

# “IMPACT OF HIGH TECHNOLOGY EXPORTS, PATENT APPLICATIONS AND RESEARCH AND DEVELOPMENT EXPENDITURE ON ECONOMIC GROWTH: EVIDENCE FROM ASEAN COUNTRIES”

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## ABSTRACT:

The increasing importance of economic growth and its crucial determinants such as high technology exports, R&D expenditures and patent applications have been found to have some impact on economic growth in one way or the other. This study has been conducted for the same purpose for which the data has been collected by the author for 26 years for Thailand. The authenticity of this data can be evident based on the databases of data gathering process. When different approaches such as unit root test, cointegration test, coefficient estimation test etc. were applied to analyze data in different contexts, the results for these tests were obtained. According to these results, the impact of high technology exports as well as R&D expenditures has been found as significant on economic growth. In addition, the impact of one control variable i.e. innovation has also been declared as significant. Moreover, in the concluding section of the study the author has also identified several benefits of this study in context of theory, practice and policy making. Apart from this, several limitations in different contexts along with recommendations to improve them have also been discussed which will be assisting the future researchers in their studies.

## Keywords:

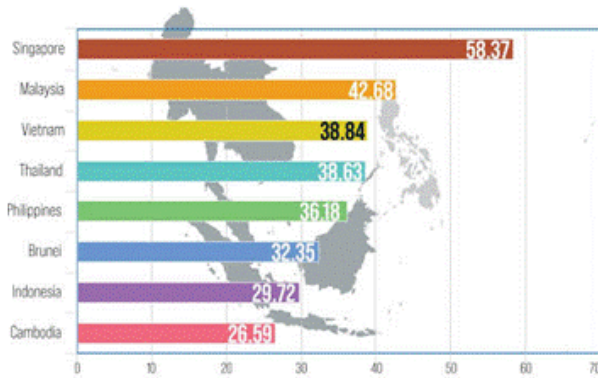
High technology exports, patent applications, ASEAN, R&D expenditure, intellectual property rights

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## INTRODUCTION

Over the course of the past three decades, Asian countries have seen a global economic rise due to the fact that these countries have high industrial outputs combined with the factor of low costs (Bank, 2013). Sustainable economic growth is the aim that developing countries are working to achieve because such innovative economies can provide higher incomes to the citizens and better opportunities for work and development of skills. Higher education, better research and development infrastructure, freedom to collaborate and a robust information structure are demands of an innovative economy (Fagerberg, Mowery, & Verspagen, 2009; Maradana et al., 2017). ASEAN countries face the challenge of low acceptance of innovation, obstacles to technological readiness and a lack of high education and appropriate skill development.

These issues also cause a hindrance in the economic development in the region. Singapore is the only innovation-driven country in the ASEAN region, while the other economically strong countries in the region like Malaysia and Thailand are investment oriented, whereas the others go through phases of fluctuations between the two extremes (Muhamad, Sulaiman, & Saputra, 2018). The below attached figure no.1 shows the comparison of innovation acceptance among ASEAN countries. Innovation acceptance is a driving force of economic development in today's technologically advanced world.

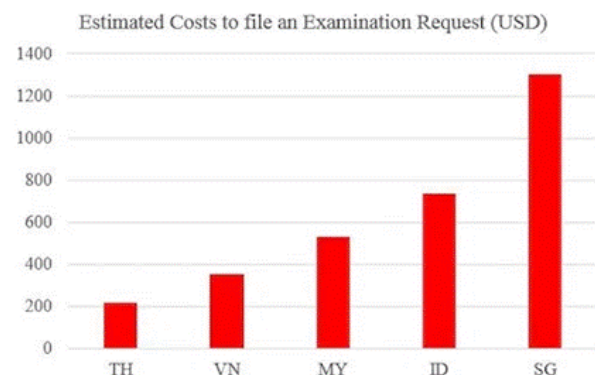


**Figure 1:** Innovation Acceptance in ASEAN Countries

In the same line of discussion, Bozkurt (2015) discussed that when a slight change occurs in the economic growth drastic changes are observed in the country’s welfare and the policies of knowledge development and technology market. A well-developed and organized R&D is the need of any economy. R&D is short for research and development and it can be defined as a sector in a company that develops the strategies for the introduction of innovative and the technological and technical developments. These developments are in the form of new products, services or policies. In addition to this, these developments can also take form of improvements and enhancements in the previously existing products, services and policies. Research and development plays an important role in the economic growth of developing countries by enhancing productivity and achievement of sustained economic growth. In addition to R&D practices and expenditure, the rights to intellectual property also play an important role in the economic growth of a country. Patents are one of the tools that attest the authenticity of intellectual property. Patents are granted to innovative inventions that show potential for intellectual application (Kim, Lee, Park, & Choo, 2012). Patents are granted by organizations for the duration of 20 years. In the similar vein, Sohag, Begum, Abdullah, and Jaafar (2015) used the number of patents registered as an indicator for the level of technological innovation

in a country. However, there is a high cost of patenting all over the world that discourages the small entrepreneurs from applying for inspection. The Figure no.2 attached below shows the cost of applying for examination of an item for getting a patent in the top ASEAN countries. Another innovation based indicator of economic growth is high technology exports. The high technology exports are composed of products that are designed and developed with high intensity of R&D. These products can belong to the field of pharmaceuticals, computers, electrical machinery, etc. (Fan, 2011; Zortuk, BAKIRTAŞ, & VARSAK, 2009).

Developing countries, like countries of the ASEAN, are undergoing a constant economic growth. These countries need to develop resources and policies that can attract investments and a steady flow of finances so that a continued growth in economy can be observed. Moreover, in an ideal situation, the governments of the developing countries must have knowledge about different factors that exert their roles in the growth and development of economies, on both the global and local scale. This need is not only restricted to the ASEAN region, but is looming around in every developing economy. Thus, there is a need to first single out these driving factors and then study their roles in the economic growth.



**Figure 2:** Estimated cost to file an examination request in USD

In light of these needs, the major aims and objectives that the author of this study outlined are given below.

- To determine the role played by high technology exports in the economic development and growth in ASEAN countries.
- To analyze the role that patent applications play in the economic development and growth in ASEAN countries.
- To study how research and development expenditure affects the development and growth of economy in ASEAN countries.

The scope of this research is to study the effect that innovation capacity exerts over the economic growth of the ASEAN region. Innovation capacity includes processes like R&D and patent development etc. The significance of this study lies in the fact that many studies (Ahmad et al., 2017; Ahmed et al., 2016; Azam, Nawaz, & Riaz, 2019; Khan, 2015; Maradana et al., 2017; Sadraoui, Ali, & Deguachi, 2014; Salahuddin, Alam, Ozturk, & Sohag, 2018; Sohag, Al Mamun, Uddin, & Ahmed, 2017) that have been conducted for assessing the role played in economic growth have contributed to the volume of literature on this topic and has helped the governments, industries and researchers of developing countries in the practical development and implementation of policies for improving economic structures of their countries. This study sees the effects of High tech exports, R&D expenditure and patent applications on economic growth.

## 1. Literature Review:

### 1.1 Schumpeter and Keynes Model of Economic Development

Schumpeter's theory of economic development appoints a dominant role to innovation and entrepreneurship in the process of economic development. Schumpeter's theory examined the changes in economy and the surrounding social structures in the environment while factoring in the endogenous variables of the system, providing a political and social aspect to the theory in addition to it being economic (Schumpeter, 2017).

Schumpeter attached a great amount of importance to economic sociology and had a firm belief on the unity of social life and the dependence of its components on each other. According to this theory, change is generated in the economy through innovative activities and entrepreneurship, which are considered the only agents that are able to carry out new set of combination of resources and of transforming the organizational structures (Witt, 2016a, 2016b). The theory of economic development presented by Schumpeter is important for understanding how technology changes affect economy but according to Dosi, Napoletano, Roventini, and Treibich (2017) it is an incomplete framework for explaining how innovation translates into economic growth. Technology affects the long term growth rate of economy as well as the short term goal achievement of microeconomic gains over the business cycle. The mixture of concepts by Keynesian theory and the Schumpeter model (Cimoli et al., 2014; Dosi, Fagiolo, Napoletano, & Roventini, 2013) joined together into a single framework allows the new framework to explicitly address the long term processes of technological changes and the dynamics of a demand-driven environment. This K+S model is ideal for explaining how the business cycle is affected by innovative and technology based interventions in the long run. Innovation, aggregate demand, industry dynamics and income distribution are explained and studied under this model.

### 1.2 Impact of High Technology Exports on Economic Growth

Maradana et al. (2017) discussed that the level and structure of innovation in a society cannot be ignored because it plays an important role in stimulating the economic growth of a country. The innovation level and structure can be studied in terms of a number of factors including high technology exports. High technology in a country is defined as the innovative products and services that have advanced features and properties. These products need expert industries and companies for

their development. These industries rely on advanced scientific and technological expertise that can be classified in terms of high R&D expenditures and total labor force. High technology sectors include industries like computer, scientific instruments, medicine, aerospace, etc. Countries with advanced technology infrastructures can achieve better levels of economic growths by exporting these technological innovations (Kabaklarli, Duran, & Üçler, 2017). The growth of interest in trade of high technology is influenced by the fact that the international economy of any country shows its competitiveness in the global technology market and the literature recent highlights that the high tech industries are the most developing in international trades (Basarac Sertić, Vučković, & Škrabić Perić, 2015; Ekananda & Parlingoman, 2017; Tebaldi, 2011). Research conducted by (Akhvlediani & Śledziewska, 2015) used panel data to analyze the V-4 countries and the EU-15 countries on basis of their high tech exports. The study showed that the determinants of high tech exports, including physical and human capitals, exert a positive significant role in the development of economy. FDI, which is considered one of the most important factors that affect global economy and its growth in developing countries, increased the level of competitiveness in the industrial production and manufacturing at a global level. Multinational corporations are, therefore, investing in technology creation in countries that have lower labor rates, utilizing these cheap labor facilities to enhance the technological development in both the host country and themselves (Kızılkaya, Sofuoğlu, & Ay, 2017). Due to these reasons, Kabaklarli, Duran, and ÜÇLER (2018) claimed the importance of high-tech investments and exports.

The ASEAN countries have shown inclination towards adoption of digital technologies and their usage for advancement in terms of social betterment economy. Mobile phone technology and the wide spread of internet has played a significant role in spreading digital technology in

the region. The large firms in ASEAN region use websites, e-stores and other mechanisms of online sales for improving the level of income in the region (Box & Lopez-Gonzalez, 2017). ASEAN economies face a continued challenge of harnessing digital technologies while pursuing prosperity and economic growth as a regional agenda. AEC blueprint for 2025 (Secretariat, 2015) maps the direction in which this region is moving in terms of economic development with support from innovation and technology and shows that the region is facing many difficulties due to unequal distribution of technology. The same unequal distribution of economy and finances is seen in the region. The K+S model discussed above, supports the claim that high technology will improve the economic infrastructure in the region. The discussed literature can be summarized into the following hypothesis.

H1: High technology exports play a determining role in the development of economic infrastructure and stability of a country.

### ***1.3 Impact of Patent Applications on Economic Growth***

The request sent to a patent office for the grant of patent for an invention of any sort, let it be a product, service, technology or merely a theoretical concept, is called a patent application (HE & ZHANG, 2017). This is a formal document that allows for the protection of an intellectual property (Xiang-jie, 2015). History shows that the patent system was developed to promote innovation and creation that can encourage economic development of a country. The offer of granting exclusive rights of intellectual property to the creator helps them feel confident and secure, enhancing the abilities and skills to a high productivity level. The patent protection also promotes the intent of investments to make commercial and market level inventions, letting the general public enjoy the fruit of the efforts; this also helps gain economic and financial benefits from inventions. In the case of disparity between different economic nations, the patent

system is a viable source of economic differences due to the proven history that patent systems are key role players in case of development enhancing and eradication of poverty. Competitive position of a country in economic standing and exports has shown to be affected by many factors including patent applications by locals. A recent study conducted for OCED region by Kabaklarli et al. (2017) showed that patent applications are positive drivers of technology exports and only a 1% increase in patent applications for a year showed the exports to raise by 3.5% approximately, improving both the local economy and foreign direct investments. The technological capability of a country can be measured numerically by the number of patented innovations over a year. Patent applications, internet and technological spread high technology development and export are all global determinants that help in improving global and local economies. Kızılkaya et al. (2017) showed a positive relationship between R&D expenditure and patent application numbers, leading to the resultant derivation of the fact that number of patent application affects economic growth positively.

The ASEAN region is diverse in the levels of acceptance of technology, education, division of income and economic structures. Number of patent applications is an indicator of innovation and innovation and economic growth are associated intricately (Raghupathi & Raghupathi, 2017), each driving the other and playing a key role in the current trends of political and government level policies and agendas in the region. The ASEAN community needs to harmonize the levels of innovation and technology development and acceptance with in each country of the region and also in terms of intra-region statistics. The K+S model discussed above claimed that innovation is a key player in the affecting the economic growth in a country, further supporting the claim that patent applications improve economic structures. The

following hypothesis is generated in result of the reviewed literature.

H2: The number of patent applications is a significant positive determinant for the level of economic growth in a country.

#### ***1.4 Impact of Research and Development Expenditure on Economic Growth***

The past few decades have witnessed an increase in the demand of R&D policies that can improve the economic structure. R&D policies include activities that encourage innovations in the society by allowing the introduction of new innovative products, services and policies aimed to improve the Regional Government policies and financial status of a country. R&D subsidies play a vital policy role in the social environment (Garau & Lecca, 2015; Haseeb, Kot, Hussain, & Jermsittiparsert, 2019). The government, private and public sectors spend their resources on strategies in the R&D department as a trade-off with the expenditure in other departments to allow the organization's labor and production processes to change effectively. R&D processes usually require new set of skills or may require the modification of current skills, creating new job vacancies or improving the skill set in the current employee teams (Ciarli, Marzucchi, Salgado, & Savona, 2018). This allows for reduction of unemployment in the society and improves income. In the context of ASEAN countries, the R&D policies that have been put to effect in the past decade have resulted in a gradual betterment of the economy in the country. For further improvement of economic status of the region, the local business and corporate resources need to invest in R&D activities in their firms and companies. Moreover, the government must indulge in increased R&D activities on the public sector level (Jacoby, Zhang, & Xu, 2018; Winoto & Siregar, 2016). This will increase jobs in the public and business sectors, leading to improved levels of economy.

According to the Keynesian theory, R&D projects and processes allow for introduction of better education and innovation systems in a society and

creates new and vital job areas in a country creating solutions for issues that hinder economic growth, such as the issue of unemployment. Corporate and government level expenditures on R&D processes do not cause any financial or economic loss but instead allow for earning and location of new resources, leading to improved levels of GDP in the country (Parlaktuna & Saricicek, 2018). Thus, there is a need to introduce new policies and projects in the R&D sector that can allow for betterment of the economic conditions of the ASEA countries to create new jobs and introduce new innovations that will allow for minimization of the job gaps and will improve the economic infrastructure in the region. Ciriaci, Moncada-Paternò-Castello, and Voigt (2016) presented an empirical research in their paper that showed that investment in the sector of R&D exercises positive effects on employment rates and the economic growth. The K+S model supports R&D processes as these processes allow for innovative inventions and policy making. Innovation has been proved to be linked with economic growth by the presented literature which can be used to show that research and development expenditure allows for economic growth. The following hypothesis has been generated to summarize this.

H3: Research and development expenditure plays a significant positive role in enhancing the economic growth in a country.

## METHODOLOGY

### 1.5 Data

Data collection is the first and foremost step for the conduction of any research and has its own importance. The data collected from reliable databases provides accurate and authentic results, thus it is very crucial to put effort in this step of a research. In this particular study, panel data has been collected for the ASEAN countries and the time period for which data has been collected is 26 years. The basic variables about which data has been collected include high technology exports, patent applications, research and development

R&D expenditure and economic growth of a country. In addition to these variables, two control variables i.e. innovation index and business freedom index have been included. As discussed above, the author has collected data from authentic sources such as World Bank and the Global Economy etc.

### 1.6 Model Specification

The purpose for which this study is being conducted is to investigate the impact of high technology exports, patent applications and R&D expenditure on economic growth of a country. After the identification of this purpose, the next step is to categorize the variables among independent and dependent variables. In this regard, high technology exports, patent applications and R&D expenditure are the independent variables of this study while economic growth is the dependent variable. Moreover, two control variables have also been added by the author for the purpose of checking their impact too in the study. All of the above mentioned variables can be represented in term of various measurement units, the details of which are given here. The dependent variable, economic growth (ECO) can be measured in terms of rate of change of real GDP. In the same fashion, the independent variable high technology exports (EXP) can be measured in terms of billions US dollars, patent applications (APP) will be measured as the number of applicants for patent and R&D expenditure (R&D) can be measured by billion US dollars. In the last, we have two control variables, one of which is innovation index (INNO) which can be measured on the base of a specific index that ranges from 0-100. Similarly, business freedom index (BFI), the other control variable can also be measured through the use of an index that ranges from 0-100 too. In the above mentioned units, all the variables that have been used in this study have been measured by the author. To proceed further in the research process, a general regression equation must be generated. The regression equation for this study can be given as:

$$ECO_{it} = \alpha + \beta_1 EXP_{it} + \beta_2 APP_{it} + \beta_3 R\&D_{it} + \beta_4 INNO_{it} + \beta_5 BFI_{it} + \varepsilon_{it}$$

Where ECO= economic growth, EXP= high technology exports, APP= patent applications,

INNO= innovation index, BFI= business freedom index and  $\varepsilon_{it}$ = error term.

Authors	Country/Group	Period	Variables	Methodology	Results
Satrovic(2018)	70 countries	1995-2015	Economic growth and high technology exports	Unit root, cointegration test, Granger casualty test, ARDL model	Short and long run relationship between high technology exports and economic growth
Freimane & Bāliņa (2016)	European Union States	2000-2013	R&D expenditures and economic growth	Panel data regression	Significant impact of R&D expenditures on economic growth
Gökmen & Turen (2013)	EU 15 countries	1995-2010	Determinants of high technology exports (FDI, human development level, economic freedom)	Granger casualty test	Long run casualty from FDI, economic freedom and human development to high technology exports
Papageorgiadis & Sharma (2016)	48 countries	1998-2011	Intellectual property rights and innovation	LLC unit root, pedroni cointegration	Significant impact of intellectual property rights on innovation
Kılavuz & Topcu (2012)	22 countries	1998-2006	High and low technology Export and economic growth	Panel data analysis	Significant impact of high and low technology exports on economic growth

**Table 1:** Empirical Evidence from Past Research Studies

**1.7 Estimation Procedure**

After the collection of data and the formation of regression equation, the author has applied several tests and techniques on that data and variables and has found out some important results regarding the purpose of this study. The basic tests and

techniques that have been adopted by the author in this study include Levin Lin Chu unit root test, Kao cointegration test and DOLS coefficient estimation approach. All the above mentioned approaches have been clearly and vividly discussed in the following section.

### 1.8 Panel Unit Root Test

The first and most basic test that has been used by the author in this study is Levin Lin Chu LLC unit root test. Unit root tests are very basic tests and are generally used to find out the integration order of the variables as well as the stationary properties related to the variables. For these purposes, generally used tests are LLC and IPS, both of which have different properties and benefits (Im, Pesaran, & Shin, 2003). One of the most important points in this regard is that LLC provide same autoregressive process while IPS provides heterogeneous autoregressive process. In addition, both these test are the extracts of augmented Dickey Fuller unit root test ADF. Studies have discussed that in the past, several unit root tests were used but they were having size and power issues due to which they were unable to provide accurate and authentic results. Moreover, these conventional tests provided non standard distribution of data. However, the recent unit root tests such as LLC and IPS do provide standard normal distribution and they also resolve the issue of size and power. It has been discussed in the previous studies that unit root tests provide information about whether the collected data is affected by its own previous values or not. Apart from that, the stochastic properties of data and variables can also be found out by using these tests. These tests are actually based on the null hypothesis and its alternate hypothesis. The null hypothesis shows that unit root is present in the data and it is non stationary in nature. On the contrary, the alternate hypothesis shows that there is no unit root and the the data is completely stationary. On the basis of these two types of hypothesis, the results are derived from unit root tests. As author has applied LLC unit root test in this particular study, the equation for this test can be written as follows:

$$\Delta y_{i,t} = a_i + \rho y_{i,t-1} + \sum_{j=1}^{pi} a_j \Delta y_{i,t-j} + \varepsilon_{i,t}$$

Here  $\Delta y_{i,t}$  is the difference that  $\Delta y_{i,t}$  shows for ith country for the specific time period of t.

### 1.9 Panel Cointegration Test

After the confirmation of order of integration among various variables of the study, cointegration tests are applied in order to find out and investigate the cointegrating relationships or long run equilibrium relationships between the variables having order of integration one. For this purpose, usually two types of tests are used which include Kao test and Pedroni test. There are two types of categorization among these tests, the first one of which is the distribution of these tests into between and within dimension approach (Engle & Granger, 1987). These two approaches are further divided into several types of statistics. In this regard, within dimension approach is divided into four types of test statistics (v-statistic, rho-statistic, PP-statistic and ADF statistic) while between dimension is divided into three types of test statistics (rho-statistic, PP-statistic and ADF statistic). Another major difference among these two approaches is that within approach provides homogeneous panel cointegration statistics while between approach provides heterogeneous group mean statistics (Enders, 2008). As discussed earlier, that IPS unit root provides heterogeneous autoregressive process, these cointegration tests provide the same process. An important aspect of cointegration tests discussed by past studies is that these tests are based upon the null and alternate hypothesis. In the context of cointegration tests, the null hypothesis suggests that there is no cointegration among the variables while the alternate hypothesis suggests that there is cointegration among the variables. So it can be inferred that if most of the coefficients in the results of these test are significant, it will mean that the null hypothesis is rejected and cointegration is present among the variables. On the contrary, if most of the coefficients are not significant, it will suggest that the null hypothesis has been accepted and there is no cointegration among the variables. In this study, the author has used Kao cointegration test, the general equation of which is presented below:



$$y_{i,t} = \alpha_i + \delta_{i,t} + \beta_1 X_{1,i,t} + \beta_2 X_{2,i,t} + \dots + \beta_n X_{n,i,t} + \varepsilon_{i,t}$$

**1.10 Coefficient Estimation Procedure**

After the integration and cointegration statuses of the variables have been considered, the next and most important thing is to investigate the presence of any long run relationship between the variables. For this purpose, two types of tests are generally used i.e. FMOLS and DOLS. These tests are actually derived from the traditional OLS test. The basic reason to derive FMOLS and DOLS from OLS is that, it showed the issues of serial correlation and endogenous variable existence in the variables (Dickey & Fuller, 1981). These issues have been effectively solved by FMOLS and DOLS tests. The past studies have presented the two important conditions of these tests, the first one of which is that these tests will be suitable if there is single cointegrating vector in variables that are integrated of order one. The second condition is that these tests will be suitable when there is long run relationship among variables and there is no cointegrating vector in the explanatory variables. If the above mentioned two conditions are satisfied, then these tests will be suitable and appropriate. The coefficients values and directions show that whether there is significant or significant and positive or negative relation between the variables. As the author has adopted DOLS coefficient estimation test in this study, its general equation is given as follows:

$$\hat{\beta}_{FM} = \left( \sum_{i=1}^N \sum_{t=1}^T (x_{i,t} - \bar{x}_i)^2 \right)^{-1} \sum_{i=1}^N \left( \sum_{t=1}^T (x_{i,t} - \bar{x}_i) \overline{ECO}_{i,t} - T \hat{\delta}_{\varepsilon u} \right)$$

In this equation,  $\overline{ECO}_{i,t}$  is the transformed variable of economic growth due to endogeneity correction while  $\hat{\delta}_{\varepsilon u}$  represents the serial correlation correction by DOLS.

**EMPIRICAL ANALYSIS**

**1.11 Results of Panel Unit Root Test**

As mentioned in the previous section that the author has applied LLC unit root test in order to probe the integration order as well as the stationarity of the variables, so the results of this test are presented in the table 2 in detail. It can be clearly viewed in the table that the values for level and first difference series have been given in contexts of constant as well as constant plus trend for all the variables that have been put under consideration in this study. In the level section of the table, it is clear that all the variables except high technology exports and business freedom index are accepting the null hypothesis. This means that in this particular section, the unit root is present while the data is non stationary. When this data is first differenced, most of the variables reject the null hypothesis indicating that the unit root is absent and the data has become stationary. In this way the order of integration is also identified for various variables. To conclude the results for LLC unit root test, it can be stated that the data is non stationary in the level series while when the same data was applied with first difference, it immediately becomes stationary. After the confirmation of order of integration as well as the stochastic properties of the variables, the data is ready to be applied cointegration test according to the nature of data gathered.

Constructs	Level		1 <sup>st</sup> Difference	
	Constant	Constant+ Trend	Constant	Constant+ Trend
ECO	-2.9243	-3.3882*	-3.32872	-2.4821***
EXP	-6.8236*	-5.2497*	-6.82732***	-7.4568***
APP	-7.2383	-7.2847**	-2.48272**	-4.4287***
R&D	-8.8362	-9.4372**	-7.43782	-8.2984*
INNO	-4.8264	-2.8247*	-3.92389*	-3.7922***
BFI	-3.8378*	-7.4729*	-8.3271**	-9.5682***

**Table 2:** Unit root test

In this table, \* represents that the rejection is one percent significant, \*\* shows that rejection is five percent significant, \*\*\* shows that rejection is ten percent significant

**1.12 Results of Panel Cointegration Test**

It has been very clear that the author has adopted the Kao cointegration test for the purpose of finding out the cointegration relationship or long run relationship between the variables. The results that came after the application of Kao test have been given in the table 3. This table shows that this test has been applied in context of two approaches named as within ‘dimension approach and between dimension’ approach. Both these approaches have their own distinct values of their test statistics. Let us analyze the within dimension first. It has been very clear in the table that three out of two statistics have rejected the null hypothesis of no cointegration indicating the presence of cointegration between the variables. On the contrary, when the same test was applied

for ‘between dimension’ approach, the results presented that two out of three test statistics have rejected the null hypothesis created for cointegration test. When the overall results are estimated, most of the values of test statistics i.e. five out of seven have rejected the null hypothesis.

This situation infers that there is cointegrated relationship existing between the variables of this study. Studies have shown that ADF and PP statistic values are very crucial in this decision, which further affirms the strength of the results of Kao test. This affirmation of the results of this test will ultimately lead the data towards the next test by which the relationship between the variables can be measured.

Alternative hypothesis: common AR coefs. (within-dimension)				
	<u>Statistic</u>	<u>Prob.</u>	<u>Weighted</u> <u>Statistic</u>	<u>Prob.</u>
Panel v-Statistic	-3.294791*	0.0287	14.683739	0.4682
Panel rho-Statistic	5.842638*	0.0373	5.8632739	0.0137
Panel PP-Statistic	-6.382413***	0.0004	-2.563881	0.0003
Panel ADF-Statistic	0.462837	0.4682	-0.468213	0.3821
Alternative hypothesis: individual AR coefs. (between-dimension)				
	<u>Statistic</u>	<u>Prob.</u>		
Group rho-Statistic	5.873638*	.00003		
Group PP-Statistic	-3.813791	0.0000		
Group ADF-Statistic	-0.369427**	0.8261		
<b>Kao test.</b>	<b>Statistic</b>	<b>Prob.</b>		
ADF	-2.287391*	0.0532		

**Table 3: Panel Cointegration Test**

In this table, \* represents that the rejection is one percent significant, \*\* shows that rejection is five percent significant, \*\*\* shows that rejection is ten percent significant

**1.13 Results of Dynamic Ordinary Least Squares (DOLS)**

The author has applied DOLS test of coefficient estimation in this study in order to find out and measure the impact of various independent variables and control variables on the dependent variable i.e. economic growth. The results of this DOLS test are presented in the table 4 clearly. These results indicate that new technology exports have ten percent significant and positive impact on economic growth because economic growth increases by 24.6% with the increase of high technology exports. In the same way, the coefficient of R&D expenditures also shows that its impact on economic growth is significant with

five percent and positive. In other words, economic growth will increase by 13.6% with the increase of R&D expenditures. However, the impact of third independent variable i.e. patent applications has not been found significant in this study. Apart from this, the impact of one control variable, innovation is also significant but the impact of the other variable has not been found as significant. The overall results of DOLS show that high technology exports, patent applications and innovation have significant impacts on economic growth of a country.

Variable	Value	Pooled	Grouped
EXP	Beta	0.246**	0.284**
	SE.	0.273	0.485
APP	Beta	0.136	0.284**
	SE	0.387	0.284
R&D	Beta	0.332**	0.213*
	SE	0.384	0.836
INNO	Beta	0.836***	0.294***
	SE	0.336	0.158
BFI	Beta	0.384	0.039
	SE	1.583	1.385
Adj. R Square	Beta	0.735***	0.347***
	SE	0.836	0.934

**Table 4:** *Coefficient Estimation Test*

In this table, \* represents one percent significance level, \*\* shows five percent significance level, \*\*\* shows ten percent significance level

## DISCUSSION AND CONCLUSIONS

### 1.14 Discussion

To find out the impact of high technology exports, patent applications and R&D expenditures on economic growth of a country in this study, the author has made some hypotheses in the earlier section of the study. The first hypothesis regarding the impact of high technology exports on economic growth was accepted by the results and has been declared as significant. This result can also be seen in the same status in past studies (SATROVIC, 2018). The other hypothesis that patent applications have significant impact on economic growth could not be accepted based on the insignificant results of the tests. A study conducted in the past has also shown the similar results of rejection (Kılavuz & Topcu, 2012). The last hypothesis was that R&D expenditures have significant impact on economic growth. The author has considered this hypothesis as accepted which is completely in accordance with past and previous researches (Gökmen & Turen, 2013). Aside from these independent variables, two variables were also involved in the current study.

These include innovation index and business freedom index. Among these variables, the impact of innovation has been found significant but that of business freedom has been considered as insignificant. These results have also been presented in the same way by the researchers in the past (Freimane & Bāliņa, 2016). The affirmation of results got through the tests in this study by giving evidences from the past studies has further increased the effectiveness of the results.

## CONCLUSION

High technology exports, R&D expenditures and patent applications have their own importance in different industrial sectors of the country. They have also been found to have some impact on the economic growth of a country in one way or the other. To study and discuss this impact in detail, the current study was conducted by the author. He collected data for 26 years in context of Thailand from the authentic database of World Bank. This data was analyzed and scrutinized by applying several tests on it such as unit root tests, cointegration tests and coefficient estimation tests based on the type of data that was collected. From the results of these tests, it was found out that the impact of high technology exports as well as R&D

expenditures on economic growth of a country has been found as significant and positive. It must be noted here that two control variables were also involved in the current study i.e. innovation and business freedom. Innovation has found to be having significant impact on economic growth of the country. Based on these results, several theoretical, practical and policy making implications have been identified by the author. Apart from this, various limitations along with suggestions to improve them have also been given.

### **1.15 Implications**

As in this study, impacts of very significant concepts such as high technology exports, patent applications and R&D expenditures is being investigated on economic growth of a country, it has several implications in theoretical, practical and policy making contexts. It will provide enough literature on the concepts of the above mentioned concepts that can be used by the other researchers or authors in their studies. It may improve or increase the quality of their researches. Other than that, it may also assist various industries and businesses to increase high technology exports, patent applications and R&D expenditures that will ultimately result in the increase in productivity and growth of that particular organization or firm and also increase their contribution in the economic growth of the country. Apart from this, this study also has the ability to provide assistance to the government officials for developing policies and regulations that will support the exports of high technology products, increase the number of patent applications and R&D expenditures so that the productivity of businesses may increase and so may the economic growth in country.

### **1.16 Limitations and Future Research Recommendations**

For the flow of knowledge and information, it is important to add and improve certain aspects of a research or study. The same is the case with this current study which has various limitations and boundaries, but that should not stop the increase in

the quantity and quality of research. For this purpose, the author has described some of the limitations along with their respective future recommendations that can be employed by the future researchers in their researches and studies so that they may get improved. First of all, the variables used in this study are limited which can be increased or may be changed with some other relevant variables. The combinations of variables may also be changed so that various aspects related to these variables may be studied in a broader context. In the same way, this study is about ASEAN countries. However, other researchers may also choose some other countries or regions for research purposes and collect data in their respective context. Moreover, the tests that have been used in this study are very few and specific. The other researchers may experiment with other tests and approaches so that more accurate results are obtained. In the last, it must be noted that the sample size that has been selected for this study is really small, which must be increased by the other authors in their studies.

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