Innovation and High-Tech Trade in Asian Countries

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Abstract

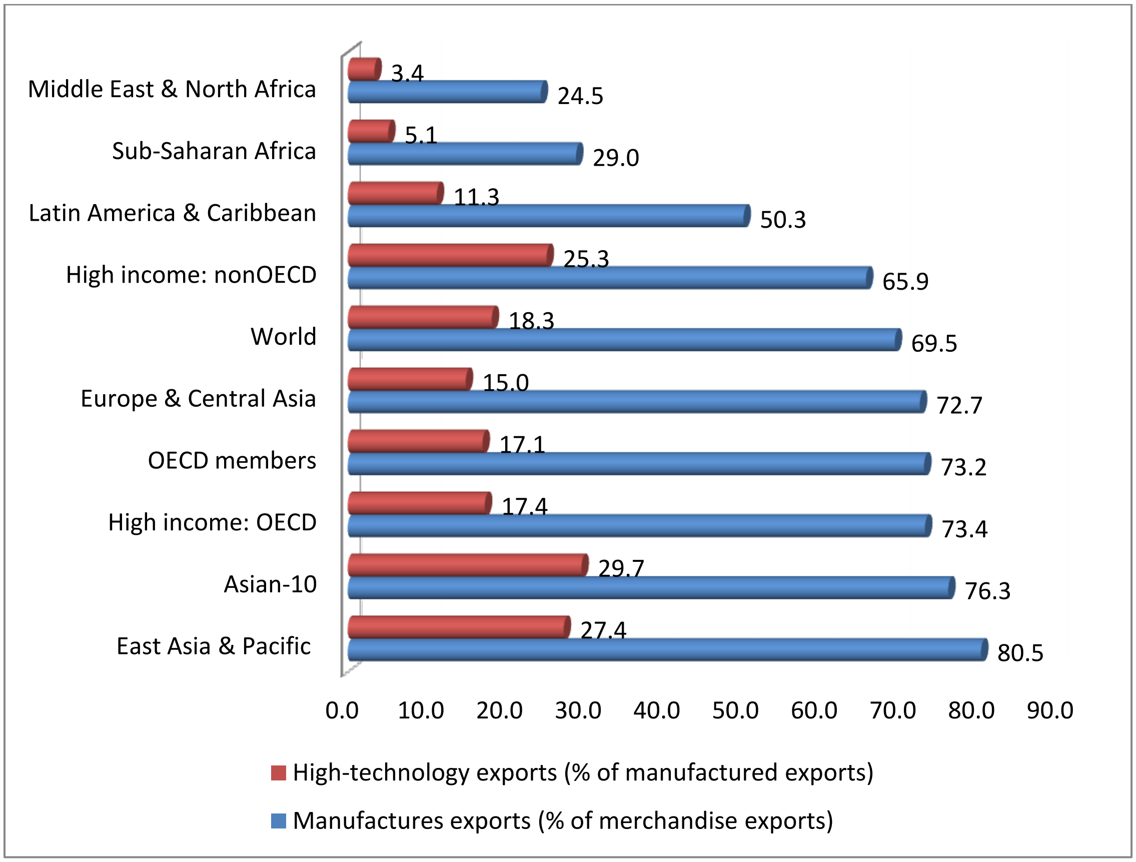
This study empirically investigates the impact of innovation on the export of high-technology products in both exporter and importer Asian countries. The existing literature examines the impact of trade and investment on innovation; however, few studies observe the role of innovation in facilitating trade. In addition, the linkages between innovation and FDI in high-tech exports in Asian countries have not been fully explored. This study confirms the theory that innovation activities are the key drivers in the export of high-tech products in Asian countries through the investment from multinational firms. In addition, in importing countries, as innovation initiated by FDI through the process of learning by importing is getting stronger, the import of high-tech product decreases.

Introduction

The last two decades has seen miracles in Asian countries through high performance in economic growth. Trade and investment are the key drivers of the success of the Asian story. Asian trade moved from import substitution to export orientation and technology driven trade. The Asian success story continued as the region began to play an important role in producing manufacturing goods to global markets. East Asia became synonymous with the 'Factory of the world' (Kimura and Obashi, 2011), thus demonstrating strong recovery from the two previous episodes of financial crisis.

The trade pattern has changed from finish products to intermediate and processing products. Different countries that specialized in different tasks have added value to the processing of products such as parts and components, imported for processing and assembly into semi-finished or finished products and re-exported to the global supply chain before they reach the final consumers. According to Feenstra (1998), market integration has brought elements of disintegration into the production process. In Asian countries, trade in intermediate input has grown at a faster rate than the world average. The reduction in information and technology cost, transportation cost and innovation policy has presented the opportunity for firms to exploit the production network through foreign direct investment.

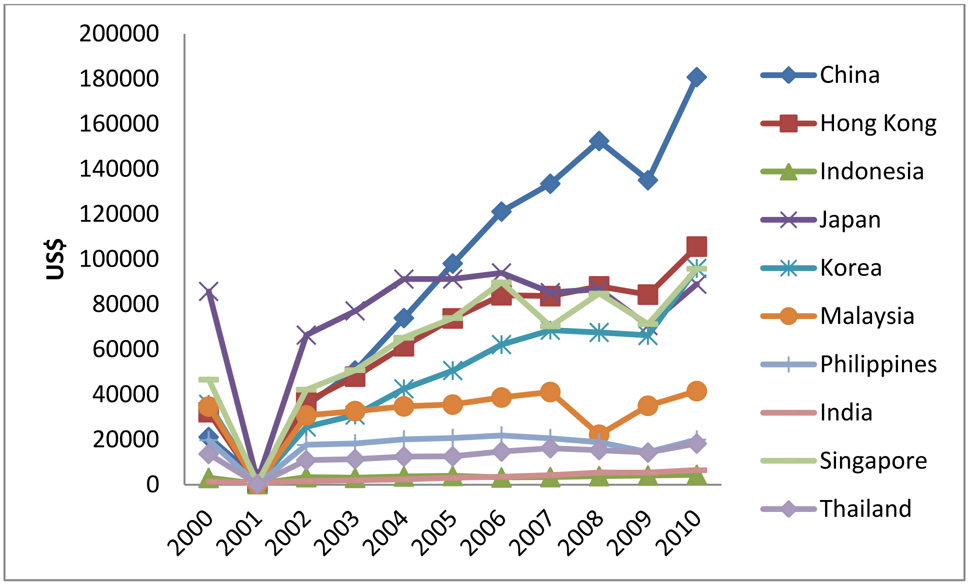
Figure 1: Manufactures Exports and High Tech Exports in 2009



Source: World development Indicators, World Bank

Recent trade data revealed that Asian countries contribute more than 55% of world's total export in high-technology products (Eurostats, 2006). Figure 1 shows that almost 76% of Asian exports are based in the manufacturing sector, 30% of which is based on high-tech exports, representing a higher rate than that of world and OECD exports. In terms of total contribution from Asian countries, China leads, followed by Hong Kong, Japan, Korea and Singapore. In 2009, Chinese total high-tech export reached US$310 billion, followed by Japan and Singapore (US$95billion) and Korea (US$92billion). The remaining Asian countries also show consistent growth in high-tech export (Figure 2).

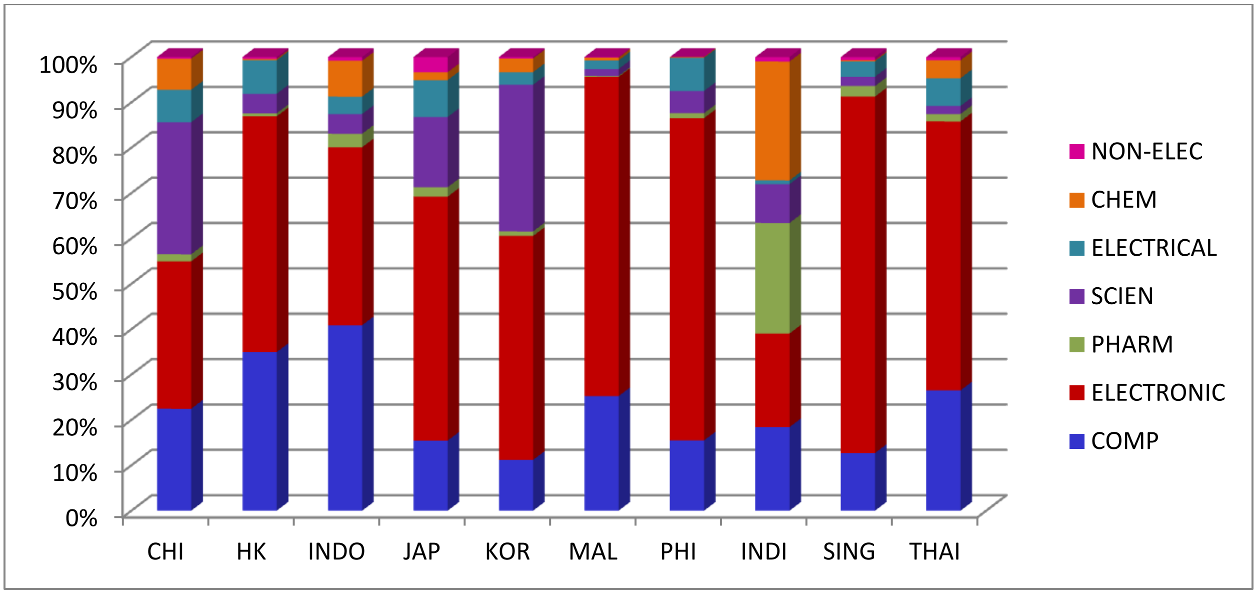
Figure 2: High-Tech Export (US$)



Source: COMTRADE, United Nation

Amador and Cabral (2007) find evidence that vertical specialization activities through international production network in East Asian are predominant in high-tech industries and are geographically concentrated compared to other regions. High-technology products depend heavily on science and technology innovation, which leads to new or improved products and services. According to Euro Statistics, the high-tech product list, based on the calculations of R&D intensity by groups of product (R&D expenditure/total sales) basically involves highly skilled workers, advanced technology, and high cost. Products are divided into nine categories, namely Aerospace, Computers/Office Machine, Electronic-telecommunications, Pharmacy, Scientific Instruments, Electrical Machinery, Chemistry, Non-Electrical Machinery, and Armament.

Figure 3: High Technology by Sector

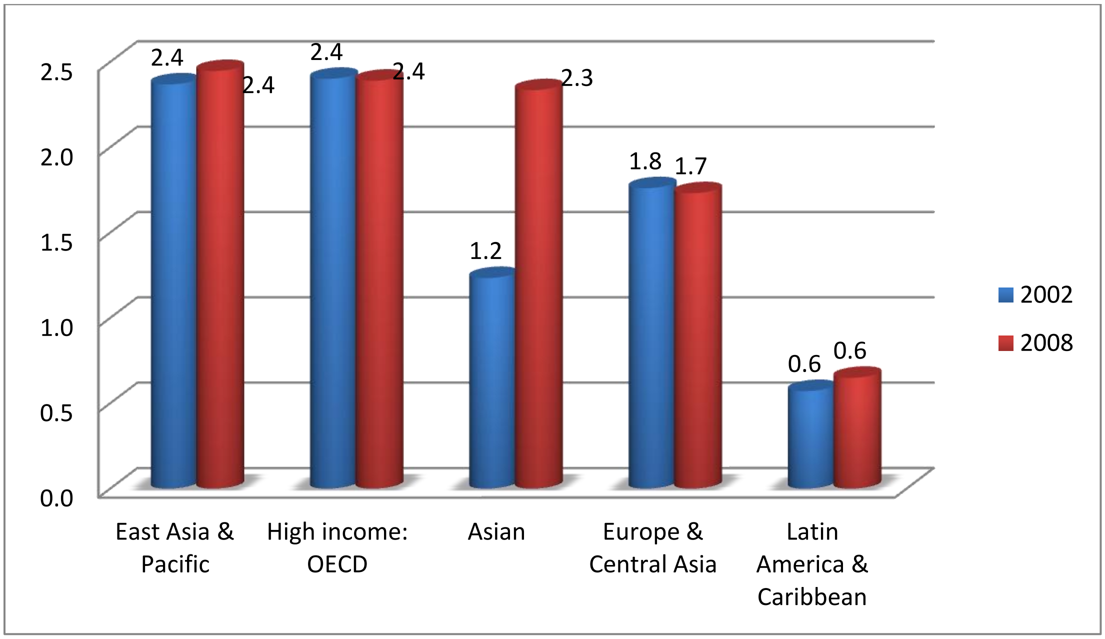


Source: Eurostats

As seen in Figure 3, computers/office machines are mainly exported from Indonesia, at a rate of around 39%, while in electronics telecommunications; Singapore exports the most, at around 78%. Furthermore, India dominated exports in pharmacy products by 22%. Korea, on the other hand, is the main exporter of scientific instruments, and India exports 17% of chemistry products to the rest of the world. In terms of both electrical and non-electrical machinery, Japan exports the most in comparison to other Asian countries.

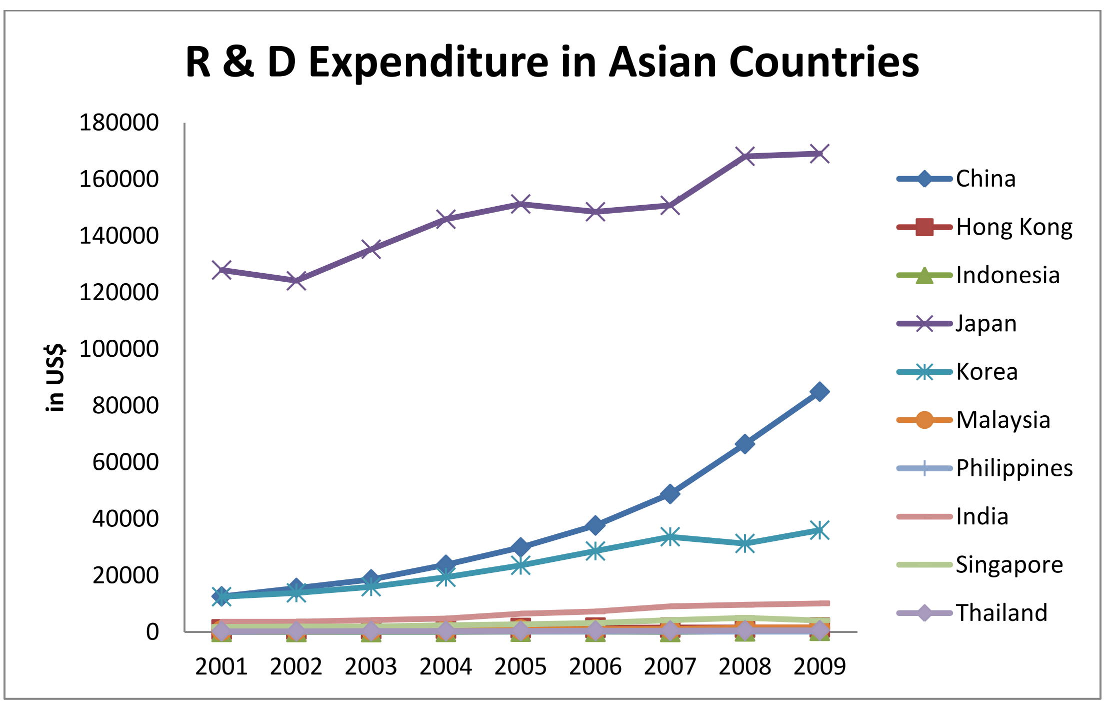
Innovation in Asia is on the rise. Asian countries have vigorously built up their capability and efforts on Innovation. In fact, Asian Property Organization (APO), headed by Japan, has formulated a common framework and strategy to harmonize the innovation efforts of member countries. In 2002, R&D expenditure in Asian was about 1.2 percent of the GDP. However, in 2009, it rose to 2.3 percent, close to that of OECD countries. Japan, as a leader in innovation, ranking number one in the world, has slowed down in terms of R&D expenditures. Japanese firms are started to invest in research and development in many locations where multinational companies are already in place. Meanwhile, China and Korea are seeing a rapid increase in theory innovation activities, while the remaining countries in the region are consistently trying hard to keep up with Japan, China and Korea.

Figure 4: R&D Expenditures as a Percentage of GDP



Source: World Competitive Yearbook

Figure 5: R&D Expenditures (in US$ million) in Asian Countries.



Source: World Competitive Yearbook

Onedora (2008) states that trade and innovation can be explained in two-way links. The first link is trade and investment as the main drivers to increase innovation via many ways such as technology transfer, competition effects and spillover effects. According to Salmon and Shaver (2006) and Schneider (2005), import spillover can occur when a firm imports a product, observes and imitates foreign production and finally develops new products to suit the local as well as global markets (also see Coe and Helpman (1995), Keller (2004), Eaton and Kortum (2001), and Neso et al. (2005)). Schneider (2005), for example, highlighted the importance of high technology import to increase domestic innovation. The country that imports high-tech products is expected to learn about new technology through spillover effects.

On the other hand, innovation can also affect trade, especially that of products with high technology content. Innovative firms that produce high-tech products will present alternatives either to export a products abroad, license the technology to third parties or invest abroad to exploit the advantage of innovations. Innovation can take the form of product innovation (through the introduction of new products) or process innovation (through improvement in the process of production, distribution or support of goods and services) (Onedora, 2008). The effect may also be negative upon high-tech export when innovation in importer countries matures and overtakes the technology and thus exporting to other countries.

This study adopts Vernon's product cycle theory, which explains the importance of innovation to high-tech exporter countries, as its represents the ability and capability of a country to produce innovative products for domestic areas and export to imitating countries. This stage explains the important of innovation in exporter's country. Meanwhile, importer countries with current innovation activities imitate production through the process of learning by import. This theory has been tested empirically by Falvey, Foster and Greenaway (2009), showing that a country's ability to imitate is an important factor within the importer country. As the technology is standardized, exporters will decide to locate the firm abroad or give the license to the third country. At this stage, importer countries might reduce the export. In fact, the high-tech products will then be produced in third-party countries and export to innovative countries. Thus, this study presents the hypothesis that innovation in both exporter and importer countries are a key driver in high-tech export. As broadly defined, innovation is not only restricted to new products but also includes the production process, services, supply chain, design, marketing and distribution.

Literature Review

According to Euro Statistics, high-tech production is determined based on three approaches: sector approach, products approach and patent approach. Sector approach is grouped based on technology intensity (ratio of R&D spending and value added); meanwhile, a products approach is based on the trade of high-tech products (the ratio between R&D spending and total sales). Finally, patent approach, or biotechnology patent, is based on International Patent Classifications.

However, an issue raised in high-tech export is that the way in which data is reported in a country does not reflect the origin of high-tech products. For instance, Xing (2012) argued that many high-tech products in China are based on processing trade, which involves importing parts and components and assembling and processing finished products before exporting them to other countries. China, which is not the owner of the products, gets credited for exporting high-tech products. The overall picture of Asian exporting is quite complicated, because the export is always associated with the production network through multinational companies. The increase of vertical FDI is allowed for more complicated cross-border production systems managed and operated by firm networking (Amador, Cabral and Maria, 2007; Hayakawa and Matsuura, 2009). Kimura and Obashi (2011) explain that the production network is well developed in machinery industries, which involves a large number of parts and components to suit the fragmentation of production.

Gervais (2009) explained that innovation can be divided into three phases: the imitation phase, the local innovation phase and the global innovation phase. The development of these phases is highly dependent on the level of IPRs system implemented by a country. In the initial phase, innovation starts through imitation of foreign technology. However, this process requires some technical skills. Then, innovation is further enhanced through modification of foreign technology in order to suit the domestic needs and market. In the advance phase, innovations take place in the form of improvements of products and the process or development of new products and processes which are globally competitive.

Intellectual Property Rights (IPR) is one of the platforms on which a firm can contribute to innovation. IPRs on innovation are usually associated with the willingness of an innovating firm to trade or invest with host countries. The agreement of TRIPs between trading countries has involved the enforcement by the host country of stronger IPR protection in order to be accepted worldwide (Gervais, 2009). Chen and Puttitanun (2005) discovered that IPRs have a positive impact on innovation in developing countries. In his study on the effect of IPRs in developing countries, Farero-Pineda (2006) also agreed that IPRs encourage innovation but have a critical impact on high-tech industries, namely pharmaceutical, biodiversity, and ethnical knowledge.

From the perspective of innovation in explaining the trade theory, many empirical studies (Schneider, 2005; Liu, 2007) reveal that innovation increases through the process of learning by importing. As suggested by Schneider (2005), imports bring additional competition and variety to domestic markets, while exports enlarge markets for domestic production, thus benefiting both consumers and businesses. In his seminal paper, Onedora (2009) acknowledges the role of trade and investment in promoting innovation through technology transfer, competition effect and scale economies. Coe and Helpman (1995) argue that innovation depends on both the domestic R&D and trading partner R&D. Thus, import of goods can benefit importing countries through spillover effects generated from learning about new technologies. According to Spulber (2008), trade in technology improves not only the quality of innovation by increasing the R&D experiments but also the efficiency of invention.

Technology spillovers also can be adopted through learning by exporting as well (Greenaway and Yu, 2004). A case study from Taiwan shows that selling in export markets may stimulate firms to improve their own technological capacity (Westphal, 2002). Salmon and Shaver (2005) have shown that exporting is associated with innovation, as exporters are more likely to access diverse knowledge about competing products and customer preferences through export intermediaries, customer feedback and other foreign agents, thus facilitating innovation.

Other than trade, FDI also serves as the main channel for technology spillover; i.e., the indirect transfer of technological knowledge through different economic activities that embody technological advance (Grossman and Helpman, 1991; Coe and Helpman, 1995; Blomstrom and Kokko, 1998; Liu and Wang, 2003; Keller and Yeaple, 2003). FDI brings technology through technology transfer and knowledge (Grossman and Helpman, 1995; Lai, 1998; Gervais, 2009). Thus, FDI contributes to the development of innovation of activities (Keller, 2004, Schneider, 2005 and Gervais, 2009; Awokus and Yin, 2010). For instance, a study conducted by Liu and Zuo (2008) investigates the impact of technology spillovers on innovation in Chinese high-tech industries through green field FDI, revealing that multinational firm activities on innovation significantly affect the performance of domestic firms. Similarly, Cheung and Lin (2004) find positive effects of FDI based on the number of domestic patent applications in China.

Data Source

The data on bilateral high tech export FDI flows are derived from COMTRADE data base, United Nation, cover the period of 2004, 2005, 2006 and 2009. Data for 2007 and 2008 have been dropped to avoid the effect of global crisis in 2007/2008. The dataset covers Asian 10 as exporters namely Japan, China, Hong Kong, South Korea, India, Singapore, Malaysia, Indonesia, the Philippines, Thailand and thirty one importers countries from European Union and Non European Union which actively involved in high tech trade. R&D expenditure in US$ million as a proxy for innovation and direct investment stocks inward percentage to GDP are accessed from world competitive yearbook. GDP and Per Capita GDP are in constant US$ in 2000 were taken from World Development indicators, World Bank.

Empirical Strategy

The empirical analysis of this study is based on a modified version of the gravity model of trade flows, which has been the workhorse for the empirical research of international trade for many years (see Anderson & van Wincoop, 2004; De Benedicts and Vicarelli (2005) Baldwin, and Taglioni (2006)). The gravity model states that the volume of trade can be estimated as an increasing function of the national income of trading countries and a decreasing function of the distance between them. In fact, other studies incorporate other variables such as GDP per capita and exchange rate (Frankel, 1992; Frankel and Wei, 1993), the product of GDP per capita and relative endowments (Frankel et al 1995), the difference in per capita income (Carrilo and Li, 2000; Elliot and Ikemoto, 2004), the average distance (Clerete et al, 2003) and the Complementary Index (Elliot and Ikemoto, 2004).

However, some studies are augmented by population (Linnemann, 1966) or per capita income (e.g., Frankel and Wei, 1998) as additional variables to measure economic sizes. Non-economic factors such as distance, common borders, common language and common colonial areas are also commonly included in the model.

In this study, the following model specification is applied:

$$LHTE_{ijkt} = \alpha_0 + \alpha_i + \alpha_j + \alpha_k + \alpha_t + \beta_1 LGDP_{it} + \beta_2 LGDP_{jt} + \beta_3 LDIST_{ij} + \beta_4 LINNOV_{it} + \beta_5 LINNOV_{jt} + \beta 6 LINCOMEGAP_{ijt} + \varepsilon_{ijkt} \quad (1)$$

The dependent variable used is the log of high-tech exports from country *i* (Asian countries − Japan, China, South Korea, Singapore, Taiwan, Hong Kong, Malaysia, Indonesia, Thailand, The Philippines and India) to 40 trading partners *j* (importer countries) in sector k (Aerospace, Computer Office Machine, Electronic-telecommunications, Pharmacy, Scientific Instruments, Electrical Machinery, Chemistry, Non-Electrical Machinery, and Armament). We focus on high-tech export (instead of high-tech import), as it represents the ability of a country to innovate as a result of high innovative capabilities.

The intercept has five parts: α_0 is a constant term, which is common to all years and country pairs; α_i and α_j refer to country specific effects, respectively, which control country characteristics; α_k is a high-tech industry; α_t refers to time effects to capture business cycle and common to all countries in the sample. The disturbance term ε_{ijt} is assumed to be normally distributed with zero mean and constant variance for all observations and used to capture any other external shocks that may affect bilateral trade between countries.

In this study, the gravity model predicts that bilateral trade should increase with market size and log of absolute difference in GDP per capita between exporters and importers but decrease with distance. A higher level of income in the exporting country suggests a high level of production, which increases the availability of goods for high-tech exports. This suggests the idea that the larger and richer countries are more likely to have more trade in high tech areas. Distance is a proxy for transportation cost, which shows that the shorter the distance, the lower the transportation cost and the higher the volume of trade between in two countries. *LGAP* is measured by log of absolute GDP per capita between exporters and importers as a proxy for the development gap in terms of income per capita and has ambiguous effects on high-tech exports. A smaller gap implies that a country tends to increase exports with partners that have similar income. On the other hand, a larger gap suggests that trade occurs because of dissimilarity in terms of GDP per capita, thus supporting the comparative advantage theory.

There are two factors widely used as a proxy for innovation: R&D expenditure and patent applications. The former refers to innovation input, while the latter refers to innovation output. This study focuses on the effects of innovation activities, and thus we use total R&D expenditures as a proxy for innovation as proposed by Lo (2011).

We augment the model by incorporating *LFDI* as a proxy for technology spillovers in exporter countries (equation 2). With the assumption of the possibility that innovation might occur through the channel of FDI, the interaction term between FDI and innovation is also included in the model (equation 3). The study anticipates a positive relationship between the interaction terms of Innovation and FDI for exporter countries to high-tech export, as higher innovation may produce spillover from FDI. However, the interaction term in importer countries may have ambiguous effects. If it positive, the innovation through the investment of FDI only reflects the process of learning by importing but not to the stage where the countries imitate and produce the high tech products and decrease high tech imports.

$$LHTE_{ijkt} = \alpha_0 + \alpha_i + \alpha_j + \alpha_t + \beta_1 LGDP_{it} + \beta_2 LGDP_{jt} + \beta_3 LDIST_{ij} + \beta_4 LINNOV_{it} + \beta_5 LINNOV_{jt} + \beta_6 LINCOMEGAP_{ijt} + \beta_7 LFDI_{it} + \beta_8 LFDI_{jt} + \varepsilon_{ijkt} \quad (2)$$

$$LHTE_{ijkt} = \alpha_0 + \alpha_i + \alpha_j + \alpha_t + \beta_1 LGDP_{it} + \beta_2 LGDP_{jt} + \beta_3 LDIST_{ij} + \beta_4 LINNOV_{it} + \beta_5 LINNOV_{jt} + \beta_6 LINCOMEGAP_{ijt} + \beta_7 LFDI_{jt} + \beta_8 (LFDI_{it} \times LINNOV_{it}) + \beta_9 (LFDI_{jt} \times LINNOV_{jt}) + \varepsilon_{ijkt} \quad (3)$$

The regressions will be estimated using either the random effects or fixed effects model, depending on the Hausman test. The random effects model is a more appropriate approach in estimating typical trade flows through a randomly drawn sample of trading partners, particularly from a larger population. However, the fixed effects model would be a better choice for estimating trade between an ex ante predetermined selection of nations (Egger, 2000). In the case of the absence of any correlation between observable and panel-specific error terms, the random effects approach would be preferred. Implicitly, the fixed effects model assumes that all explanatory variables are correlated with the unobserved effects or the specific error term that eliminates this correlation within the transformation. Matyas (1997) and Egger (2000, 2002) suggest using the Hausman test[1] to decide whether to choose a fixed effects model or a random effects model. The null hypothesis of the test is no correlation between individual effects and the explanatory variables. This implies that both random and fixed effects are consistent, but only the random effect is efficient. Meanwhile, the alternative hypothesis states that the individual effects are correlated with the explanatory variables, implying that only the fixed effects approach is consistent and efficient.

Results and Discussions

Prior to the estimation, we identified there are number of observations which the value is zero. However, we cannot simply be excluded from the database because they may contain important information. Therefore, to avoid losing observations the dependent variable will be log (1 + HTE), instead of the log of HTE.

Table 1 presents the effect of innovation on high tech exports in Asian Countries estimate with fixed effects model (FEM). Prior to the analysis, the Pooled Ordinary Least Squares (POLS) with constant term and the Random Effect Model are estimated with the same sample. However, the OLS is said to be biased since it ignores the heterogeneity problem which carried from individual country characteristics. Meanwhile, based on the Hausman test, the null hypothesis that REM is consistent and efficient is rejected. Therefore, the FEM is preferred model and will be used in this study.

[1] Hausman (1978) suggested a test to check whether the individual effects are correlated with the regressors.

Table 1: The Impact of Innovation on High Tech Export in Asian Countries

	(1)	**(2)**	**(3)**	**(4)**	**(5)**
$LGDP_i$	1.029***	0.453***	0.420***	0.420***	0.420***
	(20.42)	(6.28)	(5.68)	(5.62)	(5.96)
$LGDP_j$	0.767***	0.811***	1.35***	1.21***	1.215***
	(2.31)	(2.29)	(3.63)	(3.19)	(3.39)
$LINCOMEGAP_{ij}$	0.536***	0.032	-0.129**	-.134**	-0.133***
	(12.80)	(0.51)	(-1.87)	(-1.94)	(-2.05)
$LINOV_i$	0.068	0.235	0.410	.042	0.039
	(0.14)	(0.46)	(0.72)	(0.07)	(0.07)
$LINOV_j$	-0.198***	-0.130***	-0.086	-.085	-0.086
	(-3.46)	(-2.08)	(-1.34)	(-1.34)	(-1.43)
$LFDI_i$		1.187***	0.572***	0.529***	0.529***
		(11.89)	(3.83)	(3.38)	(3.60)
$LFDI_j$		-0.090	.022	0.032	.033
		(-0.80)	(0.18)	(0.26)	(0.28)
$LFDI_i \times LINNOV_i$			**0.522*** **	**0.549*** **	**0.548*** **
			(5.96)	**(6.07)**	**(6.44)**
$LFDI_j \times LINNOV_j$			**-0.856*** **	**-0.568*** **	**-0.567*** **
			(-4.46)	**(-2.38)**	**(-2.52)**
CONSTANT	-10.61***	-3.26	-8.07***	-6.65*	-5.397
	(-3.26)	(-0.91)	(-2.13)	(-1.71)	(-1.48)
Time Effects				F(3, 6632) = 3.12***	F(3,6626) = 3.53***
Country Effects[a]	F(30, 8361) = 19.40 ***	F(30, 6911) = 16.70***	F(30, 6635) = 18.32***	F(30, 6632) = 17.83***	F(30,6626) = 20.10***
Industry Effects					F(6,6626) = 141.73***
No. Observation	8398	6950	6676	6676	6676
F test	F(6,8361) = 129.77	F(8,6911) = 106.71***	F(10,6635) = 88.19***	F(13,6632) = 68.62***	F(19,6626) = 97.69***

Notes: Numbers in parentheses are t-statistics. ***, **, * *indicate significance at the 1%, 5% and 10% level. (a) Country Effects refer to Importer Effects.*

The coefficients for the market size (*LGDP*) for both exporters and importers are positive and statistically significant. This suggests that the bigger market size implies higher potential high tech trade flows of the countries. The results also reveal that market sizes in importers countries are bigger than exporter's countries which reflect bigger potential demand. The absolute difference between exporters and importers per capita GDP (*LINCOMEGAP*) as a proxy for income gap is negative and significant which implies that the more similar in term of income level, the more the two countries trade with each. Since the high tech products is involved with high cost and high price and thus potential destination of export should be a country that quite similar in term of the income level of Asian countries. Distance variable is dropped from the estimation because the FEM is not allowed the time invariant variable. Egger and Pfaffemayr (2003) and Cheng and Wall (2005) suggested to employ a two-step procedure where in the first stage fixed effect model is estimated with time variant variables. In the second stage, the estimated parameters (from the first stage) are regressed on the time invariant explanatory variables using OLS. However, since the distance is not really good proxy for trade cost especially in high tech trade, and thus we did not run two step procedure.

Our hypothesized variables namely innovation in column (1) revealed unpredicted results. Innovation in exporter's country is positive but not significant meanwhile for the importer countries, the coefficient is negative and significant at 1 percent. Column (2) introduces the FDI inward stock shows the coefficient for FDI in exporter countries is positive and significant. This implies that an increase of inward FDI in exporter countries causes more high products can be produced and thus increase the high tech exports. This concludes that in term of high tech sector, the FDI and export are complement each other.

In Column (3) to (5) the interaction terms between FDI and innovation is included. Prior the estimation, we test for the correlation matrix (in appendix) and the coefficient of correlation revealed that all variables are less than 0.7 including the interaction term. We also test for variance inflation factor (VIF) to quantify whether there is any severity of multicollinearity in the regression. The result of VIF is less than 5 and confirmed that there is no evidence of multicollinearity problem. Following Matyas (1995) and Egger and Pfaffmayer (2003) and Ismail (2009) the fixed effects namely time effects, industry effects and country effects are included. The interaction term between FDI and innovation in exporter's country is positive and significant. The result implies that the important of FDI in Asian countries to boost the innovation activities. In fact, the innovation in Asian countries is dominant brought by FDI. Our study supported by the findings of Liu (2007) that domestic R & D investment enables firms to innovate and thus increase export activity through increase new products sales. In addition, innovative capacity not only influence domestic R& D but also foreign R & D spending of a country's trade partners (Alvarez and Robertson (2004) and Almeida and Fernandes (2006).

On the other hand, the interaction term between innovation and FDI in importer's countries reports that it is significant and negative relationship with high tech export from Asian countries. The results implied that with the high expenditure on R&D in importer countries through FDI enable a country to improve the skill and technology adopted from learning by importing. The absorption capacity in importing countries also allow the country to observe and imitate from foreign technology and thus increase the capability to do some changes and minor modifications to serve domestic purposes and thus reduce the import of high tech products from Asian countries. This findings similar to other studies that support the idea of FDI increase the innovation activities (Keller, 2004, Schneider, 2005 and Gervais, 2009; Awokus and Yin, 2010) and thus reducing the imports.

Conclusion

This study proposed the Vernon theory can be adopted in the high tech trade which innovation is the key drivers in developing the products. Throughout the process, the domestic producers should have the capability to adapt technology in the products and increase the expenditure in R&D. The result confirms that the innovation in Asian countries brought by FDI through production network is complement to higher in high tech exports. On the other hand, from the importers perspectives, the higher expenditure in R&D either from domestic companies or multinational companies give the ability to produce their own high tech products through the process of imitation and thus reduce the high tech imports.

This study can be improved by incorporating other techniques which can handle zero observation such as Heckman Selection approach. Another alternative is to aggregate the high tech sector by summing up all high tech products. Further studies also can observe the impact of intellectual property right as a proxy for innovation.

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Appendices

1. List of Countries

Exporters	China, Hong Kong, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Thailand.
Importers	Australia, Austria, Belgium, Brazil, Canada, China, Denmark, Finland, France, Germany, Hong Kong, India, Indonesia, Ireland, Italy, Japan, Malaysia, Mexico, Norway Portugal, Philippines, Singapore, South Korea, Spain, Sweden, Switzerland, Thailand, Turkey, United Kingdom, United States.

2. List of High Tech Exports

Industry	**Products**
Computers – Office machines	75113 = Word-processing machines 7513 = Photo-copying apparatus excluding 75133, 75135 752 = Computers: excluding 7529 75997 = Parts and accessories of group 752
Electronics – Telecommunications	76381 = Video apparatus 76383 = Other sound reproducing equipment 764 = Telecommunications equipment excluding 76493, 76499 7722 = Printed circuits 77261 = Electrical boards and consoles 1000V 77318 = Optical fibre cables 77625 = Microwave tubes 77627 = Other valves and tubes 7763 = Semi-conductor devices 7764 = Electronic integrated circuits and micro-assemblies 7768 = Piezo-electric crystals 89879 = Numeric recording stays
Pharmacy	5413 = Antibiotics 5415 = Hormones and their derivatives 5416 = Glycosides, glands, antisera, vaccines 5421 = Medicaments containing antibiotics or derivatives thereof 5422 = Medicaments containing hormones or other products of heading 5415
Scientific instruments	774 = Electro-diagnostic apparatuses for medicine or surgery and radiological apparatuses 871 = Optical instruments and apparatuses 87211 = Dental drill engines 874 = Measuring instruments and apparatuses excluding 87411, 8742 88111 = Photographic cameras 88121 = Cinematographic cameras 88411 = Contact lenses 88419 = Optical fibres other than those of heading 7731 8996 = Orthopaedic appliances excluding 89965, 89969
Electrical machinery	7786 = Electrical capacitors, fixed, variable or adjustable excluding 77861, 77866, 77869 7787 = Electrical machines having individual functions 77884 = Electric sound or visual signalling apparatus
Non-electrical machinery	71489 = Other gas turbines 71499 = Part of gas turbines 7187 = Nuclear reactors and parts thereof, fuel elements etc. 72847 = Machinery and apparatus for isotopic separation 7311 = Machine-tools working by laser or other light or photon beam, ultrasonic electro- discharge or electro-chemical process 7313 = Lathes for removing metal excluding 73137, 73139

	73142 = Otherdrilling machines, numerically controlled 73144 = Other boring-milling machines, numerically controlled 73151 = Milling machines, knee-type, numerically controlled 73153 = Other milling machines, numerically controlled 7316 = Machine-tools for deburring, sharpening, grinding, lapping etc; excluding 73162, 73166, 73167, 73169 73312 = Bending, folding, straightening or flattening machines, numerically controlled 73314 = Shearing machines, numerically controlled 73316 = Punching machines, numerically controlled 7359 = Parts and accessories of 731- and 733- 73733 = Machines and apparatuses for resistance welding of metal fully or partly automatic 73735 = Machines and apparatuses for arc, including plasma arc welding of metal; fully or partly automatic
Chemistry	52222 = Selenium, tellurium, phosphorus, arsenic and boron 52223 = Silicon 52229 = Calcium, Strontium and barium 52269 = Other inorganic bases 525 = Radio active materials 531 = Synthetic organic colouring matter and colour lakes 57433 = Polyethelene terephthasase 591 = Insecticides, disinfectants

3. Correlation Matrix

	LHTE	LDISTij	LGDOi	LGDPj	LGDPCPGAPij	LINNOVi	LINNOVj	LFDIi	LFDIj	L(FDI x INOV)i	L(FDI x INOV)j
LHTE	1										
LDISTij	-0.176	1									
LGDOi	0.229	-0.0271	1								
LGDPj	0.144	0.1644	-0.0438	1							
LGDPCPGAPij	0.164	0.0133	0.1553	-0.0056	1						
LINNOVi	-0.059	0.3668	-0.0144	0.099	-0.0413	1					
LINNOVj	-0.003	0.0597	0.1044	0.0736	-0.052	0.3829	1				
LFDIi	0.293	-0.0265	0.6049	-0.0247	0.6506	-0.0267	-0.0073	1			
LFDIj	-0.036	0.2036	-0.0062	0.2677	-0.063	0.583	0.2187	-0.0309	1		
L(FDI x INOV)i	0.284	-0.0393	0.515	-0.0235	0.694	-0.0436	-0.0349	0.8992	-0.0164	1	
L(FDI x INOV)j	0.006	0.4065	-0.0304	0.5479	-0.0262	0.718	0.2789	-0.0473	0.6375	-0.0375	1