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# Commercialization of High-Tech Innovations and Economic Growth in The Worldwide Most Innovative Countries

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## **Abstract:**

*This study aimed to reconfirm the factors that caused the differences from the results of previous studies related to the relationship of R&D expenditures, the number of patent applications high-tech exports and economic growth (GDP). Cause of these differences related to the research objects, observation time and the data choice used.*

*Therefore in this study, the research objects were selected 51 countries listed in the 2018 global innovation index, which are then grouped into high-income countries, upper-middle-income, and lower-middle-income. In addition, there are also three alternative choices of data that are used to represent high-tech export variables and economic growth variables.*

*From the analysis conducted it is found that innovation activities could affect the economic growth of high-income countries in the long term and the short term.*

**Keywords:** Innovation, Economic Growth, FDI, High-tech Export

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## **1. Introduction**

In the last few decades, China has enjoyed high economic growth from very large investments in R&D activities, in which China had spent 87 billion dollars on R&D activities in 2006, making it the top third under American and Japan in spending R&D (Wu, 2010). The same thing was felt by Malaysia. Akoum (2016) states that by conducting R&D activities, countries such as Malaysia can change the direction of their economy and trade from dependence on the export of natural resources and raw materials to the export of high-tech electronic products. Furthermore, the results of his research found that innovation activity has a positive effect on economic growth which is proxied by GDP per capita.

It cannot be denied that innovation is closely related to increasing a country's economic growth. This relationship has been proven by previous researchers, which measured innovation through R&D expenditure and patent data. Meanwhile, economic growth was measured by the Gross Domestic Product (GDP). Ulku (2004) conducted research on 20 OECD member countries and 10 countries that are not OECD members by using data from 1981-1997 to see how the relationship between innovation activities through R&D and patents with GDP per capita of these countries. The results of his study concluded that patents have a very strong positive relationship to GDP per capita in OECD countries and non-OECD member countries. Then, Wu (2010) from the results of his research concluded that R&D has a positive influence on economic growth in China, in which a 0.1% increase in R & D expenditure will enhance China's economic growth by around 0.02%. The positive relationship between innovation and economic growth has also been obtained by Rastvortseva (2015) in Russia and Pece et al (2015) in central and eastern European countries.

When many researchers agree that R&D and patents have a positive relationship with economic growth and export value, there are some researchers who actually find the opposite results. Sattar et al (2013) found that patents have a negative relationship with economic growth in middle-income countries. Whereas, Shukla (2017) found that R&D expenditure and patent applications have a negative influence on the growth of GDP per capita in India. Petrariu et al (2013) also found the same results that R&D expenditure and the number of patents negatively affected the GDP of central and eastern European countries. If it is examined further, the difference in the results of the studies are due to the differences in the object of their research, which are generally low to middle-income countries. These countries have very little R&D activities and patent applications. Other causes are at the time of observation and selection of research data. For example, Pece et al (2015) used data from 2000 to 2013, and Petrariu et al (2013) used data from 1996 to 2010. Even though they both conducted research in central and eastern European countries, they got different results. Other than that these differences were caused by the selection of research data used. Although both use the GDP variable as an indicator of

economic growth, Pece et al (2015) chose to use data in the form of GDP value, while Petrariu et al (2013) used GDP data in the form of growth.

In addition to object issues, the time of the research and the selection of data, there is another suspicion that in fact R&D activities and patent applications do not directly affect a country's GDP, but through commercialization activities. It is because basically R&D and patent application activities will never be revealed to the market without commercialization activities, and one of the variables that can be proxy to measure the commercialization activities of innovation in a country is the high-tech export value. Some previous researchers have proven that high-tech export values have a positive influence on a country's GDP (Demir, 2018; Falk, 2007). Furthermore, Gani (2009) found that high-tech values have different influences on the three groups of countries studied based on the Technological Achievement Index developed by the United Nations Development Program (UNDP). He found that the strength of the positive influence of high-tech export values on economic growth per capita decreases with the decline in a country's technological performance index. Even, for groups of countries with a low technological achievement index, the results show that high-tech export values have a negative effect on economic growth per capita. Ekananda & Parlinggoman (2017) also found relatively similar results that high-tech export values did not affect the GDP growth of 50 countries that they studied by using the data period of 1992-2014. There are still conflicting or gaps in research results related to high-tech export direct relations with economic growth in a country. Thus, in this study we will try re-confirmed these direct relationships and other roles of high-tech export variables, that is variables that mediated innovation activities with economic growth in a country.

A country with high innovation activities can attract foreign investment because of new product discoveries that can expand the market, as well as the opportunity to get the first profit from its launch to the market. In other words, foreign investments measured through foreign direct investment (FDI) can provide capital, knowledge, and technology needs to commercialize inventions from innovation activities. Ismail (2013) from the results of his research has proven that FDI is an important factor in increasing innovation activities. Furthermore, the results of his research found that high FDI can increase the amount of high-tech product production, which in itself can increase high-tech exports. This identifies that FDI actually has a role as a moderator which can increase the chance of successful commercialization of innovation measured through high-tech export variables. When viewed from the existing literature, this role received less attention from previous researchers. Many previous researchers only focused on the role of FDI as a trigger that influenced innovation activities such as R&D expenditure and patents (Khachoo & Sharma 2017; Ghazal & Zulkhibri 2014; Chen & Chen 2009).

This research was conducted to reaffirm some of the factors that caused the differences from the results of previous studies, related to the object of research, the time of observation and the selection of the data used. In addition this study also

aims to analyze the role of high-tech exports as a mediating variable of innovation activity on economic growth, and the role of FDI as a moderator variable that can strengthen the success of innovation commercialization activities in the world's most innovative countries according to the 2018 global innovation index, both in the short term (5 years) and long (15 years).

## **2. Theoretical Background**

### **2.1 R&D, Patent and High-tech exports**

Many previous studies employed R&D and patents as indicators in measuring a country's innovation activities. Because according to its definition, innovation is indeed a process to find a new idea, behavior, or thing, which is qualitatively different from the existing form, implemented and can be applied in practice (Robertson, 1967). Based on this definition, it is worth saying that R&D is the backbone of innovation activity, and patents can be said to be the output of R&D activities. Another equally important activity is the commercialization of innovation because great inventions will never be revealed to the market without commercialization and certainly innovation will not contribute much to the economy of a country. This is consistent with the definition of commercialization of innovation which is an activity to introduce the latest innovations to the market (Datta et al, 2013). Based on that definition, in this study commercialization activities were proxy with the export value of high-tech products. Referring to the World Bank, high-tech exports are export values for products in the fields of aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.

Generally, R&D intensity measured by expenditure and the number of patents have a positive relationship with high-tech exports, which means that countries with high R&D intensity and patents can increase its productivity in the creation and production of the latest high-tech products, which suddenly will be able to increase the country's high-tech export value. This relationship has been empirically proven by several previous studies, including Sandu & Ciocanel (2014) who found that a 1% increase in R & D activity in the business sector can increase 3.68% high-tech export in the same year, with objects research of 26 countries that joined the European Union in the period 2006-2010. Kabaklarli et al (2017, 2018) found that the number of the patent had a positive effect on high-tech exports, in which every 1% increase in the number of patent applications, there would be an increase in high-tech exports of 3.47%.

Based on the explanation above, hypothesis 1 and 2 were developed for this study; they are:

Hypothesis 1: R & D expenditure has a positive effect on high-tech export.

Hypothesis 2: Patent application has a positive effect on high-tech export.

## **2.2 R&D, Patent, HTE and GDP**

Innovation is the locomotive of economic growth because the current competitive advantage in international trade does not only depend on a country's natural resources but is also based on innovative products and services (Alagoz et al, 2016). The sustainable innovation is the main key to increasing competitiveness. Prodan (2005) states that economies with high levels of innovation will be more independent in the market and more aggressive towards competition because they are more productive in developing new products. When the productivity of a country experiences a significant increase supported by the ability to commercialize, this will definitely have an impact on the country's economic growth. Several empirical studies have been carried out by previous researchers to prove these relationships. Wu (2010) from his research proved that R&D expenditures have a positive influence on economic growth. Ulku (2004) found that patents had a positive relationship to the GDP of OECD and non-OECD countries. Whereas Falk (2007), Demir (2017) and Ustabas & Ersin (2016) revealed that high-tech exports had a positive effect on a country's GDP.

Based on the explanation above, hypothesis 3, 4 and 5 were developed as follow:

Hypothesis 3: R&D expenditure has a positive effect on GDP

Hypothesis 4: Application patent has a positive effect on GDP

Hypothesis 5: High tech exports have a positive effect on GDP

As explained previously, commercialization is a very crucial activity because even great discoveries produced from innovation activities will never be revealed to the market without commercialization and certainly will not have a contribution to a country's GDP. Therefore, in addition to having a direct influence on GDP, HTE actually has a mediating effect between innovation activities and GDP.

Hypothesis 6: R&D expenditure influences GDP through High-tech export

Hypothesis 7: Application patent influences GDP through High-tech export

## **2.3 FDI as a Moderating Variable**

The high-tech industry requires a very large investment (Ekananda & Parlinggoman, 2017) especially in increasing production capacity. The funding needs for this investment can be fulfilled by one of them through foreign direct investment (FDI). The real evidence of how FDI plays an important role in a country's high-tech industry is what happens in China, where FDI provides many financial needs that make China become one of the giant high-tech industries (Li et al, 2018). In addition

to providing finance, FDI also plays a role in transferring technology, skills, modern management, new processes, and so on (Khachoo & Sharma, 2017). Then, countries with high levels of innovation can attract FDI to their countries (Prodan, 2005). The relationship between FDI and innovation has received the attention of many researchers to see how the relationship between them. But even so, there is still an ambiguous theoretical relation to the relationship between innovation and FDI. Some researchers argue and examine that FDI is a trigger for innovation activities, both within the scope of the company and a country (Khachoo & Sharma 2017; Ghazal & Zulkhibri 2014; Chen & Chen 2009). Some other researchers actually argue and examine that FDI is actually influenced by innovation activities (R&D, patents and high-tech exports). Tomiura (2003), Javorcik (2004) and Golubeva (2016) respectively examine the influence of R&D, intellectual property rights (including patents) and high-tech exports to FDI.

Another role that got less attention from previous researchers is the role of FDI as a variable that can moderate or help the successful commercialization of innovation activities. This relationship has been proven by Ismail (2013) who found results that high FDI can increase the amount of high-tech product production, which can increase the value of high-tech exports. So in this study, this relationship was tested through the following hypothesis:

Hypothesis 8: R&D expenditure influences high-tech exports if it is moderated by FDI

Hypothesis 9: Application patents affect high-tech exports when it is moderated by FDI

### **3. Methodology**

#### **3.1 Sample and data**

The population in this study was 126 countries included in the 2018 Global Innovation Index (GII) issued by Cornell University, INSEAD and WIPO (2018). Meanwhile, the research sample was selected by purposive sampling method based on the following criteria:

- a. Selected countries must have complete data in the World Bank Database ([data.worldbank.org](http://data.worldbank.org)) related to data on R&D expenditures, number of patent applications residents, foreign direct investment net inflows, high-technology exports, GDP and GDP growth per capita during the period 2001 – 2015.
- b. For some countries that do not have R&D Expenditures (% of GDP) in certain years during the period, it was assumed that the value was similar to the previous year. This refers to the data displayed by UNESCO on the Tellmaps UIS website.

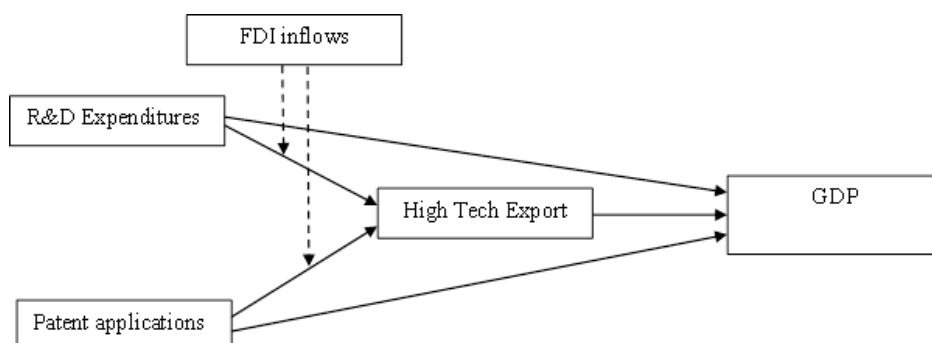
Out of 126 population countries, 51 top-ranking countries were chosen that fulfill all the criteria set to be used as research samples, as listed in the following table:

**Table 1. Research Samples**

High Income				Upper-Middle income		Lower-middle income	
Country	Rank	Country	Rank	Country	Rank	Country	Rank
Switzerland	1	Australia	20	China	17	Ukraine	43
Netherlands	2	Austria	21	Malaysia	35	India	57
Sweden	3	New Zealand	22	Bulgaria	37	Georgia	59
United Kingdom	4	Iceland	23	Croatia	41		
Singapore	5	Estonia	24	Thailand	44		
USA	6	Czech Republic	27	Russian	46		
Finland	7	Spain	28	Moldova	48		
Denmark	8	Portugal	32	Romania	49		
Germany	9	Hungary	33	Turkey	50		
Ireland	10	Latvia	34	Mexico	56		
Israel	11	Slovakia	36	South Africa	58		
Korea, Republik	12	Poland	39	Colombia	63		
Japan	13	Lithunia	40	Brazil	64		
Hong Kong	14	Greece	42	Peru	71		
France	16			Argentina	80		
Canada	18			Azerbaijan	82		
Norway	19			Belarus	86		

Source: Global Innovation Index (2018)

As explained earlier, in this study the variables used were R&D Expenditures, patent applications (resident), foreign direct investment (FDI) net inflows, high-technology exports, and GDP, with the conceptual framework as follows:



**Figure 1. Conceptual Framework**



The description of each variable in the study, and data sources can be seen in the following table:

**Table 2. Operational Variables**

Variable	Description	Source
R&D Expenditures (RDE)	% of R&D expenditures on GDP.	data.worldbank.org
Patent applications Residents (Log_Patent)	Number of application by resident to exclusive rights	data.worldbank.org
FDI inflows (FDI)	% of FDI net inflows on GDP	data.worldbank.org
High-technology exports (HTE)		
Alternative 1	% of high-technology exports on GDP	data.worldbank.org
Alternative 2	% of high-technology exports on manufactured exports	data.worldbank.org
Alternative 3	High-technology exports (current US\$)	data.worldbank.org
GDP		
Alternative 1	Growth rate of GDP per capita (annual %)	data.worldbank.org
Alternative 2	Growth rate of GDP (annual %)	data.worldbank.org
Alternative 3	GDP (Current US\$)	data.worldbank.org

To answer issues related to the period of the research and differences in the research object, six data panels were applied. They are (1) data panel of all countries with a 15-year long period of time from 2001 to 2015, (2) data panel of all countries with a 5-year short period of time from 2011 to 2015, (3) data panel of high-income (HI) countries with a long-term time period of 15 years from 2001 to 2015, (4) data panel of high-income (HI) countries with a short term period of 5 years from 2011 to 2015, (5) data panel of lower-middle-income countries (LM) and upper-middle-income (UM) with a long-term period of 15 years from 2001 to 2015, and (6) data panel of lower-middle-income (LM) countries and upper-middle-income (UM) with a short term period of 5 years from 2011 to 2015.

### 3.2 Research Model

To answer problems related to the choice of data used, six research models were developed to be tested, as discussed in the following section:

#### Model 1

In model 1 the variable of high-tech exports uses data of the percentage value of high technology product exports to GDP.

$$HTE\_GDP = \beta_0 + \beta_1 RDE + \beta_2 \text{Log\_Patent} + \beta_3 FDI + \beta_4 (RDE \times FDI) + \beta_5 (\text{Log\_Patent} \times FDI) + e \quad (1)$$

### Model 1

In model 2 the variable of GDP uses data of the GDP growth rate per capita (annual %).

$$GDP\_Capita = \beta_0 + \beta_1 RDE + \beta_2 Log\_Patent + \beta_3 HTE\_GDPratio + e \quad (2)$$

### Model 3

In model 3 the high-tech export variable uses data of the percentage of the export value of high technology products to the value of manufactured exports.

$$HTE\_Expportratio = \beta_0 + \beta_1 RDE + \beta_2 Log\_Patent + \beta_3 FDI + \beta_4 (RDE \times FDI) + \beta_5 (Log\_Patent \times FDI) + e \quad (3)$$

### Model 4

In model 4 the variable of GDP uses data of the Growth rate of GDP (annual %).

$$GDP\_Growth = \beta_0 + \beta_1 RDE + \beta_2 Log\_Patent + \beta_3 HTE\_Expportratio + e \quad (4)$$

### Model 5

In model 5 the high-tech export variable uses data of High-technology exports in current US\$.

$$Log\_HTE = \beta_0 + \beta_1 RDE + \beta_2 Log\_Patent + \beta_3 FDI + \beta_4 (RDE \times FDI) + \beta_5 (Log\_Patent \times FDI) + e \quad (5)$$

### Model 6

In model 6 the variable of GDP uses data of the GDP in current US\$.

$$Log\_GDP = \beta_0 + \beta_1 RDE + \beta_2 Log\_Patent + \beta_3 Log\_HTE + e \quad (6)$$

## 4. Empirical Findings

### 4.1 Descriptive statistics

Table 3 presents the descriptive statistics from the research data to reveal the highest standard deviation for each group of data panel. For RDE data, it is showed that the data group with the highest standard deviation was data panel two, which were all countries with a period of 5 years. Whereas for data on patents and FDI, the highest standard deviation was data panel four, which was high income countries with a period of 5 years, indicating that within a period of 5 years from 2011 to 2015, there were inequalities between countries which were the object of research, especially

high-income countries in terms of spending on R & D, the number of patent applications and FDI. Meanwhile for GDP data both in current US \$ and/or its growth, and/or GDP growth per capita, it can be seen that the data group with highest standard deviation was data panel five, namely lower-middle (LM) and upper-middle countries (UP) income with a period of 15 years, which signified an imbalance in economic growth in this group of countries, in which China had a much higher economic growth compared to other countries.

**Table 3. Descriptive Statistics**

	N	GDP & HTE (Uses data alternative 1)		GDP & HTE (Uses data alternative 2)		GDP & HTE (Uses data alternative 3)	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Data Panel 1: All countries (15 years)							
GDP	765	2,783	4,270	3,201	4,205	11,432	0,740
HTE	765	4,639	9,782	15,270	11,921	9,625	1,072
RDE	765	1,411	1,020	1,411	1,020	1,411	1,0204
FDI	765	5,473	8,679	5,473	8,679	5,473	8,679
Log_Patent	765	3,147	0,932	3,147	0,932	3,147	0,932
Data Panel 2: All countries (5 years)							
GDP	255	2,036	3,032	2,481	3,124	11,579	0,707
HTE	255	4,037	6,879	13,965	9,030	9,750	1,034
RDE	255	1,516	1,050	1,516	1,050	1,516	1,050
FDI	255	4,915	9,009	4,915	9,009	4,915	9,009
Log_Patent	255	3,178	0,963	3,178	0,963	3,178	0,963
Data Panel 3: High-income countries (15 years)							
GDP	465	1,882	3,566	2,371	3,529	11,534	0,700
HTE	465	5,657	11,073	17,553	11,560	9,941	0,869
RDE	465	1,910	0,993	1,910	0,993	1,909	0,993
FDI	465	6,064	10,0193	6,064	10,0193	6,064	10,0193
Log_Patent	465	3,248	0,972	3,248	0,972	3,248	0,972
Data Panel 4: High-income countries (5 years)							
GDP	155	1,634	2,889	2,045	2,912	11,641	0,676
HTE	155	5,110	7,895	16,016	8,036	10,035	0,830
RDE	155	2,050	0,984	2,050	0,984	2,050	0,984
FDI	155	5,966	11,328	5,966	11,328	5,966	11,328
Log_Patent	155	3,261	0,968	3,261	0,968	3,261	0,968
Data Panel 5: Lower-middle-income countries and upper-middle-income (15 years)							
GDP	300	4,179	4,861	4,488	4,809	11,276	0,772
HTE	300	3,060	7,077	11,730	11,621	9,135	1,169
RDE	300	0,638	0,379	0,638	0,379	0,638	0,379
FDI	300	4,557	5,941	4,557	5,941	4,557	5,9415
Log_Patent	300	2,991	0,845	2,991	0,845	2,991	0,845
Data Panel 5: Lower-middle-income countries and upper-middle-income (5 years)							
GDP	100	2,658	3,156	3,157	3,330	11,484	0,7479
HTE	100	2,374	4,456	10,786	9,588	9,308	1,1609
RDE	100	0,688	0,429	0,688	0,429	0,688	0,429

FDI	100	3,287	2,0452	3,287	2,045	3,287	2,045
Log_Patent	100	3,050	0,945	3,050	0,945	3,050	0,945

Source: Processed Data (2019)

#### 4.2 R Square

From the six research models applied, it was revealed that the highest R Square model that was able to explain HTE variables better was the fifth model for data panel four, which was high-income countries (5 years). The data used to represent HTE was High-technology exports data in current US \$, with R Square value of 0.163. Meanwhile, the highest R Square research model that was able to explain GDP variables better was the six research models for data panel five, namely LM & UM Income countries (15 yeras). The data used to represent GDP were data in current US \$, with an R Square value of 0.048. This indicated that in general, the use of data in current US \$ was more appropriate for representing High-technology exports and GDP variables in projecting economic growth.

**Table 4. R Square of Research Models**

Data Panel	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
All Countries (15 years)	0,016	0,003	0,008	0,009	0,100	0,024
All Countries (5 years )	0,050	0,008	0,016	0,005	0,102	0,008
HI Countries (15 years)	0,025	0,026	0,020	0,020	0,148	0,017
HI Countries (5 years)	0,041	0,042	0,022	0,034	0,163	0,013
LM and UM Countries (15 years)	0,095	0,004	0,026	0,016	0,027	0,048
LM and UM Countries (5 years)	0,043	0,030	0,028	0,003	0,030	0,031
Min	0,016	<b>0,003</b>	<b>0,008</b>	<b>0,003</b>	0,027	0,008
Max	0,095	0,042	0,028	0,034	<b>0,163</b>	<b>0,048</b>

Source: Processed Data (2019)

#### 4.3 Collinearity Statistics (VIF)

To look at the relationship between variables in this study, then it is necessary to look at its multicollinearity. This is done to avoid the occurrence of standard errors in the significance test. The following are the colinearity statistics value from this study:

**Table 5. Collinearity Statistics (VIF)**

Data Panel	RDE	Log_Patent	HTE / Log_HTE	Data Panel	RDE	Log_Patent	HTE / Log_HTE
<b>Model 1</b>				<b>Model 4</b>			
All Countries (15 years)	1,039	1,054	-	All Countries (15 years)	1,000	1,004	1,005
All Countries (5 years)	1,111	1,086	-	All Countries (5 years)	1,001	1,000	1,001
HI Countries (15 years)	1,002	1,081	-	HI Countries (15 years)	1,000	1,015	1,015
HI Countries (5 years)	1,026	1,159	-	HI Countries (5 years)	1,002	1,002	1,000
LM & UM Countries (15 years)	4,971	1,051	-	LM & UM Countries (15 years)	1,009	1,006	1,01
LM & UM Countries (5 years)	3,739	1,105	-	LM & UM Countries (5 years)	1,025	1,008	1,02
<b>Model 2</b>				<b>Model 5</b>			
All Countries (15 years)	1,000	1,017	1,016	All Countries (15 years)	1,027	1,053	-
All Countries (5 years)	1,002	1,011	1,009	All Countries (5 years)	1,001	1,085	-
HI Countries (15 years)	1,005	1,004	1,008	HI Countries (15 years)	1,002	1,081	-
HI Countries (5 years)	1,012	1,009	1,017	HI Countries (5 years)	1,026	1,159	-
LM & UM Countries (15 years)	1,005	1,067	1,066	LM & UM Countries (15 years)	4,971	1,051	-
LM & UM Countries (5 years)	1,011	1,013	1,013	LM & UM Countries (5 years)	3,739	1,105	-
<b>Model 3</b>				<b>Model 6</b>			
All Countries (15 years)	1,027	1,053	-	All Countries (15 years)	1,000	1,104	1,104
All Countries (5 years)	1,001	1,085	-	All Countries (5 years)	1,001	1,096	1,096
HI Countries (15 years)	1,002	1,081	-	HI Countries (15 years)	1,001	1,166	1,166
HI Countries (5 years)	1,026	1,159	-	HI Countries (5 years)	1,003	1,169	1,168
LM & UM Countries (15 years)	4,971	1,051	-	LM & UM Countries (15 years)	1,007	1,025	1,026
LM & UM Countries (5 years)	3,739	1,105	-	LM & UM Countries (5 years)	1,019	1,021	1,026

Source: Processed Data (2019)

In the study, the VIF value cutoff is must be lower than 5 (Garson, 2016). Based on table 5, it is known that none one of the colinearity statistics (VIF) values bigger than 5 (VIF>5). This indicates that the variables used in this study are free from multicollinearity problems.

#### 4.4 The Effect of RDE and Patent on HTE

Table 6 presents the results of the direct influence of RDE and Log\_Patent variables on HTE.

**Table 6. Results the Effect of RDE and Patent on HTE**

Hyp.	Path	Panel Data	Std. Beta	T Statistic	Std. Dev.	P Values
<b>Model 1</b>						
H1	RDE -> HTE	All Countries (15 years)	-0,023	0,020	1,178	0,948
		All Countries (5 years )	-0,072	0,008	9,385	0,994
		HI Countries (15 years)	0,065	0,003	22,010	0,998
		HI Countries (5 years)	0,102	0,889	0,114	0,375
		LM & UM Countries (15 years)	-0,068	0,001	93,301	0,999
		LM & UM Countries (5 years)	-0,085	1,188	0,071	0,235
H2	Log_Patent -> HTE	All Countries (15 years)	0,130	3,229	0,040	<b>0,001</b>
		All Countries (5 years )	0,089	1,529	0,058	0,127
		HI Countries (15 years)	0,053	1,013	0,052	0,312
		HI Countries (5 years)	0,090	1,218	0,074	0,224
		LM & UM Countries (15 years)	0,228	3,179	0,072	<b>0,002</b>
		LM & UM Countries (5 years)	0,065	0,542	0,121	0,588
<b>Model 3</b>						
H1	RDE -> HTE	All Countries (15 years)	-0,022	0,004	5,242	0,997
		All Countries (5 years )	-0,023	0,433	0,054	0,665
		HI Countries (15 years)	0,004	0,000	14,812	1,000
		HI Countries (5 years)	0,039	0,001	43,352	0,999
		LM & UM Countries (15 years)	-0,022	0,001	40,410	1,000
		LM & UM Countries (5 years)	-0,057	0,001	85,530	0,999
H2	Log_Patent -> HTE	All Countries (15 years)	-0,067	2,080	0,032	<b>0,038</b>
		All Countries (5 years )	-0,003	0,058	0,052	0,954
		HI Countries (15 years)	-0,131	3,407	0,038	<b>0,001</b>
		HI Countries (5 years)	0,027	0,383	0,071	0,702
		LM & UM Countries (15 years)	0,031	0,521	0,059	0,602
		LM & UM Countries (5 years)	0,020	0,188	0,104	0,850
<b>Model 5</b>						
H1	RDE -> Log_HTE	All Countries (15 years)	-0,024	0,010	2,389	0,992
		All Countries (5 years )	-0,019	0,005	4,149	0,996
		HI Countries (15 years)	-0,025	0,002	12,983	0,998
		HI Countries (5 years)	-0,016	0,000	33,259	1,000
		LM & UM Countries (15 years)	0,065	0,002	34,208	0,998
		LM & UM Countries (5 years)	0,107	0,001	112,489	0,999

H2	Log_Patent ->	All Countries (15 years)	-0,301	8,557	0,035	<b>0,000</b>
		All Countries (5 years)	-0,282	4,710	0,060	<b>0,000</b>
	Log_HTE	HI Countries (15 years)	-0,379	8,898	0,043	<b>0,000</b>
		HI Countries (5 years)	-0,403	5,660	0,071	<b>0,000</b>
		LM & UM Countries (15 years)	-0,143	2,182	0,065	<b>0,030</b>
		LM & UM Countries (5 years)	-0,106	0,800	0,132	0,423

Source: Processed Data (2019)

Based on table 6, it is known that none of the research models used for each data panel proved the results that RDE had a significant effect on HTE. This was indicated by no one value of P Values <0.05. Thus, H1 was rejected for all models, which meant that the RDE variable did not have a positive and significant effect on HTE. This result might be because most of the R&D activities carried out by countries were not always and solely related to the development of high-tech products. However, even though it was not statistically significant, it was generally found that R&D expenditures had a negative influence on High-technology exports when it was viewed from the direction of its influence. These results support the results of research by Mehrara et al (2017), Shukla (2017) and Petrariu (2013) who also found a negative relationship between R&D expenditures with High-technology exports. On the other hand, this result is contrary to the results of research obtained by Sandu & Ciocanel (2014) who revealed that R&D expenditures had a positive and significant effect on the High-technology exports.

Meanwhile, the results for patent variable showed that Patent had a significant and positive effect on HTE in data panel one (all Country, 15 years) and data panel five (LM & UM Income, 15 years) for model one, which was the model that uses HTE data in the ratio to GDP, so H2 was accepted only for the data panels and models. Patent also had a significant effect on HTE but in a negative direction for models that used HTE data in the ratio of total export value (model three) in data panels one (all Country, 15 years) and three (high Income Country, 15 years). The best results were shown by model 5 (use of HTE data in current US \$) which indicated that Patent had a significant effect on HTE on all data panels, exception of the data panel 6, unfortunately in a negative direction.

These results were surprising because more recent inventions patented should be applied and produced into the latest high-tech products, which could increase a country's high-technology export value. However, in this study, the opposite results were obtained generally, in which patents actually had a negative effect on High-technology exports. These results support the results of the study from Hasanov et al (2015) which found that patents negatively affected the value of overall exports in Asian countries. This also happened to research by Shukla (2017) and Petrariu (2013) who found that patents had a negative effect on high-technology exports. On the other hand, the results of this study contradicted the results of general research which found that patents had a positive effect on High-technology exports, for

example, a study by Kabaklarli et al (2017) which applied OECD countries using HTE data in ratio (%) of total manufacturing exports for the period 1989-2015 as the object of the study.

#### 4.5 The Effect of RDE and Patent on GDP

Based on table 7, it is known that RDE variables only positively and significantly affect on GDP in the data panel four consisting of high-income countries (2011-2015) for models using GDP data in current US \$ (model six) with P Values <0.05, thus H3 was accepted only for the data panels and models. This reinforced the previous statement that most of the R&D activities carried out by the countries, especially high-income countries, were not always related to the development of high-tech products, but also in other fields of science which directly affected GDP and statistically significant.

**Table 7. Results the Effect of RDE and Patent on GDP**

Hyp.	Path	Panel Data	Std. Beta	T Statistic	Std. Dev.	P Values
<b>Model 2</b>						
H3	RDE -> GDP	All Countries (15 years)	-0,018	0,977	0,019	0,329
		All Countries (5 years )	-0,014	0,405	0,034	0,685
		HI Countries (15 years)	-0,033	1,249	0,027	0,212
		HI Countries (5 years)	-0,060	1,102	0,055	0,271
		LM & UM Countries (15 years)	-0,025	0,674	0,037	0,501
		LM & UM Countries (5 years)	-0,013	0,195	0,071	0,846
H4	Log_Patent -> GDP	All Countries (15 years)	-0,051	1,439	0,036	0,151
		All Countries (5 years )	0,020	0,297	0,066	0,766
		HI Countries (15 years)	-0,115	2,726	0,042	<b>0,007</b>
		HI Countries (5 years)	-0,051	0,692	0,074	0,489
		LM & UM Countries (15 years)	0,065	1,057	0,062	0,291
		LM & UM Countries (5 years)	0,128	1,103	0,116	0,271
<b>Model 4</b>						
H3	RDE -> GDP	All Countries (15 years)	-0,009	0,514	0,017	0,607
		All Countries (5 years )	0,012	0,346	0,037	0,729
		HI Countries (15 years)	-0,004	0,199	0,024	0,843
		HI Countries (5 years)	0,031	0,585	0,053	0,559
		LM & UM Countries (15 years)	-0,001	0,015	0,042	0,988
		LM & UM Countries (5 years)	0,044	0,530	0,084	0,597
H4	Log_Patent -> GDP	All Countries (15 years)	-0,092	2,627	0,035	<b>0,009</b>
		All Countries (5 years )	0,010	0,143	0,067	0,887
		HI Countries (15 years)	-0,141	3,545	0,040	<b>0,000</b>
		HI Countries (5 years)	0,008	0,110	0,076	0,912
		LM & UM Countries (15 years)	0,004	0,063	0,059	0,950
		LM & UM Countries (5 years)	0,036	0,292	0,122	0,770



<b>Model 6</b>						
H3	RDE -> Log_GDP	All Countries (15 years)	-0,011	2,032	0,005	<b>0,043</b>
		All Countries (5 years)	-0,009	0,709	0,013	0,479
		HI Countries (15 years)	-0,003	0,352	0,008	0,725
		HI Countries (5 years)	0,051	2,785	0,018	<b>0,006</b>
		LM & UM Countries (15 years)	-0,003	0,133	0,020	0,894
		LM & UM Countries (5 years)	0,000	0,003	0,021	0,998
H4	Log_Patent -> Log_GDP	All Countries (15 years)	-0,155	5,290	0,029	<b>0,000</b>
		All Countries (5 years)	-0,095	2,470	0,039	<b>0,014</b>
		HI Countries (15 years)	-0,094	2,422	0,039	<b>0,015</b>
		HI Countries (5 years)	0,056	0,692	0,081	0,489
		LM & UM Countries (15 years)	-0,216	4,227	0,051	<b>0,000</b>
		LM & UM Countries (5 years)	-0,163	2,684	0,061	<b>0,007</b>

Source: Processed Data (2019)

In the other hand, the results of Patent variable showed that Patent had a significant effect, but in a negative direction towards GDP in data panel one (all countries, 15 years) for models four (use of GDP data in Growth rate of GDP) and model six (use of GDP data in current US\$). Patent also had a negative and significant effect on GDP in the data panels three (high-income countries, 15 years) for models two, four and six. The best results were shown by model six (use of GDP data in current US \$) which illustrated that Patent negatively and significantly affected GDP in all data panels, except the data panel four (high-income countries, 5 years). Thus, H4 was rejected for all models and data panels, given that none of the positive influences were obtained.

#### 4.5 The Effect of HTE on GDP

Table 8 demonstrates the results of statistical tests on the effect of HTE on GDP. Based on the table, it can be seen that HTE had a positive and significant effect on GDP for high-income countries both for long (15 years) and short term (5 years) data panels on the use of growth data of GDP per capita (model two) and the data usage GDP in current US \$ (model six) was specific to the data panel three (high-income countries, 15 years). Thus, H5 was accepted for the models and data panels. This result identified that high-income countries with good technological infrastructure and available capital can produce more high-tech products so it can increase the value of their exports. In other words, only high-income countries had succeeded in commercializing high-tech product innovations. These results support some of the results of previous studies, including the research by Kabaklarli et al (2018) with OECD countries using HTE data in the form of a ratio (%) of total manufacturing exports and GDP in the current US \$ for the period 1989-2015 as the object of the research. This is in line with the results of the research conducted by Ustabas & Ersin (2016) whose research objects were Turkey and Korea with using HTE data in the form of a ratio (%) of total manufacturing exports and GDP per

capita for the period 1989-2014. Both studies found that HTE had a positive and significant effect on a country's economic growth.

**Table 8. Results the Effect of HTE on GDP**

Hyp.	Path	Panel Data	Std. Beta	T Statistic	Std. Dev.	P Values
<b>Model 2</b>						
H5	HTE -> GDP	All Countries (15 years)	-0,004	0,120	0,035	0,904
		All Countries (5 years )	0,086	1,501	0,058	0,134
		HI Countries (15 years)	0,119	2,659	0,044	<b>0,008</b>
		HI Countries (5 years)	0,201	2,848	0,071	<b>0,005</b>
		LM & UM Countries (15 years)	-0,020	0,345	0,057	0,730
		LM & UM Countries (5 years)	0,106	1,092	0,097	0,275
<b>Model 4</b>						
H5	HTE -> GDP	All Countries (15 years)	-0,023	0,580	0,041	0,562
		All Countries (5 years )	-0,068	0,993	0,069	0,321
		HI Countries (15 years)	-0,021	0,369	0,057	0,712
		HI Countries (5 years)	-0,181	1,509	0,120	0,132
		LM & UM Countries (15 years)	-0,126	2,062	0,061	<b>0,040</b>
		LM & UM Countries (5 years)	-0,048	0,474	0,100	0,636
<b>Model 6</b>						
H5	Log_HTE -> Log_GDP	All Countries (15 years)	0,000	0,006	0,025	0,995
		All Countries (5 years )	-0,040	0,795	0,051	0,427
		HI Countries (15 years)	0,062	2,715	0,023	<b>0,007</b>
		HI Countries (5 years)	-0,065	0,814	0,080	0,416
		LM & UM Countries (15 years)	-0,077	1,753	0,044	<b>0,080</b>
		LM & UM Countries (5 years)	-0,084	1,068	0,079	0,286

Source: Processed Data (2019)

Whereas, for lower-middle and upper-middle-income countries, it had been proven to fail in commercializing their products. This was evident from the direction of its generally negative influence, although statistically significant results were obtained only in the five data panels (long-term period) for model four. The failure to commercialize will definitely have a negative impact on the economic growth of a country when the country has invested large amounts of funds to build infrastructure and carry out technological research with results that are not comparable.

#### 4.6 The Mediation Effect of HTE

Table 9 presents the results of SmartPLS bootstrapping which shows the indirect effect of RDE & Patent on GDP.

**Table 9. Mediation Effect Results of HTE**

Hyp.	Path	Panel Data	Std. Beta	T Statistic	Std. Dev.	P Values
<b>Model 2</b>						
H6	RDE -> HTE -> GDP	All Countries (15 years)	0,000	0,003	0,028	0,997
		All Countries (5 years )	-0,006	0,011	0,565	0,991
		HI Countries (15 years)	0,007	0,003	2,540	0,998
		HI Countries (5 years)	0,016	0,002	9,594	0,999
		LM & UM Countries (15 years)	0,001	0,000	6,439	1,000
		LM & UM Countries (5 years)	-0,010	0,000	24,711	1,000
H7	Log_patent -> HTE -> GDP	All Countries (15 years)	-0,001	0,120	0,005	0,905
		All Countries (5 years )	0,007	1,092	0,007	0,275
		HI Countries (15 years)	0,006	0,003	0,006	0,363
		HI Countries (5 years)	-0,017	0,619	0,028	0,536
		LM & UM Countries (15 years)	-0,004	0,353	0,013	0,724
		LM & UM Countries (5 years)	0,004	0,248	0,017	0,804
<b>Model 4</b>						
H6	RDE -> HTE -> GDP	All Countries (15 years)	0,001	0,002	0,296	0,999
		All Countries (5 years )	0,001	0,006	0,231	0,995
		HI Countries (15 years)	-0,000	0,000	0,865	1,000
		HI Countries (5 years)	-0,007	0,001	10,745	0,999
		LM & UM Countries (15 years)	0,003	0,000	6,159	1,000
		LM & UM Countries (5 years)	0,002	0,000	10,811	1,000
H7	Log_patent -> HTE -> GDP	All Countries (15 years)	0,002	0,495	0,003	0,621
		All Countries (5 years )	-0,001	0,151	0,006	0,880
		HI Countries (15 years)	0,003	0,357	0,008	0,721
		HI Countries (5 years)	-0,005	0,320	0,015	0,749
		LM & UM Countries (15 years)	-0,004	0,482	0,008	0,630
		LM & UM Countries (5 years)	-0,001	0,075	0,013	0,941
<b>Model 6</b>						
H6	RDE -> Log_HTE -> GDP	All Countries (15 years)	-0,000	0,001	0,006	0,999
		All Countries (5 years )	0,001	0,003	0,291	0,997
		HI Countries (15 years)	-0,002	0,002	0,964	0,999
		HI Countries (5 years)	0,001	0,000	3,143	1,000
		LM & UM Countries (15 years)	-0,005	0,001	3,534	0,999
		LM & UM Countries (5 years)	-0,009	0,001	13,512	0,999
H7	Log_patent -> Log_HTE -> GDP	All Countries (15 years)	-0,000	0,006	0,008	0,995
		All Countries (5 years )	0,011	0,728	0,016	0,467
		HI Countries (15 years)	-0,024	2,714	0,009	<b>0,007</b>
		HI Countries (5 years)	0,026	0,773	0,034	0,440
		LM & UM Countries (15 years)	0,011	1,134	0,010	0,257
		LM & UM Countries (5 years)	0,009	0,483	0,018	0,630

Source: Processed Data (2019)

From table 9, it is known that RDE did not have any significant indirect influence on GDP from all research models and data panels. They were indicated by all P

Values > 0.05. In other words, high-tech exports had no mediating effect in the relationship of R&D expenditures to GDP, which means that H6 was rejected. Whereas for Patent, HTE only had a mediating effect in the data panel three consisting of high-income countries (15 years) for model six, which was indicated by P value < 0.05. Thus, H7 was accepted for the data panel and the model.

#### 4.7 The Effect of FDI Moderation

Table 10 displays the results which showed the moderating influence of FDI that strengthened or weakened the influence of RDE and Log\_Patent on HTE.

**Table 10. Results of the Effect of FDI Moderation**

Hyp.	Path	Panel Data	Std. Beta	T Statistic	Std. Dev.	P Values
<b>Model 1</b>						
H8	RDE x FDI -> HTE	All Countries (15 years)	0,122	0,052	2,340	0,958
		All Countries (5 years )	0,194	0,028	6,874	0,977
		HI Countries (15 years)	0,114	0,005	21,365	0,996
		HI Countries (5 years)	0,188	0,002	79,445	0,998
		LM & UM Countries (15 years)	-0,033	0,000	133,437	1,000
		LM & UM Countries (5 years)	-0,019	0,000	233,446	1,000
H9	Log_Patent x FDI -> HTE	All Countries (15 years)	-0,009	0,211	0,044	0,833
		All Countries (5 years )	-0,007	0,096	0,076	0,924
		HI Countries (15 years)	-0,107	1,745	0,061	<b>0,081</b>
		HI Countries (5 years)	-0,086	0,712	0,121	0,477
		LM & UM Countries (15 years)	0,216	2,864	0,075	<b>0,004</b>
		LM & UM Countries (5 years)	0,190	1,639	0,116	0,102
<b>Model 3</b>						
H8	RDE x FDI -> HTE	All Countries (15 years)	-0,053	0,012	4,546	0,990
		All Countries (5 years )	-0,076	0,018	4,354	0,986
		HI Countries (15 years)	-0,096	0,005	17,742	0,996
		HI Countries (5 years)	-0,116	0,002	70,524	0,999
		LM & UM Countries (15 years)	0,081	0,001	55,791	0,999
		LM & UM Countries (5 years)	0,110	0,001	117,722	0,999
H9	Log_Patent x FDI -> HTE	All Countries (15 years)	0,036	0,947	0,038	0,344
		All Countries (5 years )	0,143	2,205	0,065	<b>0,027</b>
		HI Countries (15 years)	-0,041	0,691	0,060	0,490
		HI Countries (5 years)	0,179	1,791	0,100	<b>0,074</b>
		LM & UM Countries (15 years)	0,075	1,003	0,075	0,316
		LM & UM Countries (5 years)	0,069	0,583	0,119	0,560
<b>Model 5</b>						
H8	RDE x FDI -> HTE	All Countries (15 years)	-0,083	0,017	4,861	0,986
		All Countries (5 years )	-0,137	0,026	5,315	0,979
		HI Countries (15 years)	-0,094	0,007	14,422	0,995
		HI Countries (5 years)	-0,163	0,003	47,287	0,997
		LM & UM Countries (15 years)	-0,003	0,000	41,037	1,000
		LM & UM Countries (5 years)	-0,018	0,000	198,632	1,000

H9	Log_Patent x FDI ->	All Countries (15 years)	0,013	0,342	0,037	0,733
		All Countries (5 years)	0,018	0,275	0,067	0,784
	Log_HTE	HI Countries (15 years)	-0,025	0,525	0,049	0,599
		HI Countries (5 years)	-0,126	1,152	0,109	0,250
		LM & UM Countries (15 years)	-0,035	0,536	0,065	0,592
		LM & UM Countries (5 years)	0,004	0,030	0,143	0,976

From table 10, it is known that FDI did not have any significant moderating influence in the relationship between RDE and HTE from all the research models and data panels. This was indicated by no one P Values that were smaller than 0.05. Thus, H8 was rejected, which implied that the FDI did not have a moderating effect on the relationship between RDE and HTE. The results in table 6 previously also demonstrated that R&D expenditures did not have a significant direct effect on HTE. It turned out that even FDI support cannot strengthen the effect of RDE on HTE. It was because R&D expenditures were used for R&D activities in other fields of science studies outside the fields of aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery, which were the benchmark for calculating the export value of high-tech products.

On the other hand, FDI had a positive and significant moderating effect in the relationship between Patent and HTE for all country data panels in the short-term period (data panel 2) for model 2, as well as data panel five consisting of lower-middle and upper-middle countries income (15 years) for model 1. Thus, H9 was accepted for the data panels and the intended model. This result confirms the previous statement that lower-middle and upper-middle-income countries have a lack of resources they have, especially in terms of capital to transform these patents into the latest high-tech products and produce them. Thus, it requires foreign investment in foreign direct investment to make it happen even though it can only be realized in the long-term time period.

## 5. Conclusions

In this study, there were six panels of data examined, which were data panel for all countries in the long and short term periods, data panel for long and short term high-income countries and lower-middle and upper-middle-income countries for the period long and short term.

For the data panel one, it was found the following results:

- RDE expenditures did not have a significant effect on high-tech exports or GDP for all models tested. Likewise, high-tech exports did not have a significant effect on GDP.

- Patent had a significant positive effect on high-tech exports for model one, and a negative effect on model three and five.
- Patent had a significant negative effect on GDP for models four and six.

For the data panel two, the results found were as following:

- RDE expenditures did not have a significant effect on high-tech exports or GDP for all models tested. Likewise, high-tech exports did not have a significant effect on GDP.
- Patent had a significant negative effect on high-tech exports for model five, as well as on GDP for model six.
- FDI had a positive and significant moderating influence in relation to high-tech export patents for model three.

For the data panel three, the results were:

- RDE expenditures did not have a significant effect on high-tech exports or GDP for all models tested.
- Patent had a significant negative effect on high-tech exports for models three and five.
- Patent had a significant negative effect on GDP for models one, three and five.
- High-tech exports had a significant effect on GDP for models two and six.
- High-tech export had the effect of mediating the patent relationship with GDP for the selection of GDP data in the current US \$.

For the data panel four, the findings were the following results:

- RDE expenditures had no significant effect on high-tech exports for all tested models but had a significant positive effect on GDP for model six.
- Patent had a significant negative effect on high-tech exports for model five but had no effect on GDP for all research models.
- High-tech exports had a significant effect on GDP for model two.

For data panel five, the results found were as follows:

- RDE expenditures had no significant effect on high-tech exports and GDP for all models tested.
- The patent had a significant positive effect on high-tech exports for model one and had a significant negative effect on model five.
- Patent had a significant negative effect on GDP for model six.
- High-tech exports had a significant effect on GDP for model four.
- FDI had a positive and significant moderating effect on patent relationships and high-tech exports for model one.

For data panel six, we find the following results:

- RDE expenditures did not have a significant effect on high-tech exports or GDP for all models tested.
- Patent had no effect on high-tech exports but had a significant negative effect on GDP for model six.
- High-tech exports had no significant effect on GDP.

Based on the results of this study, it can be concluded that for high-income countries, innovation activities can affect economic growth both in the long term and short term. This is due to the availability of technological infrastructure, technology and capital resources that can execute (short term) the latest patented findings that can be commercialized into the latest high-tech products and produce them in large quantities. Spontaneously, this will increase the export value of these high-tech products which will later increase their economic growth. Meanwhile, for lower-middle and upper-middle-income countries, innovation activities can only affect economic growth in the long run and even then requires support of foreign investment through the influence of the moderation of foreign direct investment inflows. This is because FDI can help a country improve its innovation activities through mobilizing skilled labor, capital, new technology, and supplier cooperation (Cheung & Lin, 2004). In other words, FDI can really help lower-middle and upper-middle-income countries to cover up the shortcomings they have in terms of innovation, especially in the field of technology.

The results of this study also proved that even with the same variables, but with different data choices, the study can obtain different results not only in the level of significance but also in differences in direction of influence. For example, for the effect of the number of patent applications on high-tech exports in the data panel one, it was found a different direction between the one model using high-tech export data in the form of a ratio of GDP to model six using high-tech data export in current US \$. Although the results were equally significant, in model one, the direction of positive influence was obtained, while in the model six, the direction of negative influence was obtained. If evaluated as a whole, the selection of high-tech export data and GDP in the current US \$ gave far better results, so it is recommended that researchers can then use high-tech export data and GDP in current US \$ in their research.

The weakness of the research is that there is still inadequate R Square value for all the models and panel data used. The average value of which was still below 0.1 or 10%. The only research model with a value of R Square above 0.1 was model five for panel data on high-income countries for the period of 2011 - 2015. This indicates that there are many other variables that can be included in the research model to increase the value of R Square, which of course can be used as input for further research.

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