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High Technology Trade, Innovation and Economic Growth: Evidence from Aggregate and Disaggregate Trade Products

(Perdagangan Teknologi Tinggi, Inovasi dan Pertumbuhan Ekonomi: Bukti dari Produk Perdagangan Agregat dan Disagregat)

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ABSTRACT

This study evaluates the effect of high-technology trade on economic growth in an emerging economy, using quarterly data from 1990 until 2018. The role of innovation in moderating the high technology trade - economic growth nexus also emphasize. The empirical findings based on the autoregressive distributed lag (ARDL) approach reveal that high-tech trade, foreign direct investment and physical capital stock are statistically significant determinants of economic growth. The innovation must be presence to support or moderate the effect of high-tech industry on economic growth. Moving into subsector, the findings indicate that the development of machinery and transport equipment, mineral fuels and lubricants, manufactured goods and chemical sectors are crucial as the niche areas of focus for policy design and resource allocation. The results are robust using the fully modified ordinary least squares (FMOLS) estimation.

Keywords: High technology; technological innovation; economic growth; ARDL; FMOLS; Malaysia
JEL: O32, F14, F62, O11

ABSTRAK

Kajian ini menilai kesan perdagangan teknologi tinggi terhadap pertumbuhan ekonomi di Malaysia, menggunakan data suku tahunan dari tahun 1990 hingga 2018. Peranan inovasi dalam mempengaruhi hubungan perdagangan teknologi tinggi - pertumbuhan ekonomi juga ditekankan. Hasil dapatan empirik berdasarkan pendekatan autoregresif taburan lag (ARDL) menunjukkan bahawa perdagangan berteknologi tinggi, pelaburan langsung asing dan stok modal fizikal adalah penentu pertumbuhan ekonomi secara statistik. Inovasi mesti wujud untuk menyokong atau mengurangkan kesan industri teknologi tinggi terhadap pertumbuhan ekonomi. Beralih ke subsektor, hasil dapatan kajian menunjukkan bahawa pembangunan mesin dan peralatan pengangkutan, bahan bakar mineral dan pelincir, barang perkilangan dan sektor kimia adalah penting sebagai bidang tumpuan utama untuk reka bentuk dasar dan peruntukan sumber. Hasil dapatan masih kukuh dengan menggunakan anggaran kuasa terkecil (FMOLS) diubah sepenuhnya.

Kata kunci: Teknologi tinggi; inovasi teknologi; pertumbuhan ekonomi; ARDL, FMOLS; Malaysia

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INTRODUCTION

Malaysia welcomes the start of the new millennium with great confidence as Malaysia holds one of the best economic performances in Asia. According to World Economic Outlook, Malaysia's economy is the third largest in Southeast Asia and the 35th largest economy in the world in 2018. Figure 1 shows that Malaysia's GNI per capita has a steady growth pattern. The GNI per capita is recorded as 6,530 PPP Dollars in 1990, 11,880 PPP Dollars in 2000, 20,020 PPP Dollars in 2010, and 30,650 PPP Dollars in 2018. The progress of GNI per capita throughout the years was steady but the increase was marginal. In 1979, World Bank has defined Malaysia as an upper middle-income country. Subsequently, it slide back to lower-middle income status, and, although it has regained upper-middle income status in 1991, nevertheless, it has not been able to join the group of high-income countries (Felipe et al. 2012). Malaysia belongs to the upper-middle income group based on the World Bank standard classification. The middle-income trap refers to certain countries that stuck in a certain range of income distribution and unable to gain high-income status (Cherif & Hasanov 2015), which, exactly explained through Malaysia's GNI per capita performance.

One possible reason for middle-income trap pointed on productivity slowdown as advantages from low-cost labour and technology imitation shrinks as countries go through the stages of development. New sources of growth, such as benefits from sectoral allocation from agricultural to manufacturing, are needed to move a low-income country to middle-income country. As the process continues, innovation-driven growth – the use of new ideas, methods, processes, and technologies in production – rather than imitation (Aghion & Howitt 1992) is the key to leap out from middle- income trap. Country must constantly produce new ideas by adopting and developing new technologies to develop sustainable growth. Lucas (1993) argued that learning-by-doing is the most prominent channel to accumulate knowledge and human capital. Doing the same set of goods would stagnate production, while, introducing new goods and tasks would allow managers and workers climb up the "quality ladder" through continuous learning. Lucas (1993) further argued that the country has to do this on a large scale and must be a large exporter. Hence, trading in innovation-based goods will benefit a country from being stuck at the middle-income trap (Kayalvizhi & Thenmozhi 2018). Malaysia has a relatively small market within the region, thus, exploring into markets beyond its borders is crucial in order to sustain growth.

"High technology" firm or industry is commonly used to refer to any firm or industry that embodies products or services with the most innovative and advanced technologies (Seyoum 2004). Extensively, high technology trade involves exports and imports of products under the Standard International Trade Classification (SITC – Rev. 1)[1] and the Organisation for Economic Co-operation and Development (OECD) defined it as the manufacture of technical products with high R & D intensity turnover (Keeble & Wilkinson 2000). These sectors include food; beverages and tobacco; crude materials, inedible; mineral fuels, lubricants, etc.; animals and vegetables oils and fats; chemicals; manufactured goods; machinery and transport equipment; miscellaneous manufactured articles; and, miscellaneous transactions and commodities. Table 1 shows the performance of high technology exports of Malaysia from 1990 until 2019. Starting from 1990, high technology exports recorded an export value of RM 79,646.4 million, which contributed 38.2% of total exports. Comparing the progress a decade later, high technology exports recorded value of RM 373,270.3 million, implying a contribution of 60% of total exports, which has been the highest so far. Lastly, in 2019, high technology exports recorded at RM 986,402.5 million which contributed to 53.7% of total exports.

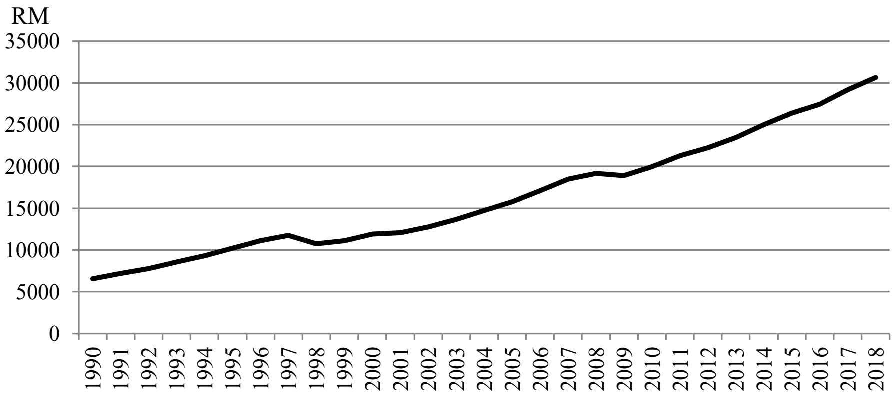

FIGURE 1. GNI per capita of Malaysia (year 1990 – 2018)
Source: World Development Indicators

TABLE 1. Malaysia's High Technology Export Performance (1990 – 2019)

Year	High Technology Exports (RM million)	High Technology Exports (% to total export)
1990	79,646.4	38.2
1995	184,986.5	46.1
2000	373,270.3	59.6
2005	536,233.7	54.6
2010	638,822.5	44.5
2015	777,355.1	42.8
2019	986,402.5	53.7

Source: Malaysia External Trade Statistics

This study examines the role of high technology trade (aggregate and disaggregate levels) in promoting economic growth in Malaysia. Previous literatures have highlighted the significance effect of trade openness or trade liberalisation (at an aggregate level) on economic growth, but the role of high technology trade in influencing economic growth is still limited. This study intends to contribute to the literature gap by fulfilling the importance of high technology industry (and selected subsectors) in order to generate high impact growth to leap Malaysia out of middle-income trap. Sustained economic growth in the industry can only be achieved with the presence of continuous innovation effort that creates new high technology product in the market. Thus, this study extends the indirect effect via the interaction of innovation to selected subsectors of high technology industry that creates the sustained economic growth. Eventually, the study stressed the effect of high technology trade to boost economic growth by taking into account of innovation to boost higher economic performance.

Malaysia has participated in all ten sectors listed under the SITC-Rev.1 definition. Amongst all these sectors, only five sectors contribute to a larger composition of high technology trade. These five sectors are: (1) Machinery and Transport Equipment, (2) Mineral Fuels, Lubricants, etc., (3) Manufactured Goods, (4) Chemicals, and, (5) Miscellaneous Manufactured Articles. These five selected sectors have contributed to almost 85% of the total high technology trade. Therefore, it is the interest of this study to focus on these highly performed sectors. The development of high technology products is in accordance with the national policy of Malaysia. In response to the Fourth Industrial Revolution (Industry 4.0), the Industry4WRD was launched on October 31st, 2018 under the governance of the Ministry of International Trade and Industry (MITI). The three main visions of the policy are (1) to form strategic partnership for smart manufacturing and related services in Asia Pacific, (2) to become the total solutions provider for advanced technology, and finally, (3) to become the primary destination for high technology industry. These visions are aimed to create innovation capacity and high skilled jobs to the nation. Hence, it is believed that high technology industry could be the stepping stone for achieving high income status.

However, innovation driven economy necessitates proficiencies to deal with requirements of knowledge-intensive and industries-based skills. Moreover in the case of high technology industry, where there is an urgent need of human capital to enhance technological capability and capacity (Xu 2000; Harbi et al. 2009; Liu & Xia 2018). One of the measures is to increase the nation's capability by adopting and developing science and technology through research and development and innovation (Kayalvizhi & Thenmozhi 2018; Sultana & Turkina 2020). Since the creation of Intellectual Property Corporation of Malaysia (MyIPO), a collective

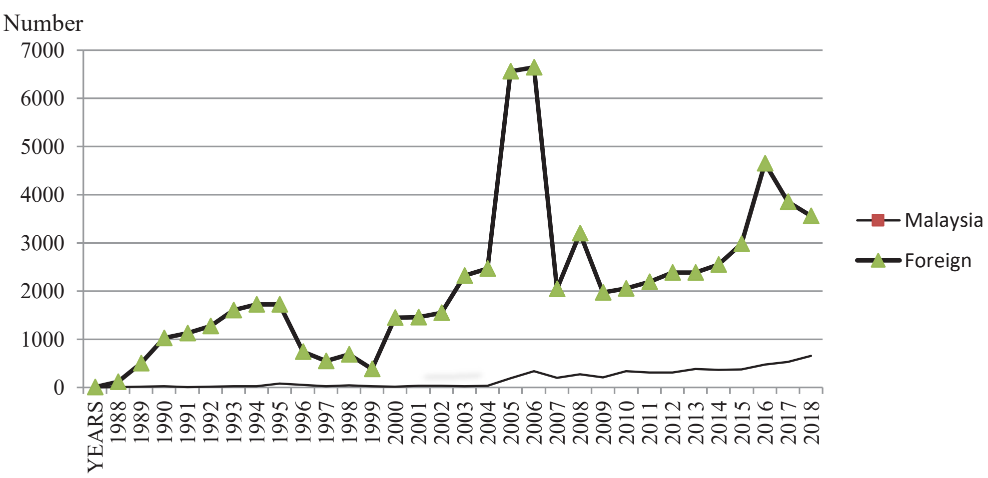

FIGURE 2. Granted Patents and Utility Innovations (1988 – 2019)
Source: MyIPO

number of patents have been given to local companies. However, it merely reached 10% of total patents granted. Figure 2 shows that patents issued to Malaysians have risen by sixty-fold during the period of 1988 and 2019. Nevertheless, most of the patents are given to multinational companies (MNCs) that are operating in the country. Leaving aside individually-owned patents, only four local organisations were granted five or more patents each between 2003 and 2007, namely; Silterra, Malaysian Palm Oil Board (MPOB), Harn Marketing, and Universiti Putra Malaysia (UPM). Interestingly, these patents have a connection with high technology products – chemistry and metallurgy, operational technology, electricity, and physics.

Large multinational companies (MNCs) continue to dominate in the Malaysian economy (Chandran Govindaraju & Wong 2011; Ahmed 2012). On an average basis, approximately 5.5% of total firms in Malaysia are actively engaged in innovation activities. These are mostly multinational firms that conduct high-end researches in Malaysia, such as Hewlett Packard, Motorola, Intel, and Dyson. Research activities generally involved electrical and electronics (E&E), chemicals, food and beverages, rubber and plastics, and automotive products. Apart from these multinational firms, several other large companies are engaged in semiconductor device manufacturing and active solid-state devices such as Agilent Tech. and Chartered Semiconductor can also be seen. However, small and medium-sized companies, which made up around 95% of the total firms in Malaysia, have minimal linkages with larger firms. The significant presence of multinational companies offer the country with strong export-oriented platforms, which are only limited to transmitting technological capabilities to home-grown companies and in proliferating the connection with the domestic economy. In order to enter into an innovation-led and high-income economy, technological learning by domestic enterprises with their foreign subsidiaries needs to be broadened.

The remaining of this paper is structured as follows: Section 2 reviews the related literature. Section 3 describes the empirical model, econometric methodology, and data employed. Section 4 reports the empirical results and interprets the findings, while the final section concludes the discussion.

LITERATURE REVIEW

The growth experience during the 1970s and 1980s had given rise to a revival of interest in the theories of long waves of economic and social development. Economists generally refer to these theories of long waves as Kondratiev long waves after the Russian economists who analysed and popularised the idea of long cycles. The theories of long waves were also advanced by Schumpeter (1939), who attempted to demonstrate the importance of technical innovation on economic growth. The Theory of Long Waves, according to the tradition of Schumpeter, postulated that long term economic development will be subjected to cyclical fluctuations. Schumpeter (1939) suggested that the ability and initiative of entrepreneurs – drawing upon the discoveries of scientists and investors – will create new opportunities for investment, growth, and employment. The earnings generated from these innovations are the deciding instinct for a novel flow of growth and acts as indicator for imitators. The cycle (each consisting of growth, prosperity, recession, and depression) differs in length and are merely attributed to basic innovation of individual entrepreneurs in the new sector of technology such as high technology sector in Malaysia. When the old basic innovation is exhausted, the yield of the corresponding investment diminishes, and a period of economic weakening follows. Hereafter, the incentive for a new innovation is there (Sternberg, 1996).

Apart from the fundamental postulation of the theory which was centered on the mechanisms of Schumpeter (1939), Mensch (1975) and Freeman et al. (1982), there also exists substantial differences on causes, validity, length and number of long waves, but their presence is generally undisputable. The differences between growth rates among different sectors are obvious and well-known. Energy and transport sectors are obvious examples in this case (Freeman et al. 1982). Most R&D intensive industries tend to grow faster and larger. Most of these industries do not even exist before the century. With industries such as electronics, aerospace, pharmaceuticals, scientific instruments, and synthetic materials, it is fairly clear that these industries with extreme growth rates are associated with clusters of technical innovations. At the other extreme, industries with less or no R&D tend to shrink or even stagnate. Hence, this study contributes to the literature when applying the theory to high technology industries emphasising on the importance of continuous R&D to enhance significant waves to economic development in accordance with the view of Schumpeter's technology-push factor on high technology industry, as a whole and on sectorial levels. Using a sample of 20 major high technology exporting countries from 2007 to 2016, Idris et al. (2021) investigate the impact of high technology trade on national competitiveness. The panel estimation results reveal that both high-tech exports and imports positively affect national competitiveness. The high-tech exports promote technological development and improve national competitiveness. The high-tech imports act as a mechanism for technology transfer and positively influence national competitiveness

Numerous studies have been done on the correlation between trade and convergence (Samuelson 1971; Stiglitz 1970; Deardorff 1986; Barro & Sala-i-Martin

1992). Baldwin (1992) explained how trade liberalisation could lead to dynamic gains for a country well equipped in capital by raising its rate of return and further encourages investment. On the other hand, relatively poor countries will experience dynamic losses in trade liberalisation as the rate of return and investment has been lowered comparatively. In other words, free trade diverge cross-country endowments as richer countries continue to gain more from trade. Matsuyama (1996) generated a model where poor nations only specialise in low technology production. Rich nations become richer because they specialise in high technology production. Two main effects of trade openness on technology absorption can be easily summarised. First, the 'pull effect' indicates the higher the degree of openness, the larger the chances of imitating and learning from outside (Grossman & Helpman 1991). Secondly, the 'push effect' stresses on the higher the outer competition, the larger the spending on R&D to penetrate competition in the international market (Holmes & Schmitz 2001). Many empirical findings (Boer et al. 2001; Comin & Hobijn 2004; Lai et al. 2006) support the positive effects on technology spillover.

However, new issue has been raised regarding the accuracy of the data representing high technology trade. These figures could not reflect the origin of high technology product. Xing (2012) argued that most high technology products from China are indeed intermediate products – parts and components are imported and assembled and/or processed into final goods before exporting to other countries. China, who is not the owner of the products, gets the credit for the export of final goods. The environment of Asian export is especially complicated as exports were always associated with production network of multinational enterprises. The growth in vertical FDI allows for more complex cross-border production chains which are managed and operated through the firm's networking (Hayakawa & Matsuura 2009; Tang & Zhang 2016). Examples are mostly obvious in machinery industries, which involve large numbers of parts and components being fragmented to complete the production process (Kimura & Obashi 2011). Coe and Helpman (1995) are among pioneers in examining R&D spillovers through international trade on domestic TFP (output). Their estimation suggests that local R&D has a positive impact on TFP, yet foreign R&D has a stronger impact than local R&D. Coe et al. (1997) extended the sample and found that TFP in less developed countries is positively significant to the R&D of their industrial partner – United States being the main spillover as United States is the main trading partner. Besides, Acharya and Keller (2009) demonstrated that productivity impact of international technology transfer frequently surpasses that of domestic R&D, especially in high technology manufacturing.

Import substitution policies practiced by most developing countries, such as Malaysia in the 1960s, have failed to produce the type and level of innovation activities that carries high opportunity costs, and thus, are not exposed to international market competition (Pack 1992). This has been argued as one of the reasons that immobilise catching-up *vis-à-vis* with advanced countries. Hence, foreign trade reforms implemented by developing countries since the 1980s could encourage the "exact" kind and amount of innovation activities to the country, which are important to sustain economic growth (Pamukcu 2003). Probably this could be the reason why there is increasing number of studies highlighting on innovation behaviours in developing countries[2]. Consequently, less developed economies could have benefitted most from diffusion-based trade as the prime entrée to innovation via interaction with leading countries and its partners. With trade, open accesses to fresh products and ideas have been established. Developing economies (non-innovative countries) indeed gain more from trade with innovative countries (Yanikkaya 2003).

However, the idea could be backward-looking as well. When poorer countries get to absorb new production technology, which eventually enhances their stock of available knowledge, it could promote further growth by triggering more innovation in richer countries to maintain competitiveness (Rodrik 1999). Hence, trade between two countries could commence another virtuous cycle of innovation-imitation-innovation, and thus, benefit from trade to all actors (Grossman & Helpman 1990; Aghion & Howitt 1998). Hence, the empirical findings remained inconclusive with some studies claimed positive linkages between trade openness and economic growth (Chang et al. 2009; Kim 2011; Jouini 2015), while others claimed no linkages, or even a negative linkages (Musila & Yiheyis 2015; Ulasan 2015). Kim and Lin (2009) found that greater openness to trade promotes economic growth for high income countries, however, hampers economic growth for low income countries. The literature is questionable as different proxies are used for international trade which relies on different analysts. This study employs high technology trade and its subsectors for the first time and adopts ARDL and FMOLS to examine the interaction with innovation performance on a transition country on economic growth.

METHODOLOGY

The Theory of Long Waves, in part by Joseph Schumpeter, attends to the value of innovation activities to postulate long term economic growth. According to Schumpeter's theory of creative destruction, entrepreneurs are motivated by the quest for profit to seek advantage of competitors via developing greater products, new techniques, new markets, or more efficient production methods. Schumpeter made his point that innovation occurs because entrepreneurs stand to reap some benefit from producing better, cheaper, and more convenient products. New innovations are created because it is indeed profitable to innovate. Economic growth not only depends on the stock of physical capital, as well as, the quality of capital (Schneider 2005). Looking at the scope of the study, focus should be weighted on the role of high technology trade and innovation activities in promoting a faster catch-up process with the intention of joining the high-income club convergence. The rationale behind the idea is that the high technology sector is an industry that embodies great length of technological intensity. The learning-by-doing and imitating, as well as genuine innovation will be created in order to remain competitive in the international market operation. Both activities will boost the nation's total factor productivity (TFP), and thus, creating income opportunities to the society.

A simple Cobb-Douglas production function has been popularised by many scholars (Schneider 2005; Sterlacchini & Venturini 2011; Souare 2013) and is modified in this study to look into the effect of high technology trade and innovation into fostering economic growth.

$$Y = AK^{\alpha} L^{\beta}$$

From the equation above, *Y* represents the total production in the economy. *K* is the level of capital stock, and *L* is the total labour-force in the country. *A* represents the total factor productivity (TFP) of an economy. Solow (1956, 1957) also mentioned TFP as "something else" for the bulk of output growth in an economy apart from physical and human capital accumulation (Ahmed & Krishnasamy, 2011; Munusamy & Rajamoorthy, 2020). Modifications of Schneider (2005) yields,

$$Y_t = A_t^{\sigma} K_t^{\alpha} L_t^{\beta}$$

$$where \;\; A_t = f\left(HTRD_t, IN_t, FDI_t\right)$$

A, therefore, represents both variables of interest that contribute to the growth of TFP,hich is high technology trade (*HTRD*) and innovation (*IN*) and foreign direct investment (*FDI*). An augmented production function can be built in which variables of interest enter as explanatory variables. Transforming the production function into logarithm form yields,

$$\begin{aligned} ln\,Y_t &= \beta_0 + \sigma_1 ln\,HTRD_t + \sigma_2 ln\,IN_t + \sigma_3 ln\,FDI_t \\ &+ \alpha ln\,K_t + \beta ln\,L_t + \mu_t \end{aligned} \quad (1)$$

where Y_t represents real GDP per capita, $HTRD_t$ represents the total high technology trade, IN_t represents the total innovation rate, FDI_t measures the inflows of foreign direct investment into the country, K_t represents the total physical capital stock, and L_t represents labour force growth. As interest shifts into the subsector of high technology trade, thus, $HTRD_t$ will be substituted by five chosen subsectors, which are (i) Machinery and Transport Equipment (MTE_t); (ii) Mineral Fuels, Lubricants, etc. (MFL_t); (iii) Miscellaneous Manufactured Articles (MMA_t); (iv) Manufactured Goods (MG_t); (v) Chemicals (CEM_t)

Referring to the modified version of Teixeira and Fortuna (2010) to include interaction terms of technological absorption capability to generate innovation for sustain growth in high technology trade industry (HTRD * IN), and modified version of Schneider (2005) to include individual effects by segregating high technology industry into five selected subsector, thus,

$$\begin{aligned} lnY_t &=_0 +_1 lnIN_t +_2 lnHTRD_t +_3 ln\left(HTRD * IN\right)_t \\ &+_4 lnFDI_t +_5 lnK_t +_6 lnL_t + \mu_t \end{aligned} \quad (2)$$

where HTRD consists of five high-technology sectors namely: MTE, MFL, MMA, MG and CEM. (*HTRD * IN*) is an interaction term between high-tech sector and innovation.

The interest of which subsequent sectors of high technology industry could contribute to economic growth is represented by Equation (1). Equation (2) takes into the account interaction of these chosen sectors with innovation specification. In order to provide comprehensive findings, each sector with interaction of innovation is tested separately as shown from Equations (3) – (7).

$$\begin{aligned} lnY_t &= \beta_0 +_1 lnIN_t +_2 \ln MTE_t +_3 ln\left(IN * MTE\right)_t \\ &+_4 lnFDI_t +_5 lnK_t +_6 lnL_t + \mu_t \end{aligned} \quad (3)$$

$$\begin{aligned} lnY_t &= \beta_0 +_1 lnIN_t +_2 \ln MFL_t +_3 \ln(IN * MFL)_t \\ &+_4 lnFDI_t +_5 lnK_t +_6 lnL_t + \mu_t \end{aligned} \quad (4)$$

$$\begin{aligned} lnY_t &= \beta_0 +_1 lnIN_t +_2 \ln MMA_t +_3 \ln\left(IN * MMA\right)_t \\ &+_4 lnFDI_t +_5 lnK_t +_6 lnL_t + \mu_t \end{aligned} \quad (5)$$

$$\begin{aligned} lnY_t &= \beta_0 +_1 lnIN_t +_2 \ln MG_t +_3 ln\left(IN * MG\right)_t \\ &+_4 lnFDI_t +_5 lnK_t +_6 lnL_t + \mu_t \end{aligned} \quad (6)$$

$$\begin{aligned} lnY_t &= \beta_0 +_1 lnIN_t +_2 \ln CEM_t +_3 ln\;(IN * CEM)_t \\ &+_4 lnFDI_t +_5 lnK_t +_6 lnL_t + \mu_t \end{aligned} \quad (7)$$

If the interaction of innovation with subsectors (i.e. IN * MTE) is proved to be significant, thus, innovation is said to boost the growth of subsectors, and ultimately, creating new addition to existing product and boosting high impact growth to the country (Schneider 2005; Mani 2000; Kumar & Siddharthan 1997; Ahmed 2012; Ron et al. 2020). To reduce the collinearity problem, the interaction term variables between innovation and five sectors is used the demean approach suggested by Balli and Sorensen (2013). This approach computes the mean of the variables, then each observation will deduct the mean. For example, (IN - $\overline{IN}$) * ($MTE - \overline{MTE}$), where $\overline{IN}$ and $\overline{MTE}$ are the mean of the IN and MTE, respectively.

THE DATA

The sample periods of this study is covering from 1990 to 2018 using the quarterly data. The real GDP per capita (Y), innovation (IN), physical capital stock (K) and labour force growth (L) are collected from Malaysian Department of Statistics (DOS). The foreign direct investment (FDI) is obtained from the United Nations Conference on Trade and Development (UNCTAD). All datasets are transformed to natural logarithm form. Data for subsectors of high technology trade, namely Machinery and Transport Equipment (MTE); Mineral Fuels, Lubricants, etc. (MFL); Miscellaneous Manufactured Articles (MMA); Manufactured Goods (MG); Chemicals (CEM); are collected from the Malaysian Department of Statistics (DOS) under SITC 1-Digit and expressed in RM million.

Real GDP per capita (Y) is the dependent variable in this study. Foreign direct investment (FDI) refers to the inflows which is expressed in millions of dollars and this variable is converted to Malaysian ringgit. Innovation rate (IN) measures the number of patent applications by residents and non-residents of the country which were filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention. Physical capital (K) is a factor of production and an input to the production process, which is proxied by the gross fixed capital formation over GDP that includes land improvements; plant, machinery and equipment purchases; and the construction of roads, railways and the like. Finally, labour force (L), which is used in both production and innovation activities, is the annual percentage of labour growth rate.

AUTOREGRESSIVE DISTRIBUTED LAG (ARDL) ESTIMATION

To estimate he above models, this study utilizes the Pesaran et al. (2001) the Autoregressive Distributed Lag (ARDL) model that estimates the bounds cointehgration, long-run estimation and short-run dynamic adjustment relationships. ARDL model also captures the effects from lagged independent and dependent variables, and by comprising sufficient number of lags, to eliminate serial correlation in the errors (Hill et al. 2012). Furthermore, the asymptotic distribution of the F-statistics is non-standard under the null hypothesis of no cointegration between the examined variables, irrespective of whether the explanatory variables are purely *I(0)* or *I(1)*, or mutually cointegrated. In another words, Bounds test allows for the unsynchronized order of integration between interested variables. Hence, it has an edge of without precise identification of order of the underlying data. This multivariate cointegration procedure also deems appropriate for the model as it caters better smaller sample size properties. Therefore, an ARDL testing approach is selected to estimate the model specifications.[3]

Assuming that the linear bounds test leads to the conclusion of cointegration and there is no non-linear relationship, we can estimate the long-run cointegration relationship among the variables as follow based on the Pesaran et al. (2001) uniform lag length (p, p, p, p, p, p) as follows:

$$\begin{aligned} Y_t = {} & \beta_0 + \sum_{i=1}^{p} \beta_1 Y_{t-i} + \sum_{j=0}^{p} \gamma_j \Delta IN_{t-j} + \sum_{k=0}^{p} \delta_k \Delta HTRD_{t-k} \\ & + \sum_{l=0}^{p} \lambda_l \Delta(HTRD \times IN)_{t-l} + \sum_{m=0}^{p} \phi_m \Delta FDI_{t-m} \\ & + \sum_{n=0}^{p} \eta_n \Delta K_{t-n} + \sum_{o=0}^{p} \varphi_o \Delta L_{t-n} + \theta_0 Y_{t-1} + \theta_1 IN_{t-1} \\ & + \theta_2 HTRD_{t-1} + \theta_3 (HTRD * IN)_{t-1} + \theta_4 FDI_{t-1} \\ & + \theta_5 K_{t-1} + \theta_6 L_{t-1} + e_t \end{aligned} \quad (8)$$

The uniform lag length (p) is subject to serial correlation test (if there is a serial correlation problem, then the general to specific approach is used to select different lag length (p, q, r, s, u, v, w). For example, let say ARDL(1,1,1,1,1,1,1) is the optimal lagged model, then the equation is as follows:

$$\begin{aligned} Y_t = {} & \mu_i + \beta\, Y_{t-1} + \delta_1 IN_t + \delta_2 IN_{t-1} + \delta_3 HTRD_t + \\ & \delta_4 HTRD_{t-1} + \delta_5 (HTRD \times IN)_t + \\ & \delta_6 (HTRD \times IN)_{t-1} + \delta_7 FDI_t + \delta_8 FDI_{t-1} + \\ & \delta_9 K_t + \delta_{10} K_{t-1} + \delta_{11} L_t + \delta_{12} L_{t-1} + \varepsilon_t \end{aligned} \quad (9)$$

and the short-run ECM equation is represented as follows:

$$\begin{aligned} \Delta Y_t = {} & \beta_0 + \sum_{i=1}^{p} \beta_i \Delta Y_{t-i} + \sum_{j=0}^{q} \beta_j \Delta IN_{t-j} + \sum_{k=0}^{r} \beta_k \Delta HTRD_{t-k} \quad {}^{s}_{l=0} \\ & + \sum \beta_l \Delta(HTRD \times IN) + \sum_{m=0}^{u} \beta_m \Delta FDI_{t-m} \\ & + \sum_{n=0}^{v} \beta_n \Delta K_{t-n} + \sum_{o=0}^{w} \beta_o \Delta L_{t-o} + \varphi\, z_{t-1} + e_t \end{aligned} \quad (10)$$

where $z_{t-1} = (Y_{t-1} - \alpha_0 - \beta_1 IN_{t-1} - \beta_2 HTRD_{t-1} - \beta_3 (HTRD * IN)_{t-1} - \beta_4 FDI_{t-1} - \beta_5 K_{t-1} - _6 L_1)$ or the error correction term (ECT) and the α and βs are the ordinary least squares (OLS) estimates of the Equation (2). The ϕ in Equation (10) is the short-run equation that contains the ECT that measures the speed of adjustment of the short-run to long-run equilibrium. *p*, *q*, *r, s, u, v* and *w* are the optimal lagged lengths, selected using the Schwarz Bayesian criterion (SBC). Based on this ARDL(1,1,1,1,1,1) model, we can compute the long-run coefficients of the determinants[4]:

$$\varphi_{IN} = \frac{\delta_1 + \delta_2}{1-\beta_i};\ \varphi_{HTRD} = \frac{\delta_3 + \delta_4}{1-\beta_i};\ \varphi_{HTRD*IN} = \frac{\delta_5 + \delta_6}{1-\beta_i};$$

$$\varphi_{FDI} = \frac{\delta_7 + \delta_8}{1-\beta_i};\ \varphi_K = \frac{\delta_9 + \delta_{10}}{1-\beta_i};\ \varphi_L = \frac{\delta_{11} + \delta_{12}}{1-\beta_i};$$

Recently, besides ARDL model, various statistical methods have been used in testing cointegration especially under the condition of non-stationary phenomenon to avoid spurious results. Another method used among time series cointegration analysis is the Fully Modified OLS (FMOLS). Philips & Hansen (1990) applied a two part transformation procedure to remove the asymptotic bias terms which requires an estimation of long-run variance matrices. FMOLS has accounted for serial correlation effects and endogeneity amongst regressors that arises from cointegrating relationship. The difference between FMOLS and ARDL is that it does not involve any stationary or cointegration hypothesis testing. As an alternative, Philips & Hansen (1990) focused more on the estimated coefficient bias rather than the existence of stationary properties in the error term. With different focuses on the band, this method would be suitable as an option for robustness checks.

RESULTS

First, the Augmented Dickey-Fuller test is used to recognise the stationary of the data. Table 2 demonstrates the results of the unit root test for all the variables used. Following Pesaran and Pesaran (1997), Y being the endogenous variable has to be stationary at first difference level. Result from Table 2 suggests Y is stationary at first difference I(1) level. All other variables have to be ascertain at level or first difference altitude. Conclusively, all variables fulfill the stationary condition at first difference I(1) at 1% significance level, onlt the FDI and labour growth (L) are stationary at level or I(0). Therefore, the empirical models support the presence of a unit root in the level of all variables except FDI and labour growth, and the absence of any unit root after the first differencing.

Table 3 reports the result for bound cointegration. As F-statistics of the model is larger than the critical values of the upper bound, null hypothesis – nonexistence of long-run relationship – is rejected at 1-percent significance level. Thus, the result suggests the presence of a steady-state long-run relationship among real GDP per capita of country, innovation rate, foreign direct investment, labour force growth and

TABLE 2. Results of the Unit Root Test

Variables	Augmented Dickey-Fuller (ADF) Test			
	Level		First Difference	
	Intercept without Trend	Intercept with Trend	Intercept without Trend	Intercept with Trend
Y	-1.0979 (0)	-1.9842 (0)	-10.4634*** (0)	-10.4383*** (0)
IN	-0.9648 (0)	-2.6286 (0)	-10.6188*** (0)	-10.5834*** (0)
MTE	-2.2013 (0)	-2.3535 (0)	-11.4784*** (0)	-11.8495*** (0)
MFL	-0.5803 (0)	-2.1076 (0)	-11.1557*** (0)	-11.1076*** (0)
MMA	-1.2259 (0)	-3.1562* (0)	-11.5346*** (0)	-11.5758*** (0)
MG	-1.3992 (0)	-2.6960 (0)	-11.4795*** (0)	-11.5656*** (0)
CEM	-1.6708 (8)	-1.5163 (8)	-1.4239*** (2)	-2.4970** (1)
FDI	-3.6445 *** (0)	-3.7940 ** (0)	-7.7907*** (3)	-7.7550*** (3)
K	-1.4340 (0)	-1.9131 (0)	-10.0130*** (0)	-9.9657*** (0)
L	-3.5038 *** (12)	-3.5434 *** (12)	-1.8530** (11)	-1.8956** (11)

Note: (1) *** indicates the rejection of null hypothesis of non-stationary at 1% significance level.
(2) ** indicates the rejection of null hypothesis of non-stationary at 5% significance level.
(3) The figure in parentheses () refers to the selected lag length.

physical capital stock in Malaysia. After examining for bound cointegration test, the process continues into the estimation of ARDL and cointegration of long-run form.

TABLE 3. Results for Bounds Test – Aggregate Level

Model	F-Statistic	
Y = *f* (HTRD, IN, FDI, K, L)	8.6079***	
	k = 5, n = 100	
Pesaran, Shin and Smith (2001) Critical Value	Lower Bound	Upper Bound
10%	1.88	2.99
5%	2.14	3.3
1%	2.65	3.97

Notes: *, ** and *** denote significant at 10%, 5% and 1% levels, respectively

Table 4 presents the estimated long-run coefficient using ARDL and FMOLS. Table 4 indicates that high-tech trade is positive and statistically significant determinant of Y at 5 percent level. The coefficients of FDI, labour growth and physical capital are also significant determinants of Y, but the labour growth has negative sign. However, innovation is not significant in enhancing Y in long-run. The findings from ARDL are consistent with FMOLS estimation – suggesting robustness in the model. Table 5 reports the estimated short-run dynamic result where FDI and physical have significant impact on Y. Nevertheless, the high tech trade and innovation are insignificant in the short-run. The error correction coefficient is negative and significant, which is consistent with the long-run relation as shown in the bounds cointegration test. The coefficient is 0.6907, which demonstrates that any short-run deviation will take about 1.45 years to move back to the long-run equilibrium or consider high speed of convergence.

TABLE 4. Estimated Long-Run Coefficients – Aggregate Level

Dependent Variable: Y		
ARDL(1, 1, 4, 0, 4, 1)		FMOLS
Variable	*Coefficient*	*Coefficient*
HTRD	0.3425**	0.4127**
IN	0.0405	0.1111
FDI	0.0328***	0.0091**
L	-0.3138**	-0.4955***
K	0.3858***	0.5734***
Constant	6.6079	1.3386

Note: *, ** and *** denote significant at 10%, 5% and 1% levels, respectively

TABLE 5. Short-Run Dynamic ECT Model – Aggregate Level

Dependent Variable: Y ARDL(1, 1, 4, 0, 4, 1)	
Variable	*Coefficient*
DY_{t-1}	0.2587**
$DHTRD_t$	0.2105
DIN_t	-0.1819
DIN_{t-1}	0.1200
DIN_{t-2}	-0.0009
DIN_{t-3}	-0.2397
$DFDI_t$	0.0227***
DL_t	0.3224
DL_{t-1}	-0.2057
DL_{t-2}	0.1096
DL_{t-3}	0.4299
DK_t	0.4056***
ECT_{t-1}	-0.6907***

Notes: *, ** and *** denote significant at 10%, 5% and 1% levels, respectively

To overcome credible difficulties, autocorrelation tests, normality test and Ramsey test are performed and results are reported in Table 6. As the level of significance for all statistics are larger than 0.05, in 95% confidence level, the model fulfills the econometric properties. Figure 3 has the result of CUSUM stability test and the model has passed stability analysis.

TABLE 6. Results of the detection statistics – Aggregate level

Test type	Serial Correlation LM test	Ramsey RESET test	Residual Normality test
p-value	0.2102	0.3019	0.1819

Moving forward from aggregate level to disaggregate level, the analysis continues to look into the effect of innovation into growth of subsectors individually. Table 7 reports the result for bound cointegration. The result suggests the presence of a steady-state long-run relationship among all variables. After examining for bound cointegration test, the process continues into the estimation of ARDL and cointegration of long-run form.

Table 8 summarises the empirical results of long-run coefficients using the ARDL and FMOLS estimations. Model 1 estimates the interaction between innovation and machinery and transport equipment (IN*MTE), the result indicates that innovation, FDI, labour growth and interaction term are statistically significant determinants of real GDP per capita (economic performance). Innovation is indeed important to moderate the positive

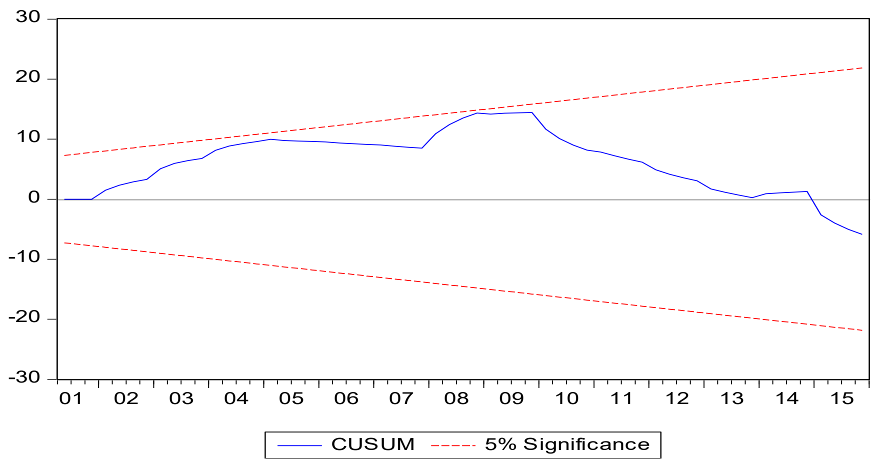

FIGURE 3. CUSUM Stability Test – Aggregate Level

effect of machinery and transport equipment on economic performance. The findings from ARDL model are consistent with the results of FMOLS – suggesting robustness in the model, except for labour force growth. Model 2 reports the interaction between innovation and mineral fuels, lubricants (IN*MFL), the result reveals that the physical capital and interaction term are statistically significant determinants of economic performance in the long-run. Again, innovation helps to moderate the positive effect of MFL on economic performance. The results of ARDL model are consistent with the FMOLS estimation result – signifying robustness of the model. For the Model 3 where the high-tech product is miscellaneous manufactured articles (MMA), the empirical result demonstrates that FDI, labour growth and physical capital have significant impact on economic performance. However, the interaction term (IN*MMA) is insignificant determinant of economic performance. Both findings of the ARDL and the FMOLS estimations are similar, indicating robustness in the model except for labour force growth.

TABLE 7. Results for Bounds Test – Disaggregate Level

Models	F-Statistic	
Y = *f* (IN, MTE, IN*MTE, FDI, K, L)	5.2604***	
Y = *f* (IN, MFL, IN*MFL, FDI, K, L)	6.3915***	
Y = *f* (IN, MG, IN*MG, FDI, K, L)	8.1894***	
Y = *f* (IN, MMA, IN*MMA, FDI, K, L)	6.7073***	
Y = *f* (IN, CEM, IN*CEM, FDI, K, L)	5.9707***	
	k = 6, n = 100	
Pesaran, Shin and Smith (2001) Critical Value	Lower Bound	Upper Bound
10%	2.26	3.35
5%	2.62	3.79
1%	3.41	4.68

Note: *** denotes significant at 1 percent level.

Moving on to Model 4 where the interaction term is between innovation and manufacturing goods (MG), the long-run results of the ARDL model conclude that innovation, FDI, labour growth, physical capital and interaction term are significant determinants of economic performance. The result of ARDL model is mostly consistent with the finding from FMOLS – demonstrating robustness in the model except for labour force growth (L) variable. Finally, the long-run results of Model 5 where the high-tech product is chemical (CEM) indicate that innovation, FDI, labour force growth, physical capital and interaction term are significant determinants of economic performance. The result of ARDL is in line with FMOLS result– indicating the model is robust. Both Models 4 and 5 also demonstrate that innovation tends to moderate the positive effect of high-tech products in enhancing economic performance.

The short-run dynamic estimations of ARDL level relations are presented in Table 9 where the dependent variable is economic growth. Only FDI and physical capital (K) have significant impact in Model 1a. The interaction term (IN*MTE) is insignificant determinant of economic growth in the short-run. The error correction coefficient is 25.72 percent of speed of adjustment. This implies that any short-run deviation will take about 3.88 years[5] to move back to long-run equilibrium. The short-run result of Model 2a demonstrates that innovation, physical capital and interaction term (IN*MFL) are significant determinants of economic growth. The error correction coefficient is 11.96 percent, where any short-run deviation will take about 8.36 years to move back to the long-run equilibrium. For Model 3a, the finding reveals that FDI and physical capital have significant influence on economic growth, but the interaction term (IN * MMA) has no significant impact in short-run. The error correction coefficient is 21.35 percent of speed of adjustment or 4.68 years to move back to long-run equilibrium.

TABLE 8. Estimated Long-Run Coefficients Using ARDL and FMOLS – Disaggregate Level

	Dependent Variable: Y									
	Model 1 (IN x MTE)		Model 2 (IN x MFL)		Model 3 (IN x MMA)		Model 4 (IN x MG)		Model 5 (IN x CEM)	
Variable	ARDL (1,4,2,0,1,1,4)	FMOLS	ARDL (1,1,1,1,0,1,1)	FMOLS	ARDL (1,4,1,1,1,2,4)	FMOLS	ARDL (1,4,1,0,1,1,4)	FMOLS	ARDL (1,1,0,1,1,4,1)	FMOLS
	Coefficient									
IN	0.5769***	0.4519***	0.2373	0.1013	0.1916**	0.2387**	0.2149**	0.2057**	0.3510***	0.3576***
FDI	0.1552***	0.0411**	0.0379	-0.0061	0.1556***	0.0256**	0.1542***	0.0351**	0.1315***	0.0309*
L	-1.1702**	0.3793	-0.8916	0.1301	-1.8675**	0.2802	-1.0124***	-0.0563	-1.0151***	-0.2636*
K	0.2919**	0.4753***	0.5652**	0.7123***	0.4043*	0.5647***	0.2538**	0.5315***	0.2920**	0.5447***
MTE	0.2504	0.2618	-	-	-	-	-	-	-	-
MFL	-	-	0.2382	0.2450	-	-	-	-	-	-
MMA	-	-	-	-	0.2289	0.2314	-	-	-	-
MG	-	-	-	-	-	-	0.2248	0.2346	-	-
CEM	-	-	-	-	-	-	-	-	0.2341	0.2368
IN*MTE	0.5978**	0.0270*	-	-	-	-	-	-	-	-
IN*MFL	-	-	0.2861**	0.2626***	-	-	-	-	-	-
IN*MMA	-	-	-	-	0.0651	0.1775	-	-	-	-
IN*MG	-	-	-	-	-	-	0.2915***	0.2187***	-	-
IN*CEM	-	-	-	-	-	-	-	-	0.1804***	0.0831**
Constant	10.5357	-0.5955	7.9064	0.1647	11.9646	-0.7749	7.6766	0.7256	9.1618	0.2224

Notes: *, ** and *** denote significant at 10%, 5% and 1% levels, respectively.

TABLE 9. Short-Run Dynamic ECT Model – Disaggregate Level

	Dependent Variable: DY (Economic Growth)				
	Model 1a (IN x MTE)	Model 2a (IN x MFL)	Model 3a (IN x MMA)	Model 4a (IN x MG)	Model 5a (IN x CEM)
	ARDL(1,4,2,0,1,1,4)	ARDL(1,1,1,1,0,1,1)	ARDL(1,4,1,1,1,2,4)	ARDL(1,4,1,0,1,1.4)	ARDL(1,1,0,1,1,4,1)
Variable			*Coefficient*		
DY_{t-1}	0.4268***	0.4387***	0.3942***	0.4022***	0.3908***
DIN_t	0.4144	0.1400***	0.2903	0.234	0.1021***
DIN_{t-1}	0.0230	-	0.0091	0.0145	-
DIN_{t-2}	0.0050	-	0.1206	0.0128	-
DIN_{t-3}	0.2443	-	0.3126	0.2491	-
$DFDI_t$	0.0399***	0.0045	0.0332***	0.0431***	0.0285***
$DFDI_{t-1}$	0.0401**	-	-	-	-
DL_t	0.4672	0.4086	0.4751	0.7767**	0.9110***
DK_t	0.4134***	0.4828***	0.4888***	0.4434***	0.4688***
$DMTE_t$	0.2214	-	-	-	-
$DMFL_t$	-	0.2305	-	-	-
$DMMA_t$	-	-	0.2089	-	-
$DMMA_{t-1}$	-	-	0.2106	-	-
DMG_t	-	-	-	0.2208	-
$DCEM_t$	-	-	-	-	0.2215
$DCEM_{t-1}$	-	-	-	-	-0.2106
$DCEM_{t-2}$	-	-	-	-	0.2010
$DCEM_{t-3}$	-	-	-	-	-0.2001
$D(IN*MTE)_t$	-0.3099	-	-	-	-
$D(IN*MTE)_{t-1}$	0.3098	-	-	-	-
$D(IN*MTE)_{t-2}$	-0.4009	-	-	-	-
$D(IN*MTE)_{t-3}$	-0.3497	-	-	-	-
$D(IN*MFL)_t$	-	0.2915***	-	-	-
$D(IN*MMA)_t$	-	-	-0.1728	-	-
$D(IN*MMA)_{t-1}$	-	-	-0.0908	-	-
$D(IN*MMA)_{t-2}$	-	-	-0.1003	-	-
$D(IN*MMA)_{t-3}$	-	-	-0.3530	-	-
$D(IN*MG)_t$	-	-	-	-0.0803	-
$D(IN*MG)_{t-1}$	-	-	-	-0.1000	-
$D(IN*MG)_{t-2}$	-	-	-	-0.2301	-
$D(IN*MG)_{t-3}$	-	-	-	-0.3395	-
$D(IN*CEM)_t$	-	-	-	-	0.0286***
ECT_{t-1}	-0.2572***	-0.1196**	-0.2135***	-0.3648***	-0.2909***

Notes: *, ** and *** denote significant at 10%, 5% and 1% levels, respectively.

Model 4a shows that FDI, labour growth and physical capital have significant impact on economic growth in the short-run. However, the interaction term between innovation and manufacturing goods (IN*MG) is insignificant impact on economic growth. The error correction coefficient is 36.48 percent of speed of adjustment and any short-run deviation will take 2.74 years move back to long-run equilibrium. Model 5a indicates that all variables have significant impact in the short-run including the interaction between innovation and chemical products (IN * CEM). The short-run dynamic results imply that only innovation serves an essential role in moderating the positive effect of chemical high-tech product in influencing economic growth. The error correction coefficient is 29.09 percent of speed of adjustment and any short-run deviation will take 3.43 years to move back to long-run equilibrium. In short, the manufacturing goods (MG) sector has the fastest speed of convergence to long-run equilibrium.

To overcome credible of model diagnostics, the autocorrelation, normality and Ramsey tests were performed and results are shown in Table 10. As the level of significance for all statistics are larger than 0.05, in 95% confidence level, the model fulfills the econometric properties. Figure 4 have the results of CUSUM Stability test and all models have passed stability analysis.

CONCLUSIONS

As the nature of high technology industry carries heavy weightage into research and development, being innovative shall maintain as one important score on sustainability growth. Although enormous amount of literatures support the evidence on the dynamics of trade liberalisation, innovation and economic growth, yet none has emerged from the standpoint of high

TABLE 10. Results of the detection statistics – Disaggregate Level

Model	Test Type and p-value		
	Serial Correlation LM test	Ramsey RESET test	Residual Normality Test
Model 1: IN * MTE	0.1107	0.3307	0.2930
Model 2: IN * MFL	0.6197	0.6753	0.3307
Model 3: IN * MMA	0.2124	0.1485	0.1458
Model 4: IN * MG	0.3001	0.1550	0.1293
Model 5: IN * CEM	0.1801	0.1132	0.2127

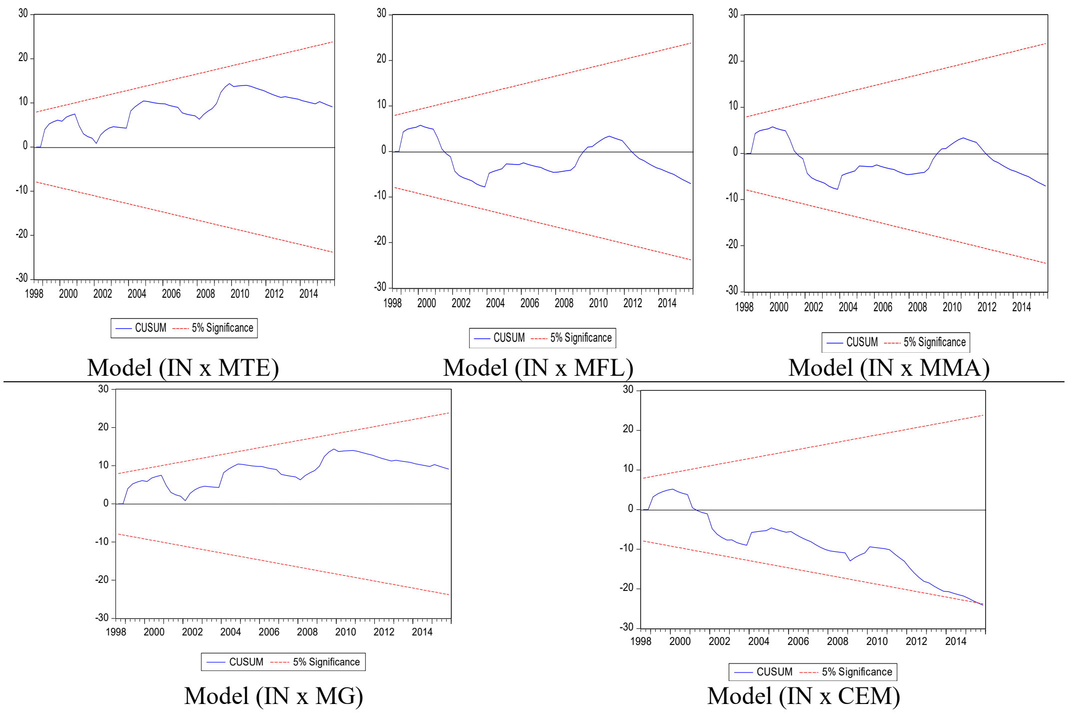

FIGURE 4. Results of CUSUM Stability Test – Disaggregate Level

technology trade. Thus, the aim of this study is to analyse the role that innovation plays in moderating the influence of high technology trade (and selected subsectors) on economic growth in order to stimulate Malaysian economic growth.

On the aggregate level, both foreign direct investment (FDI) and physical capital stock (K) significantly influencing economic growth in both short-run and long-run. Foreign direct investment still maintains as an important channel of knowledge and technology diffusion. It is the main source of access to foreign technology that stimulates economic growth. However, innovation (IN) rate is not significant in both short-run and long-run. It only realise its effect if it is channel properly to specific subsectors – emphasising the role of innovation in moderating the influence of high technology subsectors on economic growth. As physical capital stock (K) also has significant effect, the accumulation of factors of production and inputs of production should not be neglected. The physical capital stock (K) enhances the flow of knowledge and technology diffusion as well. Interestingly, labour force growth (L) does not have enough evidence to significantly influence real GDP per capita (Y) in the short-run, except only to influence real GDP per capita (Y) significantly in the long-run. Additionally, labour force growth has negative significant results in the long-run. This finding suggests that labour growth tends to have diminishing marginal product in the production process.

Moving to the subsector of high-tech trade, the interaction between subsectors and innovation variables reveal that three subsectors, namely machinery and transport equipment (MTE), mineral fuels, lubricants, etc. (MFL) and manufactured goods (MG) play important roles to enhance economic growth. All these three subsectors will only grasp to promising result in the long term, thus, affecting policy design in the long term. The innovation also plays a critical role in moderating of these three high-tech trade in promoting economic growth. High technology sectors are associated with clusters of technical innovation, which only would be significant in long-run as it takes more time to develop. However, innovation does not play a moderating role for miscellaneous manufactured articles (MMA) subsector in influencing economic growth. As a matter of fact, this sector does not thrive in short-run and long-run analysis.

Based on disaggregate level results, mineral fuels, lubricants, etc. (MFL) demonstrates significant results in both short-run and long-run. Only if focus of the economy chooses to develop a single sector independently, therefore, this sector would promote growth. As the goals of economic policies are diversified, it is suggested to promote high-tech products that enhance economic growth in the long-run, hence, leap Malaysia out of middle income trap. Another subsector tends to survive significantly in the short-run and long-run is chemicals (CEM). Chemicals products involve sulphur, oxygen, nitrogen, printer inks, fertilisers, etc., are mostly ingredients (intermediate goods) in much final items sold in markets. The wide and common use of chemicals items creates a demand in the international markets. Under the disaggregate level, chemicals sector is also the sector that shows significant influence on growth in short-run and long-run. This sector is currently the fifth largest trading sector in Malaysia. Policies that enhance innovation activities especially on chemical products will ensure greater competitiveness in the global market. Last but not least, the study has confirmed the important role that innovation plays in moderating the high technology trade and subsectors' performance. Policies that cultivate future researchers must not be neglected to ensure long term growth performance of high technology trade.

In a nutshell, policy implications for the culture of innovation and, subsectors that boost economic development shall not be neglected. In line with the current 12th Malaysia Plan 2021 – 2025, the Malaysian government plans to enhance the level of innovation and technological development. The Malaysian government has put emphasis on science and mathematics in recent years, and thus, shall be continued in future development of education reforms. Ever since the First National Science and Technology Policy have been formulated, the cultivation of research environment is steadily progressing. The Ministry of Science, Technology and Innovation (MOSTI) has to provide more grants, favorably to the subsectors that show statistically significant results. Capital accumulation through innovation contributes to growth as it makes technological progress of the economy possible. The Malaysian government has accentuated Industrial Revolution 4.0 to attract more public and private entities to focus on capital accumulation and innovation. Government policies that promotes direct and enhance capital exchange and refinement in the country should be given priority. Government is advisable to adjust policies for technology parks, with emphasis given to institutions related to these subsectors that thrive in the analysis. This could be implemented by providing these firms more autonomy from public administration, developing more structural links with universities and promoting co-operation spirit among enterprises. The transition into an innovation driven economy is a must and efforts for boosting research and development are vital for long term economic development.

NOTES

1. Full list could be obtained at http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/Annexes/ htec_esms_an4.pdf
2. Noticed Katrak (1990), Basant (1993), and Kumar and Saqib (1996) for India; Braga and Willmore

(1991) for Brazil; Pamukcu (2003) for Turkey; Guimon et al. (2018) for Chile; Kayalvizhi and Thenmozhi (2018) for emerging markets; etc.

[3] Stoian and Iorgulescu (2020) used an ARDL approach to analyze the fiscal policy and stock market efficiency in Romania, and Gamal et al. (2019) also used the same approach to examine the currency demand function and the shadow economy in Malaysia.

[4] The long-run coefficients depend on the lag structure of the ARDL model; thus, different lags will yield different model specifications and derive different long-run elasticities equations.

[5] 25.72% in 4 quarters, the full adjustment occurs in 100%. Therefore, 4 quarters / 25.72% x 100% = 15.55 quarters or 3.88 years.

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