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An Empirical Investigation of Triple Helix and National Innovation System Dynamics in ASEAN-5 Economies

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Abstract This paper exhibits the concept of Triple Helix model to explain and link university-industry-government (Triple Helix) connections to national innovation systems theory. The driver of this paper is to test the dynamics of Triple Helix concept under national innovation system in the Association of South East Asian Countries (ASEAN)-5 economies. Panel econometric analysis with cross-sectional dependence (CD) test is applied to investigate the relationship amongst Triple Helix variables. The empirical analysis employs innovation indicators of five founding ASEAN countries namely Malaysia, Indonesia, Singapore, the Philippines and Thailand for the period of 2000-2015 from an existing WDI and WCY database. Econometric results support the two research questions of this study; firstly, there is a significant relationship between innovation outcome and its key drivers under Triple Helix context of National Innovation System in ASEAN-5 economies; secondly, the extent of the relationship among government R&D expenditure with high-tech productions are positive and significant while new ideas coming from universities as scientific publications and high-tech production have positive relationship but not significant yet in ASEAN-5 countries. Overall labor productivity is positive and significant with innovation outcomes in ASEAN-5.

Keywords ASEAN-5, national innovation systems, Triple Helix model, university-government-industry, Pooled OLS

I. Introduction

The main purpose of the study is to empirically investigate the concept of Triple Helix (TH) model under national innovation system (NIS). This research is an attempt to explain the relationship of Triple Helix actors and measure empirically the extent of this relationship in the long run. Previous

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studies have postulated the concept more theoretically, while this study is the first attempt to apply quantitative methodology to investigate this concept empirically considering first five founder Association of South East Asian Nations economies, namely Malaysia, Singapore, Indonesia, Thailand and the Philippines as cross-sectional unit.

The research questions of this study are, firstly, how is Triple Helix model characterized in general and in the context of ASEAN-5? To answer this question, research followed the framework of Triple Helix model under the National Innovation System based on the theory and descriptive analysis. Secondly, how effective are the relationships among the actors of Triple Helix model in this region? In order to find out the answer, this research applies econometric techniques such as panel Regression with Driscoll-Kraay standard errors.

Triple Helix theory is the sub-system yet very important component of National Innovation system. Generally speaking, "the national innovation system of a country is composed of different sub-systems ranging from economic regime, financial structure and infrastructure to educational system, cultural traditions, and so on. Thus, economic development is regarded as the inter-action and co-evolutionary process of these sub-systems" (Freeman, 1987, 52-53; Nelson, 1993). Lundvall (1992, 22-24) defines "NIS as the elements and relationships, which interact in the production, diffusion and use of new, and economically useful knowledge and are either located within or rooted inside the boarders of a nation state. In one a word the national innovation system is defined as the network of agents and set of policies and institutions that affect the introduction of technology that is new to the economy" (Sharif, 2006; Etzkowitz and Leydesdorff, 1997, 1998, 2000).

The synergy among universities, government and industry are also known as the Triple Helix. The Triple Helix approach was introduced by Etzkowitz and Leydesdorff (1997, 1998, 2000). This Triple Helix model focus on the interaction among universities, industry and government and consider these factors are the key to the improvement of conditions conducive to innovation. Thus, all three have an important role to encourage the creation of advanced economic climate.

Etzkowitz and Leydesdorff (2000) also argue that university, industry and government are identified as the main pillars of many innovation systems theories including NIS. In this paper, we introduce the Triple Helix systems as a novel analytical concept that systematizes the key features of university-industry-government interactions, so far loosely addressed as a 'metaphor' or a 'framework', into an 'innovation system' format that highlights the key new sources of novelty and the dynamics of their interaction.

Large developing countries (like Brazil, Russia, India, China, South Africa, BRICS) postures the challenge for ASEAN to catch up with their growth

acceleration. Therefore, many economists (Stiglitz, Porter, Fagerberg, Mazzucato, Lundvall, Nelson, Kim etc.) agree that only a "high-quality innovation based growth, not just any growth could lead to a long-term sustainable economic success". Among the East Asian countries, Japan and South Korea actively build up their science, technology and innovation (STI) capacity with catch-up industrialization policies (Lundvall, 1992, 1993, 1998, 1999, 2003).

The ASEAN Economic Community (AEC) is heading towards technology driven production advantages. The AEC is trying to establish an economic region with a high level of competition, which requires a policy that includes competition policy based on advance innovation system in macro level.

Based on the ASEAN Economic Blueprint, AEC becomes very necessary to reduce the gap among ASEAN countries in terms of economic growth. Thus, to address a sustainable economic growth, AEC can promote the concept of Triple Helix model in this region. The relationship that appears in the Triple Helix, generally stems from efforts to solve the problem and produce a strategy when facing problems in innovation, not determined from a certain pattern. Through this interaction process there will be changes in the actors and the roles they are doing (Leydersdorff, 2000).

Cooperation among the government, businessman and intellectuals known as the Triple Helix concept was necessary to build the foundation of a strong national creative industry.

In order to formulate the policy that supports the aforementioned strategy, the large ASEAN nations namely Malaysia, Indonesia, Thailand, Singapore and the Philippines need to know where they stand and the gap that exist in Triple Helix system to improve the innovation culture of the countries as well the region as a whole.

Finally, it is argued that the Triple Helix interactions are an important factor in driving competition and economic growth (Freeman, 1987; Lundvall, 1998). This study will illustrate the concept by organizing this article into five major sections. Firstly, section 1 Introduce the concept and illustrate the research questions, section 2, Theoretical Background, section 3 will discuss ASEAN-5 cases, section 4 will describe data, variable and methodology and section 5 will shed light on conclusion and policy implication to find out the answers of research questions of this study.

II. Theoretical Background

1. Triple Helix Mechanism

In Triple Helix mechanism, innovation starts with an idea completely new or from his or her experiences. This idea will make networks with other firms or industries (creative industries those mostly involve in higher value-added productions. This relationship is recognized as a Triple Helix of academic-industry-government in innovation studies (Etzkowitz and Leydesdorff, 2000; Patel and Pavitt, 1994).

This whole process can start with reverse system such as, an individual at a firm might have a great idea of a technical process innovation (knowledge stage) and refer back to university lab (Bianchini, Lissoni, Pezzoni and Zirullia, 2016). Only new idea alone cannot generate new innovation, there are other socio-cultural factors induced the individual to do so. However, for the sake of this study, we are not considering other factors like social or cultural rather we are more focus on economic output contribution from high-technology industry. According to new growth theory, innovation driven product has increasing returns to scale as opposed to physical labor driven industries where the law of diminishing returns tends to offset the constant increasing returns, hence shows decreasing returns in neo classical production function. Theoretically speaking, Romer's new growth theory (1990) has been very influential and inspired many econometric studies linking R&D, innovation and hence in TH model.

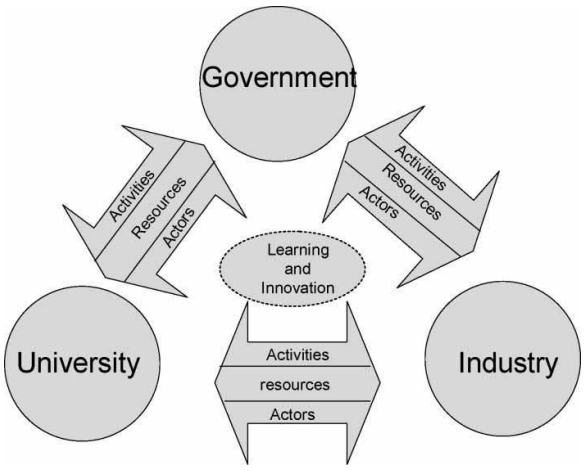

Figure 1 Effective links and integration between the three spheres of Triple Helix (Saad and Zawdie, 2005)

III. Justification of Variable Selection and Descriptive Study

1. Variable Selection

Following the theory of Schumpeter and New Growth Theory, this paper uses innovation as a concept of new process, new method, new market, new source of supply, new industry hence, new commercially value-added products for the economy (Schumpeter, 1942). Roger 2003 illustrates, this innovation diffuses from micro agent at individual or organizational level to macro stage such as National Innovation System of a country or region.

Therefore, to capture the whole process from micro to macro level, this study uses four different variables.

Generally speaking, in the case of finding the relationship between how idea generation linked with industry outcome, "the input-output indicators of NIS are mainly patents granted, scientific publications, and output of high-tech industries can be considered" (Hatzichronoglou, 1997; Afzal, 2014, 507-515; Afzal, 2013). We can explain all four proxy variables one by one to justify the variable selection process of this research. Firstly, the number of employees of a firm can be considered as a proxy of its size and industrial organization (Blau and Schoenherr, 1971) which this research use labor productivity as proxy for analysis.

R&D expenditure as percentage of GDP uses to measure the intensity of innovation-embodied production of intermediate and capital goods. This could also explain the TH model as technology commercialization such as High-Tech products (Hatzichronoglou, 1997). Whereas patents or high-tech products can be used as output indicators for R&D based science and technology research (Leydesdorff and Smith, 2014).

Pires and Garcia (2012) argue that total factor productivity (TFP) is responsible for technical efficiency, innovation and growth differences between countries. Recent econometric studies (Faustino and Matos, 2015; Lee and Narjako, 2015; Felsenstein, 2015) also confirm that higher TFP focusing on human capital development or increase labor productivity may lead to process innovation in an economy (Felsenstein, 2015).

Scientific and technical publications are another recent and popular proxy measure of new idea generation in universities or research institutes. Castellacci and Natera (2013) define it as the result of research and development funding from government activities by public system. Cai (2011), Pan Hung and Lu (2010) and Chang (2015) consider that scientific publications may be a very important proxy to measure in macro level study to identify whether these ideas are actually generating or linking the creative industries in individual countries or region backed by public research spending.

High-tech or creative industries generally refer to the scope of the industry is automotive industry, the drug industry, software industry, bio-technology and other industrial forms such as creative industries. The creative industries can be defined as a collection of economic activities associated with the creation or use of knowledge and information. "High-tech exports are one of the most popular proxies for innovation and NIS efficiency output (Afzal, 2013; Cai, 2011). Afzal and Lawrey (2012, 54) consider high-tech exports as commercialization of valuable knowledge creation". Fan (2011) argues that high-tech exports and patents outcome can represent the overall national innovation capacity and economic development as a whole. Therefore, for the purpose of this paper, we use high-tech exports as percentage of total manufacturing to capture the innovation outcome process in ASEAN.

2. Data Set and Descriptive Analysis

The data set consists of ASEAN-5 cross-country observations over the 2000-2015 period obtained from the data base of World Development Indicators[1], International Telecommunication Union (ITU) and World Competitiveness Year Book (WCY). The variables are HTE which measures the high-tech export as percentage on total manufacturing as proxy of innovation outcome, RDE as a proxy of research and development expenditure funded by government mostly, SJA as proxy of number of Scientific publication per 1000 population for new idea generation or knowledge spill over from universities, LPP is the proxy of labor productivity overall in tertiary education. Descriptive analysis of the dataset is given below.

The visualization above shows the scientific and technical journal articles published by the ASEAN countries for the period 2000 to 2015. Every country is producing scientific and technical journal articles and the number is increasing from the beginning of study period of analysis except the case in Indonesia. From 2013 to 2015, scientific and technical journal articles publication in Indonesia is constant. The lowest publication per 1000 populations is found in the Philippines from 2000 to 2008 whereas Thailand's publication number is increasing, but without any significant leap visible.

Whilst, Singapore had a small lift in scientific and technical journal article publications in year 2003, which sustained till 2004 and then followed by a steady increasing rate. The amount of Malaysia's scientific and technical journal articles faced a fall in year 2001. According to the Figure 2, Malaysia has the highest number of publications than the other countries studied during

[1] http://data.worldbank.org/indicator

2009 to 2015. In 2015, Malaysia published about 20,000 scientific and technical journal articles.

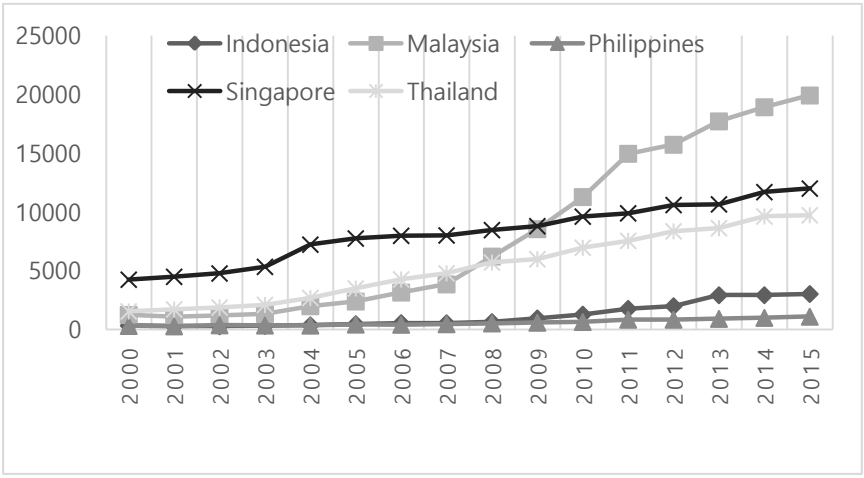

Figure 2 Scientific and technical journal articles

Source: Author calculation

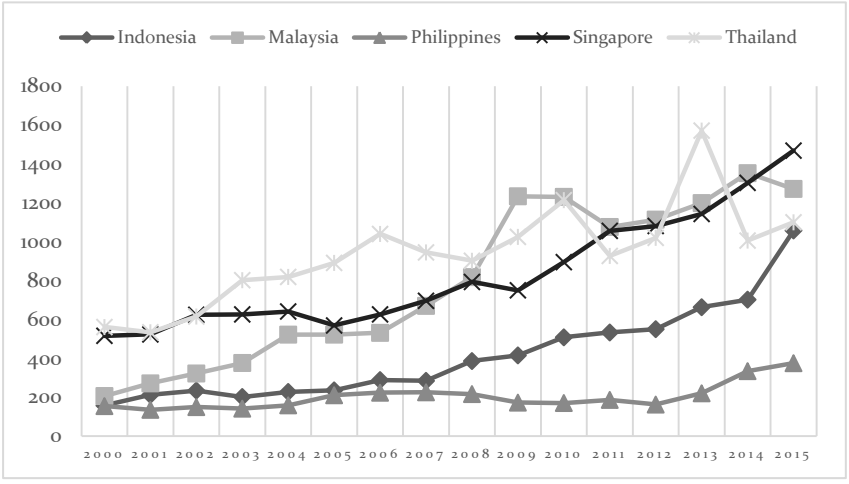

Figure 3 Patent applications, residents

Source: Author calculation

The state of patent applications claim by the residents of the five ASEAN countries is shown in Figure 3. Among the countries, the Philippines holds the least number of patent claim between the study period 2000 to 2015. Indonesia improves in patent claim in 2008, and the upward trend is sustained more in 2014, which continued till 2015. Singapore had the highest patent application claims in 2015 among the study countries. Claiming 1300 applications, Malaysian patent claim peaked highest in 2014 even though it remained constant in 2004 to 2006 and 2009 to 2010. On the other hand, the country also faces a slump in the number of patent application in 2011 and in 2015.

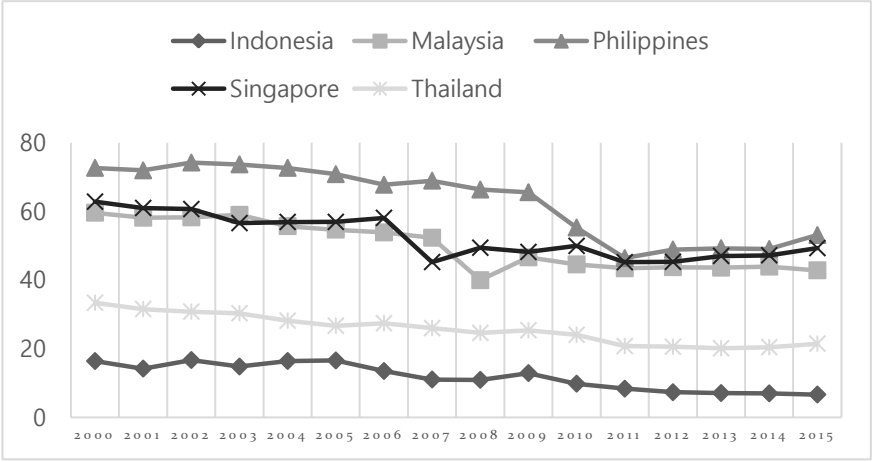

Figure 4 High-technology exports (% of manufactured exports)

Source: Author calculation

Generally speaking, high-technology exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery. The Figure 4 illustrates the high-tech export as a total percentage of manufactured exports for the five ASEAN countries. Here, high-tech exports were higher in the period 2000 and gradually decreased in 2015 for every country. The Philippines ranked top between 2000 to 2015 whereas, Malaysia and Singapore show a consistent low performance in high-tech export over the years. In 2015, Malaysia had around 43% share of high-tech exports of total exports whereas the high-tech export of Singapore was around 50% of its total export at that period. Thailand's share of high-tech export was around 34% in 2000 and declined to approximate 22% in 2015. The smallest share can be seen with Indonesia having 16% in 2000-reduced to around 7% in 2015. The slump of the high-tech exports of all

countries from period 2006 to 2011 can be denoted as one of the key events in the ASEAN economy.

The share of high-tech exports in developed economies improved basically due to the availability of cheaper raw materials, cheaper labor; increased efficiency and stronger entitlement of investment in required R&D sector; broadened outlook on high-tech trade; enhancing the quality of education; etc.

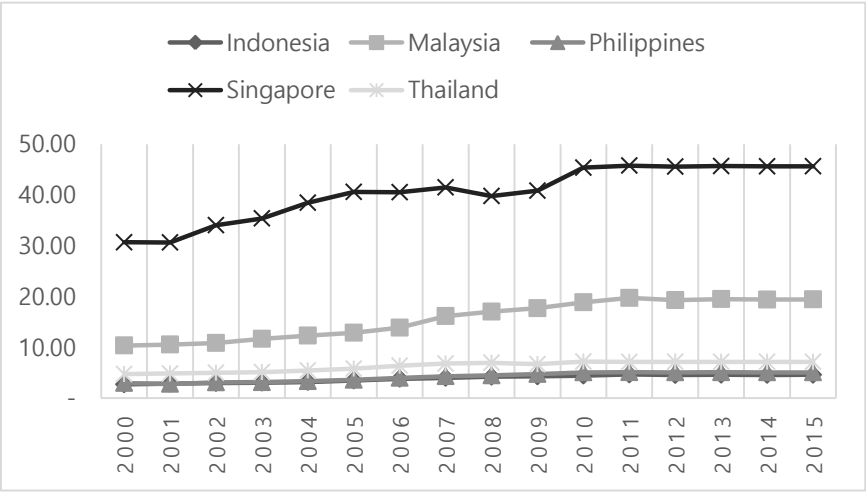

Figure 5 Labor productivity

Source: Author Calculation

The labor productivity of five ASEAN countries of period 2000 to 2015 is shown in the Figure 5 above. As we see here, Singapore holds the highest labor productivitywith 30% in 2000 and increase up to 45% in 2015. Malaysia follows Singapore having 10% productivity growth in 2000 and stayed around 19% in 2015.

Thailand lies above Indonesia and Philippines in labor productivity index from 2000 to 2015. Thailand's ratings have increased to nearly about 1.5% since 2000 to 2015. On the other hand, Indonesia and Philippines could not go above 5%.

This situation implies that Singapore has a higher living standard than the other countries. Higher labor productivity triggers the overall economic development of a nation by improving efficiency in physical capital, method of technology and human capital etc.

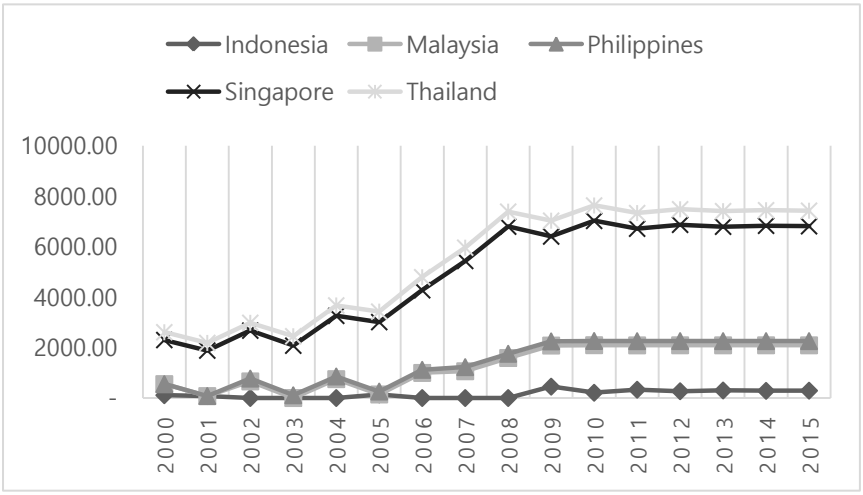

Figure 6 Total expenditure on R&D ($)

Source: Author calculation

The expenditure on R&D can directly affect the innovation condition of a country. By the above illustration a greater investment in R&D is seen in the case of Singapore and Thailand. In addition, Thailand ranked as the highest investor in R&D among the five ASEAN countries for the period 2000 to 2015. Where Singapore stands second. The R&D expenditure is least in Indonesia. Malaysia and Philippines follow an identical trend in R&D expenditure. These countries raised their R&D expenditure in 2007 which is found to be constant until 2015. The same augmentation in R&D expenditure is found in case of Singapore and Thailand in 2005 and being constant from 2012 to 2015 in Figure 6.

IV. Econometric Methodology

Our main objectives of the research are to find out Triple Helix relationship under NIS and how effective this relationship in long run. Therefore, our panel econometric model can be given as follows in order to test long run associations of our variables to justify the research objectives:

$$HTE_{it} = \alpha + \alpha_1 SJA_{it} + \alpha_2 RDE_{it} + \alpha_3 LPP_{it} + \mu_{it} \quad \ldots\ldots(1)$$

Where the subscript i=1… N denotes the country (in our study, we have 5 ASEAN countries) and t= 1…T denotes the time period (our time frame is 2000-2015), HTE is the high-tech export as percentage on total manufacturing, RDE is research and development expenditure (as % of GDP), SJA as proxy of number of Scientific publication per 1000 population, LPP is the overall labor productivity and μ is the error term in equation 1.

1. Cross Sectional Dependence Test

It is commonly assumed that distribution in panel data models is cross-sectional independent, especially when the cross-section dimension (N) is large. There is, however there is sometimes we have found the evidence of Cross-section Dependence (CD) in panel data set. In order to test whether or not the residuals from a panel estimation of the regression model are spatially independent, authors perform Pesaran's (2004) CD test. The null hypothesis of the CD test states that the residuals are cross-section ally uncorrelated. Correspondingly, the test's alternative hypothesis presumes that spatial dependence is present (Afzal and Gow, 2016) (Kao and Chiang, 2000) (Asteriou and Hall, 2007) (Bai and Ng, 2004; Peterson, 2007; Driscoll and Kraay, 1998).

In this study, Pesaran's test of cross sectional independence = 2.077, Pr = 0.0378, average absolute value of the off-diagonal elements = 0.160. On average, the (absolute) correlation between the residuals of two stocks is 0.354. Therefore, it comes as no surprise that Pesaran's CD test rejects the null hypothesis of spatial independence on any standard level of significance. As a result, our panel model should be estimated with Driscoll-Kraay standard errors since they are robust to very general forms of cross-sectional and temporal dependence (Driscoll and Kraay, 1998).

Pesaran's test of cross sectional independence = 2.077, Pr = 0.0378
Average absolute value of the off-diagonal elements = 0.354

Therefore, this research follows regression model by Pooled OLS with Driscoll and Kraay standard errors. Somewhat arbitrarily, a lag length of 8 is chosen. However, the results turn out to be quite robust to changes in the selected lag length.

2. Panel Unit Root Test

Cointegration test usually applies to understand the long run relationship between all the variables. However, before doing this test, researcher needs to

find out the stationary test of variables using unit root analysis at level (Dickey and Fuller, 1981; Phillips and Perron, 1988). However, in presence of cross sectional dependence, we cannot apply conventional unit root test. In this case, this study applied Westerlund (2007) second generation unit root test in the presence of cross section dependence (IPS, 2003; Levin et al., 2002).

3. Empirical Results

3.1 Results of Panel Unit Root Tests

To investigate the stationarity of the series used, we applied the unit root tests on panel data in the presence of cross sectional dependence. The results of these tests are presented in the following table:

Table 1 Results for panel unit root tests in the presence of CD

Variables	Test			
	Level		First Difference	
	t-statistics	p-value	t-statistics	p-value
HTE	-2.20	0.153	-1.77	0.446
RDE	-3.08	0.002	-2.92	0.006
SJA	-1.91	0.343	-2.69	0.021
LPP	-3.01	0.003	-1.63	0.531

Source: Author calculation

In this table 1, all the variables are not non-stationary at the level or first difference. In order to run cointegration test, there must have two conditions (Phillips and Moon, 1999; Stock and Watson, 1993; Saikkonen, 1991; Mark and Sul, 2003).

Variables at level (1) are non-stationary or have a unit root.
But at the 1st difference, they become stationary.

This study cannot find the presence of above conditions. Therefore, we cannot apply the conventional co-integration test in the presence of CD. According to Pedroni's Residual-Based Panel Cointegration Tests (1999, 2004; Kao, 1999; Kök et al., 2010; Granger, 1969; Engle and Granger, 1987; Johansen, 1991; Philips and Ouliaris, 1990; Lee, 2005; Adhikari & Chen, 2012; Jebli & Youssef, 2015) have mentioned cases like this, the research should apply Error Correction Model (ECM) like Driscoll-Kraay standard errors estimations in pooled OLS model.

3.2 The Regression with Driscoll-Kraay Standard Errors

Driscoll and Kraay (1998) standard errors for coefficients estimated by pooled OLS/WLS or fixed-effects (within) regression. The error structure is assumed to be heteroskedastic, auto correlated up to some lag and possibly correlated between the groups (panels). These standard errors are robust to general forms of cross-sectional (spatial) and temporal dependence. Because this nonparametric technique of estimating standard errors places no restrictions on the limiting behavior of the number of panels, the size of the cross-sectional dimension in finite samples does not constitute a constraint on feasibility.

Usually, DOLS, PMG, and FEM estimator assume that all cross-section units are independent. However, if the cross-section units show dependence among them, that could lead to the consequence of unobserved heterogeneity due to omitted observed common factors, spatial spillover effects, unobserved common factors, or general residual interdependence (Pesaran, 2004). In cases, standard techniques that do not take account of this dependence would yield inconsistent estimates of the parameter standard errors, producing incorrect inference and test statistics. Consequently, in order to correct for the presence of cross-sectional dependence, we employ DK estimator.

The Regression with Driscoll-Kraay standard errors estimations and the results are presented in Table 2.

Table 2 Results for Pooled OLS in presence of cross-section dependence

Dependent Variable: HTE Method: Driscoll-Kraay standard errors estimations in Pooled OLS				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
SJA	0.0081	0.004796	1.76369	0.153
RDE	0.012	0.00363	-5.017581	0.029
LPP	1.78	0.367460	0.394512	0.008
C	33.2066	4.7298	7.01267	0.002
R-squared	0.2043	Root MSE		18.19
Adjusted R-squared	0.345	Prob > F		0.000

Source: Author calculation

Results for Pooled OLS using Driscoll-Kraay (DK) standard errors estimations from table 02 show that, the elasticity of SJA across the panels was calculated as 0.0081. This means that a 1% increase in Scientific publications in universities or research centers in the ASEAN-5 countries generates approximately 0.0081% increase of value added high-technology production in the long-run. The variable is not significant at 5% and 10% level, which

implies that there is no significant impact on high-tech goods production from university or research centers publication outcomes in ASEAN. This also tells the story that the link between university and industry collaboration is not so much solid. This is an interesting finding from our research. Elastic coefficients of R&D are calculated as 0.012%. Therefore, an increase of 1% in R&D constitutes a positive effect on high-tech production at the rate of approximately 0.012%. On the other hand, a 1% increase in labor productivity (LPP) causes 1.78 % increases of high-tech productions in the long-run.

According to the test results of the DK estimation, RDE and LPP in the long-run affect high-tech goods production significantly both in a positive and statistical way as expected. Furthermore, the findings indicate a positive relationship between Scientific publications mostly from the universities (SJA) and high-tech goods production (THE), but statically non- significant. ASEAN member states can take this important finding into consideration to formulate their TH policy implications for future.

The above sections analyze the feedback effect between high-tech based productions, scientific publications per 1000 populations in ASEAN, R&D and labor productivity. Our model organizes and estimates such effects, and the analysis shows that research expenditure from government, overall labor productivity and Scientific publications share a positive relationship with High-technology based production, although industry represented by (high-tech production)-university (idea generation through scientific publications) linkage is still weak in ASEAN region under the broad umbrella of National Innovation system.

V. Contribution of This Study

This paper contributes to the literature in four ways. Firstly, to the best of our knowledge, little is known about TH and NIS relationship in ASEAN countries until now. Secondly, this paper presents what, we believed, is the first panel data study of the concept of NIS and TH relationship and the first from the perspective of the ASEAN countries.

Thirdly, due to the limitation of homogenous panel data approaches such as the DOLS, PMG technique, this study has applied the DK model by Driscoll and Kraay (1998) where these standard errors are robust to general forms of cross-sectional (spatial) and temporal dependence when the time dimension becomes large. Cross sectional dependence (CD) test has been done by Pesaran's test of cross sectional independence (Peterson, 2007).

Fourthly, this study examines the relationship of idea generation to the commercialization of knowledge using the proxy variables of scientific and

technical journal articles, High-tech exports as a percentage of total manufacturing exports. The results show a positive, but the weak relationship in ASEAN-5 countries. This is an interesting outcome where recently the ASEAN region is considered by many researchers as the region that region possesses "World's Most Influential Scientific Minds" (Chuah et al., 2016).

One limitation of this study may be that the data sample is small due to missing data that required the application of more econometric methods to test the hypothesis. Usually, variables like tertiary education expenditure, skills of the labor force, schooling in tertiary level are important to test our objective of the study. The unavailability of data for all the ASEAN-5 member countries does not allow us to incorporate these variables in our analysis. In future, the first difference GMM method with short time span, and the panel dynamic ordinary least square technique (DOLS) for testing the VECM model to check the serial correlation problem and the variance decomposition model to investigate the pass-through of external shocks to each variable in the model could be deployed. Finally, our results and discussion show that the most important contribution to high-tech productions as a proxy of innovation output has been made by RD expenditure and labor productivity. The scientific publications and high-tech productions have weak linkage meaning that the Triple Helix model under NIS is not working at its optimum in ASEAN-5 countries. This is in line with the research of Hassan and Bakri (2016), Chuah et al. (2016), Din, Anuar and Usman (2016), and Yaacob, Shaupi and Shuaib (2016). It is very important to engage in strong and robust collaboration among government-industry and university relationship for the long run sustainable economic growth of this region.

VI. Conclusion and Policy Discussions

Nowadays, to achieve a competitive economy, the focus should be oriented on national innovation system with some key factors, such as high-technology based value added products, R&D, new idea generation through scientific publications and overall labor productivity.

In this context, technology based production from high-tech industry backed by government and universities (following the theory of Triple Helix model) can be a powerful way to develop knowledge economy, which in turn can increase competitive performance and long-term economic development in the ASEAN region.

The aim of this study was to investigate the link between innovation output (measured by high-tech goods production), government support for innovation (measured by R&D expenditure), and new idea generation from higher

education institutes (measured by scientific and technical article publications) under National Innovation and Triple Helix context in ASEAN-5 countries over the period 2000-2015.

Our results provide evidence that economically value-added technology based production depends on new ideas from universities, government R&D expenditure and overall labor productivity in big ASEAN economies. Although the link between idea coming from high education institutes and transferred to high-tech industries are not yet strongly shape up in ASEAN-5. This is a major empirical finding from our research.

The empirical results support the two research questions of this study, Firstly, there is long run relationship between innovation outcome and its key drivers under triple helix context of national innovation system in ASEAN-5 economies; Secondly, the extent of relationship among government R&D expenditure with High-tech productions are positive and significant while new ideas coming from universities as scientific publications and high-tech production have positive relationship but not significant yet in ASEAN-5 countries. Overall labor productivity is positive and significant with innovation outcomes in the region.

In short, a 1% increase in SJA, RDE and LPP affects high-tech production by 0.0035%, 0.0762% and 3.2% successively in the long run.

The main findings show that the most important contribution to high-tech productions as a proxy of innovation output has been made by RD expenditure and labor productivity. The scientific publications and high-tech productions have weak linkage meaning that the Triple Helix model under NIS is not working at its optimum in ASEAN-5 countries. It is very important to make strong and robust collaboration among government-industry and university relationship for the long run sustainable economic growth of this region. This finding, suggest that, universities besides being promoted quality and excellence of students, they should lead them to engage in research and patent activity with local industry in order to enhance the performance in National Innovation System.

Lack of social and cultural factors such as, innovation culture within the industry, university and government policy, social motivational factors for innovation, institutional regimes, regulatory factors, political stability and foreign policy were not considered in this research. This is perhaps the main limitation of this study. To overcome this limitation, the future researcher can pursue a primary survey method at a micro level to identify the aforementioned factors to better understand the dynamics Triple Helix system and develop overall innovation policy of the nation as well as the region.

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