2. above). Import transaction matrix is derived by subtracting the matrix of domestic production from that of domestic production and import for both 1978 and 1983

[4] We have aggregated into 60 × 60 input-output table for domestic production for both 1978 and 1983 to 40 × 40 dimnsion. Except for the service sectors which are aggregated into a single service sector due to the difficulties in estimating each of the individual sector's price index, the rest of the sectors remains intact. The dimension for import matrix is the same as A matrix. Import transaction matrix is derived by subtracting the matrix of domestic production from that of domestic production and import for both 1978 and 1983

[5] The weighted averages of indices of total costs in Figure 5 and Figure 6 and of labour cost in Figure 7 and Figure 8, denoted as R*, are compactly derived from the following relationship:

$$R^* = T^* (R'T)$$

where

T* : A scalar matrix of the reciprocal of the sum of gross outputs. t^* is the elements of the principal diagonal which is equal to $1/\quad {}_i t_i$, t_i is the gross output of sector i

R : The matrix of total and labour costs of the whole economy or of the manufacturing sector.

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Jabatan Ekonomi
Universiti Pertanian Malaysia
43400 Serdang
Selangor D.E.