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ARE FOREIGN MULTINATIONALS MORE EFFICIENT? A STOCHASTIC PRODUCTION FRONTIER ANALYSIS OF MALAYSIA'S AUTOMOBILE INDUSTRY

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ABSTRACT

This paper compares the sources of total factor productivity (TFP) growth of foreign (establishments with 51% and above foreign equity ownership) and local establishments in Malaysia's automotive sector by applying a stochastic production frontier to a panel of 510 plants for the period 2000-2004. The results showed that TFP growth for local automobile plants was minimal at 0.63% and minimally negative at -0.27% for foreign plants. On average, over the study period, technical efficiency changes contributed positively toward TFP growth but scale efficiency changes were negative for both local and foreign establishments. Technical progress was minimally positive for local establishments and minimally negative for foreign establishments. The small size of plants and the lower share of white-collar workers were significant in explaining plant inefficiency in Malaysia's automobile sector. A higher capital-labour ratio was positively related to plant inefficiency and this may be due to excess capacity in the automobile sector as a result of a small domestic market. Finally, foreign multinationals are significantly more efficient than locally owned plants.

Keywords: *Technical efficiency change; technological progress; stochastic production frontier; automobile industry; Malaysia.*
JEL Classification Numbers: D24, L23, L62, O14, O53.

ABSTRAK

Kajian ini dilakukan untuk membandingkan faktor-faktor yang mempengaruhi pertumbuhan Produktiviti Faktor Keseluruhan (TFP) kilang milikan asing (pemilikan ekuiti oleh syarikat asing adalah sebanyak 51% dan lebih) dan tempatan dalam sektor kenderaan bermotor. Kajian ini menggunakan pendekatan pengeluaran pembatasan stokastik terhadap data penal bagi 510 buah loji antara tahun 2000 sehingga 2004. Keputusan kajian menunjukkan pertumbuhan TFP bagi kilang kenderaan bermotor tempatan adalah rendah pada 0.63% dan pada kadar rendah negatif iaitu -0.27% bagi kilang pemilikan asing. Secara purata, dalam tempoh kajian didapati perubahan kecekapan teknikal menyumbang secara positif terhadap pertumbuhan TFP tetapi perubahan kecekapan skel didapati bernilai negatif bagi kilang tempatan dan milikan asing. Kemajuan teknikal didapati rendah dan positif bagi kilang tempatan, manakala bagi milikan asing adalah rendah dan negatif. Saiz kilang yang kecil dan nisbah pekerja "kolar putih" yang kecil didapati signifikan di dalam mempengaruhi ketidakcekapan kilang sektor kenderaan bermotor di Malaysia. Nisbah modal-buruh yang meningkat didapati berhubungan positif dengan ketidakcekapan kilang dan ini berkemungkinan disebabkan lebihan kapasiti dalam sektor kenderaan bermotor kesan daripada pasaran domestik yang kecil. Akhir sekali, kilang multinasional asing didapati dengan signifikan lebih cekap berbanding kilang milikan tempatan.

Kata kunci: *Perubahan kecekapan teknikal; kemajuan teknologi; pengeluaran pembatasan stokastik; industri kenderaan bermotor; Malaysia.*

INTRODUCTION

In recent years, productivity growth had received greater attention from many researchers and policy makers. It was argued that economic growth in Asia is driven by the accumulation of the inputs in the production process rather than by increases in productivity. Some believe that the Asian economic miracle is largely attributable to an increase in the quantity and not the quality of the factors of production. Nonetheless, policy makers and economists alike have begun to recognise more fully the importance of technology and productivity in economic growth.

Malaysia's quest for industrialisation and the *showcasing* of the automobile sector resulted in the setting up of all sorts of *tie-ups* with foreign automobile producers. Although growth patterns in output at the aggregate level are important in examining productivity growth, it is increasingly recognised that these changes mainly take place in individual industries or plants. Presently, we observe a growing interest in analysing productivity growth at the plant (or establishment) level owing to the greater availability of data at the plant level.

Despite an increasing interest in total factor productivity (TFP) growth studies in the Malaysian manufacturing sector, no study has yet been conducted to analyse TFP growth in the automotive industry by applying the stochastic frontier approach to establishment level data. The automobile industry in Malaysia is protected and consumers have to pay a higher price for automobiles when compared to a free trade environment. This temporary infant industry protection was supposed to increase competitiveness of the automobile industry in the long run. Considering the high cost of protection, there is a prolonged debate on the competitiveness of the Malaysian automotive industry. This paper is the first attempt to study productive efficiency differentials between foreign and local establishments in the Malaysian automobile industry using the stochastic production frontier (SPF) model, and therefore provide a better understanding of TFP growth analysis at the establishment level.

We obtained total factor productivity (TFP) growth measures based on a set of panel data for foreign and local establishments using the stochastic frontier production function methodology. In order to examine the productive efficiency differential between foreign and local establishments in the Malaysian automotive industry, we then decomposed the TFP growth into technical change, technical efficiency change, and changes in scale of production. We also examined if factors such as size, ratio of white-collar workers to total number of workers, capital intensity, and whether being a foreign or a local plant affects the productive efficiency of plants in the automobile sector. The next section provides an overview of the automobile sector in Malaysia followed by a literature review of TFP studies. Methodology and data issues are then presented followed in the penultimate section by the empirical results and the last section concludes the study.

STRUCTURE OF THE AUTOMOTIVE INDUSTRY IN MALAYSIA

The automotive industry in Malaysia comprises the production of passenger cars and commercial vehicles. The launching of Malaysia's first national car project catalysed the development of complementary and supporting industries by creating opportunities for growth in the manufacturing of component parts and accessories. The production of one vehicle requires around 20,000 to 30,000 parts and components ranging from the low technology items such as brakes and batteries to the high-end gears such as engines, and electrical and electronic components. For that reason, the automotive industry succeeded in developing industry group linkages involving auto assemblers, parts and components manufacturers, government and learning institutions, as well as trade associations. The development has shown some progress, especially with the establishment of several automotive centres such as in Shah Alam (Selangor), Tanjung Malim (Perak), Pekan (Pahang), Pegoh (Melaka), and Gurun (Kedah).

The entry of Proton into the local automobile market in 1985 had restructured the automotive industry in Malaysia. It was manifested in the shift of Malaysian market demand, i.e. from imports in the form of used, reconditioned or new completely built-up (CBU) units, to one that is dominated by locally made cars. For non-Proton distributors, the entry of Proton had resulted in a much smaller slice of the cake. Initially the components of the car were entirely manufactured by Mitsubishi Companies[1] but slowly local parts were being used as technologies were transferred and skills were gained. An important milestone in the Malaysian automotive industry was the introduction of Proton Waja in 2000, which represents the first Malaysian designed car to be manufactured and actually affordable for local customers.

Established in 1993, Perodua is Malaysia's second automobile manufacturer after Proton. Perodua mainly produces compact cars and therefore does not actually compete with Proton for the same market niche. It caters for customers seeking a smaller and cheaper alternative to the Proton range. Malaysia Truck and Bus Sdn. Bhd. was set up in 1997 to produce heavy vehicles such as DRB-HICOM[2] lorries, whereas Inokom Corporation Berhad (Inokom) is another Malaysian manufacturer of light commercial vehicles and small passenger vehicles. The Inokom Atos, Getz, and Matrix are rebadged models of Hyundai's Atos, Getz, and Matrix, respectively. Meanwhile, Naza Group of Companies is the franchise holder for South Korea's Kia vehicles in Malaysia. Naza has rebadged Kia's Carnival and Carens vehicles as Naza Ria and Citra, respectively for the Malaysian market. Naza-Kia cars had been considered as national cars since 2003.

This study in general, classifies foreign plants as plants with 51% and above foreign equity ownership. A detailed breakdown of employment, gross output, value added and fixed assets in foreign and local establishments for the year 2004 (cross-section data) is provided in Table 1. In Malaysia, for the year 2004, 90% of all establishments in the automotive industry were locally owned. Employment and value added in locally-owned plants represent about 84% of the total

Table 1: Summary of the Establishment-level Data (for the Year 2004) Underlying the Malaysian Automotive Industry

Industry	Ownership	Number of establishments		Number of workers		Gross output (RM '000)		Value added (RM '000)		Capital (RM '000)	
		Value	Share	Value	Share	Value	Share	Value	Share	Value	Share
MSIC 34100	Local	15	7.21	15,711	38.84	13,510,760	68.01	2,609,348	60.81	4,161,029	70.47
	Foreign	3	1.44	1,783	4.41	2,172,611	10.94	306,187	7.14	257,948	4.37
MSIC 34200	Local	73	35.10	2,769	6.85	528,816	2.66	139,032	3.24	169,095	2.86
	Foreign	1	0.48	121	0.30	33,690	0.17	10,285	0.24	16,408	0.28
MSIC 34300	Local	100	48.08	15,625	38.63	2,541,475	12.79	895,804	20.88	1,012,342	17.15
	Foreign	16	7.69	4,443	10.98	1,079,756	5.43	330,398	7.70	287,696	4.87
	Total	208	100.00	40,452	100.00	19,867,108	100.00	4,291,052	100.00	5,904,517	100.00

Source: Authors' calculation based on unpublished Department of Statistics' data for all industries (MSIC 34100, 34200, and 34300).
Notes: MSIC 34100 - manufacture of motor vehicles and their engines
MSIC 34200 - manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers
MSIC 34300 - manufacture of parts and accessories for motor vehicles and their engines

Table 2: Development of the Automotive Industry in Malaysia (2000-2004)

Industry	Share of total employment					Share of total gross output				
	2000	2001	2002	2003	2004	2000	2001	2002	2003	2004
34100	47.33	47.34	54.5	45.83	43.25	80.89	80.61	83.73	75.34	78.95
34200	6.13	6.98	7.13	9.44	7.15	2.08	2.44	2.43	4.37	2.83
34300	46.54	45.68	38.37	44.73	49.51	17.02	16.95	13.84	20.29	18.22
Industry	Share of total value-added					Share of total capital				
	2000	2001	2002	2003	2004	2000	2001	2002	2003	2004
34100	66.92	75.25	79.06	73.14	67.95	75.84	70.65	76.61	73.77	74.84
34200	3.52	2.94	2.81	4.82	3.48	3.05	5.44	4.76	6.94	3.14
34300	29.56	21.8	18.13	22.04	28.58	21.11	23.9	18.63	19.29	22.02

Source: Authors' calculation based on unpublished Department of Statistics' data for all industries (MSIC 34100, 34200, and 34300)
Notes: MSIC 34100 - manufacture and assembly of motor vehicles and their engines
MSIC 34200 - manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers
MSIC 34300 - manufacture of parts and accessories for motor vehicles and their engines

employment and 85% of value added in the automotive sector. Fixed assets of locally owned plants represent about 90% of the fixed assets in the automotive sector in Malaysia. The share of gross output of locally owned establishments is about 83% of the total output of the automotive sector.

The shares of automobile manufacture and assembly operations (MSIC 34100 and 34200) and parts and components manufacture (MSIC 34300) in the automotive industry for the year 2000 to 2004 are shown in Table 2. It should be noted that the manufacture of automobile bodies (MSIC 34200) represent less than 10% of the total shares of employment, gross output, value added, and capital in the automotive industry. It can be gleaned from Table 2 that the bulk of output in Malaysia's automotive sector occurs in the manufacture and assembly of motor vehicles and their engines (MSIC 34100). The share of value added in MSIC 34100 was about 67% in 2000 increasing to 75% in 2001, and increased further to 79% in 2002. In 2003 and 2004, the share of value added in MSIC 34100 decreased to 73.14 and 67.95% respectively. The higher share of gross output in MSIC 34100 compared to value added generally shows the higher amount of intermediate inputs in this 5-digit industry. This is in contrast with MSIC 34300 where the share of value added is higher than that of gross output throughout the study period. The share of employment in MSIC 34300, on average, amounts to 45% of the employment in the automobile sector compared to employment in MSIC 34100, which represents 48% of total employment. This shows that MSIC 34300 is labour intensive and can be expected to generate relatively higher employment opportunities compared to MSIC 34100, although the gross output of the latter sub-industry is four times that of the former. The share of fixed assets in MSIC 34100 is much higher than that of MSIC 34300. In terms of capital accumulation, MSIC34100 has over 3.5 times more capital than MSIC 34300. If technology acquisition is sought after by Malaysia in developing the automotive sector, then MSIC 34100 should be the sub-sector that is focused upon.

LITERATURE REVIEW

There has been extensive work on both the theoretical foundations as well as the estimation of TFP growth, particularly in the Malaysian manufacturing sector using both frontier and non-frontier approaches. To name a few, such work that used the frontier approach were from Mahadevan (2002a, 2002b), and Nik Hashim and Basri (2004), while Oguchi, Nor Aini, Zainon, Rauzah, & Mazlina (2002) used the non-frontier approach. This study adds to the existing empirical literature since our interest is to investigate the productive efficiency differential between foreign and local establishments in the Malaysian automotive industry, which has yet to be explored. Nevertheless, this section will provide some insight on previous productivity studies based on either different approaches or different industries.

The various TFP growth measure methods can be categorised under frontier and non-frontier approaches (Mahadevan, 2002a). Under the frontier approach, TFP growth is shown to be composed of two factors: 1) technical change (progress) or frontier shift indicates the shift in production frontier over time due to the use of new advanced technology adopted in the production process, and 2) technical efficiency change (also known as the catching-up effect) reveals how far the industry has moved toward the efficient frontier as a result of improved utilisation of technology and equipment by employees. Hence, the frontier approaches explicitly incorporate inefficiency and account for changes in efficiency over time. Conversely, the non-frontier approaches such as the econometric estimation of production functions and deterministic index number formulae (e.g. divisia translog index), usually assume that industries are technically efficient. TFP change in the non-frontier approach is defined as the net change in an industry's output due to changes in production technology only, which is realistically inaccurate. Therefore, frontier measures are used to overcome these major drawbacks in our study.

Okamoto and Sjöholm (2000) examined productivity performance and its dynamics in the Indonesian automobile industry between 1990 and 1995 using a non-frontier approach. They concluded that the overall industry performance was poor despite large government support. Meanwhile, the spillover effect of foreign MNCs did not seem to exert a strong impact on local establishments although foreign establishments tended to perform better than local ones.

The sources of TFP growth was decomposed into technical progress, changes in technical efficiency, changes in allocative efficiency, and scale effects by applying a stochastic frontier production model to micro-level firm data in Korean manufacturing industries (Kim & Han, 2001). The empirical results based on data from 1980 to 1994 showed that productivity growth in the Korean manufacturing industries was driven mainly by technical progress. Changes in technical efficiency had a significant positive effect on productivity growth, but allocative efficiency had a significant negative effect on productivity growth. Additionally, government interventions to promote the heavy and chemical industries resulted in prevalent allocative inefficiency and diminished economies of scale across these industries.

Using a panel data of 28 industries from 1981 to 1996, Mahadevan (2002b) examined the productivity growth performance of Malaysia's manufacturing sector. The non-parametric data envelopment analysis (DEA) technique was used to calculate and decompose the Malmquist index of TFP growth into technical change, change in technical efficiency, and change in scale efficiency. The results found that the annual TFP growth of the manufacturing sector was low at 0.8% and this was driven by small gains in both technical change and technical efficiency, with industries operating close to optimum scale. In another study, Mahadevan (2002a) used the same set of panel data to compare the performance of results from two alternative methodologies namely, DEA and SPF models. It was found that both models have similar trends in the sources of TFP growth and concluded that Malaysia has obtained better technology and equipment through foreign direct investment, but it has failed to learn to use it adaptively.

Menon (1998) estimated TFP growth in foreign and domestic firms for the period 1988 to 1992 using growth accounting approach. Menon (1998) concluded that growth in real manufacturing is attributed to input growth rather than productivity growth. Industries that manufacture, such as household consumer and electrical goods, are likely to contribute to productivity growth, whereas industries that assemble, such as semiconductors and electronic parts industry, are unlikely candidates for future productivity growth.

Also using the growth accounting approach, Oguchi et al. (2002) produced different results on productivity of foreign and domestic firms in Malaysian manufacturing at the aggregate and disaggregated level. The differences between foreign and domestic firms varied widely from sector to sector. For instance, the foreign-owned firms were found to be more efficient in leading sub-sectors such as electrical and electronics, petroleum, and transport equipment, although domestic firms were as efficient as foreign firms for the aggregate manufacturing sector over the study period 1994-1996.

Productivity differentials between foreign and local plants in the Thai automobile industry was studied by Ito (2004) using 1996 and 1998 plant-level data. Ito (2004) used labour productivity and relative TFP as dependent variables to compare foreign and local establishments' productivity in the Thai automobile sector. Labour productivity measure ignores the substitution of labour for other inputs while the relative TFP measure allows for differential substitution across inputs. Both measures do not account for inefficiency in production. The results suggested that labour productivity is higher at foreign affiliated plants compared to local plants. In the case of the relative TFP measure, the study shows that there is no evidence of foreign plants having higher TFP than local plants that can be attributed to the foreign plants' firm-specific advantages.

Lieberman and Dhawan (2005) compared the resource base of Japanese and U.S. automobile producers within the context of the stochastic frontier production function based on 336 observations over the period 1960 – 1997. Work-in-process (WIP) inventory is used as a determinant of efficiency to proxy for lean production capabilities on the factory floor. WIP inventory is an indicator of manufacturing skills with lower WIP inventories being associated with higher labour productivity. Scale economies was also used as a determinant of efficiency and was being measured by average output per assembly plant of each firm. The capability of auto assemblers to coordinate with component suppliers via subcontracting as opposed to in-house parts manufacturing operations was also included as a determinant of efficiency. This capability of integrating operations versus subcontracting is measured by the firm's value added as a proportion of sales. Other variables used to measure efficiency in the study by Lieberman and Dhawan (2005) included number of vehicles produced, cumulative output, and design quality, whereas inputs in the production process include labour and capital. The result of the study showed that scale economies and lean manufacturing skills as proxied by lower WIP inventory levels enhances efficiency.

METHODOLOGY AND DATA

Stochastic production frontier (SPF) models were independently introduced by Aigner, Lovell, and Schmidt (1977), and Meeusen and Van den Broeck (1977). Schmidt (1986) and Greene (1993) gave an extensive literature survey on the subject. Since SPF recognises the random noise around the estimated production frontier, it is possible to distinguish between random errors and differences in inefficiency. In a simple case of a single output and multiple input production function, the SPF predicts the outputs from inputs by the functional relationships as stated by Coelli, Rao, and Battese (1998):

$$y_{it} = f\left(x_{j,it}, t, \beta\right) \exp \in_{it} \quad \text{where} \quad \in_{it} = v_{it} - u_{it}$$
$$\text{with} \tag{1}$$
$$u_{it} \sim \left|N\left(m_{it}, \sigma_u^2\right)\right| \quad and \quad v_{it} \sim \left|N\left(0, \sigma_v^2\right)\right|$$

where $f(.)$ is a suitable functional form; y_{it} denotes the output of plant i at time t ; $x_{j,it}$ is the corresponding level of input j; t is a time trend used to capture technological change, and β is a vector of unknown parameters to be estimated. The error term, $\in_{it}$ is composed of a random error component, (ν_{it}) and an inefficiency component (u_{it}) which are independent from each other. The random error component ν_{it} is assumed to be a standard symmetric, independent, and identically distributed (i.i.d.) error term, and uncorrelated with the regressors. In SPF literature, it is assumed that u_{it} is distributed as a non-negative truncation of the normal distribution with unknown variance σ^2_{it}.

The technical efficiency of production for the i^{th} plant at the time t is defined as the ratio of the actual output (y_{it}) to the potential or efficient output y^*_{it} .

$$TE_{it} = y_{it} / y^*_{it} \qquad (2)$$

A plant is technically efficient when the *TE* value is equal to one (i.e. the plant has an inefficiency effect equal to zero).

Production functions can be empirically estimated. The simplest form of a production function that is commonly used is the Cobb-Douglas production function as shown by equation (3) below:

$$1\text{n}\, y_{it} = b_0 + b_L \, 1\text{n}L_{it} + b_k \, 1\text{n}K_{it} + b_M \, 1\text{n}M_{it} + b_t t \qquad (3)$$

where y_{it} is the gross output and the independent variables are value of capital (K_{it}), labour (L_{it}) measured in wages, value of intermediate inputs (M_{it}), and a time trend (t). The Cobb-Douglas functional form is restrictive in that the elasticity of substitution equal unity and the returns to scale is fixed. The Cobb-Douglas functional form assumes Hicks neutral technological change. In the case of a translog production function, non-neutral technological change is assumed. The translog production function is given by equation (4) below:

$$\begin{aligned} 1\text{n}\, y_{it} &= \alpha_0 + \alpha_L \ln(L_{it}) + \alpha_K \ln(K_{it}) + \alpha_M \ln M_i + \frac{1}{2}\beta_{LL}\left[\ln(L_{it})\right]^2 + \frac{1}{2}\beta_{KK}\left[\ln(K_{it})\right]^2 + \\ &\frac{1}{2}\beta_{MM}\left[\ln(M_{it})\right]^2 + \left[\beta_{LK}\ln(L_{it})\ln(K_{it})\right] + \left[\beta_{LM}\ln(L_{it})\ln(M_{it})\right] + \left[\beta_{KM}\ln(K_{it})\ln(M_{it})\right] + \\ &+ \beta_{tL}(\ln L_i)t + \beta_{tK}(\ln K_i)t + \beta_{tM}(\ln M_i)t + \alpha_t t + \frac{1}{2}\beta_{tt}t^2 + v_{it} - u_{it} \qquad (4) \end{aligned}$$

In these equations, y_{it} is the gross output and the three independent variables are value of capital (K_{it}), labour (L_{it}) measured in wages, and value of intermediate inputs (M_{it}). The technological change index in equation (4) is based on the coefficients of time, time squared, and the interaction of time with the three inputs, which is data dependent. The maximum-likelihood estimates of the parameters in the translog stochastic frontier production function model defined by (4) are obtained using the program FRONTIER 4.1. The translog parameterisation of the SPF model allows for non-neutral technical progress. If all β_{tj} s are equal to zero, then technical change is neutral. If all β s are equal to zero, the production function reduces to the Cobb-Douglas function with neutral technical progress. The SPF functional form is determined by testing the adequacy of the Cobb-Douglas production function model relative to the less restrictive translog production model as specified above.

Hypothesis tests based on the generalised likelihood-ratio (*LR*) test are conducted to select the functional form and to determine the presence of inefficiencies. Various tests of hypothesis of the parameters in the frontier production function can be performed using *LR* test statistic, λ, given by

$$\lambda = -2[\lambda (H_0) - \lambda (H_1)] \tag{5}$$

where $\lambda (H_0)$ and $\lambda (H_1)$ denote the value of the log likelihood function under the null and alternative hypothesis, respectively. This test statistic has approximately a chi-square distribution with degrees of freedom equal to the difference between the parameters involved in the null and alternative hypothesis.

The data were mean-differenced for the panel data analysis. The first test is the selection of the functional form, where the null hypothesis is that the Cobb-Douglas is an adequate representation of the data. The second test is to examine whether the technical efficiency effects are not simply random errors. We defined $\sigma^2 = \sigma^2_u + \sigma^2_v$. The key parameter is $\gamma = \sigma^2_u / \sigma^2$, which lies between 0 and 1. γ is the ratio of the variance of the non-negative random variable *u*, as a proportion of total variance due to the random variables, *u* and *v*. If the null hypothesis that $\gamma = 0$ is true, then technical inefficiency is not present, indicating that the mean response function (Ordinary Least Squares - OLS) is an adequate representation of the data. In the extreme cases, $\gamma = 0$, shows that the deviations from the frontier are due entirely to noise, while a value of unity would indicate that all deviations are due to technical inefficiency. The closer γ is to unity, the more likely it is that the frontier model is appropriate.

Given the estimates of parameters in equation (4), technical efficiency change of establishment *i* at time *t* is then defined as

$$TEC_{i,t+1} = \frac{TE_{i(t+1)}}{TE_{it}} \tag{6}$$

The rate of technical change is defined by

$$TC_{it} = \frac{\partial \ln f(x_{it,t})}{\partial t} = \alpha_t + \beta_{tt} t + \beta_{tL} (\ln L_i) + \beta_{tK} (\ln K_i) + \beta_{tM} (\ln M_i) \quad (7)$$

Technical change for the i^{th} production unit can be calculated directly from the estimated parameters by evaluating the partial derivative of the production function with respect to time (at a particular date point). The technical change index is based on the coefficients of time, time squared, and the interactions of time with the three inputs. However, this technical change may vary for different input vectors if technical change is non-neutral. Following Coelli, Estache, Perelman, & Trujillo (2003), we used the mean between adjacent periods as a proxy for technical change.

Both TC_{it} and TEC_{it} vary over time and across production units. The final term required in calculating TFP change is scale efficiency changes. The scale efficiency change measure requires the calculation of production elasticity for each input at each data point. From the coefficients estimated in equation (4), the elasticities of output with respect to the different inputs are calculated as follows:

$$\eta_{iLt} = \frac{\partial \ln f(x_{it,t})}{\partial L} = \alpha_L + \beta_{LL} \ln L_i + \beta_{LK} \ln K_i + \beta_{LM} \ln M_i + \beta_{tL} t \quad (8)$$

$$\eta_{iKt} = \frac{\partial \ln f(x_{it,t})}{\partial K} = \alpha_K + \beta_{KK} \ln K_i + \beta_{LK} \ln L_i + \beta_{KM} \ln M_i + \beta_{tK} t \quad (9)$$

$$\eta_{iMt} = \frac{\partial \ln f(x_{it,t})}{\partial M} = \alpha_M + \beta_{MM} \ln M_i + \beta_{LM} \ln L_i + \beta_{KM} \ln K_i + \beta_{tM} t \quad (10)$$

The standard returns to scale elasticity for firm i in period t is given by

$$\eta_{it} = \eta_{iLt} + \eta_{iKt} + \eta_{iMt} \quad (11)$$

The scale factor for the ith firm in period t is calculated as follows:

$$SF_{it} = \frac{(\eta_{it} - 1)}{\eta_{it}} \quad (12)$$

The scale efficiency changes between period t and (t+1) is given by the summation of the average of the scale factor for the ith firm between the two periods multiplied by the change in the respective input usage as follows:

$$SEC_{i,t+1} = 0.5[(SF_{i,t}\eta_{iL,t} + SF_{i,t+1}\eta_{iL,t+1})(L_{i,t+1} - L_{i,t}) + (SF_{i,t}\eta_{iK,t} + SF_{i,t+1}\eta_{iK,t+1})(K_{i,t+1} - K_{i,t}) + (SF_{i,t}\eta_{iM,t} + SF_{i,t+1}\eta_{iM,t+1})(M_{i,t+1} - M_{i,t})] \tag{13}$$

Finally, TFP change or growth, between period t and (t+1) can be defined as follows:

$$\ln\frac{TFP_{i,t+1}}{TFP_{i,t}} = TEC_{i,t+1} + TC_{i,t+1} + SEC_{i,t+1} \tag{14}$$

Calculation and decomposition of the various components of TFP change was conducted following the steps illustrated in Coelli et al. (2003, p.63) before we could analyse the efficiency, technical progress, and scale efficiency changes of the local and foreign establishments in the automotive industry.

In the second part of the model, the inefficiency term, u_{it} , was made an explicit function of k explanatory variables, $z_{k,it}$, associated with characteristics of establishments in the automobile sector in Malaysia. We used Battese and Coelli's (1995) method of parameterising u as a function of firm specific variables in addition to the inputs labour, capital, and raw materials. The u_{it} are independently but not identically distributed as non-negative truncations of the normal distribution of the form

$$\text{uit} \sim N\left[\delta_0 + \sum_{k=1}^{4}\delta_k z_{k,it}, \sigma^2\right] \tag{15}$$

where δ is a vector of unknown parameters to be estimated and $z_{k,it}$ is a vector of explanatory variables as collected in our study. We estimated σ^2, vector β, and δ by maximum likelihood estimation (MLE) methods. In order to differentiate the growth in productivity between local and foreign establishments, we created a dummy variable where establishments with 51% or more foreign equity were considered as foreign establishments. We incorporated the following variables within the technical inefficiency component of the stochastic frontier, as follows:

$$u_{it} = \delta_0 + \delta_1 \ln SIZE_{it} + \delta_2 \ln KL_{it} + \delta_3 \mathrm{FD}_{it} + \delta_4 \ln WSH_{it} \tag{16}$$

$SIZE_{it}$ represents gross-output of the ith firm divided by the average automobile industry gross-output, KL_{it} represents capital per unit of labour, FD_{it} is a dummy variable denoted 1 if the establishment has greater than or equal to 51% foreign equity, and WSH_{it} denotes the share of white collar workers where white collar workers refer to professional and managerial, supervisory, and technical personnel, as well as clerical workers. A large plant as depicted by the *SIZE* variable, enhances the ability to exploit economies of scale. The *SIZE* variable can also be used to measure market power in an industry.

Alternatively, large plants can lead to the loss of control by top managers resulting in a lower level of efficiency compared to smaller plants. Ownership by foreigners of more than 50% of the equity in a firm provides control over key aspects of a firm's operations allowing for the exploitation of firm specific assets of the foreign firm. We would expect multinationals to possess large amounts of intangible assets compared to local firms and thus be more efficient. This expectation of higher efficiency and productivity of multinationals has led to attempts to attract foreign direct investment into host countries by offering all sorts of fiscal incentives in the hope of transferring technology or generating spillover effects to local firms.

The production frontiers were fitted for a single output and three inputs, namely,

y - gross output in value terms
K - capital in value terms
L - wages of labour in value terms
M - intermediate inputs in value terms

Data on gross output, capital, wages, and intermediate inputs were compiled from unpublished data provided by the *Department of Statistics, Malaysia*. The industrial classification used in this study is that of the *Malaysian Standard Industrial Classification 2000* at the five-digit level. The automotive industry is divided into three groups, as follows:

i) MSIC 34100 - manufacture and assembly of motor vehicles including engines;
ii) MSIC 34200 - manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers; and
iii) MSIC 34300 - manufacture of parts and accessories for motor vehicles and their engines.

The output (or dependent variable) is the value of gross output. Of the inputs, labour was entered as a value although it is available both in value terms and the number of workers. The value measure was chosen so that it can reflect the earnings of skilled and unskilled workers since the earnings of white- and blue-collar workers are lumped together and cannot be distinguished. Fixed capital stock was taken as the capital variable since data on capital expenditure is not available. Intermediate inputs consisted of value of materials consumed including electricity purchased, value of fuels, lubricants, and water consumed, and all other input costs (excluding non-industrial services such as advertising, legal fees, postage, etc.). All the four variables used (measured in value terms) in the analysis were not deflated by any economic deflator. The use of nominal value measures was unlikely to introduce much bias since there was not much change in the price levels that could distort the measurement of the variables.[3]

In the panel (balanced) estimation, a time trend, *t*, was included to identify any trend in the data involving a total of 510 observations between 2000 and 2004. The trend is normally interpreted as technological change in the industry production process. The panel estimation was used to answer the questions raised in the statement of problem in the introduction.

EMPIRICAL RESULTS

For the panel data analysis, 510 observations from the automobile industry were mean corrected prior to estimation so that the first order parameters can be interpreted as elasticities at the sample means. The two forms of the stochastic frontier production of the Cobb-Douglas and the translog model respectively as in equation (3) and (4) were employed with time *t* included as a variable to reflect the impact of technology change on the dependent variable, that is, gross output. The ML estimates of the parameters of the Cobb-Douglas and translog stochastic frontier production function models are presented in Table 3.

For the selection of the functional form, the value of the generalised likelihood-ratio statistic for testing the null hypothesis, $H_0{:}\beta_{ij} = 0$ was calculated to be $LR = -2\ \{-129.07-(302.17)\} = 346.2$. This value was compared with the upper five percent point for the $\chi^2_{0.5,10}$ -distribution, which was 18.31. Thus, the LR test indicated that the Cobb-Douglas production function was not an adequate specification for the automotive industry, given the assumptions of the translog stochastic frontier production function model.

The null hypothesis that there are no technical inefficiency effects ($H_0 : \gamma = \partial_0 = \partial_1 = \partial_2 = \partial_3 = \partial_4 = 0$) was rejected at the 5% significance level.

The LR test provided a statistic of 259.6, which was significant since it exceeded the 5% critical value of the mixed χ^2 distribution of 11.91 with six degrees of freedom obtained from Table 1 of Kodde and Palm (1986). Hence there are frontier parameters in the regression equation and the OLS assumption of zero inefficiency effects can be rejected.

Table 3: Maximum-Likelihood Estimates of the Stochastic Production Frontier of the Automotive Industry (Year 2000 - 2004)

Variables	MODEL A (Cobb-Douglas)		MODEL B (Translog)	
	Coefficient	t-ratio	Coefficient	t-ratio
Constant	0.5409	6.2667	0.45636	13.34777
ln *K*	0.0551	7.9236[a]	0.05927	3.57964[a]
ln *L*	0.2113	15.3570[a]	0.14759	7.96047[a]
ln *M*	0.7354	69.7802[a]	0.57424	45.18520[a]
T	-0.0003	-0.0528	0.00190	0.37180
$(\ln K)^2$			0.00275	0.83008
ln *K**ln *L*			0.00433	0.64104
ln *K**ln *M*			-0.00551	-0.96763
(ln *K*)**t*			-0.00181	-0.59906
$(\ln L)^2$			0.10956	4.89413[a]
ln*L**ln*M*			-0.09171	-6.16258[a]
(ln *L*)**t*			-0.00419	-0.54680
$(\ln M)^2$			0.12114	10.05158[a]
ln*M***t*			0.00385	0.70182
t^2			0.00389	0.46297
∂_0	0.5944	6.6629	-0.21909	-6.28860
SIZE	-0.0110	-3.0900[a]	-0.26763	-21.81871[a]
KL	0.0046	1.0585	0.03394	1.66588[b]
FD	-0.0023	-0.7111	-0.08975	-2.81841[a]
WSH	0.0026	1.3273	-0.00718	-2.21901[b]
σ^2	0.0355	15.7416	0.02747	15.78507
γ	0.2594	0.9362	0.78574	19.95709
Log-likelihood	129.0678		302.1683	
LR test of the one-sided error	56.8748		259.6171	

Note: a significant at 1% significance level
b significant at 5% significance level

The results of Model B (Table 3) for the maximum likelihood examination of the translog production function showed that all the input coefficients were positive and statistically significant. The intermediate inputs were extraordinarily important for the automobile sector in Malaysia. This was followed by the labour input coefficient and lastly the capital input coefficient. All the input coefficients were significant at the 1% level or better. The second order parameters βLL and βMM showed an unexpected positive and significant sign, but βKK was insignificant. The estimated σ^2 was statistically significant at the 1% level. The γ value of 0.786 was significant at the 1% level. This justified the use of the stochastic frontier production model as opposed to the OLS model due to the presence of inefficiencies in the automobile industry.

The negative and significant coefficients for *SIZE* (ratio of establishment gross output to average industry output) and *WSH* showed that larger establishments and higher shares of white-collar workers reduced inefficiency in this stochastic frontier model. The positive and significant sign for *KL* was unexpected. Higher *KL* ratios would lead to higher inefficiency of plants in Malaysia's automobile sector. Perhaps, excess capacity in terms of capital reduces plant efficiency. Green and Mayes (1991) explained that capital intensive industries have higher sunk costs and encounter difficulties in adjusting behaviour as demands and technology changes. The dummy variable denoting foreign establishments, *FD*, was significantly negative in explaining inefficiency. Therefore, foreign establishments were more efficient than local establishments.

The results of the TFP growth decomposition[4] are shown in Table 4. It can be observed that over the years 2000 to 2004, TFP growth of local establishments continuously improved from -0.89% in 2001 to 2.05% in 2004. This contrasted with the erratic pattern of TFP growth for foreign establishments being negative in 2001 and further declining to -3.5% in 2002 before improving to 3.59% in 2003 and declining again to -0.61% in 2004. For the total sample, TFP growth showed an improving trend akin to that of local establishments.

The negative TFP growth in 2001 for local establishments can be attributed to negative growth in all the components of TFP growth, that is, negative technical efficiency change, negative technical change, and negative scale efficiency changes. In the case of foreign establishments for the year 2001, technical efficiency improved at 1.49% while technical change and scale efficiency changes declined respectively at -0.71% and -1.35%. The combined effect of foreign and local establishments yielded negative growth for all the components of TFP change in 2001.

Table 4: TFP Growth of the Malaysian Automotive Industry and its Components

		Total sample	Foreign	Local
TEC	2000-01	-0.0164	1.4940	-0.2178
	2001-02	0.8361	-3.4130	1.4028
	2002-03	1.9719	6.4034	1.3810
	2003-04	1.6830	-0.5181	1.9765
		(1.11865)	(0.99158)	(1.13563)
TC	2000-01	-0.4084	-0.7140	-0.3676
	2001-02	-0.0236	-0.3456	0.0194
	2002-03	0.3767	0.0422	0.4213
	2003-04	0.8009	0.4558	0.8469
		(0.1864)	(-0.1404)	(0.23)
SEC	2000-01	-0.4315	-1.3511	-0.3089
	2001-02	-1.0384	0.2556	-1.2110
	2002-03	-0.8857	-2.8562	-0.6229
	2003-04	-0.7482	-0.5523	-0.7744
		(-0.776)	(-1.126)	(-0.7293)
TFP	2000-01	-0.8562	-0.5711	-0.8942
	2001-02	-0.2258	-3.5032	0.2111
	2002-03	1.4629	3.5894	1.1793
	2003-04	1.7357	-0.6146	2.0491
		(0.52915)	(-0.2749)	(0.63633)

Note: Average annual growth rates are in parentheses

Technical change (TC) continuously improved for both local and foreign firms although the improvement was quite marginal. For local firms, technical change was -0.37% in 2001, improving to 0.02%, 0.42%, and 0.85% respectively for the years 2002, 2003, and 2004. A similar trend of marginal improvement in technical change occurred for foreign establishments improving from -0.71% to -0.35%, 0.04%, and 0.46% respectively over the years 2001 to 2004. On average, technical change was 0.23% for local versus -0.14% for foreign establishments, resulting in a 0.19% technical change for the combined sample.

Technical efficiency changes (TEC) improved from -0.22% in 2001 and became positive for local establishments in the years 2002 to 2004 with technical efficiency change being 1.98% in 2004. The technical efficiency change in foreign establishments switched signs for all the years examined in the study. On average, technical efficiency change was slightly higher for local establishments at 1.14% compared to 0.99% for foreign establishments resulting in an average growth of 1.12% for the total sample.

Scale efficiency changes (SEC) contributed negatively to TFP change for local, foreign, as well as the total sample. The fluctuations in scale efficiency changes for local establishments were less than that for foreign establishments. On average, the inappropriateness of scale was more pronounced for foreign establishments (-1.13%) compared to local establishments (-0.73%) in explaining TFP change.

CONCLUSION

In this study, foreign ownership refered to establishments with foreign equity ownership above 50%. Establishments may have government ownership but this is simply considered as local ownership as opposed to foreign ownership. On average, over the period 2000-2004, technical efficiency changes contributed positively toward TFP growth, but scale efficiency changes were negative both for local and foreign establishments. Higher capital-labour ratios were associated with higher inefficiency and this may be attributed to excess capacity as a result of production at a less than optimal scale when producing for a small domestic market. The small size of plants and the lower share of white-collar workers were significant in explaining plant inefficiency in Malaysia's automobile sector. Foreign establishments were more efficient than local establishments.

Overall, local establishments' minimal TFP growth (0.64%) was slightly greater than that of foreign establishments (-0.27%) albeit in an environment of protection. Of the different components of TFP change, the catching-up effect or the narrowing of the gap between frontier technology and a firm's actual production was most dominant for local establishments showing an increasing trend over the study period. In the case of local firms, TFP growth arising from improvements in technical efficiency was more important than from technical progress. Government policy in enhancing efficiency should be promoted in the local establishments of the Malaysian automobile sector. On average, technical progress was minimally positive for local establishments (0.23%) and minimally negative for foreign establishments (-0.14%). Although the shift in the technological frontier was quite marginal; both local and foreign establishments showed an increasing trend in technology acquisition over the study period. Scale efficiency changes were mostly negative for local as well as foreign establishments. The negative value for the scale efficiency changes, especially for the local sub-sample, showed that the prior industrial policy of exploiting economies of scale within the context of HICOM is no longer effective in promoting productivity in the automobile sector of Malaysia.

AFTA and trade liberalisation will see increased competition in the automobile sector in Malaysia where foreign presence has already been felt. The multinational corporations and their further division of labour in the ASEAN region that aspire to be one big market will definitely be a force to contend with for the local automobile producers. Hopefully, the local producers will be able to rise to this challenge and survive this competition, producing efficiently at an optimal scale by embracing technical progress and striving to improve productivity.

END NOTES

1 Proton was launched as a joint venture with Mitsubishi Companies, a Japanese conglomerate.

2 The Heavy Industries Corporation of Malaysia Berhad (HICOM) was incorporated in 1980 and then merged with Diversified Resources Berhad (DRB) to form the biggest conglomerate in Malaysia in 1996, named DRB-HICOM. The conglomerate spans from automotive manufacturing, property development, and services.

3 Over the period of study, Ringgit Malaysia was pegged at RM3.80 against the US dollar.

4 TFP change = TEC + TC + SEC. The summation of the components TEC, TC, and SEC for each ownership group may not be exactly equal to TFP change because the indices are constructed for each establishment individually before the average is calculated for the different ownership groups.

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