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Value-Added Performance in Malaysian Manufacturing: To What Extent Research and Development and Human Capital Matter?

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Abstract: *This paper examines the relationship between research and development (R&D), human capital and performance of the manufacturing sector in Malaysia, spanning the period 2000-2010. It takes into account ownership structure to highlight differences in the roles of R&D and human capital in boosting performance. The results show the significant role of R&D and skilled labour in increasing value-added across sub-sectors of manufacturing, for both local and foreign firms. Unskilled labour contributes significantly to local firms compared with foreign ones. However, the magnitude of the impact of R&D on performance is found to be much smaller; with significant impacts for both local and foreign firms. This suggests that the extent of R&D has not been fully realised in the manufacturing sector, even with the higher averages in R&D expenditure by foreign firms. Therefore, the types of R&D for performance are important for policymakers to address, in that, the focus should move beyond the narrow view of R&D (namely the size of R&D expenditure).*

Keywords: research and development; skilled labour; human capital, value-added; manufacturing; Malaysia

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1. Introduction

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Research and development (R&D) and human capital development have long been recognised as the main drivers of economic performance. These indicators have once again regained attention as many developing countries struggle to sustain their growth rates. Ang and Madsen (2011) confirm that R&D play an important role in determining the growth of six Asian miracle economies and given this, many other developing countries have begun to pursue innovation and knowledge to drive growth. Malaysia is no exception. Indeed, the role and contribution of R&D and human capital to economic performance at the national and sectoral levels is a key concern of Malaysian policymakers to move the economy out of the middle-income trap (NEAC, 2009; EPU, 2015; World Bank, 2013).

Based on the 11th Malaysia Plan (2016-2020), the country embarks on a more challenging journey, targeting complex and diversified products that can contribute to high value-added performance (EPU, 2015; Chandran & Devadason, 2016). Nevertheless, this 5-year plan has limited information of how R&D and skills can contribute to value creation despite the fact they have been recognised as critical for economic competitiveness. The key question is: how and to what extent do R&D and human capital affect economic performance, given that both are important drivers of value creation? The role of unskilled labour also requires attention, as quality, diversification and sophistication of manufacturing is still low in developing countries, including Malaysia.

At the country level, innovation activities are often considered in the context of both R&D and human capital. Romer (1986), Lucas (1988), Grossman and Helpman (1991) employed R&D and human capital as proxy for innovation in explaining endogenous growth. Grossman and Helpman (1991) examined cross-country growth differences and found that small countries with comparative advantages in scientific and technological know-how from abroad benefited most from R&D activities. Based on literature, defining the role of human capital and R&D is country and sector specific. Nonetheless, evidence on how human capital and R&D influence performance of developing countries, especially at the sectoral level, is somewhat limited. Two major concerns are noted in the literature with regard to developing countries, including Malaysia. First, studies examining the role of R&D and human capital development at the sectoral level are few. Past studies have examined the role of human capital and R&D at the national level (Islam, Ang & Madsen, 2014; Hanushek, 2013; Ang & Madsen, 2013). Further, studies at the firm level appear to frame their approach of examining the contributions of R&D and human capital in a static way. For instance, studies (Wignaraja, 2012; Hashi & Stojčić, 2013; García-Zamora, González-Benito & Muñoz-Gallego, 2013)[1] that employed a cross-sectional (static) approach, lacked the dynamism that longitudinal studies are able to provide. Thus, previous studies have yet to capture the dynamics of human capital and R&D that the present study offers. In fact, in most of these studies, issues are framed within the theories of the firm, taking on a resource-based view using cross sectional data. As time lag should be considered in assessing the impact of human capital and R&D, longitudinal data is required. Second, results on the magnitude of the effects of R&D and human capital are still not known and as claimed by Sharma (2012), they are largely mixed depending on the estimation techniques employed and the sectors examined. Since Malaysia has historically taken a position of FDI-led strategies, it will be interesting to examine the nexus of R&D, human capital and performance based on ownership structure. This study, additionally, contributes to the existing literature by examining and estimating the effects of R&D and human capital in a more dynamic way at the sectoral level to inform the policymakers on the magnitude of its impact on performance. For this purpose, the sample firms were divided based on ownership to examine the differences in the role of R&D and human capital in influencing performance of local and foreign firms.

In analysing the link between R&D, human capital and sectoral performance, the Malaysian manufacturing sector serves as an interesting case study for a number of reasons. First, the manufacturing sector emerged as the second largest contributor to Gross Domestic Product (GDP), with a share of 30 per cent in early 2000. Its share of GDP, however, declined to 23 per cent in 2014. The decline in performance of this sector is attributed to the lack of innovation (including technological progress) and human capital (World Bank, 2010). However, there is still a lack of empirical evidence on the impact and role of R&D and human capital on the performance of the manufacturing sector. Second, the expansion of the manufacturing sector in Malaysia is vital given its contribution to exports. The manufacturing sector remains the largest contributor, at 80 per cent and 62 per cent of total exports in 2000 and 2014 respectively. The historical success in export oriented manufacturing though indisputable, is recently compounded with critical problems. While Malaysia is successful at producing low value-added activities, moving up the value chain remains a challenge for the manufacturing sector. Indeed, Rasiah (2011) highlighted that Malaysia's manufacturing sector is at the crossroads, since the late 1990s. The declining share of manufacturing in GDP and exports since the global financial crisis, further raised concerns of a premature deindustrialisation process in Malaysia. Regardless of the excellent blueprints (Industrial Master Plans I, II and III), the inability of the manufacturing sector to realise technological shifts to date have also called into question the effectiveness of related policies.

Again, despite the criticisms levelled at the manufacturing sector in terms of its technological progress and catch-up, national data suggests that R&D activities and human capital accumulation have both improved significantly in Malaysia. The number of R&D researchers (per million people) had increased from 89 in 1996 to 365 within 10 years, while R&D expenditure as a share of GDP grew five-fold, from 0.2 per cent in 1996 to 1.1 per cent in 2010. Likewise, quality of the labour force had also improved; employees who have tertiary education accounted for 20.3 per cent of total workforce in 2002 but it rose to 24.5 per cent in 2011. Similarly, in the manufacturing sector, significant progress in R&D spending and human capital development had been recorded over the years. Human capital, measured by number of skilled workers to total workforce, had increased by 74 per cent (based on the manufacturing surveys), while real R&D expenditure recorded a value four times higher in 2010 compared with 2000. Interestingly, national data on R&D and human capital contradicts with the pessimistic claims on the current state of the manufacturing sector. Some of the contradicting claims may have been due to the static approach adopted in previous studies, where most of them used cross-sectional data, with static time space, that limits the evolutionary understanding of how R&D and human capital influence the performance of the manufacturing sector.

Therefore, this paper examines the relationship between R&D and human capital (skilled labour) with performance, specifically value-added growth[2] of the manufacturing sector, based on survey data of selected manufacturing firms in Malaysia. The relationships are further studied by examining ownership (foreign or local) structure of the firms. The authors applied the panel cointegration techniques of Pedroni (1999) and Kao and Chiang (2001). These methods are able to account for heterogeneity and endogeneity. This study contributes to literature on the impact of R&D and human capital on performance, through an evolutionary perspective for Malaysia. It refines and validates previous findings that slow technology progress and unskilled labour have hindered the performance of manufacturing firms. It also attempts to understand how critical R&D and human capital are, especially skilled labour, in affecting the performance of the manufacturing sector in Malaysia.

The rest of the paper is organised as follows. Section 2 reviews the literature to establish the theoretical links between R&D, human capital and economic performance. Section 3 discusses data sources and details the model specification and methodology of the study. The findings are discussed in Section 4 while section 5 concludes the study.

2. Literature Review

2.1 Research and development and economic performance

The role of innovation in economic performance can be traced to Solow-Swan's (1956) neoclassical framework. However, the factors that explain innovation were not specifically identified in this model. Consequently, Romer (1990) extended the growth theory and model by introducing R&D and imperfect competition in the base model. Technological advancement from purposive R&D activities is rewarded by some form of ex post monopoly power. Indeed, the gaps in the level of development between advanced and developing countries may be explained by the differences in R&D investment (Ogundele et al., 2012).

Similarly, innovation is pivotal in contributing to firm-level performance. Empirical studies by Griliches (1979, 1986) on the direct link between R&D and economic performance, as well as productivity, including those evidences at firm level, laid the foundation for many other scholars. Falk (2012) found a positive effect of R&D intensity on sales growth in Austria. Likewise, Hall and Mairesse (1995) found R&D influences productivity of manufacturing firms in France. Following which, an evolutionary approach is considered to provide a useful framework to study innovation at the firm, or even sectoral level. This evolutionary process is characterised by inter-technological assimilation, uncertainty and innovation based on firm-level competition (Dosi & Nelson, 2013). Using this framework, Rasiah, Kong and Lin (2010) affirmed the critical role of innovation in the integrated circuits (ICs) industry performance of Taiwan and China. The R&D is usually undertaken by large firms, private R&D centres and universities, where enormous government support is provided since investments in technology involved huge costs and uncertainties that can possibly lead to market failure (Rasiah, 2004). It is therefore, important for firms to invest in R&D in order to compete in the global market.

As for R&D intensity by ownership, in developing countries, research showed that foreign firms are more proactive than local firms. To avoid market failure and costly R&D activities, firms, especially in developing countries, tend to use foreign direct investment (FDI) to invest in new technology (Urata & Kawai 2003). Similarly, as observed by many scholars, R&D activities are usually concentrated in foreign relative to local-owned firms, especially in developing countries. Therefore, it is important to study the link between R&D and performance of local and foreign firms. The World Investment Report (UNCTAD, 2005) cited a shifting trend of R&D activities to developing economies, though such activities are still concentrated in the advanced economies. Initially, R&D was driven by market demand for locals, but recently, the trend has changed due to increase cost of such activities and consequently, transnational corporations (TNCs) have begun to relocate their activities to developing countries given the cost advantage position as well as the availability of vast pool of human capital in the latter. For example, accessibility to high-tech human capital has attracted many information and communication technology (ICT) and pharmaceutical TNCs to diversify their R&D activities to India (UNCTAD, 2005).

Albeit the strong relationship between TNCs and R&D activities in developing countries, Odagiri and Yasuda (1996) concluded that most R&D activities by TNCs in the Japanese economy have only limited effect on the volume of production. This is mainly due to lack of technological absorptive capacities in undertaking new or innovative technological upgrading in the host country. In this aspect, having the required human capital is important for the adaptation of R&D and subsequently for the improvement in firm performance. The above arguments preclude the importance of assessing the impact of R&D on firm performance on aggregate, and by ownership.

2.2 Human capital and economic performance

The role of human capital on performance is well documented in the literature. Lucas (1988) introduced the concept of human capital and physical capital in his neoclassical growth theory. According to this model, economic progress is a function of the level of human capital development. Human capital is defined from two perspectives, educational attainment and learning by doing. The learning process involves risks, uncertainties and costs (Lall, 2000). The “S” learning curve explains lucidly capabilities to acquire knowledge. Different technologies need different learning processes. Some technologies are embodied, while others depend extensively on tacit knowledge. Thus, knowledge is perceived as critical for performance.

In organisational studies, the resource-based view of firms links human capital to performance. Based on this theory, scholars regard human capital as a core competency factor, or as what Hamel and Prahalad (1994) defined: a valuable set of assets and internal capabilities of firms. The latter is an extension of the initial work of Penrose (1959) taking on from the resource-based view of firms[3], propounded by Rumelt (1984), Dierickx and Cool (1989), Barney (1991, 1995) and Teece, Pisano and Shuen (1997). These studies have argued that firm specific factors such as human capital and R&D matter. Empirical evidence shows that firms with high investments in human capital tend to enjoy superior profits (Ahmed, 2003). Investments in human capital strengthen the intangible assets of firms, which is none other than intellectual capital. More intellectual capital equals greater competitive advantage of the firm to differentiate the products or processes from other competitors, allowing the firm to sustain its profits in the long-run. Similar studies for Malaysian industries found human capital to have a significant and substantive relationship with firm performance, regardless of the industry type (see Bontis, Chua & Richardson, 2000). Many scholars have highlighted that natural resources, technology and attaining economies of scale is imitable, but human capital and its strategies are distinctive and flexible, and therefore inimitable (see Becker and Gerhart, 1996). This could preserve a firm's competitive advantage and increase its survivability. Indeed, skills and knowledge embedded in human capital are the most important factors for performance. Given that human capital is a key driver, effective capitalisation of human capital, in turn, increases the competitive advantage of the firms (Ndinguri, Prieto & Machtmes, 2012).

3. Methodology and Data

3.1 Data source and description

Data used in this study is obtained from the annual surveys of the manufacturing sector, conducted by the Department of Statistics Malaysia (DOSM). For 2000-2010, there was a change in the industrial classification from Malaysia Standard Industrial Classification (MSIC) (2000) to MSIC (2008) for the year 2009-2010. As such, this required data to be aggregated to the 3-digit MSIC level for the ensuing empirical enquiry. This study used the industry classification concordance table provided by DOSM to match the industries. Data on value-added, R&D expenditure, employment by skills and fixed assets therefore cover 19 sub-sectors, spanning the period 2000-2010. The dataset is a balanced panel of 209 observations.

To obtain real values, nominal values of value added, R&D expenditure and fixed assets were deflated using the producer price index (PPI) at the sectoral level. The sample size of each sector represents its population. It varies across the 19 individual sectors. For example, the food and beverages industry account for 15 per cent of the total sample size in 2010, while the coke, refined petroleum products and nuclear fuel industry account for less than 1 per cent of the sample size. Due to differences in the number of firms for each sub-sector, the average values of value added, R&D expenditure, employment and fixed assets are analysed. Employment data obtained from the survey are further classified into skilled and unskilled labour to measure human capital. In the literature, skills represent human capital. Given that there is lack of information on types of occupation and years of experience, this study follows Barro and Lee (1994) and used education as the proxy to classify labour into skilled and unskilled; the number of workers with at least diploma and above qualifications are classified as skilled labour while workers holding below diploma qualifications are classified as unskilled.

The study used proportion of skilled labour in total labour force as the measure for human capital. The sample is also spilt based on ownership structure, foreign and local. Foreign firms are classified as firms that have more than 50 percent foreign paid-up capital.

Some limitations of the data warrants attention. First, the researchers were unable to measure the capital and R&D investment stocks due to data limitations. Hall and Mairesse (1995) indicated the importance of correcting the double counting of R&D expenditure in capital.[4] The R&D expenditure is measured separately avoiding the issue of double counting as expenditure on new process, techniques, applications and products including the investigation of the commercial feasibility of such new discoveries. Second, qualification as proxy to measure human capital as skilled and unskilled labour was used. The results of the study should be interpreted with caution taking into account the measurement and the proxy used in the study.

3.2 Model specification and empirical strategy

The model specification for examining the relationship between R&D, human capital and sectoral performance is based on the production function. Hall and Mairesse (1995) showed that direct production function approach is preferred to show the impact of R&D. Following, Hall and Mairesse (1995), three variants of the model are proposed[5], as shown below:

Model 1:

$$lnVadd_{it} = \alpha_i + \beta_1 lnCap_{it} + \beta_2 lnL_{it} + \beta_3 lnR\&D_{it} + \varepsilon_{it} \quad (1)$$

Model 2:

$$lnVadd_{it} = \alpha_i + \beta_1 lnCap_{it} + \beta_2 lnUL_{it} + \beta_3 lnSL_{it} + \varepsilon_{it} \quad (2)$$

Model 3:

$$lnVadd_{it} = \alpha_i + \beta_1 lnCap_{it} + \beta_2 lnUL_{it} + \beta_3 lnSL_{it} + \beta_4 lnR\&D_{it} + \varepsilon_{it} \quad (3)$$

where, $Vadd_{it}$ represents the real value-added output, Cap_{it} is the real fixed assets, L_{it} is total labour, UL_{it} is the number of unskilled labour, SL_{it} is the number of skilled labour and $R\&D_{it}$ is the real research and development expenditure. α_i captures the possibility of sector specific fixed effects and ε_{it} denotes the estimated residuals, which represent deviations from the long-run relationship. All values are transformed into logarithm.

Model 1 focuses on total labour, while model 2 disaggregates labour into skilled and unskilled. Finally, model 3 combines labour by skills with R&D expenditure as explanatory variables. The variables of interest are the coefficients for skilled labour (human capital) and R&D expenditure (innovation). The empirical strategy for the estimating the above models involves several steps, as detailed below.

First, the unit root test is conducted to check the stationarity of individual variables in the panel data. Various techniques have been used to test the stationarity, given that the augmented Dickey-Fuller (ADF) test of unit root is insignificant in rejecting the null of non-stationary, especially for panels with short time series data (Campbell & Perron, 1991). As an alternative, the Levin, Lin & Chu (2002) unit root test, hereafter LLC, and Im, Pesaran and Shin (2003) unit root test, hereafter IPS, are used. The LLC test assumes a common unit root process, while the IPS and Fisher-ADF each assume individual unit root process. Second, once the stationarity order is identified, we apply the Pedroni (1999) and Kao (1999) tests to determine the cointegration between the variables, in order to establish the long-term relationships. Pedroni (1999) proposed panel cointegration techniques that account for heterogeneity among individual members of the panel (Lee & Chang, 2008). Pedroni (1999) hypothesised the cointegration regression as follows:

$$y_{i,t} = \alpha_i + \delta_{i,t} + X_1\beta_{1\,i,t} + X_2\beta_{2\,i,t} + \ \ldots + X_m\beta_{m\,i,t} + e_{i,t}$$

$$t = 1,\ldots, T;\ i = 1,\ldots, N;\ m=1,\ldots, M \qquad (4)$$

where T refers to the period of observations, N to individual members of the panel and M is the number of explanatory variables. The slope coefficients $\beta_{1i}, \beta_{2i}, \ldots, \beta_{Mi}$ are allowed to vary by the individual member panel. The parameters, α_i *and* $\delta_{i,t}$, refer to the intercept and deterministic trend of member-specific panels respectively, although $\delta_{i,t}$ term is often omitted. Pedroni (1999) proposed two types of tests, which account for seven different statistics. The first four are based on pooling the residual for the "within" dimension, while the balance three refer to the "between" dimension. The null hypothesis of both types of test focus on no cointegration between the variables. The critical value to reject the null hypothesis is developed by Pedroni (1999), using the Monte Carlo simulation method. The v-statistic is based on a one-sided test, where large positive values reject the null hypothesis, while the remaining tests reject the null hypothesis when the negative values are large (Lee & Chang, 2008). For the purpose of robustness, the study includes the Kao (1999) residual cointegration test. The Kao test applies the ADF to test the cointegration among the panel members. Cointegration exists when the null hypothesis is rejected. The cointegration test is performed repeatedly to the overall sample and the split samples by ownership.

Third, once we find the existence of long-run relationships, the Fully-Modified Ordinary Least Square (FMOLS) and the Dynamic Ordinary Least

Square (DOLS) methods developed by Pedroni (2001) and Kao and Chiang (2001) respectively, are used to estimate the long-run coefficients. The study ignored the Ordinary Least Square (OLS) approach as it had expected asymptotic bias from heterogeneity across individual sectors. Therefore, the OLS standard error generally cannot be used for valid inference. Since the variables are transformed into logarithmic values, the long-run coefficients represent their elasticities.

4. Empirical Results

Table 1 shows the descriptive statistics. On average, only 15.3 per cent of the labour is skilled in the overall sample. In terms of ownership, the utilisation of unskilled to skilled labour remains high in manufacturing, not just for local firms, but also foreign firms. This affirms that the Malaysian manufacturing sector is still highly dependent on unskilled labour, and this feature is not specific to firm ownership. Regarding the two variables of interest, R&D and human capital, it is obvious that foreign firms spend more on R&D and employ a larger number of skilled labour relative to local firms. Interestingly, the data reveal largest variation in R&D expenditure relative to the other variables. The variations in R&D expenditure further justify the empirical testing on innovation and performance.

Table 1: Descriptive statistics, in levels and logarithmic values

	Level	Log	
Overall sample	Mean	Mean	Std. Dev.
Value added (million)	19.0	15.0	1.4
R&D expenditure (thousand)	91.4	9.5	1.9
Capital (million)	23.7	15.5	1.5
Labour (person)	72	4.1	0.6
Unskilled labour (person)	61	3.9	0.6
Skilled labour (person)	11	1.8	1.0
Local firms			
Value added (million)	19.2	14.8	1.5
R&D expenditure (thousand)	80.3	9.0	2.0
Capital (million)	20.2	15.2	1.6
Labour (person)	59	3.9	0.7
Unskilled labour (person)	51	3.7	0.6
Skilled labour (person)	8	1.5	1.1

Table 1: (Continued)

Foreign firms			
Value added (million)	27.6	16.5	0.9
R&D expenditure (thousand)	175.7	10.2	3.1
Capital (million)	62.1	17.0	1.1
Labour (person)	274	5.4	0.5
Unskilled labour (person)	236	5.2	0.6
Skilled labour (person)	38	3.3	0.7

Note: Value added, R&D expenditure and capital (for level) is expressed in Malaysian ringgit. The mean value is calculated by diving each industry values by the number of firms in each industry.

Ignoring stationarity leads to spurious results. Therefore, the variables were tested for stationarity using panel unit root tests. Table 2 shows the results for the overall sample, as well as for the sub-samples of local and foreign firms respectively. Both tests, the common unit root process represented by the LLC and the individual unit root process by IPS and Fisher-ADF, confirmed that the variables are stationary at first differences *I* (1). The same applies for sub-sample data of local and foreign firms, although the LLC[6] for skilled labour and R&D are found to be stationary at levels.

Table 2: Unit root tests

	InVadd	***InCap***	***lnL***	***lnUL***	***lnSL***	***lnR&D***
			Overall Sample			
Levels						
LLC	-0.28	-0.73	-0.29	-0.17	4.69	-0.39
IPS	1.22	2.02	0.58	0.79	1.58	-0.89
Fisher-ADF	24.83	21.39	31.10	29.41	22.27	52.79**
First difference						
LLC	-2.42***	-5.03***	-6.82***	-8.26***	-5.20***	-6.21***
IPS	-1.33*	-2.47***	-3.11***	-3.79***	-4.16***	-4.60***
Fisher-ADF	51.10*	65.36***	74.23***	82.07***	89.41***	97.31***
			Local Firms			
Levels						
LLC	-0.09	-0.55	-1.28	-1.17	-1.67**	-1.67**
IPS	0.54	1.52	0.40	0.74	-0.60	-1.13
Fisher-ADF	30.24	23.69	32.67	28.81	46.69	49.02
First difference						
LLC	-1.97**	-3.20***	-7.90***	-7.81***	-11.63***	-15.37***
IPS	-1.97**	-2.47***	-3.58***	-3.45***	-6.27***	-9.89***
Fisher-ADF	58.49***	65.00***	81.99***	79.17***	115.40***	159.35***

Table 2: (Continued)

	Foreign Firms					
Levels						
LLC	2.12	-1.11	3.98	3.66	3.16	1.44
IPS	0.11	0.04	1.88	1.45	2.81	-0.25
Fisher-ADF	35.54	35.87	20.4	22.44	12.67	33.88
First difference						
LLC	-2.75***	-5.95***	-7.21***	-7.86***	-8.76***	-6.90***
IPS	-2.95***	-4.22***	-4.47***	-4.82***	-4.90***	-4.47***
Fisher-ADF	72.60***	91.599***	92.84***	97.56***	99.18***	93.36***

Note: (***), (**) and (*) indicate rejection of the unit root at 1%, 5% and 10% levels, respectively.

An examination of the relationship between the variables was established by plotting the pooled data for the overall sample. Figure 1 shows the bivariate relationships between the explanatory and dependent variables. Data appears to fit the estimation quite well with all explanatory variables having positive associations with the performance measure, in this case value added.

As all variables are found to be stationary at first differences, testing of panel cointegration to identify the long-run relationships between the variables was done. Two sets of cointegration tests are proposed, within dimension and between dimensions (Pedroni, 1999, 2004). The within dimension approach includes four different statistics, namely panel *v*, panel *p*, panel PP and panel ADF. The within dimension approach pools the autoregressive coefficients across different sectors to assess unit root on the estimated residuals, while taking into account common time space and heterogeneity across sectors. Conversely, the between dimension approach includes three statistics, namely group p, group PP and group ADF, which are based on average of individual autoregressive coefficients related to unit root test of the residuals of each sector in the panel.

Table 3 presents the results of the panel cointegration tests for both the within and between dimension panel cointegration test statistics. Four out of seven tests proposed by Pedroni (1999) confirm that within group and between group reject the null hypothesis of no cointegration at the 1 percent significant level in all three models: overall sample, and the sub-samples of local and foreign firms. The Kao residual test has also rejected the null of no cointegration at 1 per cent significance level. Therefore, the results affirm that there are long-run relationships among the variables in the model.

Finally, the long-run impact of R&D and human capital on value-added using the FMOLS and DOLS techniques were evaluated (see Table 4). The coefficients of both regressors reflect elasticities. For the overall sample, the results of FMOLS and DOLS are fairly consistent. Interestingly, for the overall sample, with regards to human capital, skilled labour significantly impacts performance. A one percent increase in the proportion of skilled labour significantly contributes around 0.51 percent to 0.65 percent to value-added. In contrast, unskilled labour does not seem to impact performance, despite the fact that unskilled labour accounts for a large proportion of the workforce in manufacturing. When we split the sample by ownership, both skilled and unskilled labour significantly impacts performance of local firms. However, for foreign firms, only skilled labour significantly contributes to their value-added.

Figure 1: Bilateral relationships

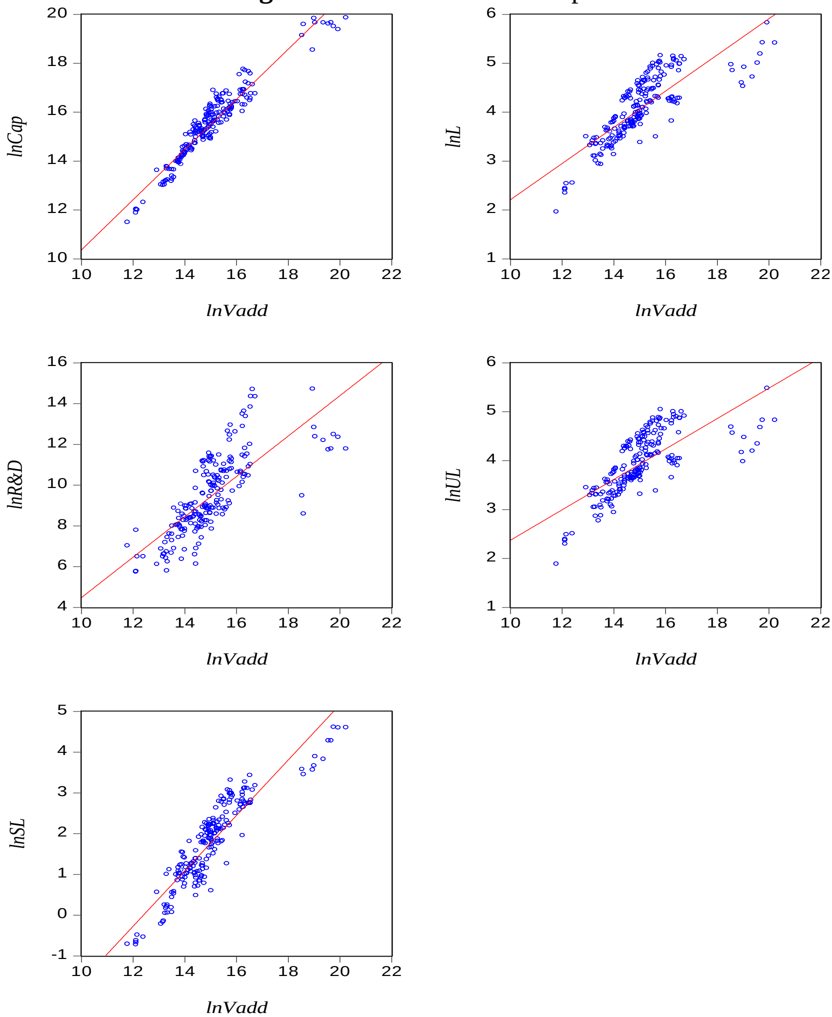

Table 3: Cointegration test results

Pedroni Residual Cointegration Test	Overall			Local Firms			Foreign Firms		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Within-dimension									
Panel v	-2.11	-1.40	-2.72	-2.16	-2.06	-2.20	1.59*	-0.96	0.76
Panel rho	1.99	1.94	3.48	1.58	1.98	3.36	-0.09	0.75	1.35
Panel PP	-2.68***	-3.39***	-2.87***	-5.47***	-3.93***	-3.28***	-8.86***	-6.69***	-8.99***
Panel ADF	-4.25***	-4.98***	-2.28**	-6.32***	-5.23***	-2.61***	-8.99***	-6.10***	-8.45***
Between dimension									
Group rho	3.95	3.90	5.35	3.87	3.27	5.01	3.15	3.83	4.85
Group PP	-2.55***	-2.70***	-3.63***	-4.55***	-7.17***	-4.45***	-6.89***	-7.64***	-8.52***
Group ADF	-2.96***	-3.55***	-1.49*	-5.09***	-6.69***	-2.45***	-7.25***	-5.26***	-4.42***
Kao Residual Cointegration Test									
ADF	-6.09***	-7.39***	-8.12***	-8.98***	-9.29***	-10.07***	-9.90***	-8.94***	-10.46***

Note: (***), (**) and (*) indicate the hypothesis of no cointegration is rejected at 1%, 5% and 10% respectively.

Table 4: Long Run Estimations Dependent Variable – Value Added

	FMOLS			DOLS		
Overall Sample	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
InCap	0.41***	0.45***	0.44***	0.40***	0.51***	0.47***
InL	0.49***			0.50***		
InR&D	0.12***		0.07***	0.12***		0.07***
InUL		0.04	0.09		-0.11	-0.005
InSL		0.59***	0.51***		0.69***	0.65***
Local Firms	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
InCap	0.32***	0.34***	0.36***	0.28***	0.35***	0.33***
InL	0.68***			0.75***		
InR&D	0.05***		0.03**	0.04**		0.02
InUL		0.35***	0.35***		0.45***	0.40***
InSL		0.45***	0.41***		0.29***	0.39***
Foreign Firms	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
InCap	0.32***	0.28***	0.26***	0.26***	0.23**	0.19**
InL	0.36***			0.27***		
InR&D	0.05***		0.05***	0.08***		0.08***
InUL		0.15	0.11		0.16	0.02
InSL		0.39***	0.33***		0.41***	0.33***

Note: (***), (**) and (*) represent the coefficient significance at 1%, 5% and 10%, respectively.

Local firms appear to have benefited from the utilisation of unskilled labour. The results indicate the importance of unskilled labour for local firms and their 'complementary' effects with that of skilled labour in these firms. The following offers some explanation in that regard. First, with less sophisticated technology and production methods that remain unchanged for some time, the contribution of unskilled labour to value-added of local firms is even more critical. Second, the decline in output and the subsequent loss of jobs even among the skilled when shortages as unskilled labour prevailed in labour-intensive firms, it further supports the complementary effects of both skilled and unskilled for firm performance. Thus, unskilled labour is still needed to justify the performance of local firms that is less technologically advanced. Having said that, we do not recommend that local firms should continue to rely on unskilled labour.

The R&D has significant impacts on performance. However, the coefficients of R&D are much smaller relative to the other explanatory variables, which imply lower impact of R&D expenditure relative to impact from capital accumulation and human capital for value-added creation. For foreign firms, a one percent increase in R&D spending across the sub-sectors for the period of 2000-2010, increases value added between 0.05 percent and 0.08 percent, based on the FMOLS and DOLS estimations respectively. The low effects of R&D on value-added are also observed among local firms. The results on R&D imply the following. Though the R&D expenditure by local firms is much less compared with that of foreign firms, wherein the average R&D expenditure is one-sixth that of foreign firms, the magnitude of the impact of R&D on value creation remains somewhat similar for both local and foreign firms. This suggests that the effects of R&D for sectoral performance in manufacturing have not been fully realised. The government support for R&D has largely focused on universities, public research organizations and meso-organizations. Rasiah (2011) argued that connections are still lacking between firms and organizations that are entrusted with knowledge creation – particularly local firms. Additionally, Chandran, Rasiah and Wad (2012) also found that firms in Malaysia are clearly not innovating at the frontier. Efforts to improve R&D may have been hindered by lack of human resources in the science and technology fields. Many studies affirm that a major challenge facing Malaysia is the low contribution of skilled labour and R&D investment. Thus, policy makers should devise a more appropriate mechanism to improve the contribution of R&D and human capital.

5. Conclusion

This paper has examined the impact of innovation and human capital on the performance of 19 sub-sectors in the Malaysian manufacturing sector for the period 2000-2010. The proxy for innovation and human capital include R&D expenditure and skilled labour respectively, while sectoral performance relates to industry value-added. In order to show evidence of those relationships, ownership structure, both local and foreign were analysed. Using the production function as a basis for the model, the panel cointegration tests confirmed the existence of long-run relationships between the individual panel members for the overall sample, and the sub-samples of local and foreign firms. Further, investigations using the FMOLS and DOLS estimations on industry performance, found that the impact from skilled labour is large, positive and significant. Hence, the existing policies must improve the quantity and quality of the human capital.

Likewise, the relationship between R&D expenditure and value added is also positive and significant, but its impact is considerably low. This reflects poor quality of R&D, which is undertaken in the manufacturing sector in

Malaysia. Radical product and services development are lacking in manufacturing to contribute significantly to the value-added activities of this sector. Although foreign firms undertake, relatively, more R&D, their activities are still hosted in the parent company. There is a greater allocation for process and product improvement, which is mainly incremental, and therefore, remains insufficient to provide large impacts to value-added. Policy makers should revisit strategies to encourage more R&D activities that focus on creating large impacts on the manufacturing sector. They also have to redress the effectiveness of the R&D assistance programmes and create an ecosystem that fosters the intended R&D activities. Indeed, a matching fund should be considered to foster better academia, government and industrial collaboration in R&D activities.

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Notes

1. Usually, these types of studies use questionnaire survey to collect data and provide information and insights. However, the limitation is that it lacks dynamism, given the nature of data. Other studies, examining innovation and performance link, use mainly cross-sectional Community Innovation Survey (CIS) datasets, while panel data remains limited due to the matching problems of different surveys. In the finance literature, most studies use panel data and relate R&D with financial performance.
2. Value-added is a value based performance measure that gives importance on value creation.
3. See more details in Kor & Mahoney (2004).
4. Hall and Mairesse (1995) highlighted two main issues in measuring the return of R&D, namely the choice of depreciation rate when constructing stocks and double-counting of R&D expenditure.
5. Estimating three variant models also allows for robustness checks.
6. The results of the IPS are considered conclusive given that it allows for heterogeneous autoregressive coefficients, and hence, are more powerful than the LLC.

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