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Economic Impact of CO_2 Emissions on Malaysia's Manufacturing Sector Productivity Growth

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Introduction

The Malaysian economy recorded a strong growth with significantly improved economic and financial fundamentals in the year 2000. This performance has placed Malaysia in a stronger position to respond to the more challenging economic environment in the future. Real GDP recorded a growth of 8.5%, in 2000, well above the 5.8% achieved in 1999. While growth was supported by strong external demand, it was the rise in private consumption and the strong revival of domestic investment that mainly contributed to economic growth. The strong private investment was observed in several industries where levels of production and capacity utilisation had expanded in response to rising demand. As a result, labour market conditions also improved significantly in year 2000 when the estimated unemployment rate declined to 3.1%.

Policy strategies to diversify the economic structure of Malaysia continued beyond the year 2000 to further deepen and widen the industrial base, to enhance the development of the services sector as a second engine of growth and to venture into new areas of growth. In 2000, value added

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from the manufacturing sector grew strongly by 21% with significant increases in production of both export and domestic-oriented industries, setting a new record for manufacturing production. Reflecting the overall growth of the economy, value added in the services sector also rose by 4.7%. Value added in the construction sector turned around to register a positive growth of 1.1%. In the agriculture sector value added remained positive despite sharply lower growth in palm oil production and declines in rubber and cocoa production (Bank Negara Annual Report, 2000).

Malaysia's Productivity Performance

Following the contraction in 1998, the economy recovered in 1999 with a growth of 5.6 % driven by a series of policy initiatives undertaken by the Government of Malaysia to stimulate the economy. On a quarterly basis the GDP registered a growth of 4.8 % in the second quarter, 8.5 % in the third quarter, and 10.8 % in the fourth quarter (Productivity Report, 1999). As the Malaysian economy continues to face the challenges brought about by the dynamics of globalisation, it has to be more resilient and competitive. To achieve this, economic fundamentals have to be strengthened with the emphasis on productivity and quality driven growth strategies that enhance efficiency in the utilisation and management of productive resources. In this context, the enhancement of Total Factor Productivity (TFP) is imperative. By definition, TFP measures the synergy and efficiency of the utilisation of both capital and human resources. Positive TFP growth indicates efficient utilisation and management of resources, materials and inputs necessary for the production of good and services. For the period of 1989-99, the economy recorded a TFP growth of 1.6 % resulting in a corresponding 3.8 % average growth rate of productivity. In 1999 productivity grew by 3.9 % from RM21, 207 in 1998 to RM2, 026 (Productivity Report, 1999).

The productivity growth contributed 70 % to overall economic growth while employment contributed 29 %. In terms of GDP, employment, capital and productivity as supported by government policy initiatives the economy in 1999 enunciated following the recent economic crisis improved domestic demand and stimulated recovery. This resulted in a higher GDP growth of 5.6 % (1998: -7.5 %) and productivity growth of 3.9 % (1998: -1.8 %). To improve competitiveness, industries need to incorporate productivity-driven growth strategies in their corporate objectives. These include the implementation of productivity and quality management system, improvement through benchmarking activities, intensifying the application of information technology, skill upgrading of human capital and quality products through research and development. For example quality systems such as MS ISO 9000 Certification helped companies achieve a high level of excellence. Until 1999, 1,858 companies used to be certified under the MS ISO 9000 systems (Productivity Report, 1999).

The sustainability of higher economic growth will continue to be driven by productivity through the enhancement of TFP. Development strategies of TFP will emphasise on quality of workforce, demand intensity, economic restructuring, capital structure and technical progress. To improve the competency of workers, investment in human resource development is pertinent. Until the end of 1999, 2.3 million employees had been trained under the Human Resource Development Fund (HRDF), with disbursements approved totalling over RM680 million. In 1999, 13.8 % of the employees were trained in technical areas, 28.7 % in areas on productivity and quality, 14.7 % in information technology and 5.2 % in management (Productivity Report, 1999).

During the period of 1996-2001, Malaysia's productivity growth of 3.3% surpassed that of several selected OECD countries also, namely the United States (2.3%), United Kingdom (1.5%), Canada (1.4%), France (1.2%), Japan (1.3%), Germany (1.1%) and Italy (0.8%). At the East Asian nations' level, this percentage is also higher than that registered in South Korea (3.2), Singapore (2.0%), Thailand (-0.3%) and Indonesia (-0.8%), (Productivity Report, 2001).

Green Productivity Concept

Before the 1950s the common business response to environmental pollution was to ignore such problems. This was possible when the problems were relatively small and the awareness of health and environmental impacts was not high. In 1960s a common approach to pollution was to disperse concentration of the pollutants for example, by constructing tall smokestacks and extending pipeline into the sea to dilute water pollutants. It was soon realised that many pollutants were toxic even at small concentrations and some chemicals retained their toxicity for a very long period. These diluted pollutants accumulated in soil and water and eventually found their way to the food chain. When industries and communities began to exceed the environment capacity to assimilate their wastes, efforts were made to establish environmental standards in order to regulate the discharge of pollutants. In 1970s, this resulted in the use of treatment systems to ensure the discharge from industries and other enterprises met stipulated environmental quality standards.

The concept of Green Productivity (GP) is drawn from the integration of two important developmental strategies - productivity improvement and environmental protection. Productivity provides the framework for a continuous improvement while environmental protection provides the foundation for sustainable development. Therefore, GP is a strategy for enhancing productivity and environmental performance for overall socio-economic development. It is the application of appropriate techniques, technologies and management systems to produce environmentally compatible goods and services. GP is applicable not only to the manufacturing sector, but also to other sectors like agriculture and services. It also addresses the interaction between economic activities and community development. As with large industries, it is also for small- and medium-sized industries (SMIs) for the purposes of mobilising scarce organisation resources to increase productivity and protect the environment (National Productivity Report, Malaysia, 1998).

Malaysia's Air Pollution Status

In the Seventh Malaysia Plan (1996-2000), approximately RM1.9 billion was allocated in the Government's development budget for the improvement and protection of the environment as well as to conserve and promote sustainable resource use. However, environmental quality monitoring programmes of the Department of Environment (DOE) continued to supplement its enforcement work, and to uphold the

Environmental Quality Act (EQA), 1974 that was amended in 1996.

Emissions from mobile sources, stationary sources and open burning activities remained the most significant sources of air pollution in 2000. Based on the source inventory compiled in 2000, a total of 6,490 agro-based and manufacturing industries were identified. Out of 16 types of manufacturing industries, the main polluting sources were food and beverage industry with 1,538 sources constituting 23.7% of the total number, followed by electric and electronic industry (738, 11.4%), chemical-based industry (729, 11.2%), paper (571, 8.8%), textile (481, 7.4%), metal finishing and electroplating (343, 5.3%), crude palm oil mills (343, 5.3%) and raw natural rubber factories (128, 2%), figure 3, (Malaysia, Environmental Quality Report, 2000).

The objective of this paper is to examine the impact of carbon dioxide emissions on productivity growth of Malaysian manufacturing sector.

Methodology and Estimation Procedures

An attempt was made to apply the conventional growth accounting framework utilized by Stiger (1947), Albramovitz (1956), Kendrick (1956), to this study developed by Solow (1956, 1957), finally brought to fruition by Kendrick (1961) and further refined by Denison (1962, 1979), Griliches and Jorgenson (1986), Jorgenson et al. (1987) and Dollar and Sokoloff (1990). The production of each industry is expressed as a function of capital, labour, raw materials and time. It is assumed that the production process is characterised by constant returns to scale for each industry, so that the proportional increase in all inputs results in a proportional change in industrial output. This approach provides more room for decomposition of contributions of factor inputs and technological change to economic growth. Likewise economists are more interested in intensive growth, which is expressed in the form of growth in output per worker (labour productivity). Furthermore, an economy's standard of living not is determined by its total output but by the amount of output available per person as stated by many economists like Dollar and Sokoloff, (1990). As with Pittman, (1983); and Chasto et al., (1997), yet the most obvious deficiency in the above mentioned growth accounting models is found to be the exclusion of externalities such as pollutant emissions generated by the manufacturing sector in the form of undesirable output. This paper will contribute to the available literature on growth accounting method in that it will draw methods to calculate the real total factor productivity growth by internalising the pollutant emissions beside the input terms in the production function. Accordingly, total factor productivity growth became an indicator of green productivity, which takes into account economic development and environmental protection, as has been explained in the introductory part of this paper.

The main objective has been to apply the above-mentioned conventional growth accounting framework under assumptions of competitive equilibrium (where factors of production are paid the value of their respective marginal products) and constant returns to scale. The Divisia Index basically decomposes the output growth into the contribution of changes in inputs (such as capital, labour, materials input growth), an undesirable output (such as carbon dioxide emissions), and total factor productivity (TFP) growth. In other words, considering the data at any two discrete points of time, say T and T-1 the growth rate of output Q for an industry can be expressed as a weighted average of the growth rates of capital (K), labour (L), intermediate inputs (M) and carbon dioxide emissions (CO2E) plus a residual term typically referred to as the rate of growth of TFP. Hence the TFP growth of each industry is computed as the difference between the rate of growth of output and weighted average of the growth in the capital, labour, intermediate inputs, and carbon emissions where the weights are the respective shares of each input in the industry's gross output. It follows that

$$\begin{aligned} \overline{W}iT &= [\ln Qi(T) - \ln Qi(T-1)] - \overline{W}iK\,[\ln Ki(T) - \ln Ki(T-1)] \\ &- \overline{W}iL\,[\ln Li(T) - \ln Li(T-1)] - \overline{W}iM\,[\ln Mi(T) - \ln Mi(T-1)] \\ &- \overline{W}iCO2E[\ln CO2Ei(T) - \ln CO2Ei(T-1)] \qquad [1] \\ i &= 1 \quad \text{and } T = 1970 - 1996 \end{aligned}$$

where the weights are given by the average value shares

$$\overline{W}^{i}_{K} = 1/2[(WiK(T) + WiK(T-1)],$$
$$\overline{W}^{i}_{L} = 1/2[(WiL(T) + WiL(T-1)],$$
$$\overline{W}^{i}_{M} = 1/2[(WiM(T) + WiM(T-1)],$$
$$\overline{W}^{i}_{CO2E} = 1/2[(WiCO2E(T) + WiCO2E(T-1)], \text{ and}$$
$$\overline{W}^{i}_{T} = 1/2[(WiT(T) + WiT(T-1)]$$

According to Tham (1997), $\overline{W}^{i}_{K}$, $\overline{W}^{i}_{L}$, $\overline{W}^{i}_{M}$ and $\overline{W}^{i}_{CO2E}$, denote the shares of capital, labour, material and carbon dioxide emissions, Q output and T time of manufacturing sector and bar indicating a simple average over two successive time-periods, (T) and (T-1) and the average productivity growth term, $\overline{W}^{i}T$, is the translog index of TFP growth.

Secondly, following Dollar and Sokoloff, (1990), Wong's (1993), Elsadig Musa (1998) and Jesus Felipe (2000), when constant returns to scale is imposed

$$W^{i}_{L} = (1 - W^{i}_{K} - W^{i}_{M} - W^{i}_{CO2E})$$

Assuming $W^{i}_{K} = \alpha$, $W^{i}_{M} = \beta$ and $W^{i}_{CO2E} = \lambda$, the equation becomes

$$\ln\Delta Qi,T = \alpha.\ln\Delta Ki,T + \beta.\ln\Delta Mi,T + \lambda.\ln\Delta CO2Ei,T$$
$$+ (1-\alpha-\beta-\lambda).\ln\Delta Li,T + \ln\Delta TFPi,T \qquad [2]$$
$$i = 1 \quad \text{and } T = 1970-1996$$

where Q is the growth value of output, K is the capital input, L is the labour input , M is the materials input and CO2E is carbon dioxide emissions of the Malaysian manufacturing sector, and α , β and λ are the elasticities of output with respect to capital, material and carbon dioxide emissions respectively.

For the purposes of this study, and to avoid multicollinearity between the input terms, equation [2] was transformed by dividing each term by L (labour input) and then the output elasticity was calculated with respect to capital deepening, material-labour ratio and dirty fuel emissions intensity, i.e. α, β and λ, respectively. According to Dollar and Sokoloff, (1990), the production function was as follows: -

$$\ln(Q/L)it = a + \alpha 1 \ln(K/L)it + \alpha 2[\ln(K/L)it]^2 + \beta 1 \ln(M/L)it + \beta 2[\ln(M/L)it]^2 + \lambda 1 \ln(CO2E/L)it + \lambda 2[\ln(CO2E/L)it]^2 \quad [3]$$

It follows that

$$\alpha i = \alpha 1 + \alpha 2(K/L)i$$
$$\bar{\alpha} = \alpha 1 + \alpha 2\overline{(K/L)}$$
$$\beta i = \beta 1 + \beta 2(M/L)i$$
$$\bar{\beta} = \beta 1 + \beta 2\overline{(M/L)}$$
$$\lambda i = \lambda 1 + \lambda 2(CO2E/L)i$$
$$\bar{\lambda} = \lambda 1 + \lambda 2\overline{(CO2E/L)}$$

Since the intercept (a) has no position in the calculation of the productivity growth rate indicators, equation [3] becomes:

$$\ln\Delta(Q/L)i,T = \bar{\alpha}.\ln\Delta(K/L)i,T + \bar{\beta}.\ln\Delta(M/L)i,T + \bar{\lambda}.\ln\Delta(CO2E/L)i,T + \ln\Delta TFPi,T \quad [4]$$
$$i = 1 \text{ and } T = 1970 - 1996$$

where $\bar{\alpha}$, $\bar{\beta}$ and $\bar{\lambda}$ denote the shares of capital deepening, material-labour ratio and carbon dioxide emissions intensity, Q output and T time of manufacturing sector and bar indicating a simple average over two successive time-periods, (T) and (T-1) and the average productivity growth term, TFPiT, is the translog index of TFP growth.

Thus, equation [4] expresses the decomposition of labour productivity growth into the contributions of capital deepening, increased usage of materials input per unit of labour, CO_2 emissions intensity and TFP growth. To calculate the total factor productivity average annual growth rate as well as the average annual growth rates of other productivity indicators in the model after the estimation of the production function equation [4] becomes

$$\ln\Delta TFPi,T = \ln\Delta(Q/L)i,T - [\bar{\alpha}.\ln\Delta(K/L)i,T + \bar{\beta}.\ln\Delta(M/L)i,T + \bar{\lambda}.\ln\Delta(CO2E/L)i,T] \quad [5]$$

Carbon dioxide emissions as the air pollutant emissions generated by the manufacturing sector are treated as an undesirable output and applied to the models. Autoregressive estimator was applied to two models generated from a production function to measure the shift in the production functions of Malaysia's manufacturing sector. An annual time series data of five digits over the period 1970-1996 from Department of Statistics was employed in forms of gross value of output, number of employment, value of fixed assets, and cost of input. Carbon dioxide emissions (Kt) were obtained from United Nations Institute of Advanced Studies, Tokyo, Japan. Except for the number of employment and carbon dioxide emissions, the data were deflated by producer price index (1972=100) to obtain the real value of variables from its nominal data. Gross national product annual data were obtained from economic reports and deflated by consumer price index (1980=100) to get its real value. The first Model (Model1) referred to (Jorgenson *et al*, 1987) expressed the decomposition of growth value of output into contribution of changes in capital, labour, material inputs, carbon dioxide emissions and total factor productivity growth. The second model (Model2) referred to (Dollar and Sokoloff, 1990) expressed the decomposition of labour productivity growth (output per worker) into the contributions of capital deepening (capital per worker), material-labour ratio (material per worker) carbon dioxide emissions intensity (CO_2 emissions per worker) and total factor productivity growth.

Analysis of the data for the model1 showed that estimated coefficients of capital, labour and material inputs of manufacturing industry sector were significant at 5 percent level and the estimated coefficients of carbon dioxide emissions was significant at 10 percent level. In the second model material-labour ratio estimated coefficient and some of carbon dioxide intensity were significant at 5% level and the rest were significant at 10% level. By Durbin-Watson values the two models have no problem of autocorrelation (Table 1 and 2).

Table 1: Output Elasticity of Malaysian Manufacturing Sector Productivity Indicators 1970-1996, (Model 1)

Intercept	0.63932
	(4.95600)*
Capital	0.05889
	(2.40800)*
Labour	0.04100
	(1.96057)*
Material	0.87231
	(19.4800)*
Carbon Dioxide Emission	0.02890
	(1.01400)
Adjusted R^2	0.99980
Durbin-Watson	2.14980

Notes: Figures in parenthesis are T-values
* Indicates significant at 5% level
** Indicates significant at 10% level

Table 2: Output Elasticity of Malaysian Manufacturing Sector Productivity Indicators 1970-1996, (Model 2)

Intercept	-0.65483	
	(-1.10300)	
Capital Intensity	α_1	α_2
	-0.17833	0.050649
	(-1.65900)**	(2.35000)*
Material-Labour Ratio	β_1	β_2
	0.88548	-0.00621
	(4.24100)*	(-1.20000)
Carbon Dioxide Emissions Per Worker	λ_1	λ_2
	-1.14370	-0.21478
	(-2.37000)*	(-2.41300)*
Adjusted R^2	0.94532	
Durbin-Watson	1.97311	

Notes: Figures in parenthesis are T-values
* Indicates significant at 5% level
** Indicates significant at 10% level

Empirical Analysis

Empirically, our analysis was to compare the productivity indictors within the manufacturing sector for the entire period (1970-1996). In order to study the effect of government policies to improve the manufacturing sector productivity growth as well as to study the impact of industrial pollutant emissions on productivity growth of Malaysian manufacturing sector, the study period was split into three phases. These phases, which correspond with the major policy changes, are 1971-1979, 1980-1986 and 1987-1996. The 1970s witnessed the birth of Malaysia's era of export-oriented economy. The policy shifted from import substitution to labour intensive and export oriented industries with electronics and textiles as main areas of emphasis and growth. And also, the decade of 1980s saw further diversification of the economy into more advanced industries. The Heavy Industries Corporation of Malaysia (HICOM) was conceived in 1980. As a result of these polices the range of economic activities and sources of growth had become more diversified. The period 1987-1996 witnessed further diversification of the economy into more advanced industries. Also, during this period the economic structural transformation took place in the Malaysia's economy, and the manufacturing sector became an engine of growth. In this period the policy makers developed the first and second Industrial Master Plans and gave priority to the twelve industries to contribute more to the Malaysia's industrial development. The results generated using the two earlier mentioned models used for the empirical analysis are presented in the following section. Table (3) shows that annual growth rate contribution of gross value of output, Gross National Product (GNP), capital, material, labour in terms of number of employment, were positively contributing to manufacturing sector annual productivity growth during the entire period (1970-1996). Rather, negative annual growth was shown in some years due to the economic slowdown in these years by global economic crisis. Moreover, the annual growth rates of the carbon dioxide emissions of the manufacturing sector were higher in most of the years in the entire period (1970-1996) due to the fast shifting from the agricultural activities to manufacturing activities without consideration to the air pollutant emissions produce by industries (Table 3). The manufacturing output average annual growth rate for the entire period of the study (1970-1996) was 15.74448, capital 17.2677, number of employment 9.89226, material 15.9716, carbon dioxide emissions 8.70459, and Gross National Product (GNP) 14.0619.

The manufacturing output average annual growth rate of the sub period of (1971-1979) was 17.0225, capital 14.7195, number of employment 12.1416, material 17.4309, carbon dioxide pollution emissions (7.67523, and Gross National Product (GNP) 20.7368. The manufacturing output average annual growth rate of the sub period of (1980-1986) was 8.07823, capital 20.0071, number of employment 2.46886, material 7.8692, carbon dioxide emissions 5.88599, and Gross National Product (GNP) 11.6206.

The manufacturing output average annual growth rate of the sub period of (1987-1996) was 19.5781, capital 17.6093, number of employment 12.7758, material 19.9337, carbon dioxide emissions 11.6040, and Gross National Product (GNP) 10.1541. The annual growth rate of carbon dioxide emissions was higher than the annual growth rate of GNP. This is due to the fact that during this period the structural transformation took place in Malaysian economy and the manufacturing sector has become the engine of growth and generated most of Malaysian wealth with very high level of carbon dioxide emissions as the undesirable output produced by the sector during the sub period (1987-1996). However, the results indicated that the overall capital annual growth rates of the manufacturing sector outweighed the problems of labour and material in the entire period and sub periods of the study. It showed clearly that there was direct effect of the government policies and plans that were applied to the manufacturing sector which is experiencing high growth rates after the structural transformation took place in the Malaysian economy in 1987. The largest component of cost in the Malaysian manufacturing sector is the cost of raw material. This can have serious adverse impact on the Malaysian Balance of Payments as shown in the Annual Report of Bank Negara (1991) which reported that imported raw materials constituted 20 per cent of the raw materials utilised by resource-based industries while non-resource-based industries as much as 60 per cent of the required raw materials. In particular, leading industries in the manufacturing sector such as electronics and electrical machinery can have an imported raw materials content as high as 70 % of the total cost. Shortage of skilled labour may cause a serious constraint on capital utilisation. Skilled labour is required to operate the new technologies embodied in new plants and equipments so that available capital stock may be utilised efficiently. Hence skills training and the deepening of skills are of vital importance for the full utilisation of capital.

Table 3: Productivity Growth Rates of Manufacturing Sector, in Malaysia %

Year	Output	Capital	Labour	Material	CO2 Emissions	GNP
1970	10.1649	18.9356	10.1825	9.56032	12.0485	1.65139
1971	13.5037	18.8561	18.6452	14.5072	8.82489	1.07494
1972	77.0238	63.2685	44.5264	75.7074	-2.08463	58.6175
1973	-3.27358	-3.15696	-5.60291	0.92664	9.09075	16.6175
1974	14.01498	26.9802	2.81360	12.6158	2.65416	-7.68847
1975	15.0103	11.0054	13.0816	16.8638	23.3274	18.8137
1976	-2.53552	-7.85030	6.87014	-4.13391	-4.96373	6.16695
1977	9.65495	1.00011	8.09113	9.08505	2.78990	71.5926
1978	19.6394	3.43724	10.6672	21.7459	17.3897	19.9940
1979	16.3552	25.4933	19.3873	18.8254	2.63460	8.84936
1980	18.1365	23.6808	16.2392	19.7193	10.0984	67.5937
1981	-0.68377	12.3043	-10.2016	-0.87375	-0.82079	3.48370
1982	11.1176	36.8407	-5.32832	10.2437	24.2172	6.89483
1983	12.1742	15.9106	1.17487	10.5648	-8.63263	8.44960
1984	-2.16531	16.6535	-4.54793	-2.14231	3.73073	-6.04946
1985	1.61294	9.16663	0.55851	-1.25283	9.97436	7.87767
1986	18.1453	6.48890	8.11262	22.0883	1.83442	10.8209
1987	37.0501	10.6346	598293	39.2006	4.52144	6.26439
1988	0.57789	-5.60861	-15.6477	0.07503	14.5703	-2.45771
1989	21.9842	31.1850	21.0115	21.7923	13.8343	11.0050
1990	25.1650	29.1523	15.6503	24.6865	24.9733	6.89408
1991	12.1221	23.4377	5.84960	11.7005	13.7455	13.5323
1992	21.8396	21.9809	22.4975	20.7966	15.3098	2.71623
1993	18.2655	15.2517	-3.26281	20.9183	1.78739	30.9886
1994	22.8173	19.7333	13.3955	24.4673	16.3800	10.92415
1995	17.3222	21.0530	4.26679	14.2076	9.08370	10.3634
1996	20.0697	20.3932	5.83119	19.3375	-	10.64378
1970-1996	15.7448	17.2677	9.89226	15.9716	8.70459	14.0619
1971-1979	17.0225	14.7195	12.1416	17.4309	7.67523	20.7368
1980-1986	8.07823	20.0071	2.46886	7.8692	5.88599	11.6206
1987-1996	19.5781	17.6093	12.7758	19.9337	11.6040	10.1541

Notes: Calculated from the original data

Results of Model 1

When the industrial carbon dioxide emissions (Kt) was added to the model besides the above mentioned input terms, to study the impact of carbon dioxide emissions generated by the manufacturing sector due to the consumption of fuel and other sources of energy in the manufacturing activities, the contributions of gross value of output, capital, labour, and material, to the average annual productivity growth of manufacturing sector remained constant as before the carbon dioxide emissions were added as undesirable output into production system. The carbon dioxide emissions impacted only the total factor productivity, which is indicated as the technological progress of the manufacturing sector. It means that carbon dioxide emissions impacted the quality of input terms, which is expressed in the form of total factor productivity.

The contribution of total factor productivity to the average annual productivity growth of manufacturing sector was negative for the entire period of the study (1970-1996), sub-periods of (1980-1986) and (1987-1996), their contributions respectively were -0.00012, -0.00105 and -0.00025. Positive contribution was observed for the sub period of (1971-1979) i.e. 0.00073 (Table 4).

The average annual growth rate of carbon dioxide emissions was very high in all sub periods of the study. The highest growth rate of carbon dioxide emissions was 0.11018 for the sub period (1987-1996). In this period there were tremendous manufacturing activities, consuming very high levels of fuel and other sources of the energy into the industrial activities. The level of carbon dioxide emissions increased rapidly due to the intensive activities of industries. And the lowest carbon emissions level was for the sub period (1980-1986) at 0.05317. There was a slow down in the economic activities due to the economic crisis, as well as slower industrial activities compared to the sub period 1987-1996, i.e. the period of economic structural transformation, which gave the manufacturing sector the leading role in the Malaysian economy (Table 4).

Table 4: Productivity Indictors of Malaysia's Manufacturing Sector, (Model1)

Productivity Indicators	1970-1996	1971-1979	1980-1986	1987-1996
Total Factor Productivity	-0.00012	0.00073	-0.00105	-0.00025
Gross Value of Output	0.13600	0.14201	0.07510	0.17735
Capital	0.14932	0.12328	0.17981	0.15164
Labour	0.08704	0.10832	0.01943	0.11836
Material	0.13922	0.14620	0.07248	0.18414
Carbon Dioxide Emission	0.08004	0.07078	0.05317	0.11018

Results of Model 2

The second model expressed the decomposition of labour productivity growth (output per labour) into contributions of capital deepening (capital per worker), material labour ratio (material per labour) and total factor productivity growth. The performance of the manufacturing sector was measured using productivity indictors that were obtained from the estimated coefficients of this model. To study the impact of carbon dioxide emissions on productivity growth of manufacturing sector, carbon dioxide emissions per worker was applied to the model. The results showed there was no change in labour productivity contributions to average annual growth rates of the manufacturing sector during the periods of the study. Their contributions remained as they were before adding carbon dioxide emissions per worker. There was no significant change on the contributions of the capital per worker and material per worker in terms of its average annual growth rates. There was also a significant impact of carbon dioxide emissions per worker into total factor productivity growth (Table5). This indicates that carbon dioxide emissions impacted the technological progress of the manufacturing sector more than other productivity indicators of the sector as undesirable output.

Table 5: Productivity Indictors of Malaysia's Manufacturing Sector, (Model 2)

Productivity Indicators	1970-1996	1971-1979	1980-1986	1987-1996
Total Factor Productivity	0.00173	0.00708	-0.00314	-0.00025
Labour Productivity	0.01341	0.01039	0.01577	0.01458
Capital Intensity	-0.00129	-0.00055	-0.00346	-0.00026
Material –Labour Ratio	0.01359	0.01135	0.01436	0.01521
Carbon Dioxide Emissions Per Worker	-0.00063	-0.00748	0.00801	-0.00062

Conclusions

The manufacturing sector has been the engine of growth for the Malaysian economy since economic structural transformation took place in Malaysia's economy in 1987. The sustainability of higher economic growth will continue to be driven by productivity through the enhancement of total factor productivity. Total factor productivity development strategies will emphasise on quality of the workforce, raw material, capital structure and technical progress. The manufacturing sector is an important in the Malaysian economic development. The improvement and slowdown of total factor productivity contribution to manufacturing sector industries in terms of average annual growth rates are dependent on the inputs used in the production of manufacturing sector industries, that were reported earlier to be of low quality and insufficient.

This paper contributes to the literature of growth accounting method in the area of calculating the real total factor productivity growth by internalising the pollutant emissions besides the input terms in the production function. By this technique total factor productivity growth becomes an indictor of green productivity, which puts into consideration economic development and environmental protection, as has been explained in the introductory part of this paper.

The factors affecting the output growth of the manufacturing sector as identified using Jorggerson *et al.* model are the individual contributions of capital, labour, material, carbon dioxide emissions and the combined contribution of the quality of these inputs expressed as the total factor productivity. In fact, the higher level of carbon dioxide emissions generated by the manufacturing sector slowed the growth rates of total factor productivity by internalising the carbon dioxide emissions beside the traditional input terms in the form of undesirable output produced besides the original products of the sector in the model as shown in the result of model 1. While the factors identified as influencing the labour productivity (that is indicated as a good measure of standard of living rather than output because it measures output per person) of the manufacturing sector from Dollar and Sokoloff model are the individual contributions of capital deepening, material-labour ratio, carbon dioxide emissions intensity and the simultaneous contribution of the quality of these factors expressed as the total factor productivity. The carbon dioxide emissions per worker had slowed down the contribution of TFP (technological progress) of the manufacturing sector more than that of the first model due to the problems of labour, during the entire period of the study that witnessed the rapid industrial development in the Malaysian economy, which generated higher level of pollutant emissions due to the industrial activities.

Finally, putting together results of the two models this paper found that industrial activities are related to the growth rate of carbon dioxide emissions generated in the production process of the manufacturing sector. This appears in the form of undesirable output that had slowed the productivity growth of the manufacturing sector in general and the contributions of total factor productivity of the manufacturing sector in particular.

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