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Competitiveness and Workforce Status in the Malaysian Micro-Electronics Sector

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Abstract

This paper seeks to empirically examine the importance of human capital and technology development in Malaysia using firm level evidence from the electronics industry which is one of the key engines of growth. This is done by estimating a translog stochastic production frontier and obtaining overall and input specific technical efficiency measures. The results are used to assess current policies on human capital and technology development. Some of the policies currently in place are shown to be suboptimal in the long run due to the lack of an integrated policy framework. This calls for the systemic coordination of human capital and technology development policies in a broader policy setting to promote policy coherence involving network cohesion (which is shown to result in regional differences in efficiency performance), technology transfer and diffusion, and a change in the nature of government's role - all of which need to operate within an effective national innovation system to improve competitiveness and promote growth.

1. Introduction

Human capital has long been established as an important factor of production. For a rapidly developing economy such as Malaysia, technology development too is an important input for increasing output growth. Recognition of this underpins Malaysia's effort to industrialise and move away from being a predominantly agricultural and primary goods producing economy, and attract foreign direct investment (FDI) with the Promotion of Investment Act passed in 1986.

Malaysia is one of the fast growing economies in the Asia-Pacific region that has done well despite the setback of the 1997/98 financial crisis. While Malaysia's average annual real GDP growth rate was 6% over the last three and a half decades, and since 1970, its inflation rate has not exceeded 4%, and the highest unemployment rate was only 7%. In 2004, the structural transformation in the economy saw a doubling of the manufacturing GDP share of 14% in 1975.

Within manufacturing, the electronics sector[1] grew more than eightfold in real terms, increasing its share of manufacturing output from 14% in 1987 to 30% in 2004. In the same year, when manufactures accounted for 83% of merchandise exports, about 60% were electronic products worth US$48.2 billion. Malaysia's success in the electronics industry started in the early 1970s with offshore chip assembly. In the early 1980s, it progressed to consumer electronics, and in the late 1980s, it was computer-related equipment, and the most recent stage involves the production of communication and

[1] This refers to the production of computer peripherals, integrated circuits, semiconductor devices, printed circuit boards, audio and video equipment, opto-electronics, flexible manufactures, information and communication. Malaysia is currently the world's fifth largest exporter of semiconductors.

networking equipment. The electronics industry has been the major recipient of FDI, absorbing more than one third of total manufacturing between 1996-2003 (MITI 2004). However, this growth industry faces a serious challenge from low-cost producers such as China which is fast emerging with a focus on volume manufacturing in semiconductors, computers and telecommunications. Thailand too is stepping up its efforts to tap into the huge market potential in this industry.

In order to remain competitive, Malaysia's output growth needs to be productivity growth driven and the *Ninth Development Plan 2006-2010* has reemphasized human capital and technology development as key areas of focus in this objective. The urgency of this matter is clear in view of Malaysia's goal of attaining developed country status by 2020. Thus it is timely to provide an analysis of the contribution of human capital and technology development to efficiency performance in the dynamic growth Malaysian electronics industry. More importantly, an assessment of the framework within which policies related to these focus areas operate, sheds light on policy making and provides lessons for other rapidly developing economies on a similar growth path.

This paper augments existing studies in four ways. First, the use of firm level evidence allows for more accurate micro level policy analysis. Second, this is the first attempt to study the technical efficiency[2] (TE) and input-specific efficiency measures of Malaysia's electronics firms. The latter measures enable greater depth in efficiency analysis, bringing new evidence to light. To our knowledge, the World Bank (1997) is the only other TE study on Malaysia using firm-level data but the sample of firms are drawn from various manufacturing industries, thus masking the differences in firm performance across different industries and resulting in rather broad conclusions and policy prescriptions for the manufacturing sector as a whole. There are also two strong assumptions underlying the estimated stochastic production frontier model of the World Bank Study.

Like most stochastic production frontier models, the World Bank study assumes a particular distribution for technical efficiency and this is purely based on the attractiveness of the statistical properties of the assumed distributions without any theoretical justification.[3] Here, our model relies on the generalised least squares estimation technique and hence does not require the imposition of an ad hoc assumption on the distribution. The implication of this is that TE is not assumed to differ by the same rate for all firms. The World Bank (1997) model also assumes constant returns to scale but this assumption is relaxed in our model.

The third contribution of this study is the empirical investigation of the impact of human capital and technology development, together with a range of other factors, on TE of the

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[2] Increased technical efficiency results from the more efficient use of technology and inputs (due to the accumulation of knowledge in the learning-by-doing process, diffusion of new technology, improved managerial practice, etc.) and is represented by movements towards the production frontier that indicates the maximum possible output attainable.

[3] Most stochastic frontier models assume that technical efficiency follows a half-normal or truncated normal distribution.

firms. This is used to highlight the need for the systemic coordination of human capital and technology development policies to obtain maximum TE. Fourth, the qualitative survey results are used to show that these two polices need to be integrated within a broader policy framework which will necessitate greater government involvement of a different kind.

The rest of the paper is organised as follows. The next section provides a profile of the sample of firms surveyed in the first half of 2006 and explains what kinds of data were obtained from the survey. Section 3 details the production frontier model used for estimation and section 4 presents the empirical evidence obtained. Section 5 discusses the results in light of current policies on human capital and technology development, and the need for an integrated policy framework as a long term strategy to sustain growth. Section 6 concludes.

2. Data on Sample of Firms

The survey undertaken in 2005 produced 70 responses with relevant data for econometric analysis.[4] This was made up of 30 firms from the Klang Valley and 40 in Penang. These are the two regions that are most heavily populated with firms in the electronics industry. A list of firms from the Ministry of International Trade and Industry was obtained and systematic sampling was undertaken. If the firm had closed down, merged or declined to be interviewed, then the next firm in the list was contacted. The sample included small and medium enterprises (SMEs) defined as those employing less than 300 workers, and large firms, defined as those employing more than 300 workers. Foreign ownership was defined as firms with 50% or more foreign equity and they were found to be predominantly involved in semiconductors, computer and peripherals, while local firms were found mostly in consumer electronics production involving low value added assembly. The profile of the firms sampled is detailed in table 1.

Table 1 Summary Statistics of Firms

	Penang	Klang	SMEs	Large Firms	Foreign Firms	Local Firms
No. of firms	40	30	22	58	63	17
Value Added	11.24	11.51	9.35	11.06	11.98	10.89
Capital	11.01	11.62	10.02	11.73	12.61	10.68
Labour	2.48	2.52	2.31	2.78	2.83	2.61

Note: Value added, capital and labour are logarithmic values and they are averaged over the number of firms in each category.

[4] This was made possible by the grant provided by the East Asian Development Network under the purview of the World Bank.

Table 1 does not show significant differences in the value added and capital expenditure of the representative firm (since it is averaged over the number of firms) in Penang and the Klang Valley. However, these variables are larger for the foreign firms and large firms. While almost all the foreign firms are large firms, the latter group registers smaller values as it includes the local firms which are generally not as large as foreign firms. The sample data nevertheless show considerable within-firm differences as there is a wide range in the categories of value added, capital expenditure and sales for firms.

In addition to obtaining the above quantitative data (see table 2 for other types of data collected), the survey questionnaire was designed to interview and discuss with staff at senior management level on various aspects of worker skills, training, research and development (R&D), such as availability of staff and government incentive structure for R&D.

3. The Random Coefficient Stochastic Production Frontier Model

The frontier concept initiated by Farrell (1957) emphasizes the idea of maximality which it embodies, and represents the 'best practice' technology. The frontier estimates a relationship that provides a benchmark of the most efficient firm. The generalized version of the random coefficient frontier model (Kalirajan and Obwona 1994) underlying the Cobb-Douglas production technology can be written as:

$$\ln Y_{it} = \gamma_{1i} + \sum_{j=1}^{n} \gamma_{ij} \ln X_{ijt} \qquad (1)$$

where i represents no. of firms;
j represents no. of inputs used;
t represents time period;
Y = output;
X = inputs;
γ_{1i} = intercept term of the i^{th} firm; and
γ_{ij} = actual response of output to the method of application of the j^{th} input used by the i^{th} firm.

Since intercepts and slope coefficients can vary across firms, we can write:

$$\gamma_{ij} = \bar{\gamma}_j + u_{ij}$$
$$\gamma_{1i} = \bar{\gamma}_1 + v_{1i} \qquad (2)$$

where $\bar{\gamma}_j$ is the mean response coefficient of output with respect to the j^{th} input;
u_{ij} and v_{1i} are random disturbance terms; and
E (γ_{ij}) = $\bar{\gamma}_j$, E(u_{ij}) = 0 , Var (u_{ij}) = σ_{uit} for $j = t$ and zero otherwise.

Combining equations (1) and (2):

$$\text{Ln } Y_{it} = \bar{\gamma}_1 + \sum_{j=1}^{k} \bar{\gamma}_j \text{ Ln } X_{ijt} + \sum_{j=1}^{n} u_{ij} \text{ Ln } X_{ijt} + v_{1i} \quad (3)$$

Following Aitken's generalized least squares method suggested by Hildreth and Houck (1968), and the estimation procedure by Griffiths (1972), the firm-specific input response coefficients and the intercept from the model can be obtained. These estimates provide two types of TE measures, input-specific TE and overall TE. Thus technical efficiency stems from two sources. One is the efficient use of each input that contributes individually to TE and can be measured by the varying slope coefficients γ_{ij}, and the other is from any firm-specific intrinsic characteristics that are not explicitly included, which may produce a combined contribution over and above the individual input contributions. This 'lump sum' contribution, if any, can be measured by the varying intercept term.

From the varying individual response coefficients, the frontier production coefficients are chosen to reflect the condition that they represent the production responses of the 'best practice' techniques. That is, $\gamma_j^* = \max \{ \gamma_{ij} \}$ where $i = 1, \ldots n$ and $j = 1, \ldots k$. Thus the input specific technical efficiency can be calculated for each firm *i*, as the ratio of the actual response coefficient to the frontier coefficient, that is,

$$\text{Input-specific TE}_{ij} = \frac{\gamma_{ij}}{\gamma_j^*} \quad (4)$$

This measure enables us to identify which firms are more or less efficient with respect to which inputs. The highest magnitude of each response coefficient and intercept given by γ^* form the frontier coefficients of the production function representing the maximum possible output attainable. Thus the potential output of the firm can be realized when the best practice techniques are used and this is given by

$$\text{Ln } Y_{it}^* = \gamma_1^* + \sum_{j=1}^{k} \gamma_j^* \text{ Ln } X_{ijt} \quad (5)$$

where X_{ijt} is the actual level of the j^{th} input used by the i^{th} firm in period *t*.

The literature indicates that firms realize their potential output by following the best practice techniques of their chosen technology, given the prevailing economic environment. Thus different methods of applying various inputs will influence the output differently. The inference is that the output response from an input applied according to the best practice technique for a given technology will be higher than, if the same amount input is not applied according to the best practice technique. This is captured by the overall TE measure defined as the ratio of the observed output to the maximum possible attainable output in period *t* is given by

$$TE_{it} = \frac{Y_{it}}{Y_t^*} \qquad (6)$$

Based on the above, the translog model which considers varying returns to scale using cross-sectional data was estimated as:

$$\text{Ln } Y_i = \beta_o + \beta_D D + \beta_L \text{Ln } L_i + \beta_K \text{ Ln } K_i + \beta_{KK} (\text{Ln } K_i)^2 + \beta_{LL} (\text{Ln } L_i)^2 + \frac{1}{2} \beta_{KL} (\text{Ln } L_i)(\text{Ln } K_i) + u_i + v_i \qquad (7)$$

where Y = value added output;
D = dummy that takes on the value of 1 for firms in Penang and 0 otherwise;
L = number of workers employed;
K = fixed capital assets expenditure and
i = 1, … 70

The overall TE measure obtained is then computed and used as the dependent variable in a separate regression to investigate empirically the significance of the influence of various factors including human capital and technology development as set out in table 2.[5]

Table 2 Data for Determinants of Technical Efficiency

Variable	Symbol	Description
Capital-Labour Ratio	K/L	Fixed capital asset expenditure per unit of person employed in RM million.
ICT expenditure	ICT	Proportion of fixed capital spent on computer controlled machinery
Age of Firms	AGE	Number of years since the firm's initial establishment in Malaysia
Size of Firms	SALES	Sales in RM million
Foreign Ownership	FOREIGN	Dummy variable that takes a value of 1 for foreign ownership and 0 otherwise.
Exports	EXPORT	Value of exports in RM million
High Skilled Workers	HSKILL	Proportion of engineers in the firm's workforce
Training Provided	TRAINING	Average amount of funds spent on training as a proportion of sales over the last 3 years.
R&D Expenditure	R&D	Average amount spent on R&D as a proportion of sales over the last 5 years.
High Technology	HTECH	Dummy variable takes a value of 1 if firm's production process uses high technology and 0 otherwise.

[5] In some stochastic frontier estimations, the factors affecting TE are included in equation (5). But in the above case, this would result in considerable loss in degrees of freedom and hence was not done.

As the TE measure is bounded between 0 and 1, it has to be transformed to Ln TE - Ln (1-TE) in order to comply with standard normal assumptions of the error term in a multiple regression equation. Due to this transformation, the regression coefficients have no direct interpretation but it is possible to calculate the elasticity value from the estimated coefficient if the independent variables are logged.[6]

4. Empirical Results

The estimates of the model are provided in table 3. It can be seen that all but one of the coefficient estimates are significant at the 5% level. The insignificant parameter represents an unclear relationship between capital and labour and this is possibly due the non-availability of disaggregated data to show how certain types of capital or labour can be complements or substitutes. The second-order coefficient for capital indicates increasing returns, and for labour, it shows decreasing returns.[7] The positive coefficient on the dummy variable implies that firms in Penang have a higher potential output than those in the Klang Valley but this has little bearing on the TE of the firms in the two regions, as TE is a ratio and depends also on the observed output level of the firms.

Table 3 Estimates of the Stochastic Production Frontier Model

Variables	Frontier Estimates
β_o	1.16 (0.716)*
β_D	0.71 (0.251)*
β_L	0.565 (0.127)*
β_K	0.337 (0.087)*
β_{KK}	0.0076 (0.0018)*
β_{LL}	- 0.0212 (0.0011)*
β_{KL}	0.0183 (0.0127)

Note: Figures in parenthesis are asymptotic standard errors.
* means that the coefficient is significant at the 5% level.

Various specification likelihood ratio (LR) tests reveal the following. First, the null hypothesis of a Cobb-Douglas functional form (H_0: $\beta_{KK} = \beta_{LL} = \beta_{KL}$) is rejected with the LR statistic of 4.38 against the χ^2 (3) value of 7.81 at the 5% level. Second, the Breusch-Pagan (1979) Lagrange Multiplier test for random coefficient variation produced a χ^2 (7)

[6] Equating TE/1-TE to the antilog of the estimated coefficient value and solving for TE gives the elasticity value of the variable's effect on changes in TE.

[7] Once again, especially for labour, one can expect the marginal returns to be different for varying labour skills.

value of 25.81 which was significant at the 5% level. This implies that the test results support the functional form with varying coefficient specification for the present data set.

Tables 4 and 5 provide information on the efficiency performance in various categories of the firms. On average over the entire sample, firm's overall TE (not accounting for size and ownership) was about 84%, indicating some potential to increase output by the more efficient use of resources and technology. In particular, it can be seen that firms in Penang were more efficient than those in Klang in terms of overall as well as input-specific TE. However, small firms' TE was the lowest at 75.6%, and foreign firms were more efficient than local firms.

Table 4 Frequency Distribution of Overall Technical Efficiency (no. of firms)

Efficiency Measure (%)	Penang	Klang	SMEs	Large Firms	Foreign Firms	Local Firms
Below 70	3	7	5	1	-	4
70-79	7	11	13	15	12	6
80-89	18	5	2	26	31	3
90-95	7	4	2	10	13	2
95-99	4	3	-	6	7	2
Total	40	30	22	58	63	17

Table 5 Mean Technical Efficiency Measures (%)

	Overall Efficiency	Capital Efficiency	Labour Efficiency
Penang	88.3	80.1	76.3
Klang	79.6	82.0	64.9
SMEs	75.6	74.4	72.7
Large Firms	83.4	81.8	73.1
Foreign Firms	85.1	79.7	75.4
Local Firms	78.3	81.3	69.6
Total Sample	83.9	81.2	70.6

The input efficiency levels in table 5 also show that in general, labour is at least 10% less efficiently used than capital. In Penang however, the gap between labor and capital efficiency is narrower, and within SMEs, the gap is smallest. The latter points to the possibility of a lower level of labour skill employed in SMEs compared to large firms, but that which is adequate for the type of capital being employed in SMEs. The input-specific efficiency measures can be interpreted in the following way. In the use of capital, the efficiency measures suggest that large firms with an average efficiency of 81.9% could employ about 18% less capital in moving to their production frontier. On average, firms in the sample could be about 30% more efficient without increasing the number of workers employed to potentially increase their output.

On the other hand, although foreign firms appear to be less efficient than local firms in using capital, they are better able to combine their capital with the labour employed such that their overall efficiency is higher at 85.1% compared to local firms at 78.3%. This is in line with the observation (whose details are unreported to save space) that firms who use capital efficiently may not necessarily use labor efficiently. Even more revealing is the fact that firms who are most efficient overall (since they follow the best practice technique) may however not be the most efficient in the use of both inputs in the sample either. This highlights differences in the way the firms combine inputs in their production process. While further analysis on this is undertaken later, a full scale study to explain these variations in efficiency is beyond the scope of this paper.

Determinants of Technical Efficiency

This section provides the empirical analysis on the determinants of overall TE in the total sample as seen in table 6. The estimations were undertaken using ordinary least squares, and were corrected by White's (1980) procedure for the presence of heteroskedasticity when necessary. The Ramsey Reset test did not show any serious problems of functional misspecification. The range of $\overline{R}^2$ was between 0.67 and 0.73, which is satisfactory for a cross-sectional sample. It is not surprising that all of the regressions show that the constant is significant, as it is likely to have picked up institutional and systemic influences not specified in the model used. Regressors that are dummy variables or are measured by proportions, are not logged in the regression. Also, when variables are highly correlated with each other, their influence is not always estimated in the same regression.

The K/L ratio is a measure of the firm's capital intensity and to some extent, this reflects technology-intensity.[8] This variable is not found to be significant and there are two plausible reasons. A high ratio indicting high capital intensity is likely if the firm acquires the best technology (which may be high in cost) but it is not necessarily true that firms are able to use the technology and resources efficiently. The speed of transformation in firms with newly adopted capital-intensive technology may have brought sufficiently

[8] This is seen when measures of K/L ratios for the electronics industry is compared with the OECD product classification for the technology profile for Malaysia in UNIDO (1985).

Table 6 Empirical Estimates of Factors Influencing Technical Efficiency in Total Sample

	Ln TE (1)	Ln TE (2)	Ln TE (3)	Ln TE (4)	Ln TE (5)	Ln TE (6)
Constant	1.65*	1.87*	- 0.83*	-1.01*	0.97*	1.46*
Ln K/L	0.78	0.60	0.57	0.46	0.51	0.63
ICT	2.12**	1.87**	2.94	2.04**	1.76**	1.96**
Ln AGE	0.01		0.16*			
Ln SIZE	0.21**	0.14		0.21**	0.29*	0.19**
FOREIGN	0.44	0.39			0.49	0.32
Ln EXPORT	0.11**	0.19*	0.21*	0.18*	0.18*	0.17*
HSKILL	1.01**	1.21*	1.28*	1.02**		1.08**
TRAINING	1.41	1.75*	1.67**	1.36	1.28	
R&D	1.08**		1.45*	1.01**	1.00**	
HTECH	0.91	0.89	1.35*	1.41*		0.88
HSKILL*R&D	0.11		0.15	0.13		
HSKILL*TRAINING	-0.06*	-0.01*	0.12	-0.04*	-0.03*	-0.03*
$\overline{R}^2$	0.68	0.71	0.67	0.73	0.72	0.67

Note: TE has been appropriately transformed.
* and ** represent significance at 5% level and 10% level respectively.

high profits to weaken the incentive for firms to use the new technology efficiently. Also, in order to qualify for various incentives from the government, many firms could have accumulated capital which they did not have sufficient knowledge to use efficiently.

The ICT variable which is a key input in electronics production has a positive significant impact on TE as it allows increased output via better use of resources. However, the influence is not strong (as it is significant at the 10% level) and this could be due to the exclusion of investment in software and applications as well as telecommunications in the capital stock as firms did not have the breakdown on this type of data. The importance of ICT is highlighted by Lee and Khatri (2003) who show that the real rate of return on ICT capital stock is said to be three times higher than the non-ICT capital stock.

In column (1), the AGE variable is positive but insignificant. While being in business longer brings production experience and allows for learning-by-doing, in the electronics industry, the latecomer advantages related to TE still seem to exist to a significant extent. However, when SIZE and FOREIGN variables are excluded in column (3), AGE appears statistically significant. This accommodates the idea that with age, it is likely that firms expand (and enjoy economies of scale), and proportionally more foreign firms have long established themselves in Malaysia to experience higher TE. In column (2), SIZE and FOREIGN variables are seen not to have an effect on TE and it is likely that these effects are subsumed by variables such as AGE and TRAINING. But when SIZE is included in the regression without AGE and FOREIGN in column (4), it can be seen that the high levels of output lead to increased TE possibly because of the opportunities provided by large production for learning-by-doing gains.

The FOREIGN variable does not appear significant even when other correlated variables such as EXPORT, AGE, and SIZE are not included.[9] But Ariffin and Figueiredo (2004) show that MNCs in Malaysia's electronics sector have superior technological capability relative to local firms in the area of process development. This is in line with Dunning's (1988) explanation that foreign owned firms' advantage stems from specific knowledge of the use of resources due to R&D experience, exposure to international competition, and the availability of resources to invest in high technology capital. But the lack of skilled workers in Malaysia may not have allowed foreign firms to exploit the full benefits of the use of their imported technology in raising output to its maximum possible level.

The EXPORT variable on the other hand is positive and significant, indicating that exposure to international competition makes it necessary for firms to improve the way in which resources and technology are used. When export incidence (export as a proportion of sales) was used as an alternative variable, it turned out to be insignificant, reflecting the fact that most firms, even the SMEs (at least those in the sample) were export-oriented, and thus the level of exports was the more discriminating factor.

With human capital, the coefficient on HSKILL shows that a higher proportion of engineers are able to use resources and technology more efficiently, as they are involved

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[9] Perhaps the use of a dummy does not capture the relationship well, and foreign equity share of capital for which data could not be obtained, might have been a more effective alternative.

in equipment maintenance and upgrading, as well as in making minor adaptations to process technologies. Larger firms have the resources to hire skilled workers as seen by the fall in significance levels in HSKILL when both SIZE and HSKILL variables are included in the regressions. On average, large firms' ratio of training to sales is almost twice as large as small firms, and 80% of the foreign firms compared to only 50% of the local firms trained their employees. However, the effect of TRAINING is ambiguous as results are inconsistent in the regression estimates. This points to the possible ineffectiveness of local training programs in terms of delivery, or they may not be directly relevant to the workers. These possibilities are further discussed in the next section.

To consider the joint effect of highly educated workers who are also trained, the interaction term HSKILL*TRAINING is used. The negative and significant coefficient of this variable indicates that firms with a highly educated workforce are not necessarily committed to training. This could also imply that large firms may not be spending enough on training for any significant impact.

The effect of R&D in general is only significant at the 10% level and this is partly due to the long lead and lag effects of R&D. Another factor could be the type of R&D, be it process or product development that is being undertaken.[10] While the survey reports that 48% of the firms have done either one of them or both, process development is still the more dominant form of R&D. But in some instances process development could also lead to product development[11] or vice versa.

The effects of an interaction term with training and R&D (not shown here) did not show any conclusive results either.[12] One reason could be that the type of training (be it from abroad, or the local regional skills development centre, or in-house training) relevant for R&D could not be delineated from the survey to better understand the relationship between training and R&D. Another interaction term of R&D with HSKILL is insignificant although one would expect that a firm having a high proportion of engineers is more inclined to invest in R&D and thereby improve TE. As R&D is a risky venture which takes time to pay off, the interaction effects may be significant with the use of panel data.

The HITECH variable on the other hand has no impact on TE as seen in columns (1), (2) and (5) because this dummy variable is highly correlated with FOREIGN as all foreign firms indicated that they were high tech firms as well. Interestingly, Noor et al. (2002) show that having high technology is not good enough as firms also need experience in using current technology before being in a situation to benefit from technological effort. However, in columns (3) and (4), HITECH has a positive significant impact on TE.

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[10] Developing technologically new or significantly improved products is product development and significant improvements in the way the manufacturing and related processes are used constitute process development.

[11] For example, new designs of products require new production puzzles to be solved.

[12] Causality effects that could run from TE to TRAINING and R&D are minimised as the latter two variables are averaged over the last few years.

5. Integrated Policy Framework

Here, the quantitative results obtained above are analysed together with other types of questions asked in the survey to provide a qualitative perspective in order to better understand policy making for sustained growth. As the electronics sector is export-oriented, it must keep improving its competitiveness via a reduction in costs of production. While the above evidence supports the well-known fact that human capital and technology development policies are crucial for this purpose, the survey also brings to light the importance of an integrated policy framework. This framework shows the need not only to coordinate the two polices and ensure that they work hand in hand, but also the need for policy coherence in a broader setting, as illustrated in figure 1.

For human capital and technology development policies to have a significant effect, there must be an appropriate environment that creates the right form of synergy from various sources such as FDI, the national innovation system, network cohesion, and technology transfer. This calls for government intervention of a special kind. The following sections develop the arguments for policy coherence and the nature of the government role based on the above framework.

5.1 Human Capital Development

While the empirical results indicate that highly skilled workers significantly improve TE, one strong response from the survey was the lack of skilled workers with particular skills noted by 74% of the firms. This problem which is not new has been raised by the World Bank (1989, 1995) but it has possibly worsened since the late 1990s which marked the move of Malaysian manufacturing from labour-intensive to capital-intensive operations. At the macro level, the increase in education expenditure as a percentage of GDP has been very slow in Malaysia. This ratio for 1980-99 averaged only 5.4% compared with an average of 5.3% in the 1970s. At 6.6%, the figure for 2000-04 shows some improvement but much remains to be done. Neither is the rise in the proportion of the labour force with tertiary education from 2.5% in 1975 to 20% in 2005 enough. The Malaysian Science and Technology Centre (MASTIC) reports that the 2010 target of 35% with tertiary level of education is still below the levels already achieved in 2003 by developed countries such as Japan (36%), the United States (41%), Ireland (43%) and Finland (36%) (MASTIC, 2004).

For appropriate technology development, human capital development also needs to ensure that there is a cohort of science and technical graduates available (unless more are to be imported from overseas). This is not the case in Malaysia. Table 7 shows this group accounted for only 52% of the total number of local graduates during the period 2001-2005, of which 21% are from technical courses. In the field of engineering alone, Malaysia would need 210 000 engineers to support the country's development by 2020 but there were only about 52 000 engineers at the end of 2003.[13]

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[13]Opening Speech at the2004 Conference on Engineering Education as reported in *The Sun* 15 Dec 2004.

Figure 1

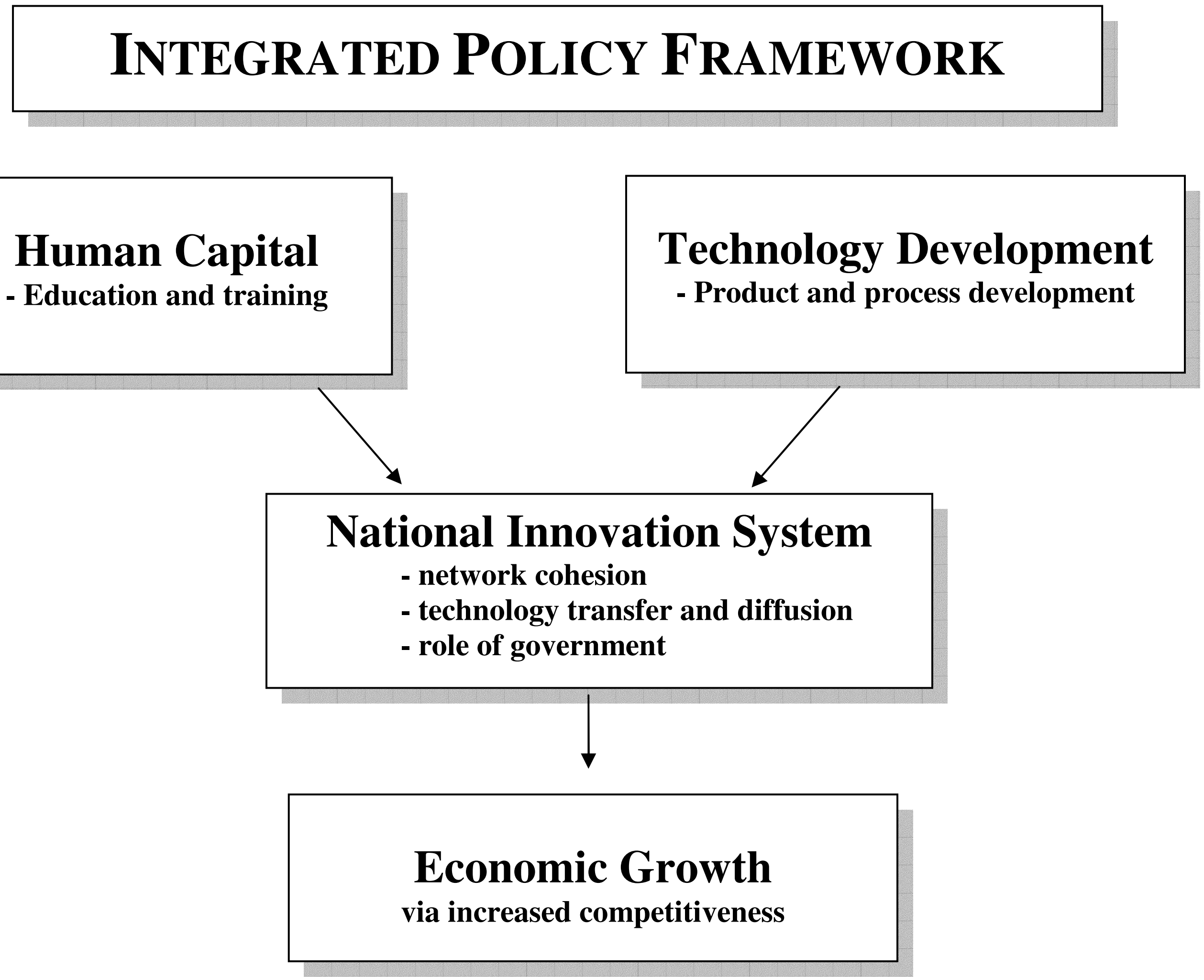
INTEGRATED POLICY FRAMEWORK
Human Capital
- Education and training
Technology Development
- Product and process development
National Innovation System
- network cohesion
- technology transfer and diffusion
- role of government
Economic Growth
via increased competitiveness

Table 7 Output of Degree Courses

	1991-1995	1996-2000	2001-2005
Arts, Humanities, Social Science	49 018 (62%)	87 882 (58%)	161 102 (48%)
Sciences such as Medicine, Agricultural Science and Pure Science	19 642 (25%)	38 273 (26%)	100 967 (31%)
Technical, Engineering, Architecture	10 508 (13%)	24 343 (16%)	70 650 (21%)

Source: Five-Year Malaysia Plans, EPU.

It is unclear how the situation can be improved given the general perception that science subjects are tough. The MASTIC (2005) reports that 42.3% of its survey respondents thought so. Perhaps even more disturbing is the finding that 45.5% of the people interviewed felt that the quality of science and mathematics education in schools was not satisfactory. In April 2006, the government announced plans for a major revamp of the education system, which has been criticized for the huge stress on obtaining good grades at the expense of being well-rounded. The rudimentary and text-book oriented approach is said not to be conducive for students to be creative and experimental, both of which are necessary for technological innovations.

However, small steps have been taken towards improving the educational system. The teaching of mathematics and science in English began in 2003 and students entering university are now required to take the Malaysian University English Test although passing it is not compulsory. This is because the English language was deemed important for tuning into technological advancements, and obtaining access to information on the Web. In fact, concern of the lack of English language proficiency among workers ranks as the second most important skill deficiency in our survey.

The general lack of skilled workers has forced some firms to employ workers who are less than qualified for the job. This mismatch does not augur well for improvements in firm performance. While training is one option that firms have used to reduce the problem, 56% of firms, most of whom are SMEs, point to the high cost of external training and the risk of losing workers to rival firms after training. The Human Resources Development Fund (HRDF) which was established in 1993 with a matching grant from the government is of some help although it not a subsidy scheme for training workers to develop necessary skills. While the HRDF was considered critical by firms in their decision to train, 62% of the firms report that the HRDF is slow (taking as long as five weeks) to reimburse claims sent in by firms. Neither were the firms persuaded to use the fund although the utilization of the fund has been extended from two to five years. In addition, 25% of firms were not sure where and how to go about getting access to these funds, and the SMEs in particular, were not aware of various special schemes set aside for training workers by the Small and Medium Scale Development Corporation.

Another concern of the firms was the type of training provided by the industrial training institutes. About 50% of them felt that the courses could have been better tailored to their needs, and that the absence of feedback or evaluation forms provided after the course to make suggestions for further improvement. They saw this as showing little commitment on the part of the training institutes to make their courses more relevant. This was, however, not the opinion of firms who used the Penang Skills Development Centre which was established in 1989. They indicated that in general, they were satisfied with the training provided.[14] This corroborates with the finding (not shown here) that TRAINING has a positive and significant impact on TE when it is regressed against the sample of firms located in Penang. This centre currently has an affiliation with 16 well-known partner universities in Malaysia and overseas, and is managed by the industry unlike the government-run Selangor Human Resources Development Centre near the Klang Valley.

The effectiveness of location-specific training also emerges in a separate regression (not reported here), when it is found to significantly affect labour efficiency. However, it is unclear if this effect is picking up the possibility of the inherently better skilled workforce in Penang even before training, but the summary statistics show that the average proportion of engineers in a firm's workforce (measured by the HSKILL) is not very different in both states. However, this effect could be masking the fact that more engineers in Penang are overseas- rather than locally-trained. Although this particular information was not sought in the survey, 73% of the managers interviewed found that, in general, the locally-trained engineers were less adoptive when it came to learning new aspects of the trade. While this sentiment is not new,[15] it is disturbing that it still persists. To address this concern, all local undergraduates are now required to do a minimum of four months internship and industrial attachment (*Ninth Malaysian Plan 2006-2010*). In addition, the Graduate Training Scheme launched in Aug 2005 aims to equip local graduates who have been unemployed since 2003 with specialised skills. In 2005, 7 992 graduates were trained. The Graduate Reskilling Scheme, on the other hand, is targeted at engineering and selected technical graduates with no previous employment history. By the end of 2005, 2 370 graduates had participated in various courses. Another program, the Graduate Apprenticeship Program,[16] which was initiated in 2005, saw a total of 9 225 graduates benefit by mid Sept 2005. The government could also seek out research institutes abroad that are willing to develop innovative courses customized to the specific

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[14] The divided opinion amongst the firms could have affected the expenditure for training, thereby producing ambiguous empirical results of the TRAINING variable on TE.

[15] The Malaysian Employers' Federation criticized local fresh graduates for not meeting employers' needs (see *The New Straits Times* 28 Jan 2002). A survey undertaken by the Knowledge Worker Exchange Sendiran Berhad, a Multimedia Development Corporation subsidiary, revealed that graduates from local institutes of higher learning lack depth in their IT skills and English language proficiency, and that mismatch of skills still continues (see *The New Straits Times* 15 Feb 2004).

[16] Graduates are attached to companies for work experience and training, and at the end of their stint, the companies can choose to employ them.

needs and capabilities of Malaysia's electronics clusters. This may include the Industrial Technology Research Institute or the Electronics and Telecommunications Research Institute in Taiwan, the Korea Advanced Institute of Science and Technology or the Indian Institute of Information Technology.

Lastly, it is important to note the emerging requirement in the breadth of workers' skills. For instance, interest is now in personnel equipped with managerial and entrepreneurial expertise although they possess technical skills, as indicated by 50% of the large firms surveyed. They explained that this is partly due to extension in their activities towards distribution, sales and marketing. Thus industrial training institutes have to provide a good combination of technical and managerial courses. There are two positive steps in this direction. One is the introduction of techno-entrepreneurship courses to all science, technology and engineering undergraduates. The other is the three-fold increase in the government's development allocation for management training from the period of 2001-2005 to about RM 510 million for the next five years.

5.2 Technology Development

Technology development has undoubtedly been important in Malaysia's successful move from a resource-based economy to a knowledge-based economy, spearheaded by the electronics industry in particular. This was done primarily by attracting FDI into this industry. In the 1970s, the MNCs brought with them technology that could be used with the abundant unskilled labour that was then available and established a significant presence in Malaysia. While the World Bank (1997) shows that there have been substantial spillover effects from FDI to the local firms, Narayanan and Wah (2000) provide evidence that technology transfer from MNCs has been limited in the areas related to operations, maintenance, production management and quality control, all of which are aspects of process technology. The authors argue that MNCs have yet to share in the area of R&D expertise such as product or equipment development, and design or moulding. Similar evidence is provided by Ariffin and Figueiredo (2004).

According to Hobday (1995), technological expertise can be imparted indirectly when strong subcontracting or other links are established between firms in the electrical and electronics and supporting sectors as shown by the experiences in other East Asian economies. The stringent quality, delivery, and reliability standards required by their clients pressure supporting firms to improve their own management, production and technological capabilities. Noor et al. (2002) support this by showing that sales to foreign MNEs in the electronics sector are positively related to the propensity of firms to instigate quality assurance/quality control procedures to adopt new technology.

In our survey, 51% of the firms claimed that they transferred some form of technical expertise to supporting firms to better meet their needs but the extent and nature of these transfers were unclear. An attempt was then made to see if firms who claimed that they have benefited from links with the MNCs did indeed register higher TE. A dummy variable was used to represent this group in a regression against overall TE and input-specific TE. It was found that the overall TE and capital efficiency did improve while there was no significant impact on labour efficiency. It can thus be inferred that such links are potentially useful to local firms.

On the other hand, our survey showed that less than 35% of the firms sourced more than half of their input needs locally. Reasons given include the fact that the required inputs are simply not available locally,[17] or the quality of local inputs is less than satisfactory and the local suppliers are unable to meet delivery deadlines, while foreign firms typically relied on their own suppliers at home or those who have relocated to Malaysia. While some firms indicated that initial contact with the MNCs to convince them to use their services for outsourcing was not always easy or smooth, others, who are suppliers to Intel, Xircom, Motorola, and National Semiconductor in Penang, did not find this. The reason is that some of the personnel from these companies helped set up the suppliers' firms. In addition, the Global Supplier Program (to develop and upgrade capability of local companies through training and smart partnerships with MNCs and this involves training in critical skills and linkage with MNCs) launched in 2000 in Penang has seen some great success in setting up local firms as suppliers. One observation from the survey of these supplier firms was that the upgrade in technology they had undertaken was likely to have helped increase capital efficiency, as shown by the empirical evidence.

Technological activity is, however, also linked to the technological competency of local firms (Cohen and Levin 1989) and this is where Malaysia's deficiency is self-evident for a number of reasons. First, the importance of R&D for industrial technological development was only officially recognised by the government in 1990 by the *National Plan for Action*. Initial priority was given to the building of Malaysia's strength in the primary sector which led to the establishment of research institutions focusing on agriculture (mainly rubber, oil palm and rice) cultivation technology and productivity. Second, local manufacturing was initially protected for a domestic market and lacked the competitive pressures to undertake R&D. Third, as a result of export expansion, R&D activities were dominated almost entirely by foreigners, particularly in key sectors like the electronic and electrical products.

The table below shows some indicators on Malaysia's R&D efforts. Although R&D expenditure has doubled in some years, the R&D to GDP ratio is still very low compared to other countries. Also, the targets set for the R&D expenditure to GDP ratio of 1.5% by 1995 and 2% by 2000, have never been met. In 2002, there was a reversal of the target to 1.5% to be met by 2010.

The advanced economies of the US, Japan, and some European countries lead the world in the proportion of GDP spent on R&D, with the OECD average of 2.23% in 2003. The 2002 figures show that the ratios of the Asian first-tier NIES of Korea, Taiwan and Singapore are higher than Malaysia by three to four times while the Chinese and Indian ratios are 0.78% and 1.09% respectively. While table 8 shows that the number of researchers, (full-time and otherwise) per 1000 labour force, has improved. Malaysia still

[17] It should be noted that purchases from local firms do not necessarily imply the use of domestically-made materials since local firms can act as intermediaries to supply imported materials as well.

pales in comparison with the other countries (see figure 2) where she is ranked among the lowest and is surpassed by the emerging economies of South Africa, China, the Czech Republic and Argentina. In an effort to enhance national capacity in R&D and to achieve a competent workforce, a target of 50 researchers per 10 000 labour force has been set to be reached by 2010.

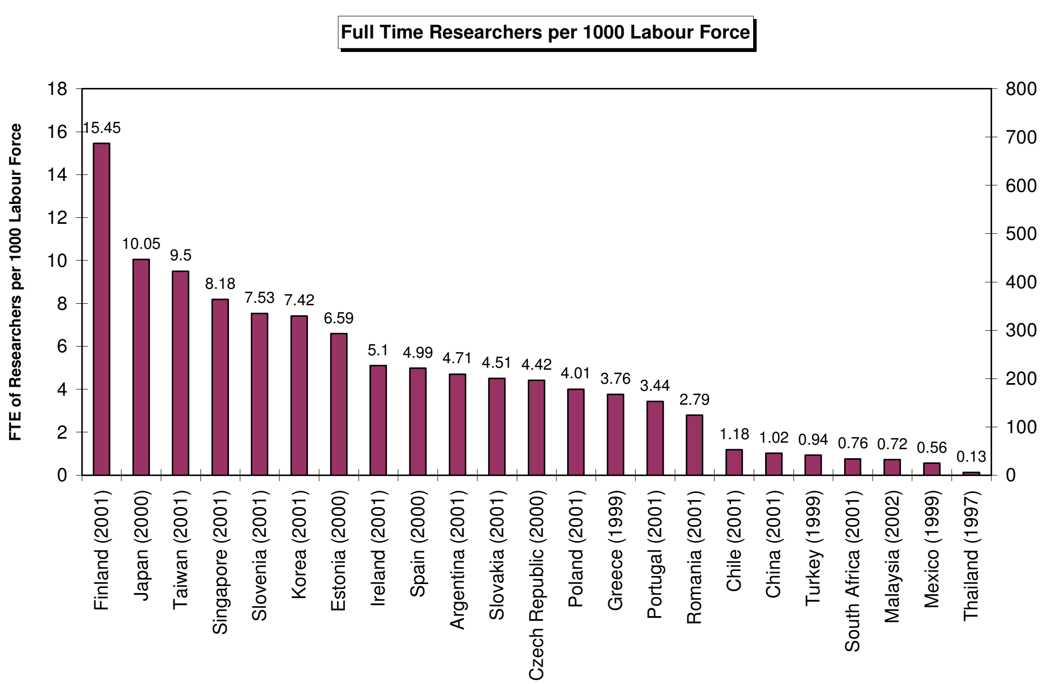
Table 8 National R&D Indicators

	1992	1994	1996	1998	2000	2002	2005[1]
Amount spent on R&D (RM million)	550.7	611.2	549.1	1127	1671.5	2500.6	4300
R&D expenditure /GDP	0.37	0.34	0.22	0.39	0.49	0.69	0.9
Researchers per 10 000 labour force	2.1	5.8	5.1	7	15.6	18	25
Full time researchers per 10 000 labour force	2.1	2.9	2.2	3.8	6.7	7.2	n.a.

Note: [1] is an estimate.

Source: MASTIC (2004) and EPU (2006).

Figure 2



Source: MASTIC (2004)

In our survey, the lack of research personnel was ranked as the highest deterrent to undertaking R&D by the firms interviewed. The quality of researchers was also a concern. The MASTIC (2005a) reports that the majority of researchers in the private sector had a bachelor degree (68.5%) followed by a masters degree (10.1%) and a PhD degree (2.4%). In fact, 60% of the foreign firms admitted that they generally accessed R&D support from abroad given the unsophisticated R&D infrastructure (in terms of space and equipment) in Malaysia. Furthermore, the wide range of R&D incentives offered by the government was not sufficient to encourage firms to move into extensive or frontier type R&D work as 65% of the large firms explained that they were willing to fund such operations if they expect worthwhile rates of return from doing so in Malaysia.

This in part explains the high public sector to private sector R&D expenditure, especially during 1990-95 where the former averaged 53%. Although this ratio has since decreased to about 34%, this is masked by the fact that many government enterprises that have been privatized continued to enjoy R&D privileges of some sort. Also, 93.4% of the R&D outsourcing activities involved the private sector of which 75.3% was sourced overseas (MASTIC 2005a). The MASTIC (2004) report also shows an increasingly greater proportion of companies that are Malaysian rather than foreign owned and controlled are undertaking R&D, unlike the early 1990s where it was mainly undertaken by the MNCs. This to some extent can be attributed to most government R&D schemes being offered to locally controlled and owned companies with at least 50% or 30% local equity holding depending on the type of grant.[18]

5.3 A Long Term Strategy

In addition to some of the above mentioned policies for improving human capital and technology development, the Malaysian government has also devised other strategies, most of which are short to medium term in nature, to cope with the situation. One policy has been to encourage skilled Malaysians to return home but this has not solved the brain drain problem. While there are no official data on out-migration available,[19] Pillai (1995) estimated that at least 40 000 Malaysians or on average 5 000 per year migrated to Australia, New Zealand, Canada and the US between 1983 and 1990. The first attempt at the brain gain program to lure highly skilled personnel, both foreign and Malaysian, started in 1995. This program attracted 94 (24 Malaysians and 70 foreigners) scientists but they all returned to their home/host countries by 2004. In 2001, another program known as the Returnees Program aimed at attracting only highly skilled Malaysians has also met with limited success. While there is an estimated 30 000 Malaysians working abroad, only 665 had applied from 2001 to Aug 2004. Of this, 279 applications were approved but only 165 had taken up the offer and returned (MASTIC 2005a). There is thus a need to re-examine the efficiency of Malaysia's 'brain gain' initiatives and to

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[18] This is in contrast to Singapore's strategy where for every S$1 invested in R&D by a MNC between 1991 and 1999, the Singapore government invested 30 cents (Amsden et al. 2001). Today, the Singapore model speaks of success in providing generous support in the form of laboratories and the protection of intellectual property and financial incentives.

[19] Mainly because Malaysia does not have a formal policy nor does it impose controls on nationals working abroad.

develop a compelling value proposition to attract, develop, and retain talented Malaysians both within and outside the country. Malaysia should learn from the Korean government's successful offer of a very attractive incentive package for Korean-American scientists and engineers to return home through the 1970s.

Another policy to address the brain drain problem includes the import of foreign workers (both skilled and unskilled) This saw an increase is the number of legal foreign workers from 136 000 in the early 1990s to 1.8 million in 2005. In 2000, there were 70 245 expatriates (skilled workers) comprising 9.4% of foreign workers and in 2004, this number rose to 74 343 workers who only comprise 3% of foreign workers, indicating the existence of a high proportion of unskilled workers. The import and easy availability of unskilled workers has been reported to discourage the move to higher value added manufacturing activities. But this strategy of relying on foreign labour and enticing Malaysians to return home may not be plausible in the long run. Here, an integrated policy framework is proposed as a long term strategy in figure 2.

We first start with human capital development. While the need to revamp the education system has been recently voiced, there has been little discussion on how this is to be done. Heckman (1999) outlines a strong argument for early intervention based on skill begets skill, and argues for an investment strategy that lays strong foundation for the formation of cognitive and non-cognitive skills in early childhood. He stresses that non-cognitive skills and motivation are important determinants of success and this is related to the need to cultivate and develop entrepreneurship qualities. This is easier than trying to address the dearth of entrepreneurs at a later stage with incentives and training as it is more difficult to remedy entrenched values and attitudes. Also, English has to be progressively brought back as a medium of instruction in all subjects.[20] Communication skills in a global language are vital for progress in this increasingly integrated and globalised environment.

The concept of working or building up ideas and thought processes from base level information or primary level data is now quite obsolete given that a lot of the information can be obtained from the Internet. That is not to say that modern technology has not enhanced learning but rather different means of teaching and testing must be devised in accordance to the new mode so as to encourage critical thinking in students. This is required to instill an inquisitive and inquiring mind that is not seeking straight answers and in the event, will not hesitate to overcome challenges in the ever changing business environment or when undertaking R&D in a laboratory.

There is, however, a need to ensure there are sufficient qualified teachers for these purposes. According to the *Ninth Malaysian Plan 2006-2010*, all secondary school teachers and 25% of primary school teachers would have a first degree by 2010. At the tertiary level, the bottleneck constraint in engineering skill formation also needs to be

[20] Sometime in the 1970s, Bahasa Melayu replaced English as the medium of instruction in schools. This was a political decision to help address the poverty and income inequality problem in the Malay community that resulted in the 1969 racial riots.

overcome with qualified teachers. To increase the flow of 3000 engineers per year, requires 12 000 in a 4-year program and with a student teacher ratio of 15:1 requires a good 800 teachers with appropriate engineering and science qualifications at the postgraduate level. Thus there is much to be done and this is succinctly voiced by the Prime Minister, Abdullah Badawi, in his speech at the National Economic Action Council Meeting in Jan 2004, '… we need nothing less than an "education revolution" to ensure that our aspirations instill a new performance culture of the public and private sectors ….. to nurture a new kind of human capital that is equal to the tasks and challenges ahead.'

In addition, to produce local graduates who are equipped with the required skills, there has to be close collaboration between the universities, the government and other institutions to organize, conduct or restructure courses that are considered relevant, essential, and practice-oriented to cater to the needs of the industry. Currently, much is left to market forces but an active government role in the initial setup is vital to get it going. While some industrial training institutes are successful (the Penang Skills Development Centre in particular), in general there is insufficient coordination, assessment and monitoring tools in place of various programs offered in the 30 or so institutes.[21] While there needs to be an overall body to oversee these operations within a framework of national policy, priorities and targets, the success in Penang points to the need for autonomy at the regional level where there is decentralized decision making on training strategies. This is because different regions may require different types of training and greater innovation is likely to follow when local initiatives can be effectively harnessed (Cortright 2006). For instance, unlike Penang, the Klang Valley is observed to have had little success in building a value-adding supplier chain and thus requires a different type of training from that in Penang. On the other hand, Joho, the least electronics based region, is integral to a Singapore/Johor cluster (often as a base for firms relocating from Singapore) and hence has different needs from Klang and Penang. The development of cluster dynamics is thus internal to the region and it is likely that the Vendor Development Program initiated in 1995 to match SMEs to MNCs at the national level will be more effective with a region-specific focus. There is also a need for this program to shift from the provision of a market for SMEs to upgrading technology.

Another important feature of cluster dynamics in the electronics industry is the environment that nurtures technopreneurs and the best Asian model for that is Taiwan (Mathews 1997, Ernst 2000) where, as in California's Silicon Valley, a large agglomeration of high-tech firms makes it a highly vibrant technology region. This not only requires skilled manpower but also an appropriate level of network cohesion. The latter can take on a two-pronged approach i.e. the strong coordination between firms and that between firms and other institutions to stimulate network synergies. Our survey shows that at least 20% more firms in Penang than the Klang Valley teamed up with

[21] To date, about 5 advanced training centres in collaboration with the foreign governments of Germany, France, Britain, Spain and Japan have also been set up. However, it is not clear what mechanisms are in place to monitor the design and delivery of the training courses to evaluate their relevance to the needs of the industry.

other firms although there are many informal firm-to-firm exchanges which are mainly undertaken by large firms. Such knowledge sharing is important to build their communications network but the SMEs in general were quite reliant on industry associations and the government only to a small extent.

Interestingly, the Klang Valley is locationally positioned to benefit from the central government services and it enjoys an extraordinary infrastructure such as that offered by the Multimedia Super Corridor (MSC). [22] There exist mixed views on the success of this grandiose cluster which is meant to house and promote high-tech industries (Wahab 2003, Jussawalla and Taylor 2003). On the other hand, the Bayan Lepas Free Industrial Zone of Penang became a successful industrial cluster that attracted a large number of electrical and electronics companies. Klang valley was not set up as an industrial zone initially and thus may have lost out on first-mover locational advantages.

The second approach to network cohesion refers to the collaboration between firms and universities, government agencies and/or research institutions. Such linkages were only found in about 4.2% of the firms surveyed. For this type of cooperation to work, end-user needs must be clearly understood and correctly identified, and best-practice research management principles must be in place (Thiruchelvam 1999). While some success has been achieved in this regard with the Standards and Industrial Research Institute of Malaysia, the Malaysian Institute of Microelectronics System, and the Malaysia Industry-Government Group on High Technology, these institutions act more as catalysts than get involved to a large extent in collaborative work unless they are approached by the firms themselves. The government also has in place nine technology incubator centres, some of had successful outcomes. [23] Under this arrangement, the university provides office space, use of equipment, consultancy services and training to the tenant companies. In return, the company outsources its R&D through contract and collaborative arrangements, obtains expert advice on technology, marketing and finance. During 2001-2005, a total of 400 companies have benefited from these services (EPU 2006).

The survey interviews indicated that firms did not see the potential benefits of linking up with the institutions as they felt bureaucracy, loss of flexibility in decisions,[24] and the academic-orientation of the institutions were impediments to successful outcomes. Thus the government needs to improve its efforts towards dispelling these notions and provide the right environment to encourage synergies between the parties involved. The various government grants set aside for these purposes as well as for R&D activities in general

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[22]The MSC (which sits on a 15 km by 40 km real estate) launched in 1996 was Malaysia's first initiative to lay the foundation for the knowledge-based economy in the hope of becoming Asia's Silicon Valley. Interestingly, Cortright (2006) explains that it is difficult or nearly impossible for public policy to intentionally create an industry cluster where they do not already exist although the Research Triangle Park in North Carolina is an exception.

[23] These are documented for Universiti Putra Malaysia, Universiti Kebangsaan Malaysia, Universiti Sains Malaysia and Universiti Teknologi Malaysia in EPU (2005a).

[24] In fact, Thiruchelvam (1999) notes that these institutions and the universities are constrained by existing civil service regulations from adopting more responsible and flexible management practices.

have, however, found limited success (see Tham and Ragayah 2006 for details).[25] While one of the aims of the government's R&D schemes is to develop indigenous capability, this is done at the expense of excluding foreign-dominated companies with various shareholder restrictions. It is unclear if this is too high a price to pay as there is a lesson to be learnt from Singapore which has now succeeded in getting MNCs to establish R&D activities locally. For the latter to work, a reliable process of safeguarding proprietary rights and processes must be in place.

Although firms play an important role in providing an environment for fostering the R&D culture because they participate in the adoption, assimilation, adaptation, innovation, and technology diffusion, they are only part of a larger network of organisations that contribute to the strengthening of a nation's technological capabilities. This network within a nation has been labeled as a National Innovation System (Kaldor 1979, Porter 1990). For this system to be effective, the three political actors (the state, the local business and the MNCs) have to cooperate and do their part. As discussed above, there is room for improved cluster governance. In particular, the co-location of firms and institutions is only a necessary condition and strong co-ordination between them is vital for stimulating network synergies. The government has to portray the correct image to firms when trying to build links between firms, universities, and public research institutes. A change in the mindset towards a more consultative approach to dealing with business is required. The exchange of information between all three actors is not happening freely or as frequently, and thus a move to a more holistic approach to policy making, whereby policies are implemented in such a way that they work coherently, is impeded.

6. Conclusion

Firm-level evidence from Malaysia shows that capital deepening must be accompanied by sufficient labor and skill deepening in conjunction with an effective technology development program to allow a more effective adaptation and application of new technology. The dynamics underlying the interaction between the identified factors determine the success of human capital and technology development policies in sustaining growth. While human capital and technology development policies are necessary, they are not sufficient conditions for growth. These polices must be well coordinated and integrated into a broader setting with other support policies, all of which need to operate within an effective national innovation system to increase competitiveness and growth.

The random coefficient production frontier model adopted here provided an indication of overall efficiency and input-specific efficiency of the sample firms. The results revealed that methods of application of different inputs varied widely in the electronics firms, and

[25] While it is noteworthy that a Monitoring Unit was established in 2002 to foster accountability and assess the effectiveness of the management of these various grants, it may be too early to make a proper evaluation.

highlighted the importance of network cohesion. This type of analysis is important for periodic review and bench marking of the performance of electronics firms in many categories such as different regions, large and small firms, foreign and local domination etc.

The industrial upgrade of firms, at least in Penang, reflects the successful establishment in the horizontal form of cluster dynamics. However, substantial progress has yet to be made on the vertical front which entails movements into R&D of the basic type. While applied research can solve the current and immediate future needs of industry today by focusing on particular application or use, only basic research capabilities which increase the general knowledge base can provide more radical or breakthrough solutions. It is arguably best to move forward in incremental steps to build on, extend and combine existing strengths and at the same time increase efforts on a massive scale to upgrade existing skills and capabilities.

At the same time, Malaysia cannot afford to continue crawling up the technology ladder (because other nations are running up from behind with lower labour costs). For instance, a targeted approach towards FDI can help in this regard. At this stage of Malaysia's development, the government needs to ensure that MNCs have in place a plan for specific technology transfer or development that would benefit Malaysia, given the short product cycle in electronics. This means that close monitoring and appropriate support should be priorities of the government.

Second, there needs to be continuous calibration and training with industries to design programs oriented towards the needs of the firms in a specific cluster in terms of business finance, business assistance, and technology transfer. This is best left to regional level industry associations. However, overall coordination and constant monitoring and evaluation of programs is to be done by the government to prevent local actors from pursing pursue their own (parochical) agenda. Thus a delicate balance between central decision-making power and decentralization needs to be achieved.

Contrary to the assertions of advocates of less government intervention, in rapidly developing economies, the role of the government is not to be diminished but changed significantly. It must be one that creates the right environment to encourage the type of success that can only be obtained if market forces are allowed to operate. The watchdog role of the government comprises facilitation, monitoring, and evaluation using clear performance tools and targets, all of which are to be determined in consultation with the private sector. The complex mix of the interaction between the government, the MNCs and the local business to achieve the right balance will have a significant role in influencing affecting the competitive position of the electronics industry.

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