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Absorptive Capacity and Technology Spillovers: A Quantile Regression Approach

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Abstract: *Employing a quantile regression estimator, the study presents new evidence on the role of human capital in exploiting the technology effects from foreign direct investment (FDI) in low-technology industries. A new model of human capital to capture the non-linearity of FDI effects according to employees' educational qualifications was developed. This study examined whether workers' absorptive capacity had different effects on FDI spillover at different points of conditional distribution. Although the study found that the ability of employees with degrees and diplomas to exploit foreign technology exceeds the median quantile, it also acknowledges the existence of both 'over-skilled' and 'over-educated' workers at a higher quantile of FDI distribution. As the problem of shortages and mismatch between skills and education for workers with degrees and diplomas still hinders firms from applying advanced technologies from FDI, this study proposes using the law to make firms work with universities. Firms could inform universities of the industry's in-demand skills regularly and get involved in the development of the university curriculum to ensure that graduates are equipped with skills and knowledge that can be 'transmitted' to different industries.*

Keywords: Technology effects; Foreign direct investment; Human capital; Absorptive capacity; Quantile regression
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1. Introduction

As Malaysia heads towards becoming a high-income nation by 2025, studies on foreign direct investment (FDI) often include foreign investors acting as vehicles of cutting-edge technology and knowledge to improve workers' skills (Yunus, 2021; Yunus & Masron, 2020). Empirical studies also show that the recipient countries of FDI will reap greater benefits depending on the ability of the firm, which is closely related to the concept of 'absorptive capacity' (Girma et al., 2001; Girma & Görg, 2005; Zhang et al., 2010). Absorptive capacity is an important factor that can improve the productivity of any firm, and is interrelated with dimensional processes, which include acquisition, assimilation, transformation, and exploitation (Daghfous, 2004; Vega-Jurado et al., 2008; Zou et al., 2018).

Malaysia acknowledges that the mastery of viable technologies through FDI inflows are in line with the increasing number of graduates in higher education, as employees' education level is considered a determinant of a firm's absorptive capacity (Yunus et al., 2014, 2015). In addition, Malaysia's development agenda prioritises (R&D) research and development budgets for public universities, and encourages collaborations with industry (EPU, 2016; Yunus, et al., 2014). Nonetheless, evidence points to highly educated Malaysian workers still struggling to master new technological practices brought in by FDI, and value-added R&D activities still being at a low level. The wide technology gap has stunted the ability of local workers to learn and is likely to shift FDI towards low-technology industries, where it is commensurate with the level of workers' ability (Ismail, 2001; Yunus, 2020; Yunus & Hamid, 2019). The mismatch between workers' ability and the transferred technologies causes a diminishing return of workers with degrees, which ultimately also affects industry productivity (Yunus, 2017, 2018).

There is scant research on human capital as the main proxy of absorptive capacity, despite the necessity of gauging workers' absorptive capacity in assimilating FDI technology (Yunus & Abdullah, 2022b). This can be done by measuring individual absorptive capacity at the firm level. The present study, therefore, aims to gauge the level of employees' absorptive capacity to assimilate technological spillover from FDI companies in the manufacturing industry according to their educational qualifications. Although the process of knowledge application starts from education, there is hardly any specific measurement to gauge employees' ability to adapt to and assimilate educational knowledge into the firm's production processes (Szulanski, 1996; Von Hippel, 1994). Thus, institutions of higher learning should use industry feedback to evaluate the effectiveness of current curriculum practices in producing graduates with the skills required by industry.

Secondly, the econometrics analysis in this study will provide additional findings on employees' assimilation of FDI technology in low-technology industries. Existing studies on absorptive capacity mostly concentrate on high-technology industries and are aimed at a high aggregation level (Flôres et al., 2007, Imbriani et al., 2014; Jabbour & Mucchielli, 2007). This is because capital and technology investments from foreign investors may be more pronounced for high- and medium-technology industries, which also tend to employ workers with high academic qualifications (Yunus & Masron, 2020). However, in the Malaysian manufacturing sector, there has been an increase in the number of graduates with tertiary education, but a decreasing variance in academic credentials (Michie, 2001; Yunus, 2017, 2018; Yunus & Abdullah, 2022a; Yunus & Wahob, 2019).

Taking this into account, the study opts for a quantile regression analysis to examine the relationship between absorptive capacity and FDI, particularly to capture the non-linearity of FDI effects. As quantile regression is fully flexible, it best fits the study's purpose of seeing whether workers' absorptive capacity, measured by level of education, has different effects on FDI spillover at different points of conditional distribution (Buchinsky, 1994). The econometric analysis will inform the policies and strategies that can be implemented if employees' absorptive capacity is below the median level for the distribution of FDI spillover.

The quantile regression approach is likely a more accurate analytical tool than other estimators, such as the standard ordinary least squares (OLS) estimator or the generalized method of moments (GMM) technique. The quantile regression method allows variations in conditional distribution to be examined and postulates a correctly determined linear model for the conditional quantile. Since OLS and GMM focus on conditional mean functions for dependent variables, they are considered insufficiently accurate, especially in evaluating employees' productive characteristics, such as education and experience (Buchinsky, 1998; Falaris, 2008; Koenker & Machado, 1999).

Section 2 reviews the literature related to past empirical studies on absorptive capacity and FDI spillover. Section 3 discusses the data and research methodology. Section 4 discusses the analysis of the results. Finally, Section 5 offers a conclusion and final remarks for policy implications.

2. Literature Review

The application of the absorptive capacity concept is of much interest to researchers. To date, however, studies on proxies to measure absorptive capacity remain limited, and researchers are unlikely to reach a consensus (Behera, 2015; Girma & Görg, 2005; Vega-Jurado et al., 2008; Vu, 2018). Various proxies can be used for absorptive capacity R&D intensity, R&D expenditure, export intensity, patents, firm size and age, human capital, and technology gap (Ahuja & Katila, 2001; Behera, 2015). Among the proxies mentioned, R&D has been widely used in recent studies, but the results have been inconsistent. For instance, Tsai (2001) finds that absorptive capacity (proxied by R&D intensity) has a positive effect on productivity. Similarly, Behera (2015) and Kinoshita (2001) report that firms with greater absorptive capacity (measured by R&D stocks) benefited more from foreign presence than other domestic firms. Mowery and Oxley (1995), on the other hand, conclude that R&D intensity does not positively affect external learning capability. Barrios and Strobl (2002) suggest that domestic firms active in R&D demonstrate greater absorption capacity. Furthermore, they argue that exporting firms, which are more vulnerable to competition in foreign markets, are likely to have higher levels of technology and absorption capacity compared to non-exporting firms. Considering the disparities in most studies, Vega-Jurado et al. (2008) caution that absorptive capacity does not depend on R&D activities alone but is also influenced by a set of internal factors, namely organisational knowledge, social integration mechanisms, and formalisation. All these factors can positively or negatively impact a firm's absorptive capacity, which is also determined by the firm's ability to absorb the knowledge overflow.

Similarly, there is no consensus on how firm size and age influence absorptive capacity and sources for innovation (Ahuja & Katila, 2001; Kotha et al., 2011). Researchers have argued that more traditional organisations and larger companies typically have more resources to invest, but such benefits may be offset by routine rigidity. In contrast, younger companies or organisations often lack the resources to invest in absorptive capacity because of their smaller size, even though they are more flexible. A recent study by Zou et al. (2018) investigates the relationship between a firm's age and size and its ability to innovate, in particular, its absorptive capacity as the fundamental driver of innovation. They find that for small firms, there is a positive relationship between size and absorptive capacity, and the opposite for larger firms. In terms of firm age, the study reports no significant results for young firms, but a negative relationship between absorptive capacity and mature firms. Other studies also imply a correlation between absorptive capacity and the age and size of a firm, with generally a positive correlation for smaller and younger firms (Mowery & Oxley, 1995; Sørensen & Stuart, 2000).

The impact of domestic investment in enhancing FDI inflows (Lautier & Moreaub, 2012; Ndikumana & Verick; 2008; Yunus, 2021) receives less attention compared to the impact of FDI inflows on domestic investment (see Ahmed et al., 2015). Similarly, most studies consider R&D investment as a "host or domestic investment." It is frequently applied as a proxy of absorptive capacity, probably due to incomplete data in the industry, which is still in its infancy (Mohamad & Bani, 2017; Yunus, 2021). Yet, recent studies examining the relationship between absorptive capacity *via* R&D proxies (i.e., R&D expenditure and investment) and FDI inflows focus on its influence on technological innovation and productivity (Castellacci & Natera, 2013; Fu et al., 2011; Lau & Lo, 2015; Liu et al., 2001). To date, no study has explicitly measured the extent to which the absorptive capacity of domestic direct investment promotes FDI spillover at the industry level.

Human capital has long been recognised in the literature as a catalyst and complement in stimulating national economic growth, increasing productivity, and attracting foreign investors. In discussing foreign technology spillover, however, studies examining the magnitude of human capital as an agent of absorptive capacity, either through education or training proxies, are still lacking (Borensztein et al., 1998; Tu, et al., 2006). Only a handful of studies have measured absorptive capacity using proxies that represent human capital. For instance, Martinkenaite and Breunig (2016) use the ratio of white-collar workers to total employment to represent a firm's absorptive capacity. They found discrepancies between individual and organisational absorptive capacity, and thus postulated that the interaction between the micro level (individual) and the macro level (firm) would increase a firm's absorptive capacity.

Meanwhile, at the sector and industry levels, Khordagui and Saleh

(2016) utilise years of schooling as a proxy of human capital to examine the role of institutional quality and trade openness in mediating both knowledge and technology spillover from FDI for 45 emerging and Middle Eastern economies from 1990 to 2009. The findings in their study do not support human capital, trade openness and institutional quality as an effective intermediary factor in the influx of FDI. This reflects the notion of absorptive capacity, where a country's ability to absorb the benefits offered by FDI varies by sector. However, the positive effects of FDI spillover appear in the host economy after years of schooling as a control variable of absorptive capacity is factored into their model estimation.

Mohammad et al. (2018) examine the relationship between knowledge spillover from FDI and knowledge creation using the threshold level regression method. This study considers the level of development of information and communication technology (ICT) and English language proficiency. Using cross-sectional data for 190 countries' year average from 1995 to 2014, the results indicate that there is a non-monotonic effect of human capital and R&D on the creation of knowledge. Their study also confirms the existence of a threshold effect in the relationship between knowledge spillover and knowledge creation. They found that knowledge spillover is positive and significant in influencing knowledge creation. The positive effect was greater after exceeding the threshold level. In other words, the level of ICT development and English proficiency could affect knowledge creation after exceeding the threshold level. The researchers, however, acknowledge two limitations, leading them to suggest further studies to use public and private R&D expenditure separately. Secondly, as they used the year average for higher education as proxies for human capital, future researchers may be able to use different measures—such as the number of researchers—in studying the relationship between knowledge overflow and FDI inflows. Thirdly, they also suggest relevant studies' on threshold levels using time series and panel data.

As such, the present study fills the gaps in the literature on absorptive capacity and FDI by using less-explored absorptive capacity proxies, particularly the role of education as measured by academic qualification, private domestic investment from local investors, ICT investment expenditure, and firm size through a panel data analysis approach in low-technology industries.

3. Data and Methodology

3.1 Data and scope of study

The study focuses on four low-technology industries, as classified according to 2011 Organization for Economic Co-operation and Development (OECD) standards. To address the issue of heterogeneity that usually arises at industry-level study, especially in developing countries (Anwar & Sun, 2019), the industries were chosen based on their R&D characteristics or technology intensity. Based on the classification and balanced panel data, this only covers only four industries, namely food and beverage (15), textiles (17), wood (20), and publishing, paper and printing (21).

The study's main data source is manufacturing surveys from 2010 to 2018 conducted by the Department of Statistics Malaysia. The summary of statistics with definitions of the variables used is presented in Appendix 1.

3.2 Theoretical framework of absorptive capacity and FDI spillover

The theoretical framework in this study is based on Cohen and Levinthal (1989) and Blomstrom and Kokko (1998), who revealed that the presence of foreign multinationals creates both potential learning opportunities and technology spillover. However, to ensure that the benefits and spillover from FDI can be assimilated, the host country needs to have the initial development of related knowledge and capacities, which determines how far technological effects can spread in the host country. Thus, absorptive capacity is crucial for realising the contagion of technology spillover. As an extension of this theory, strong evidence from empirical studies show that the absorptive capacity of a host country depends on two levels of technology, domestic firm and national. The absorptive capacity at the domestic firm level involves technology intensity and qualified workers (Cohen & Levithal, 1990; Girma & Görg, 2005). At the national level, meanwhile, absorptive capacity is influenced by the quality of human capital or human capacity, infrastructure, as well as financial and technological strength (Borenzstein, 1998; Keller, 1995; Nguyen et al, 2009). Therefore, through the combination of these two levels of absorptive capacity, the variables chosen in this study can be considered 'true' enhancers of absorption capacity. These consist of investment expenditure in R&D and ICT, as well as other factors, such as private investment, firm size, and the number of workers with the highest qualification certificates.

3.3 The estimation model

The specification model of technology spillover developed for the study is based on ideas from Yunus (2020) and Girma and Görg (2005). However, this study differs in that it uses human capital as the primary proxy representing absorptive capacity. The interaction between the level of education according to the highest qualification certificate of labour and technology spillover is measured specifically to assess workers' capacity to absorb the impact of foreign technologies through the presence of multinational corporations (MNCs) established in local industries. Girma and Görg (2005) use the technology gap as a key proxy of their absorptive capacity to measure the magnitude of beneficial spillover likely to be derived from FDI, by making the productivity spillover from FDI their dependent variable.

In this study, FDI spillover as the dependent variable, defined by the number of FDI companies (*SFDI*) channelling 'technology effects' into a firm (Bandick & Hansson, 2009; Bwalya, 2006; Yunus & Masron, 2020), is measured using this formula:

$$lnSFDI_{it} = \sum_{i}^{N} SFDI_{it} ln\left(\frac{1}{SFDI_{it}}\right) \quad (1)$$

where $SFDI_{i,t}$ is the number of foreign firms towards industry *i* (index of the industry in the low-technology industry, namely (i) food and beverage, (ii) textiles, (iii) wood, and (iv) publishing, paper, and printing) as a percentage of the total number of foreign firms in a two-digit industry sector in a year (t = 2000-2018).

For the main independent variables, this study extends Girma and Görg's (2005) absorptive capacity model to measure workers' absorptive capacity (*ACP*) to capture the 'technology effects' brought by the foreign company's presence from equation (1). This study measured workers' level of absorptive capacity separately according to three levels of academic qualifications: (i) degree and above (*ACP_DEGREE*), (ii) diploma and Higher School Certificate (HSC) (*ACP_DIPLOMA*), and (iii) Malaysian Certificate of

Education (MCE)/Malaysian Certificate of Education Vocational (MCEV) (*ACP_MCE*) using the following formula:

$$ACP\_DEGREE_{i,t} = DEGREE * (SFDI_{i,t} / MaxSFDI_{i,t} (SFDI_{i,t-1}) \tag{2}$$

$$ACP\_DIPLOMA_{i,t} = DIPLOMA *(SFDI_{i,t} / MaxSFDI_{i,t} (SFDI_{i,t-1}) \tag{3}$$

$$ACP\_MCE_{i,t} = MCE * (SFDI_{i,t} / MaxFDI_{i,t} (SFDI_{i,t-1}) \tag{4}$$

where *Max SFDI* is the highest number of foreign firms capturing two-digit sectors (industry leader) that are present in the sector in a specific year.

To capture possible non-linear effects, the following equations present the quadratic effects that arise from workers' absorptive capacity categorised according to educational qualification and technology spillover of FDI as shown by ¥,

$$¥Degree = n_1 ACP\_DEGREE_{i,t} + n_2 ACP\_DEGREE^2 \tag{5}$$

$$¥Diploma = n_1 ACP\_DIPLOMA_{i,t} + n_2 ACP\_DIPLOMA^2 \tag{6}$$

$$¥MCE = n_1 ACP\_MCE_{i,t} + n_2 ACP\_MCE^2 \tag{7}$$

where *n* are parameters to be estimated. n_2 is set as = 0, which implies that the degree of FDI spillover is either high or low with workers' absorptive capacity. The quadratic specification is more flexible, as it allows the level of FDI-induced spillover effects to vary with absorptive capacity. Assuming $n_1 > 0$ and $n_2 < 0$, the effect of higher employee skills on FDI spillover will begin to fall when the absorptive capacity exceeds the critical level (or turning point) $ACP = - dACP = -(\frac{n_1}{n_{d2}})$. The high level of absorption capacity indicates the ability of local firms to recognise, exploit and assimilate foreign technology, that typically occur through 'demonstration-imitation' processes in the Malaysian manufacturing industry.

Hence, the following equation presents both the absorptive capacity model, *ACP*, by educational attainment and their quadratic effects, ¥, with other vectors of absorptive capacity proxies that are rarely investigated to influence FDI inflow, X_{it}, namely, FDI spillover lag (SFD_{it-1}), R&D expenditure (*RD_EXP*), ICT expenditure (*ICT_EXP*), as well as private domestic investment from local investors (*PDI*) and firm size (*FS*) (Vu, 2018; Yunus, 2021; Zou et al., 2018) .

$$lnSFD_{it} = B_1 lnSFDI_{i,t-1} + B_2 n_1 ACP\_DEGREE_{it} + B_3 n_1 ACP\_DIPLOMA_{it} + B_4 n_1 ACP\_MCE_{it} + B_5 n_2 ACP\_DEGREE_{it}^2 + B_6 ACP\_DIPLOMA_{it}^2 + B_7 n_2 ACP\_MCE_{it}^2 + B_8 lnX_{it} + \mu_{it} \quad (8)$$

3.4 Econometrics analysis: Quantile regression estimator

To measure whether the absorptive capacity variable had a non-linear relationship, the study used quantile regression to consider the effects under different absorption conditions (Koenker & Hallock, 2001). The non-linear methodology was chosen because absorptive capacity distribution is best captured using several quantiles at different levels. Quantile regression can reveal information about the asymmetric and non-linear effects of conditional variables on dependent variables. It can capture the effect of rapid changes in absorptive capacity on the sign and intensity of FDI inflows across different quantiles. Since the study examines the relationships at different points of the conditional FDI spillover distribution, quantile regression could determine the relationship between proxies of absorptive capacity and FDI spillover.

The standard linear regression technique estimates the mean relationship between a set of absorptive capacity (x) regressors and other control variables, i.e., FDI spillover (y) based on a function conditional mean E (y | x), which gives only a partial view of the relationship between FDI and absorptive capacity. The model equation (8) is expanded to present the quantile regression model (Q) as follows:

$$Q_\theta(SFDI_{i,t}|VX_{i,t}) = \alpha_\theta + B1_\theta ACP_{i,t} + B2_\theta ACP_{i,t}^2 + \mu_\theta \quad (9)$$

where θ is 10th, 25th, 50th (median), 75th, and 90th percentiles of the FDI spillover distribution, and $SFDI_{i,t}$ is FDI spillover. $VX_{i,t}$ is the vector of control variables for absorptive capacity. $ACP_{i,t}$ and $ACP_{i,t}^2$ are workers' absorptive capacity by educational attainment and their quadratic effects, respectively. $B1_\theta$ and $B2_\theta$ are the slope coefficients quantifying the effect of absorptive capacity on FDI spillover at quantile θ. μ_θ is the error term.

The estimates of α_θ and B_θ, which involves minimisation of sample size and weighted absolute values of the residuals (Buchinsky,1998; Koenker & Bassett, 1978), can be defined as:

$$MinB_{\theta}\alpha_{\theta} = \sum_{t=1}^{T} P_{\theta}\,(SFDI_{i,t} - \alpha_{\theta} - B1_{\theta}ACP_{i,t} - B2_{\theta}ACP_{i,t}^{2}) \quad (10)$$

where P_{θ} (V) is the check function given by P_{θ} $(V) = V(\theta\text{-}1_{p\leq 0})$; $1_{p\leq 0}$ is the indicator function. The function of $P_{\theta}(V)$ as a weight that enforces dissimilar residual values, whether positive and negative, depends on the value of θ. When $\theta = 0.5$, this is the median estimator (Koenker & Hallock, 2001).

4. Results and Discussion

The results of the study will be presented in two parts. Part I will discuss the robustness tests used in the study to assess the sensitivity of empirical findings to alternative estimation. Part II will use quantile regression to measure the proxies used as absorptive capacity in influencing FDI spillover in low-technology industries.

4.1 Robustness checks

A robustness check was carried out using robust standard error quantile regression (Machado et al., 2011) to assess the sensitivity of empirical findings to alternative estimates. Five models were presented and tested at the 50th quantile level by inserting control variables alternately into the model, as reported in Table 1.

In Model (1), past stock FDI variables were estimated alongside workers' absorptive capacity by educational qualifications and their quadratic effects, yielding a positive and significant result between the dependent variable and its lagged. On the contrary, negative results were found for employees' absorptive capacity and their quadratic effects at all educational levels, thus, influencing FDI spillover at the median quantile of FDI distribution.

For Model (2), the study included R&D expenditure in the model estimation. The results showed a complementary relationship between human capital and domestic R&D. Thus, an increase in R&D efforts, along with the ability of highly educated labour to exploit foreign technology, will increase the firms' ability to use and develop new technologies (Cohen & Levithal,1989; Siang et al., 2012; Teixeira & Fortuna, 2010). Meanwhile, for

MCE-qualified employees, an insignificant relationship with FDI technology spillover was confirmed. This may be due to the lagging impact of current R&D on low-educated labour, which is only evident after several years, considering the time required by the workers to exploit the technology.

Table 1: Robustness Checks at 50th Quantile in Low-Technology Industries, 2000-2018

Variables	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Lagged FDI Spillover ($SFDI_{it-1}$)	0.238* (0.009)	0.218** (0.009)	0.284*** (0.013)	0.219** (0.009)	0.330* (0.013)
ACP_ DEGREE	-0.194** (0.195)	0.274* (0.062)	0.203** (0.083)	0.218* (0.044)	0.326** (0.027)
ACP_ DEGREE^2	-0.436** (0.427)	0.270** (0.091)	0.263** (0.068)	0.241* (0.033)	0.372** (0.016)
ACP_DIPLOMA	-0.323* (0.243)	0.148 (0.071)	0.150*** (0.030)	0.232* (0.028)	0.384** (0.021)
ACP_DIPLOMA^2	-0.058* (0.057)	0.140*** (0.038)	0.170** (0.044)	0.210** (0.018)	0.381* (0.014)
ACP_MCE	-0.318 (0.256)	0.237 (0.029)	–	–	–
ACP_MCE^2	-0.315 (0.301)	0.214 (0.049)	–	–	–
RD_EXP	–	0.340* (0.022)	0.352** (0.017)	0.382** (0.019)	0.416* (0.026)
ICT_EXP	–	–	–	-0.409* (0.302)	-0.327** (0.031)
PDI	–	–	-0.121* (0.023)	–	-0.325** (0.027)
FS	–	–	–	–	0.262** (0.071)
Constant	5.318** (0.256)	6.004** (0.258)	5.596* (0.034)	5.223* (0.278)	5.185** (0.083)
Pseudo R^2	0.726	0.811	0.879	0.812	0.832
No. of observations	76	76	76	76	76

Notes: The dependent variable for the quantile regression is FDI spillover. *ACP_ DEGREE* = absorptive capacity of employees with degree qualifications, *ACP_DIPLOMA* = absorptive capacity of employees with diploma qualifications, *ACP_MCE* = employees' absorptive capacity with MCE/MCEV qualifications, *ACP_ DEGREE*^{2} = the quadratic effects of workers with degrees, *ACP_DIPLOMA*^{2} =the quadratic effects of workers with diplomas, *ACP_MCE*^{2} = the quadratic effects of workers with MCE/MCEV qualifications, *RD_EXP* = R&D expenditure, *ICT_EXP* = communication and technology investment, *PDI* = share of direct domestic investment, *FS* = firm size. All variables are transformed into natural log. Entries in parentheses are robust standard errors and all variables are transformed into natural log. ***, ** and * denote statistical significance at 1%, 5% and 10%, respectively.

This study dropped the insignificant variables of MCE and re-estimated the model by including investment expenditure in ICT and private domestic investment alternately into Model (3) and Model (4). Similar patterns of results found for both models, where technology investment is negatively associated with foreign technology. This reflects Göçer et al. (2014) idea of crowding-out effects—that increased ICT investment expenditure and private domestic investment could prevent high FDI outflow. This is often due to the low level of innovation and technology efficiency in low-technology industries.

The firm size variable was jointly estimated into Model (5), yielding two interesting results. First, the p-value of absorptive capacity for both degree and diploma coefficients were greater than Models (3) and (4). This finding is similar to Vu's (2018) study that reported a positive correlation between workers' absorptive capacity, firm size, and technology. Secondly, using industry sales revenue as a proxy to firm size, the study found that profitable MNCs tend to spill over their technology (Lautier & Moreaub, 2012; Zou et al., 2018). The results of this study are also consistent with previous literature, such as Cohen and Klepper (1996) and Lichtenberg and Siegel (1991), which found a positive correlation between R&D and firm size.

4.2 Quantile regression result

The quantile regression results of absorptive capacity for FDI distribution at five different quantiles—10th, 25th, 50th (median), 75th, and 90th—for low-technology industries are presented in Table 2. In evaluating the capability of the firm's absorptive capacity, as proxied by lagged FDI spillover, a positive and significant effect was found across the quantiles. This implies that the existing spillover effects can be exploited by workers through imitation activities, and the impressions could still increase the spillover of new technologies from FDI.

Table 2: Quantile Regression Results for Low-Technology Industries, 2000-2018

Variables	10th quantile	25th quantile	Median	75th quantile	90th quantile
Lagged FDI Spillover ($SFDI_{it-1}$)	0.218*** (0.031)	0.283*** (0.001)	0.274** (0.001)	0.225** (0.000)	0.212*** (0.001)
ACP_DEGREE	0.035* (0.004)	0.143** (0.007)	0.225** (0.021)	0.269* (0.012)	0.286** (0.021)
ACP_DIPLOMA	0.024* (0.005)	0.117** (0.008)	0.158* (0.022)	0.229* (0.013)	0.243** (0.022)
ACP_MCE	0.114* (0.073)	0.142* (0.120)	0.154** (0.018)	0.210* (0.163)	0.224*** (0.019)
ACP_DEG^2	0.030** (0.002)	0.125* (0.004)	0.215* (0.010)	0.255* (0.005)	0.280* (0.010)
$ACP\_DIPLOMA^2$	0.143*** (0.002)	0.127** (0.004)	0.152** (0.011)	0.214* (0.006)	0.221**** (0.011)
ACP_MCE^2	0.169* (0.037)	0.131 (0.060)	0.135** (0.004)	0.205 (0.006)	0.211* (0.004)
RD_EXP	0.249*** (0.027)	0.268** (0.026)	0.274*** (0.041)	0.321* (0.025)	-0.235** (0.042)
ICT_EXP	0.230** (0.034)	0.238*** (0.023)	0.267 (0.032)	0.322* (0.032)	-0.249 (0.027)
PDI	0.200* (0.029)	0.212*** (0.073)	0.237* (0.082)	0.346* (0.098)	-0.239** (0.072)
FS	0.083* (0.141)	0.078* (0.103)	0.152** (0.145)	0.162*** (0.149)	0.141** (0.084)
Constant	5.085*** (0.023)	5.091*** (0.024)	5.177*** (0.006)	5.174*** (0.073)	5.181** (0.006)
Pseudo R^2	0.868	0.844	0.845	0.837	0.813
No. of Observations	76	76	76	76	76

Notes: The dependent variable for the quantile regression is FDI spillover. *ACP_ DEGREE* = absorptive capacity of employees with degree qualifications, *ACP_DIPLOMA* = absorptive capacity of employees with diploma qualifications, *ACP_MCE* = employees' absorptive capacity with MCE/MCEV qualifications, ACP_DEGREE^2 = the quadratic effects of workers with degrees, $ACP\_DIPLOMA^2$ =the quadratic effects of workers with diplomas, ACP_MCE^2 = the quadratic effects of workers with MCE/MCEV qualifications, *RD_EXP* = R&D expenditure, *ICT_EXP* = communication and technology investment, *PDI* = share of direct domestic investment, *FS* = firm size. All variables are transformed into natural log. Entries in parentheses are robust standard errors and all variables are transformed into natural log. ***, ** and * denote statistical significance at 1%, 5% and 10%, respectively.

Regarding workers' capacity by their level of academic qualification in low-technology industries, the values of the absorption coefficients of employees with degree and diploma qualifications showed an increasing trend starting from the 25th quantile to the 90th quantile of FDI spillover distribution. At the median quantile, the results, as presented in Table 2, show that a 1% increase in foreign technology absorptive capacity by tertiary-educated workers will lead to an increase exceeding 20% and 15% in technology spillover by foreign companies established in Malaysia.

A noteworthy result points to the level of absorptive capacity for degree and diploma workers and their quadratic effects, which were remarkable at the 75th and 90th quantiles of the conditional FDI spillover distribution. At both quantiles, a 1% increase in the absorptive capacity of degree and diploma workers will increase FDI spillover into low-technology industries. On average, the increase exceeds 25% and 21% for degree and diploma workers respectively.

Two plausible reasons for this are technological progress and 'over-skilled' and 'over-educated' workers. First, technological progress in an economy increases demand for a labour force with a high level of knowledge and skills. This could explain why workers' absorptive capacity is at a high quantile level. The findings raise some concerns, including whether the technology brought in by FDI is too low to be assimilated to a high degree, or whether FDI activities are still concentrated on low-value-added production activities that do not require high technology.

Another concern involves the high cost of external capital from foreign investors to be brought into the industry. These concerns, however, are not addressed in the current research due to the limitation of current panel data on the issues, particularly the technological overflow from FDI according to the skill capacity of labour at the industrial level.

Nonetheless, previous studies by Yunus (2017) and Lopez-Garcia and Montero (2012) show that workers with degrees or diplomas, as well as the skilled labour section, were more likely to be placed in low- and medium-skilled occupational categories, such as clerical, sales and services, craft, and trade. Thus, the tendency to capture both technology and knowledge skills is greater within the scope of such occupations. These findings are consistent with signal theory, which asserts that education only serves as a guide for employers to organise the most productive employees or as an indicator of natural ability (Spence, 1973). This result suggests that the high demand for diploma and degree workers is based on labour productivity, reflecting their ability to absorb foreign technology at a high quantile level in this industry.

For the absorptive capacity of MCE/MCEV workers and their quadratic effects, a positive relationship was found with FDI inflows across conditional FDI spillover distribution. The results in Table 2 also shows a continuously increasing trend of absorptive capacity of this group of workers, and it can be seen from the median quantile up to the 90th quantile, indicating that the overall FDI inflow into the sector exceeds 20%. This result also implies that the technology was adopted by employees whose secondary education fit the level of skills possessed, thus confirming the compatibility between education and skills that leads to a high level of job satisfaction. Past studies have shown that when employees have a high level of satisfaction, this will translate into high productivity for the firm (Böckerman et al., 2011; Yunus, 2017; Yunus & Wahob, 2018).

This study also suggests that FDI in low-technology industries remains within the application of backward technology in production and therefore, workers' absorptive capacity is not the main motive for FDI to enter the industry. Even though these reasons sound plausible, proving it requires more than the existing data in our study. A study in another developing country, Thailand, also found a similar situation (Michie, 2001). FDI in Thailand did not require many skills. The diffusion of both technical knowledge and management skills was relatively low, as local Thai workers with low educational qualifications were unable to capture the positive effects from FDI spillover. The investment in human capital enhancement was thus lower in low technology industry.

A notable result, as shown in Table 2, is direct domestic investment, ICT, and R&D investment showing higher absorptive capacity at the 75th quantile of the conditional FDI distribution. A 1% increase in the absorptive capacity resulting from R&D activity, ICT investment, and direct domestic investment will attract more than 30% of FDI spillover. The human capital variable, in contrast, only attracted less than 28% at the same quantile in low-technology sectors. This suggests increased competition among private investment companies. Cooperating with foreign clients and dealing with high-quality projects in Malaysia might have forced these companies to increase their learning ability and to spend more on R&D activities, especially in new and diversification projects (MIDA, 2020; Yunus, 2021).

However, at the 90th quantile, the level of absorption capacity of local firms in their own investment activities were worst in the 90th quantile of conditional FDI distribution, as the variables negatively affected FDI inflows. The negative findings could be attributed to the crowding-out effect, whereby the level of innovation efficiency was still low despite the increased volume of in-house investments. These investments may stifle FDI inflows (Göçer et al., 2014). The negative result performing at a higher quantile in this study also affirmed the non-linear effects appearing between the absorptive capacity of firms and FDI in the low-technology industry, which implied wide technological gaps between host-owned and foreign-owned technologies. This is consistent with Aitken and Harrison (1999) and Girma and Görg (2005), who showed that low-technology firms derive real benefits not from the spillover effects of FDI, but rather from the effects of competition between MNCs that have multiple technologies to enter local firms—thus hindering the firm from absorbing a wide range of technologies which may require different skills and technologies within the firm itself.

The absorptive capacity measured by the firm size variable yielded positive and significant results across quantiles in low-technology industries. This finding is consistent with previous studies stating that the firm's size, measured either by total asset or total size, is one of the main determinants for FDI (Kathuria, 2001). In terms of classification by industry, however, the study's findings contradict Schumpeterian theory, which postulates that large industries are generally more innovative than their smaller counterparts due to better technology and a high level of absorptive capacity (Fisher & Temin, 1973; Schumpeter, 1934; Shefer & Frenkel, 2005).

In this study, the positive influence of firm size on FDI spillover is evident in the lower quantile until the 75th quantile of conditional FDI distribution. This finding is in line with the Malaysian government's intention of focusing on aspects, such as the provision of industrial sites and infrastructure facilities that could facilitate foreign investment (EPU, 2016). For foreign investors, this could reduce the cost of providing the basic facilities required and thus lead to a high return of foreign companies operating in the manufacturing industry. Past studies have confirmed that factors, such as low labour cost and the availability of adequate physical infrastructure in low-technology and small-sized firms are the main determinants of MNCs' location choice (Kathuria, 2001).

5. Conclusion and Policy Implication

The study performed quantile regression analysis to examine how workers' absorptive capacity level in assimilating and imitating the overflow of foreign technologies through 'demonstration-imitation' or 'learning effects' can increase FDI inflows in low-technology industries. Overall, low-technology industries will begin to benefit from FDI if the domestic investment in technology and R&D and the effect of firm size attain the 50th absorption quantile. Therefore, it can be concluded that all the absorptive capacity proxies used in this study can attract around 20% to 26% of technology spillover from foreign companies into Malaysian low-technology industries.

The percentages show that the capacity of low-technology industries to attract FDI is less than 50%. Therefore, this study suggests the establishment of large-scale training institutions with comprehensive and extensive training policies at all education levels. These policies should not only focus on tertiary-level students to increase their future productivity, but also school leavers to reduce the risk of unemployment.

For the latter group, the initiative can be implemented through the introduction of pre-vocational subjects for a few hours in school. In addition, creating a post-school skills centre equipped with materials and tools for practical skills as well as teaching trained instructors is among the best alternatives. However, all these proposed efforts to improve their knowledge in manufacturing, machine learning and data technology require policy considerations and financial support from the government.

Given the rapidly changing employment landscape in the Fourth Industrial Revolution, this study recommends that universities formulate comprehensive policies to enhance collaboration with industries to accept lecturers for short courses and industry attachments, apart from merely involving industries in curriculum formulation. A special body can be established at the university level to channel industry-related information as initial preparation to lecturers. This will enable current experience in the industry to be transformed into the formulation of new curricula, and channel to students the actual skills required by the industry.

This study also reveals that institutions of higher learning should continuously improve the quality of teaching by incorporating added value skills, especially in terms of communication skills, critical thinking, creativity, and entrepreneurship. This can be implemented through periodic monitoring carried out by a special team established in said institutions.

Interestingly, this study found that the absorptive capacity of local firms in their own investment activities reached higher coefficient values from the lower until 75th quantile of conditional FDI distribution as compared to the human capital proxy. This finding should motivate the government to increase domestic investment in order to raise the technical capability and profitability of domestic firms, resulting in a high capital return for FDI. To encourage local firms to engage in R&D activities, special subsidies and tax exemptions should be given, which will in turn promote FDI inflows into the industry.

Lastly, this study proposes using a survey to assess and measure the labour absorptive force in the FDI technology transfer process. This should be conducted inherently through the presence of MNCs in domestic firms, as the measurement is fundamentally complicated and capacity overflow proxies exist in the study. More interestingly, future studies can conduct surveys to assess and measure the level of absorptive capacity of labour and firms according to the mechanisms of technological spillover brought by FDI. Such a survey could inform the government to focus on specific policy training and education in attracting more FDI inflows.

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Appendix 1: Summary Statistics for Variables in Low-technology Industries, 2000-2018

Variables	Definition of Variables	Observations	Mean	Standard deviation	Min	Max
FDI spillover (SFDI)	The number of foreign firms in Malaysian manufacturing sector by industry classification as a percentage of the total number of foreign firms in a two-digit industry sector in a year	76	4.002	0.413	3.401	4.883
Lagged FDI Spillovers ($SFDI_{i,t-1}$)	Lagged of number of foreign firms in Malaysian manufacturing sector	76	3.982	0.420	3.367	4.875
ACP_ DEGREE	Absorptive capacity for degree-holding workers is measured as (percentage of degree-holding workers from total employment) * (percentage of the total number of foreign firms)	76	3.945	0.549	1.887	4.943
ACP_ DIPLOMA	Absorptive capacity for diploma-holding workers is measured as (percentage of diploma-holding workers from total employment) * (percentage of the total number of foreign firms)	76	1.981	1.359	0.642	8.660
ACP_MCE	Absorptive capacity for workers with MCE/MCEV qualifications is measured as (percentage of workers with MCE/MCEV qualifications from total employment) *(percentage of the total number of foreign firms)	76	4.075	0.494	1.281	4.717
ACP_DEGREE^2	The quadratic effects of degree -holding workers' absorptive capacity squared	76	2.285	2.131	0.693	11.180
$ACP\_DIPLOMA^2$	The quadratic effects of diploma -holding workers' absorptive capacity squared	76	3.955	2.715	1.308	17.320
ACP_MCE^2	The quadratic effects of MCE/MCEV workers' absorptive capacity squared	76	8.149	0.989	2.542	9.434
RD_EXP	R&D expenditure (share of R&D expenditure from total R&D expenditure)	76	9.688	1.716	6.973	14.102
ICT_EXP	ICT investment expenditure (share of ICT investment expenditure to gross domestic product)	76	8.831	1.394	6.080	12.851
PDI	Private domestic investment from local investors (share of private domestic investment from total private domestic investment)	76	3.945	0.549	1.887	4.943
FS	Firm size (industrial sales revenue in the sub-sector divided by the number of total industries)	76	12.853	0.7908	11.761	14.712