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Impacts of Technological Gap & Economic Factors on Trade Flows of Emerging East Asian nations

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List of Acronyms

CIF	Cost, Insurance and Freight
FOB	Freight on board
GDP	Gross Domestic Product
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
The US	The United States of America
The UK	The United Kingdom of England
WDI	World Development Indicator (World Bank)
UN	United Nations

Abstract

The paper uses an augmented gravity model to examine trade flows from emerging East Asian nations (including China) to developed countries. A ''technological gap'' variable is constructed and integrated in a gravity model to investigate its impacts on those export flows. Theory in the field of trade and technology suggests that economies should be specialized to exchange reflecting advantages and disadvantages. However, this paper shows that the wider the technological gap is, the less nations trade. In other words, bilateral trade partners will trade more if they have a smaller gap of technological capabilities.

Relevance to Development Studies

The impressive growth of emerging Asian countries is normally considered as the results of more than two decades of rapid growth under the recent globalization manifested in the rise of laissez-fare industrial policies and trade openness (Ha-Joon Chang, 2003). Hence, to understand the drivers underlying of their miracle growth are of importance for growth policy. These growth forces are the potential inter-relation between technological gap and trade flows among them.

This paper is expected to contribute to the present literature the empirical evidences of the significant correlation between the technological gap and the exporting value from these emerging Asian countries to the developed ones.

Our research prove that the exporting flows from developing to developed countries does not follow the underlying force of comparative advantages but the narrower the technological gap, the more nations trade, or in detail, if the developing nations have less gap in technology capabilities with those of developed nations, they will trade more and probable grow faster.

Keywords

Trade, East Asia, gravity model, technological gap, national technology capabilities.

Chapter 1: Introduction

1.1 Background & research motivation

Trade and technology have long been economists' concerns. Nonetheless, never before, these issues have been at central debates of both academic and political worlds. At present, one of the most arguable topics is the trade wars between emerging industrialized countries, such as China, and the current powerful manufacturers, such as the US that even made the Economic Nobel Laureate Paul Krugman (for his new trade theory) recently admitted that ''Why economists (including me) got wrong about globalization'' (Krugman P., 2019)[1]. In his essay, the ''combination of technology and policy'' (probably, international trade policy) are attributed for the reasons of the surge in manufactured exporting flows from developing countries that affected more seriously on inequality and jobs (in the US) than economists have estimated.

In facts, the inter-relation between trade flows and technological change or the ''comparative advantages'' have been arguably explained in large extend by many theories and empirical studies. In conventional models of comparative advantage on trade, economies are assumed to have constant return to scales and perfect competition. Relying on these two conditions, trade between nations only arises in case they are differences in tastes, factor endowments or technology. While Ricardian model promote the technological differences are the main reasons for bilateral trade, Heckscher-Ohlin-Samuelson model emphasizes on factor endowments (see Krugman 1987). These classical models are just descriptive without any clear translation from the theories into practice. The New Trade Theory[2], which mainly relies on the assumptions of market imperfections and increasing returns to scale, claims for replacing the comparative advantages in explain the natures of trade and technological disparities ''in a more complex and sophisticated manner'' (Deraniyagala, S., and B. Fine, 2003). However, the comparative advantages presenting in these new trade models ''seem to be very few'', and the new trade theories are nearly unable to translate the theoretical results into practical policy (Krugman 1996: 23–24). Therefore, in the realm of international trade theory, comparative advantage is

[1] In recent essay in 2019, Economics Nobel Prize Laureate Paul Krugman, who won the prize for his new trade model, admitted that ''What Economits (including me) Got Wrong about Globalization'' that he was not aware that Chinese competition have been hitting Americans through free trade and catching-up technologies at the situation that he called ''hyper globalization''. It is surprised that he also admitted his international trade model was defective.

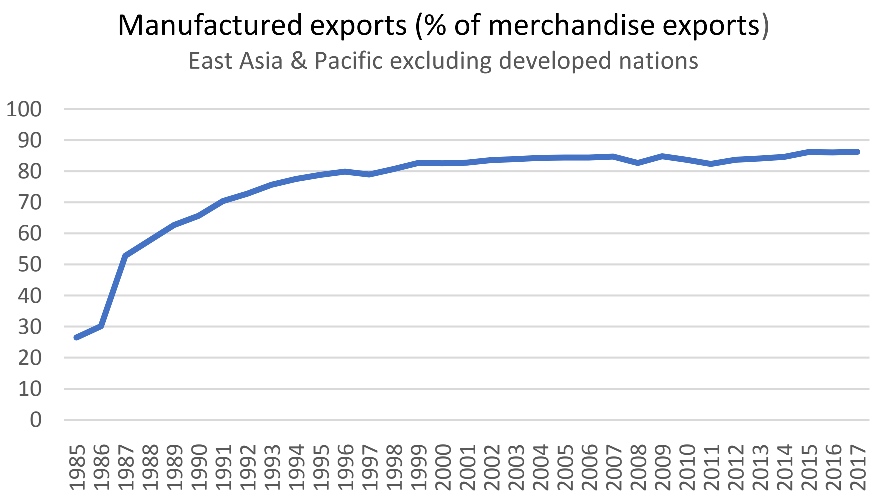
[2] Ethier (1982); Krugman, P. (1984, 1986); Brander and Spencer (1985); Eaton and Grossman (1986); Grossman and Horn (1988); and Grossman and Helpman (1991)

still the dominant doctrine underlying the nexus between trade and technological change which has been officially considered as rationale for free trade agreement (WTO, 2009).

In fact, the mechanism is that if economies are open to international trade, comparative advantages will guide the domestic resources to where their contribution to local manufacture is optimum and the gains from trade arise from this specialization (Krueger Anna O, 1974; Bhagwati, 1980). Moreover, under free trade, developing countries tend to specialize in low-technology goods and the developed countries have intention to produce high-technology products due to the impact of learning by doing on the initial pattern of comparative advantage (see Lucas 1988, Boldrin and Scheinkman 1988, and Matsuyama 1992).

Nonetheless, the reality seems not to comply the theory of comparative advantages the more developing countries trade, the more proportion of manufactured exports of merchandise exports rises. Table 1.1 shows that the percentage of manufactured exports (or technology-intensive goods) of East Asian & Pacific nations (excluding developed ones) has been increasing more than 300% during the period of 1985 – 2011 when globalization reflecting on free trade and industrial policy was playing the central role in their economic growth. That means the comparative advantages would not be able to explain the appropriate characters of international trade for this situation, and there must be a different mechanism underlying the relationship between trade flows and technological gap between Global South and Global North.

Table 1.1 Percentage of manufactured exports of merchandise exports



Source: World Bank Indicator on 2nd November 2019

Thus, there is a still a question that, if the comparative advantage is not able to explain the increase in manufactured exporting flows from developing nations to developed nations, what is the reasons for that?

This paper is ambitious to answer that question by carrying out an empirical study on the impacts of the technological gap on the exporting flows from emerging East Asian countries and developed ones. Relying on Arco Technology Index (Archibugi & Coco 2004, 2005 & Archibugi et al, 2009), we construct the synthetic indicator measuring the technological capabilities at national level. After that, we can calculate the ''gap'' of technological capabilities between nations and investigate this technological distance on exports of East Asian nations to developed ones for both manufactured and non-manufactured sectors.

1.2 Research questions and contribution

This paper aims at investigating some economic determinants, and especially, the significant impact of technological gap on trade flow, or exporting flows, between emerging East Asian nations and developed ones. The significant impacts of economic and geographic factors on exports have been theoretically and empirically proved. However, the effect of technological gap is still limited. The mechanism of technological impact on trade flows are arguable in two points. First, classical trade theories (Ricardian, H-S-O models) promote the comparative advantages as the forces underpinning the trade between nations, while this doctrine has been empirically proved as invalid theory (Alwyn Young, 1993; Imbs J. and Wacziarg R., 2003; Dani Rodrik, 2006). Second, contrary to the comparative advantage theory, empirical evidence shows that the less technological distance is, the more nations trade each other. According to Lall (2000), East Asian countries tend to produce more technology-intensive, and less low-technology goods.

Therefore, this research essay intends to use an augmented form of Gravity Equation to answer the important question that:

> ''Does technological gap (technological distance) significantly impacts on the export flows between emerging East Asian nations and developed ones?''

In fact, we intend to examine the effects of export flows from developing countries to developed countries on both types of goods: manufactured and non-manufactured. Through this examination, we expect to capture the negative relationship between technological gap and the manufactured export flows so as to confirm the hypothesis that comparative advantage law is inexplainable for this case.

Furthermore, the model will then investigate the impacts of some typical determinants of bilateral trade flows including population, GDP, and geographic distance. These controlling variables are also essential for the unbiased estimation.

Through responding to this question, the study is expected to contribute to empirical literatures the different point of view on the relationship between the export flows and the technological capabilities of nations that we may rely on to create the development policies for the Global South.

1.3 Scope and limitation of the study

This empirical study covers 21 countries including 15 developed ones – 12 EU countries plus USA, Japan and Korea South (Belgium, Denmark, Finland, France, Germany, Greece, Irelands, Italy, The Netherland, Portugal, Spain, UK, plus two important world traders: USA and Japan), and 6 emerging East Asian nations (China, Indonesia, Malaysia, Thailand, and Vietnam) in a period of 2003 – 2015. Thus, we will have a panel with 1,170 observations which is relatively large sample for panel regression.

The sample is somehow particular. However, it is consistent to the research motivation that we are interested in the emerging East Asian nations, especially the trade and technology patterns between them and EU-US in the recent period of 2003-2015. We choose the most notable emerging nations in East Asia excluding other ones which are classified as emerging nations by WB or UN and less relevant to our researching purposes. For the sample of importers (developed countries), we choose 15 out of 36 OECD nations who have high income and account for large shares in trade.

1.4 Data and methodology

Data of this study is exploited from various reliable sources. Trade flows including manufactured and non-manufactured exports are from UNCTAD Data Center for International Trade in Goods and Services. Popular economic variables including GDP and Population data are taken from World Development Indicators of World Bank (2019). The geographical distance is from notable source of CEPII.

The most important data is the technological distance composite index which comprise 7 sub-indicators that we have to collect from different sources. Number of granted patents is from USPTO ; Mean years of schooling comes from UNDP, and other indicators including Number of technical & scientific

Journals per million people, Individuals using the Internet (% of population), Fix telephone subscriptions and mobile cellular subscriptions per 100 people, Electrict Power Consumption (Kwh per capita), School enrolment, tertiary (% gross) are derived from WDI (2019).

1.5 Organization of the research paper

The study is organized by four more chapters. Chapter 2 is to provide the literature showing the theoretical base and the research gap. Chapter 3 is to explain the methodologies applied for this study, and especially, how to construct the important technological distance variable to show the impacts of technological gap between bilateral trade partners on their trade flows. The econometric analysis, results and discussions are presented in the Chapter 4. Finally, Chapter 5 is to make the conclusions and policy implications for developing Global South.

Chapter 2: Review of Literature

2.1 The economics of technological change and trade

2.1.1 The classical trade theory & comparative advantage

Until 1970s, the classical theory of international trade and technology had been dominated by the doctrine comparative advantage and rested on the assumptions that economies are explained by perfect competition and constant returns to scale. Under these conditions, trade arises among countries regarding the differences in tastes, technology, or factor endowments (Krugman, P. 1987).

After the initial concept of absolute advantage mentioned by Adam Smith (The wealth of nations, 1776), Ricardo explained the idea of comparative advantage that trade occurs by costs and technological differences. Thus, countries are likely to allocate their resources to the most productive economic activities (Laursen, 2005). However, there is no technological change and spill-over of knowledge in the Ricardian model (Berkum & Meijl, 1998). After that, the Heckscher-Ohlin-Samuelson trade theory emphasized the differences in factor of endowments. In this conventional trade model claims that comparative advantage is driven by the proportions of larbor-intensive or capital-intensive resources. H-S-O model predicts that nations will export goods that they have advantages. Developing countries are supposed to export commodities with high labor-intensive proportion and developed ones are likely to export capital-intensive products (Krugman, P & Obstfeld, M 2010). In H-S-O model, although production functions are identical across nations, there is still no factor represented for innovation and diffusion nature of technology.

As comparative advantage "principle has shaped the way economists view the world, and it serves as the basis for our profession's overwhelming support of free trade" (Rodrik Dani, 1998), vast of literature have been contributing to the clarification of this theory. Findlay (1987) considered comparative advantage as "deepest and most beautiful result in all of economics", while Harrigan (2003) claimed that it is "an unassailable intellectual cornerstone".

At micro-level, there are attempts to test the theory of Ricardian theory of comparative advantage and H-S-O theorem3. In fact, the comparative advantage effects have been measured by various aspects as Laursen (2005) summarized. Bela Balassa's (1965) proposed the first methodology to estimate "Revealed Comparative Advantage" (RCA). After that, this measurement has been used for measuring global trade specialization to determine technological

[3] To review more, see Deardorff (1984). "Testing trade theories and predicting trade flows,"

specialization relying the patent statistics (Soete and Wyatt 1983; Cantwell 1995; D'Agostino et al. 2013; Liegsalz and Wagner 2013) or to estimate the specialization of production (Iapadre, 2001; Laursen and Salter, 2005).

At macro-level, various empirical studies have been investing effort to investigate the mechanism that comparative advantage promote trade, technology, and obviously growth. At very first, Cherney (1961) emphasized that the analysis of trade and development policy, especially in less-developed countries, should be carried out in the light of comparative advantages and the ''attack on the use of comparative advantage is biased on its omission of various non-market elements''. Krueger (1974) and Bhagwati (1980) claimed that the reason of the underperformance of developing nations is their failure in controlling the national resource flows driven by the comparative advantage. Literature also indicated the mechanism that when domestic markets are open to international trade, comparative advantage will direct the national resources to where their impact to local manufacture is optimum. Countries will then enjoy the gains from trade arising from this specialization (Krueger, 1998 & Dollar and Kraay, 2001).

So far, lots of literature have been supporting the comparative advantage theory, however, there have been many empirical studies that indicate the shortcomings of the doctrine. Imbs and Wacziarg (2003) proved that when income rises, economies will be more diversified instead of more specialized. Moreover, the specialization would encounter the diseconomies of scale in which growth of firms finally curbs due to the bound effect of ''learning-by-doing'' (Alwyn Young, 1993). Furthermore, Rodrik (2006) found that specialization are not determined by ''natural'' factor of endowments as H-S-O model claims, but the ''artificial'' industrialization policies with the notable conclusion that ''successful countries have always pushed the limits of their static comparative advantage and diversified into new activities that are the domain of countries considerably richer than they are''.

2.1.2 The new trade & technology theory

Since the theory of comparative advantage is unable fully explain the true patterns of the relationship between international trade and technology, there is another case for ''a new breed of models that emphasizes increasing returns and imperfect competition'' (Krugman, P. 1987). In fact, new trade theory is the summary of many attempts to explain the mechanism underlying the relationships among trade flows, technological change, and growth relying on the standpoints that economies are characterized by increasing in returns of scale and imperfect competition. Generally, there are two approaches in constructing new trade models. The first way is to assume that an industry constitutes many firms in which perfect competition is retained or the ''external economies of scale''. The second approach consider that internal economies of scale will lead to imperfect competition (Berkum & Meijl, 1998). Unlike classical trade models, new trade theories claims to demonstrate the dynamic evolution of comparative advantage and the impacts of international technological competition on the international trade (Romer 1990, Grossman and Helpman 1991).

As widely considered the cornerstone of new trade theories, Dixit & Stiglitz (1977) introduced a trade model of monopolistic competition that emphasized the ''preferences for differentiated products''. Relying on the Dixit-Stiglitz model, Krugman (1979) to propose two symmetric economies showing that both traders partners can gain from international trade regarding the effects of economies of scale. Furthermore, Dixit and Victor (1980) & Lancaster (1980) also indicated that the economies of scale will cause the arbitrary specialization at national level on the monopolistic industries (Krugman, P. 1987).

From the angle of technological change in new trade theory, Grossman and Helpman (1991) contributed to the new trade theory that international trade can foster the national R&D activities by transferring technological information, pushing competition, and especially, the expand of market size under the innovation forces. However, it is ambiguous that global on the opposite way, trade can negatively impact on the R&D sectors by shifting innovative activities. Another trade and technology models promoted the positive nexus between the openness concentrating on imported capital goods and growth. According to these models, technological diffusions are considered as proportional to the capital goods which contain new knowledge (Coe,1995; Lee 1995; Romer, 1992).

Finally, the new trade theory claims for replacing the ''old'' trade theory which is dominated by comparative advantage principle (Deraniyagala, S., and B. Fine, 2003). However, this replacement is of concern regarding two ambiguous points of new trade models. First, Krugman (1996) admitted that the new trade theories seem not to be able to convert the theoretical conclusions into realistic policy (Krugman 1996: 23–24). Second, contrary to the conclusion of Krugman (1981) on the mechanism of intra-sectoral trade in the world economy, the openness of China in the early 1990s has pushed the trade between emerging countries (such as China) and high-income countries growing faster and it have been less intra-sectoral. This situation may be explained by H-S-O model rather than Krugman's (Deraniyagala, S., and B. Fine, 2003). Therefore, the role of comparative advantage in explaining the relationship between international trade and technological change is still arguable.

2.2 Technological capability measurements at national level

As discussed above, in general, technological capabilities have always been one of the most crucial factors in international trade and growth literatures. There is a large consensus in vast amount of economic theories that innovation is the crucial determinant of stable growth by creating more effective productivity and competitiveness. Thus, measuring them at national level is essential but it would be a challenge because they are ''far from being uniformly distributed across countries, regions and firms" (Archibugi, D., Coco, A., 2004). There have been a lot of innovation indicators developed on systematic data collection and surveys at firm, industry, technological sectors, and country-level4. In order to compare and investigate the impacts of technological change between nations, this paper will concentrate on synthetic technological capability indicators at the country level. Various new indicators of national technological capabilities have recently built on implicit theoretical consensus about the characters of technology, and specific methodologies & data. The well-known indices are the WEF Technology Index (World Economic Forum 2001-2003 ; Furman, Porter, & Stern, 2002), UNDP Technology Achievement Index (TAI) (UNDP, 2001; Desai et al., 2002), the United Nations Industrial Development Organization (UNIDO) Industrial Development Scoreboard (UNIDO, 2002; Lall and Albaladejo, 2001), the Science and Technology Capacity Index developed by the RAND Corporation (Wagner et al., 2004), and ArCo Technology Index (Archibugi, D., Coco, A., 2004). The analysis of implicit assumptions, theoretical base, and methodologies will provide the comprehensive looks on technological gap measurements at country level.

2.2.1 The implicit assumptions & theory of technological capabilities

2.2.1.1 The implicit assumptions

The first assumption is the consideration that ''country" is unit of research. In fact, countries (for example, China or India) constitute by differential parts, and probably are not homogeneous. However, in order to compare technological capabilities at national level, countries' technology & innovation system is ''somehow capable to distribute knowledge across the whole country" (Pavitt, Keith & Patel, Pari, 1988 and Patel, P., & Pavitt, K. 1994).

[4] To review see Sirilli, G. (1997); Smith, K. (2005).

The second assumption is related to the usefulness in comparing international technological capabilities. The comparison at country-level is still useful even the heterogeneity within country. Relying on the concepts of national innovation systems5, it is possible to analyze the technological for country-level because these ''provide one of the main institutional settings for know-how generation and diffusion'' (Archibugi, D., Coco, A., 2004). There are many successful empirical studies for developing countries including Hobday, M. (1995) for Asia, or Lall, S., & Pietrobelli, C. (2002) for Africa. Moreover, the selection of data to construct composite technological indicators would be biased because it may not sufficiently reflect the differences among nations in their different stages of development. The comparisons will be more significant if they are relied on ''more similar national systems of innovation'' (Jeffrey James, 2006).

The final assumption is that the different factors or sub-indicators which contribute to the formation of technological capabilities composite indices should be correlated among them. Countries with high percentage of gross tertiary school enrolment and people using internet correspondingly have a high rate of number of patents granted or number of technical & scientific journals per capita. Thus, in order to capture the differences, we should select more homogeneous groups of countries (Castellacci, Fulvio & Archibugi, Daniele, 2008).

2.2.1.2 Theory of technological change

Technological capabilities have long been considered as a fundamental factor that it seems to be understood as ''measurement without theory''[6]. However, it is useful to clarify the measurements of the indexes intend to place on which theoretical ground (Archibugi, D et al. 2009). Furthermore, as mentioned above, the nature of knowledge is heterogeneous, and they are the synthetic indicators. Therefore, the theories that we rely on to construct technological indexes should be able to support this composition depending the aspects that authors intend to promote. Since we need to compare various methodologies that we sit on to create the indexes, the commonalities are clarified to rationalize the comparison (Archibugi, D., & Coco, A., 2005).

Firstly, the understanding of technological capabilities should be clarified clearly. Although there is a large consensus that technological capabilities and

[5] See Andersen, Lundvall, & Sorrn- Friese (2002), Edquist, C. (Ed.). (1997) ; Freeman, C. (1995)

[6] Well-known expression from Koopmans, T.C (1947) ''Measurement without theory'', Rev. Econ. Stat. 29 (3) (1947) 161–172.

production capability are tightly inter-related, they are conceptually different in the meanings. The former is considered as stock of knowledge. It creates the production capability and vice versa. The two economic phenomena are separated. (Lall, 1990).

Secondly, although technological capabilities may be constructed by number of heterogeneous components, literature have shared the view that these elements could be categorized by three aspects: (1) disembodied and embodied knowledge; (2) codified and tacit knowledge; and (3) the generation and the imitation of innovation (Archibugi, D., & Coco, A., 2005):

(1) Embodied/Disembodied: it is plausible that technological capabilities have both embodied and disembodied nature. The embodied technology can be in infrastructure, capital goods, technological equipment, and the disembodied technological capabilities are manifested on, for example, technical & scientific knowledge or human skills. According to Archibugi, D., & Coco, A. (2005), there is still debate on the relative importance between embodied forms and disembodied expertise of technology, however, there is a consensus that both types of technological capabilities are vital for the technology foundation of countries.

(2) Codified/Tacit: as Archibugi, D., & Coco, A. (2005) stated, knowledge constitutes *codified elements* including scientific & technical publications, patents, manuals, or blueprints, and tacit components that are embodied in technical experts and qualified labours, and associated with the learning-by-doing processes (Lundvall and Johnson 1994). While the codified knowledge is obvious to be measured, the tacit elements are difficult to be captured. In practice, codified knowledge can rely on the fundamental technological components, whereas there is only way to quantify the tacit knowledge that is based on the capabilities of labour force with the assumption that higher educated labours are capable to learn and work better (Archibugi, D., & Coco, A. 2009).

(3) Generation/Diffusion: there is no doubt that the creation of knowledge and its spill-over contribute are of importance for technological capabilities at national level. Some nations can be very well at generating new technologies but may utilize this new knowledge at slow pace. However, other nations may absorb technology from somewhere to apply domestically at high speed. This means that technological capabilities of a country should be measured by both sub-indicators represented for the ability of inventions, and those represented for the capability of diffusion and application (Archibugi, D., & Coco, A. 2005).

Thirdly, there is the same methodological perspectives that sub-indicators used for building the various aspects of technological capabilities are able to be added up altogether. This means those technological components is assumed to be complementary, and not substitutional (Antonelli, 2003).

Finally, literature has shown that there are many limitations on available data sources which can be used for both developing and developed countries. Indeed, selecting the sub-indexes for constructing the technological capabilities composite indicator must take into account the number of countries in the sample and their social-economic conditions (less developed, developing or developed). The methods applied for developed nations may not be utilized for developing ones (Archibugi, D., & Coco, A. 2005). Nevertheless, there are effort on analytical platform that have been carried out. OECD (2003) established range of indicators which are available and reliable. Sirilli, G. (1997) examined the nature of the indicators.

To sum up, there are a lot of requirements and information for the construction of technological capabilities indicator. Nonetheless, we need to emphasize that the indicators should be able to at least capture three aspects of knowledge including embodied & disembodied knowledge, codified & tacit technological cognition, and the creation, imitation & spill-over of technology.

2.2.2 Reviews of notable technological capabilities composite indices

2.2.2.1 WEF Technology Index

The first technology index is the WEF Technology Index which was constructed by World Economic Forum (2001-2003), and elaborated by Furman, Porter, & Stern (2002). It constitutes three main technological components including: (1) innovative capacity which is formed by the combination of: patents granted at USPTO, ratio of tertiary enrolment, and survey data); (2) Information & communications technology (ICT) diffusion which is measured by the mixed components of internet, telephone, PCs, and survey data; and (3) technology transfer which is measured by manufactured exports and survey data.

The WEF index is estimated for a set of 75 countries which are divided into two groups relying on the number of patents they created. These two groups contain 21 core countries and 54 non-core countries. Furthermore, the first two elements (1) & (2) are considered adequate sources for the group of core countries due to resting on the assumption that these countries do not much rely on the technology transfer. All of three elements (1), (2), & (3) are considered for non-core countries, however, the innovation capacity (1) is weighted lower.

2.2.2.2 UNDP Technology Achievement Index (TAI)

The second notable Technology Achievement Index (TAI) was constructed by UNDP Human Development Report (UNDP, 2001) and developed more by Desai et al. (2002). In this indicator, the technology achievement is measured by four components and each of them is calculated by two sub-indicators, including:

(1) The creation of technology (sub-indicators: patents created residents and registered in their national offices and the ''receipts of royalty and license fees''.

(2) The diffusion of newest technologies (internet hosts, and medium/high-tech exports).

(3) The diffusion of oldest technologies (telephone mainlines and electricity consumption)

(4) The human skills (mean years of schooling and tertiary science enrolment)

This index was made for a set of 84 nations and data of 8 sub-indicators are reported by UNDP.

2.2.2.3 UNIDO

The third effort in construction of technological capabilities index is the works of UNIDO (2002), the United Nations Industrial Development Organization (UNIDO) Industrial Development Scoreboard. This works is also rested on the previous paper of Lall and Albaladejo (2001) measuring the technological capabilities for a set of 87 countries.

UNIDO technology index aims at estimating the crucial components of the industrial competitive capabilities including four factors:

(1) Technological effort (measured by number of patents granted by USPTO, and enterprise financed R&D);

(2) The Competitive industrial performance (measured by manufactured value added (MVA), medium/high-tech share in MVA, manufactured exports, and medium/high-tech share in exports);

(3) The technology imports (relied on FDI, foreign royalties payments, and capital goods); and

(4) The skills and infrastructures (measured by technical enrolment at tertiary level and telephone mainlines).

In general, Lall and Albaladejo (2001) and UNIDO (2002) constructed few indicators which based on these four technological components. Nonetheless, they do not create a synthetic indicator that constitutes various aspects of technological capabilities as a combined index.

2.2.2.4 RAND Science and Technology Capacity Index

The next technological capabilities indicator is RAND Science and Technology Capacity Index which built by Wagner et al. (2004) for the RAND Corporation. This study examined a set of 76 nations and eight indicators reflecting technological capabilities are classified as three main categories:

(1) The enabling factors (measured by the proxies of GDP and tertiary science enrolment);

(2) The resources (measured by R&D expenditure, number of institutions and number of scientists and engineers); and,

(3) The embedded knowledge (measured by patents, scientific and technical publications, and co-authored scientific and technical papers).

After that, a composite technological capabilities index is constructed relying these sub-indicators in which it results in various outcomes due to different weights of the above three main categories.

2.2.2.5 ArCo Technology Index

According to Archibugi and Coco, 2004, the ArCo Technology Index (ArCo TI) are formulated by three aspects of technology, including:

(1) The innovative activity (measured by patents granted by US patent office and scientific & technical publications);

(2) The technology infrastructure (including old and new ones which are represented by % individual using internet, telephone and mobile subscriptions, and electricity power consumption);

(3) The human capital (measured by science and technological tertiary enrolment, years of schooling, and literacy rate).

In fact, this ArCo TI relied on the methodologies of Technology Achievement Index (TAI) and the UNIDO index (2003) as presented above to create a new synthetic technological indicator that is able to measure the technological capabilities of 162 countries in two periods (1990 & 2000). Therefore, this index has various advantages. First, it does capture three natures of knowledge which are the creation of technology, the diffusion of knowledge, and the human development. Second, the index is composed by sub-indicators that are compatible across almost all countries, both developing and developed. Last, the ArCo TI is measured by the way that all the sub-indicators can be summed up as a composite index reflecting the core values of knowledge. Regarding on these benefits, this paper select ArCo TI methodology to construct the Technological Gap Index for the sample of 6 developing, 15 developed countries in the period of 2003-2015.

2.3 Augmented gravity model

According to WTO & Yoto V. Yotov et al. 2015[7], during the last few decades, there have been a dramatical increase in globalization waves manifested in the rise of free trade and laissez-fare industrial policies. Accordingly, a reliable and effective tool to analyse the effects of international trade in terms of quantitative and detailed trading policies is more and more essential for both academic world and policy makers. Therefore, gravity model, which is considered as workhorse in international trade theory & practices, has largely been used to evaluate the impacts of determinants of trade due to its various advantages. First, the gravity model in international trade is very intuitive since it imitates the metaphor of Universal Gravitation Law of Newton. The model forecasts that bilateral trades are positively proportional to their masses and negatively proportional to their frictions such as their bilateral distances. Second, although the gravity model seems to be simple, it is considered as ''realistic general equilibrium environment'' model that can accommodate numerous factors (countries, sectors,..etc) simultaneously. The gravity methodology can capture the effects from the change of one market to others or even the rest of the world. Third, the theories of gravity model are so concrete that we are confident in using it. Fourth, one of the most crucial characters of gravity model that it is so flexible that it can be augmented with broad range of other economic factors to examine their impacts on trade, from investment, environment to technology. Finally, one of the most effective natures of the gravity model is that it is very powerful in predicting international trade flows with 60-90 percent in cases of aggregate or sectoral data.

[7] Yoto V. Yotov et al. 2015 ''An Advanced Guide to Trade Policy Analysis: The Structural Gravity Model'', World Trade Organization.

2.3.1 The evolution of gravity model

As borrowed from the physical theory: Newton's Law of Gravity, the gravity equation model is applied for international trade analysis by the predicts that trades, or gravitational forces, between two countries is ''directly proportional to the product of their masses and inversely proportional to the distance (trade frictions) between them" (Yoto V. Yotov et al. 2015) as shown in the equation below:

$$T_{ij} = A\frac{Y_i Y_j}{D_{ij}} \qquad \textbf{(2-1)}$$

Where:

- T_{ij}: is the value of exports from countries i and j
- D_{ij}: is measurement of bilateral distance between them
- Y_i, Y_j : are their respective national incomes
- A: constant proportionality

As stated in many studies[8], Tinbergen (1962) and Pöyhönen (1963) carried out the first empirical study to transfer the gravity equation (2-1) to the empirical analysis to show that bilateral trade flows is positively correlated to their national incomes, and negatively related to their bilateral distances. Linnemann (1966) did another empirical research with more variables and attempted to generalize as theoretical justification using Walrasian general equilibrium system despite '' Walrasian model tends to include too man explanatory variables for each trade flow to be easily reduced to the gravity" (Deardoff, A.V. 1995). However, only after the works of Anderson (1979), the theoretical foundations of gravity model is built on the assumption that ''product differentiation by place of origin and Constant Elasticity of Substitution (CES) expenditures" (Yoto V. Yotov et al. 2015). Relying the same methodologies with Anderson (1979), Bergstrand (1985) went further by successfully derive a reduced form of gravity model for bilateral trade including price indexes. Moreover, Helpman & Krugman (1985), and Bergstrand (1989, 1990) elaborated the implications of gravity estimation regarding Heckscher-Ohlin framework (Deardoff, A.V. 1995).

Until early 2000s, the influential paper of Eaton and Kortum (2002) developed gravity specification on the supply side resting on Ricardian framework using intermediate goods data. Furthermore, Anderson and van Wincoop (2003) continued to develop the Armington-CES model (Anderson, 1979) and

[8] To review more on gravity model in international trade, see Peter A. G. van Bergeijk and Steven Brakman (2010) ; and Yoto V. Yotov et al. (2015).

promoted ''the importance of the general equilibrium effects of trade costs'' (Yoto V. Yotov et al. 2015). In addition, there have been other notable studies that emphasized in various aspects including Chaney (2008) & Helpman et al. (2008) (the access of heterogeneous firms), Costinot et al. (2012) & Chor (2010) (a sectoral Ricardian model). Especially, the notable works of Arkolakis et al. (2012) that presented generate isomorphic gravity equation which retain the gains from trade.

Finally, one of the most recent studies in gravity model, Allen et al. (2014) constructed ''the universal power of gravity by deriving sufficient conditions for the existence and uniqueness of the trade equilibrium for a wide class of general equilibrium trade models'' (Yoto V. Yotov et al. 2015).

2.3.2 The augmented gravity model: theory & best practices

Since the basic gravity structure is very flexible, it can be integrated with other variables in order to examine the nexus between the trade and those augmented factors. From the basic gravity equation (2-1), we can take log for both sides, and augmented with other variables as following:

$$Ln(trade)_{ij(t)} = \beta_0 + \beta_1 Ln(trade)_{ij(t-1)} + \beta_2 Ln(POP)_{it} + \beta_3 Ln(GDP)_{it} + \beta_4 Ln(POP)_{jt} + \beta_5 Ln(GDP)_{jt} + \beta_6 Ln(DISTANCE)_{ij} + \sum_s^n \beta_s Ln(X_s)_{ij} + \varepsilon_{ij(t)} \qquad \textbf{(2-2)}$$

In which:

- $Ln(trade)_{ij(t)}$: value of exports from country i to j in year t
- $Ln(trade)_{ij(t-1)}$: value of exports from country i to j in year t-1
- $Ln(POP)_{it}$: population of country i in year t
- $Ln(POP)_{jt}$: population of country j in year t
- $Ln(GDP)_{it}$: GDP of country i in year t
- $Ln(GDP)_{jt}$: GDP of country j in year t
- $Ln(X_s)_{ij}$: the augmented variables, such as exchange rate, tariff,…etc
- $\varepsilon_{ij(t)}$: error terms
- $\beta_1 = 0$ when (2-2) is static model, and $\beta_1 = 1$ when (2-2) is dynamic.

Although the augmented gravity model provides us with the most effective tool to estimate the impacts of many factors on trade flows, however, according to Yoto V. Yotov et al. 2015[9], the gravity estimation also has a lot of challenges that need to apply appropriate solutions and best practices.

[9] An Advanced Guide to Trade Policy Analysis: The Structural Gravity Model'', WTO 2015

The first problematic is the obvious appearance of ''multilateral resistance terms'' (MRTs). The bilateral trade does not only depend on the trade cost, but also on the MRTs, and hence, the disregard of MRTs may lead to omitted variable bias (Anderson and Van Wincoop, 2003). As reviewed by Yoto V. Yotov et al. 2015, there are three ways to overcome MRTs. First, Olivero and Yotov (2012) proposed that MRTs could be solved by using exporter-time and importer-time fixed effects in a dynamic gravity model with panel data (β_1= 1). Second, Anderson and Van Wincoop (2003) applied iterative custom non-linear least squares programming with static model. Finally, Baier and Bergstrand (2009) approximately estimate the MRTs by the so-called "remoteness indexes" which is built as functions of bilateral distance, and GDP.

The second problem in solving structural gravity model is the existence of zero trade flows. Because the estimation equation is transformed into logarithmic form, the OLS estimators are not able to capture the information of zero trade observations. There are several solutions for zero trade flows challenge. The simplest method is to add a very small value to replace zero trade data, however, it is theoretically inappropriate and Head and Mayer (2014) showed that this method should not be used because the regression results will depend on the measuring units and the explanation of coefficients since the elasticity is missed. Moreover, Eaton and Tamura (1995) and Martin and Pham (2008) introduced Tobit estimator. Nevertheless, the gravity estimation is silent to the Tobit thresholds determination. But lastly, this problem of the Tobit model was solved by Helpman et al. (2008) whose paper demonstrated the two-step selection process in which the exporters will absorb fixed costs to enter into a market.

The third potential challenge is the Heteroscedasticity of trade data since Santos Silva and Tenreyro (2006) stated that the presence of heteroscedasticity may cause the estimation of the impacts of trade costs and policy biased as well as inconsistent if the gravity equation is estimated by OLS with log-linear form. The best solution for this problem recommended by Santos Silva and Tenreyro (2006) is to utilize the PPML estimator. This methodology simultaneously solves the potential problem of zero trade flows.

The last challenge mentioned in this paper is the endogeneity problem in gravity estimation equation. One of the typical problems is that endogeneity between trade policy variables and the trade flows due to the correlation between trade policy and unobservable cross-sectional trade costs. Theoretically, according to Mathyas, L., & Harris, M. (1998) there are three ''standard solutions'' for this problematic, including (1) using past values of the exogenous variable as instruments for the lagged dependent variable; (2) transforming the model into first differences ; and (3) applying instrumental variable (IV) regression to GMM estimation. Nonetheless, in practice, the IV estimation is normally used despite of ''the lack of reliable instruments" (Yoto V. Yotov et al. 2015). Finally, Egger and Nigai (2015) and Agnosteva et al. (2014) stated that pair-fixed effects are better in measuring bilateral trade costs than the standard set of gravity variables.

To sum up, indeed there are more challenges for augmented gravity estimation such as estimating gravity with disaggregated data, adjusting trade policy changes, the non-discriminatory trade policy, and bilateral trade costs. However, they seem to be out of the scopes of this paper.

Chapter 3: Methodology and data

3.1 The augmented gravity model estimation

The augmented gravity model is used under the logarithmic transformation which relies on Matyas & Harris (1998) and Egger (2000) general gravity model:

$$\begin{aligned} Ln(trade)_{ij(t)} = {} & \beta_0 + \beta_1 Ln(trade)_{ij(t-1)} + \beta_2 Ln(POP)_{it} + \beta_3 Ln(GDP)_{it} \\ & + \beta_4 Ln(POP)_{jt} + \beta_5 Ln(GDP)_{jt} + \beta_6 Ln(DISTANCE)_{ij} \\ & + \beta_7 Ln(TECHDIST)_{ij(t)} + u_{ij} + \lambda_t + \varepsilon_{ij(t)} \qquad \textbf{(3-1)} \end{aligned}$$

In which:

- $Ln(trade)_{ij(t)}$: value of exports from country i to j in year t
- $Ln(trade)_{ij(t-1)}$: value of exports from country i to j in year t-1
- $Ln(POP)_{it}$: population of country i in year t
- $Ln(POP)_{jt}$: population of country j in year t
- $Ln(GDP)_{it}$: GDP of country i in year t
- $Ln(GDP)_{jt}$: GDP of country j in year t
- $Ln(DISTANCE)_{ij}$: geographical distance between cities of country i and j
- $Ln(TECHDIST)_{ij(t)}$: "technological distance" or technological gap between country i and j (see the construction of this important variable in 3.1.3).
- u_{ij} : fixed country-pair effects
- λ_t : time effects, t = [1, T]
- $\varepsilon_{ij(t)}$: error terms

While all the economic variables including exporting values, population & GDP and geographic distance are commonly used in general gravity model to be determined their impacts on trade, the new variable, technological distance which is then constructed and augmented in the model to measure the effects of technological gap at national level on trade flows from exporters to importers. The construction of the crucial technological gap variable will be explained more in 3.3.

In this case, the equation is to estimate the impacts of those economic factors, and especially, of the technological distance on the bilateral trade flows between 6 emerging Asian countries and 15 developed countries over a period of 2003 – 2015, which means we have 1,170 bilateral observations for both manufactured and non-manufactured trade flows.

3.2 Methodology: econometric specifications for gravity model

As stated in the regression equations (3-1), augmented gravity model is utilized in which the new explanatory, technological distance, is included while traditional independent variables are still introduced: population, GDP, and physical distance. In general, we apply dynamic model in which we add the value of exports of the previous year into the model (3-1) as the explanatory variable with the implication that the exporting value of year t normally relates to the exporting value of year (t-1). Theory of gravity model in international trade[10] shows that the behaviour to choose trade partners is not only based on prices (which are changeable), but also relied on unchangeable factors (at least in short term) such as trade agreements, interests, languages, or history. Thus, lag (t-1) of exports variable should be included despite it consequently cause potential endogeneity.

In fact, the general augmented gravity model of Matyas & Harris (1998)[11] and Egger (2000)[12] is applied under the logarithmic transformation with panel data regression shown in equation (3-1) to solve potential problematics of the gravity model.

The panel regression model is used due to the research of Matyas (1997) and Egger (2000) that if the time effects (cross-sectional analysis assumes T=1, $\lambda_t = 0$) and country-pairs effects (time-series method assumes $u_{ij} = 0$) are not considered, it may lead to incorrect inference due to endogeneity and heterogeneity. Thus, we choose the regressing method including both time and fixed country-pairs effects. We estimate the gravity equation (3-1) relying on the econometric model of Matyas & Harris (1998) & Egger (2000) that the Fixed Effect Model is used under the assumption that heterogeneity is correlated with the regressors (Green, 1997), we test this hypothesis by Hausman Test allowing us to reject the Random Effect hypothesis. Besides, the Breusch-Pagan Lagrange multiplier test is carried out to show that OSL, which is an option for panel data, is not preferred.

Furthermore, this method helps to eliminate the unobservable linkages between the endogenous trade policy covariate and the error term in gravity regressions (Baier and Bergstrand, 2007). In addition, the multilateral resistance

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[10] To review gravity model in international trade, see Peter A. G. van Bergeijk and Steven Brakman (2010), "The Gravity Model in International Trade: Advances and Applications". Cambridge University Press.

[11] Mathyas, L., & Harris, M. (1998) proposed general equation and econometric specifications for panel regressions for gravity model.

[12] Egger P. (2000) proved that Fixed Effect model would be the right choice for this model.

terms which was emphasized by Baldwin and Taglioni (2006) will be solved by this exporter-time fixed effects (Olivero and Yotov, 2012).

Another problem of this model is that the independent variables are not strictly exogenous. For example, according to national accounting, GDP and export of country i at time t are implicitly endogenous. By applying Fixed Effect Model, the endogeneity that is generated by the presence of heterogeneity term in this lagged independent variable and in the error-term will be omitted. Furthermore, we have to solve the residual potential endogeneity. According to Matyas & Harris, (1998) we can overcome this endogenous problematic by utilizing the lags of the most likely endogenous independent variable as the instrumental variable (IV). Referring the equation (3-1), the lags of variable $Ln(trade)_{ij(t-1)}$ which is the export value at year (t-2) is utilized as IV to solve this potential endogeneity. The regression results in chapter 4 (Table 4.1 & 4.2) show that this is successful instrumental variable.

The final problem of the estimation is to cope with the Time-Invariant variables (geographical distance or dummy China) in fixed effect model. In term of econometrics, we can solve this obstacle by two ways. First method is to run Least Squares Dummy Variables (LSDV). The other solution is to utilize Fixed Effect Model with the second OLS regression as following estimation equation:

$$FE_{ij} = \alpha_0 + \alpha_1 Country\ Dummies + \alpha_2 Ln(DISTANCE)_{ij} + \varepsilon_{ij} \quad \textbf{(3-2)}$$

Finally, the possible solutions for zero trade flows are carefully presented in the review of augmented gravity model (2.2.2). However, there is no zero trade flows for this panel data.

3.3 Constructing ''technological distance'' variable

As stated in the equation (3-1), the crucial point of this paper is to investigate whether the change in technology gap between nations significantly impacts on their bilateral trade flows? For example, if the stock of knowledge of a developing country like Vietnam were to be closer to that of a developed nation like Netherlands, the trade flows of these two nations would be correlatively affected? Indeed, we need appropriate indicator for technological capabilities which is applicable worldwide, for both developing and developed countries despite the heterogeneous aspects of technology. (Archibugi, D., & Coco, A., 2005). Thus, the national technological capability proxy should be synthetic indicators comprising typical macroeconomic sub-indicators which are able to compare nations' technological abilities and their change over time (Archibugi, D et al., 2009). In addition, this technological indicator should be calculated yearly that we can capture the impacts of its variation on trade flows as the research's motivation.

In the last several decades, literatures on technology and innovation[13] have stated that international organizations and researchers have constructed various macro-level measurement for national technological capabilities. According to the review of technological measurement by Archibugi, D., & Coco, A. (2005), those notable indicators include the WEF Technology Index (World Economic Forum 2001-2003 ; Furman, Porter, & Stern, 2002), UNDP Technology Achievement Index (TAI) (UNDP, 2001; Desai et al., 2002), the United Nations Industrial Development Organization (UNIDO) Industrial Development Scoreboard (UNIDO, 2002; Lall and Albaladejo, 2001), the Science and Technology Capacity Index developed by the RAND Corporation (Wagner et al., 2004), and ArCo Technology Index (Archibugi, D., Coco, A., 2004). Additionally, the newest one is Technology Creation Index by Khayyat & Lee (2015). Generally, these macro technological indices share the similarity that they all comprise three main components: (1) creation of technology and innovation, (2) infrastructure and technology spill-over, and (3) human capital (Archibugi, D., & Coco, A., 2005).

Among them, ArCo Technology Index (Archibugi, D., Coco, A., 2004) is chosen as the proxy for measuring the technological gap between nations regarding three reasons as mentioned above. First, Technology Creation Index by Khayyat & Lee (2015) is ignored because it created just for developing countries, while our aim is to compare across developing and developed ones. Second, WEF Technology Index is not able to use because it contains other social-economic measurements, such as (1) quality of the macroeconomic setting, (2) robustness of the public institutions (Archibugi, D., & Coco, A., 2005) while we just need to measure the technological gap. Third, in term of infrastructure and diffusion of technology, RAND indicator does not fully contain ICT indicators which has tightly been associated with the technological level of nations in the context of current high-tech economy (Archibugi, D., & Coco, A., 2005). Lastly, ArCo Technology Index is selected because it relies on the advantages of the rest two indicators: (TAI) (UNDP, 2001; Desai et al., 2002) and Industrial Development Scoreboard (UNIDO, 2002; Lall and Albaladejo, 2001) that it focuses on measuring the technological capabilities across countries and changing overtime.

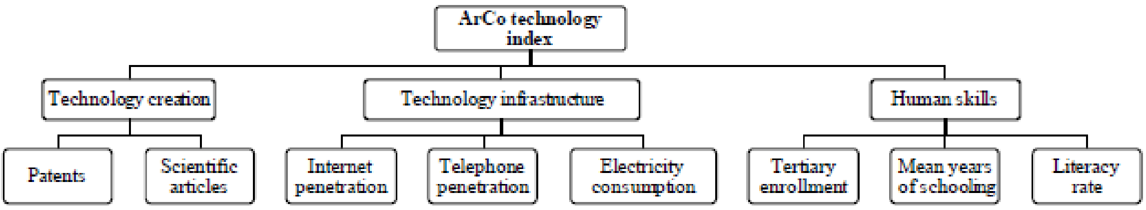
[13] Including previous works of many authors: Lall (1992) ; Lundvall (1992) ; Pianta, M. (1995) ; Smith K. (1997) pp. 86-106 ; Freeman & Louta, 2001 ; Lall, S. (2001a), (2001b).

In detail, Archibugi, D. & Coco, A. (2004) constructed ArCo Technological Index taken into account three typical dimensions of technology:

- **The creation of technology abilities** which is also considered as ability to create new technology that is based on the proxies of number of patents registered at US patent office and scientific publications
- **Technology infrastructure** or the ability of diffusion of technology that is proxied by internet, telephone mainlines and mobile, and electricity consumption.
- **Human capital** or human skills that is calculated through the scientific tertiary enrolment, years of schooling, and literacy rate.

The variable TECHDIST is then defined as the absolute difference between the ArCo technological index (TI) of the pair of traders.

$$TECHDIST = |TI_{ij} - TI_{ji}| \quad \textbf{(3-3)}$$



Let take I_x as one of the eight indexes, it will be calculated as:

$$I_{x(it)} = \frac{Actual\ value\ _{it} - Minimum\ value\ _{t}}{Maximum\ value\ _{t} - Minimum\ value\ _{t}} \quad \textbf{(3-4)}$$

Thus, the overall Technological Index of country I at year t is:

$$TI_{it} = \frac{I_{it}^{creation} + I_{it}^{diffusion} + I_{it}^{skills}}{3} \quad \textbf{(3-5)}$$

Since the data sources for the sub-indexes of Technological Index are of importance, we will discuss all of them in detail in 3.4 ''Technological distance (TECHDIST composite indicator) data description".

3.4 Data set & description

The research's purpose is to investigate the trade flows from emerging East Asian nations to (exporters) to the developed nations. Thus, we select 6 emerging East Asian countries including China, Indonesia, Malaysia, Philippines, Thailand, Vietnam, and 15 developed countries comprising 12 most EU (Belgium, Denmark, Finland, France, Germany, Greece, Italy, Irelands, The Netherlands, Portugal, Spain, UK), two important Asian traders (Japan, and Korea South), and the biggest importer: the US.

Trade flows

Exporting value is used as bilateral trade flows between countries. Total export is divided into two types of merchandise: manufactured and non-manufactured exports which exploit from UNCTAD Data Center, International trade in goods and service. The data is from UN Comtrade and categorized into non-manufactured goods (agriculture and other primary goods), and manufacturing goods.

Population and GDP

Population and GDP are derived from World Development Indicator (WDI 2019).

Geographical distance

This physical distance is taken from the notable source for some typical variables of gravity model: CEPII. According to CEPII manual for The Geodist Database (Thierry Mayer & Soledad Zignago, 2011), there are four types of distances for gravity model. The first two indicators ''dist, and distcap'' are relied on the latitudes and longitudes of the most important cities in term of population and capital cities respectively. The other two distances ''distw, and distwces'' are weighted on internal (intra-national), and international bilateral distances[14]. Among them, we choose the distcap as geographic distance variable because we study the trade flows from East Asia to EU where distance is far enough to eliminate other potential bias in gravity estimation.

Technological distance (TECHDIST composite indicator) data description

The variable ''TECHDIST'' composite index constitutes 8 sub-indicators as presented in 3.3. However, the indicator of literacy rate is excluded because two reasons. First, there is limited data on literacy rate for those countries. Second, for those nations, the literacy rate is relatively equal, and it is embodied in the mean years of schooling. Therefore, we can drop it out without any serious bias (Rakicevic J. & Savic G. 2018).

Another concern on sub-indicators data is the number of granted patents in the US Patent and Trademark Office (USPTO, 2019). According to Archibugi,

[14] Mayer T & S. Zignago (2005)

D. & Coco, A. (2004), there is a bias in collecting from USPTO is that the US inventors will have higher propensity to register their inventions in their domestic agency. Thus, to avoid this bias, we estimate by comparing between the Japanese and US patents granted by European Patent Office (EPO) by the estimated formula below:

Estimated US domestic patents = [JAP(USA) x USA(EPO)] / JAP(EPO).

Where:

- JAP(USA): is the number of patents granted to Japan by USPTO
- JAP(EPO): is the number of patents granted to Japan by EPO
- USA(EPO): is the number of patents granted to US by EPO

Table 3.1. Sources of sub-indicators to construct TECHDIST

Data characteristics	
Sub-Indicators	**Sources**
Patents: number of granted patents on million people.	USPTO, United State Patents and Trademark Office and EPO – European Patent Office on 1st October, 2019
Number of technical & scientific Journals per million people.	WDI on 5th June, 2019
Individuals using the Internet (% of population)	WDI on 5th June, 2019
Fix telephone subscriptions and mobile cellular subscriptions per 100 people.	WDI on 5th June, 2019
Electrict Power Consumption (Kwh per capita)	WDI on 5th June, 2019
School enrolment, tertiary (% gross)	WDI on 5th June, 2019
Mean years of schooling	UNDP on 1st October, 2019

Chapter 4: Results and discussion

4.1 Findings & discussion

The econometric results are reported on Table 4.1 and Table 4.2 in which the dependent variable is the exports from emerging East Asian countries to developed ones for two types of exporting flows: manufactured and non-manufactured respectively.

The estimated coefficients of explanatory variables are regressed by three methodologies for panel data including OLS, Fixed Effects (FE) and Radom Effects (RE). Nonetheless, we carry out Breusch-Pagan Lagrange multiplier test to not prefer OLS and Hausman test to prefer FE than RE (see Appendix 1 & 2). Therefore, in this case, the Fixed Effects is the most appropriate estimator. Furthermore, the regression results of IV with FE option in Table 4.1 & 4.2 show that all the coefficients of both IV and FE are at the same signs and level of significance, and their size are not much different. Thus, our estimation is robust, and the endogeneity problem is successfully solved by applying instrumental variable which is lags of the export value at year (t-1). Consequently, the IV results in both Table 4.1 & 4.2 are preferred.

According to the IV results, all variables have high-level of significance at 1% with the same sign for both cases of manufactured and non-manufactured exports except the technological gap is only significant in term of manufactured goods and the signs are opposite for each case. The regression results of technological gap variable strongly support our hypothesis that a smaller gap in technology capabilities foster trade flows from developing to developed world.

In fact, technological distance is negatively correlated with the manufactured exporting flows from the developing to developed countries at significance level of 5%. That means the narrower the technological gap is, the greater the exports flow from emerging to developed countries. In other words, relying on this empirical result, we may state that the larger difference in technology capabilities may not be the force arising trade as stated by comparative advantage theory but the barrier. Furthermore, the adverse nexus between technological gap and manufactured exporting flows does make sense that if technological levels between two nations are relatively equivalent and comparable, they would be more likely to trade each other, and on the opposite direction, if their technological gap is relatively large, the production patterns may be considerably different that their demand might not fit each other. In addition, in case of non-manufactured export flows in Table 4.2, the technological distance is insignificant. However, its positive coefficient, which means technological gap is positively correlated to non-manufactured exports (commodities), is somehow consistent to Deardorff A.V. (1980) that comparative advantage law is valid for the case of commodities on average.

For the coefficients of population of exporters and importers are negative and highly significant at 1% for both manufactured and non-manufactured goods, however, the meanings are different. Regarding manufactured flows shown in Table 4.1, when exporters' (developing countries) population increases (certainly, others are ceteris paribus), their manufactured exports significantly reduce. The reason would be that if the domestic market size expands, producers are more likely to turn to supply internal demand which they understand much more than international market. However, in case non-manufactured goods, the negative coefficient of exporters' population (Table 4.2) would indicate that when their number of residents grows, they should export primary products less (such as agriculture) to ensure the local necessity. Lastly, the significantly negative relationship between importer's (developed countries) population and the exporting flows from developing countries could be explained by the situation that if their market size were to be bigger enough, entrepreneurs in developed nations would exploit the economies of scale and the available technological know-how to create manufactured goods themselves instead of importing.

The regression results for both manufactured and non-manufactured goods show that exporters' and importers' GDP are strongly positive correlated to the exporting flows at 1% significance level. These results are consistent with economic theory that the wealthier the countries are, the more they trade.

Regarding to the case of controlling geographical distance variable, because it is time-invariant factor, the application of FE model will omit its effect. Despite it is not relevant to our study purpose, and it has widely been proved to be negatively related to trade flows in vast of literature, there are possibly some solutions for this problematic. Besides the two proposed methods which are stated in 3.2, there would be two more ways to solve this econometric problem. First, we can interact geo-distance variable with other time-variant explanatory variables. Second, we can also refer its coefficient in RE model as Matyas and Harris (1998) suggested that "for strictly more policy reasons, the random effect model may be preferred, as the effects of explanatory variables are not diminished the presence of a relatively large set of dummy variables". The Table 4.1 demonstrates that the sign of geographical distance is negative with trade flows that is consistent to previous literature.

Table 4.1. The regression results of OLS, RE, FE & IV (in case of manufactured export flows)

Dependent variable: Ln(trade)	**OLS**	**RE**	**FE**	**IV**
Constant	-9.367	-9.570	77.862	-
$Ln(trade)_{ij(t-1)}$	0.633***	0.540***	0.105***	0.060***
$Ln(POP)_{it}$	-0.098***	-0.094***	-3.798***	-3.987***
$Ln(GDP)_{it}$	0.363***	0.415***	0.807***	0.836***
$Ln(POP)_{jt}$	-0.320***	-0.269***	-5.396***	-5.304***
$Ln(GDP)_{jt}$	0.768***	0.802***	0.888***	0.867***
$Ln(DISTANCE)_{ij}$	-0.452***	-0.532***	-	-
$Ln(TECHDIST)_{ij(t)}$	**0.122***	**0.221****	**-0.270****	**-0.309****
R-square within		0.3328	0.534	
R-square between		0.9710	0.549	
R-square overall	0.9282	0.9263	0.516	0.5274
Observations	1,169	1,169	1,169	1,168
Number of groups		90	90	90

Note: *, **, and *** are 10%, 5% and 1% level of significance respectively.

Table 4.2. The regression results of OLS, RE, FE & IV (in case of non-manufactured export flows)

Dependent variable: Ln(trade)	**OLS**	**RE**	**FE**	**IV**
Constant	-4.042	-4.067	44.758	
$Ln(trade)_{ij(t-1)}$	0.729***	0.697***	0.152***	0.061**
$Ln(POP)_{it}$	-0.036	-0.046	-3.507***	-3.758***
$Ln(GDP)_{it}$	0.153***	0.175***	0.804***	0.864***
$Ln(POP)_{jt}$	0.022	0.045	-2.838***	-2.502***
$Ln(GDP)_{jt}$	0.416***	0.430***	0.944***	0.898***
$Ln(DISTANCE)_{ij}$	-0.476***	-0.523***	-	-
$Ln(TECHDIST)_{ij(t)}$	**-0.011**	**0.015**	**0.184**	**0.101**
R-square within		0.193	0.387	
R-square between		0.975	0.309	
R-square overall	0.8958	0.896	0.273	0.3688
Observations	1,169	1,169	1,169	1,168
Number of groups		90	90	90

Note: *, **, and *** are 10%, 5% and 1% level of significance respectively.

4.2 Limitations

Firstly, this research is just empirical study for specific case that examine the impacts of technological gap on the exporting flows from the so-called emerging East Asian countries to selected 15 high-income OECD countries in the period of 2003-2015. Therefore, the result is limited at the particular sample that is unable to generalize as comprehensive discovery or to be able to deny Comparative Advantage doctrine. In fact, at least, for the case of non-manufactured, the technological gap is statistically insignificant on the exporting value with positive sign. That means technological gap cannot fully explain the exports from developing to developed nations in case of non-manufactured goods. If the statistical sample of this research were to be enlarged as population, the zero trade flows would arise considerably. Consequently, they can influent on the econometric results.

Secondly, there are various limitations in constructing technological capabilities at national level that they can lead to the biased measurements, and therefore, incorrect estimation. For example, because technological capabilities are heterogeneous, and thus, their measurements are relied on the condition that "more similar national systems of innovation" (Jeffrey, 2006). That means there is always the potential bias in selecting countries at the relative similar technological levels to measure. Furthermore, according to current characters of international technology trading, some countries may foster their technological capabilities by importing inventions and modern technologies, and hence, the technological measurement in this paper would be biased.

Finally, the econometric results would also be biased if the prices are not included in the estimated equation[15] (Yoto V. Yotov et al. 2015, pp 20-21). Although it is presented in 3.2 that the sticky prices are potentially relied on some not-easy-to-change factors, they have recently been less unchangeable due to the higher speed of new technology inventions. For instance, if there are more and more international companies reach certain level of high-tech that they will be able to produce sophisticated products at similar quality, the monopoly in term of quality is then less effective. The pricing factor will become significant. Moreover, another reason is that we do not have the separated trade flows data (manufactured and non-manufactured) adjusted by PPP. Nonetheless, the exporting value data extracted from UNCTAD Data Center is said to be collected in term of domestic currencies converted to US dollar by the adjustment of suitable exchange rates that somehow reflects the effects of pricing.

[15] This is also reviewed in 2.3, Chapter 2.

Chapter 5: Conclusion and further research

5.1 Conclusion

This research is an effort to examine the impacts of technological gap on the trade performance, especially the export flows, from the emerging East Asian (including China, Malaysia, Indonesia, Philippines, Thailand & Vietnam) to selected 15 high-income OECD countries (12 EU, two Asian strong traders: Korea Republic and Japan, and the US) in the period of 2003-2015. In addition, the export flows are categorized into two types including: manufactured and non-manufactured merchandise.

In order to achieve the researching purpose, we utilize the dynamic gravity model of Matyas & Harris (1998) and Egger (2000) with typical controlling variables including Population and GDP of both exporters and importers, and bilateral geographical distance. In addition, we construct the technological capabilities composite index and augment it into this augmented gravity model.

Among many technological indexes, including WEF Technology Index, UNDP Technology Achievement Index (TAI), the United Nations Industrial Development Organization (UNIDO) Industrial Development Scoreboard, the Science and Technology Capacity Index developed by the RAND Corporation (Wagner et al., 2004), and ArCo Technology Index, we rely on the methodology of the ArCo Technology Index to construct the technological capabilities at national level for those countries in the period of 2003-2015. In fact, there are some key points in building appropriate technological gap at country level. First, the technological gap should be synthetic indicator (containing various popular sub-indicators) that it is able to eliminate the heterogeneous nature of knowledge and measurable across different countries. Second, this synthetic knowledge index must be able to capture three elements that literature has shared the same views as crucial nature of knowledge, including: (1) the creation of technology; (2) the technological infrastructures; and (3) the development of human skills.

After successful in constructing technological gap between countries, this paper applies three methods of panel data analysis, including OLS, Random Effects & Fixed Effects, for both types of trade flows: manufactured and non-manufactured exports from developing to developed nations. These three methods are applied simultaneously to show that only FE panel regression considers the time effects (according equation (3-1), cross-sectional analysis assumes T=1, $\lambda_t = 0$) and country-pairs effects (time-series method assumes $u_{ij} = 0$, equation 3-1), and otherwise, the estimation would lead to incorrect inference (Matyas, 1997; Egger, 2000). Furthermore, the success in introducing instrumental variable (IV), which is the lags of export value year (t-1)[16], to solve the potential endogeneity of residual in case by the FE option re-enforces the robust estimator. Thus, the regression results of the IV adjustment are proved to be most suitable for this gravity model.

According to the estimation results demonstrated in Table 4.1 & 4.2, economic variables of both exporters and importers (GDP, Population) are significantly correlated to export flows of both categories: manufactured & non-manufactured merchandise. However, the meanings are different for each situation. The exporters' population and manufactured exports value is negatively related because producers would turn to focus their domestic markets when their size are bigger. However, in case of non-manufactured goods, the negative nexus between exporters' population and export flows means that the export of commodities (such as agriculture) in developing countries may be curbed to serve the rise of internal demand. Moreover, negative relationships between importer's population and export flows for both cases of goods (manufactured and non-manufactured) can be explained that manufacturers in developed nations may shift their attentions to domestic markets to exploit the economies-of-scale effects resulted by the increase of population.

In case of GDP, for both types of goods, the significant and positive correlation between export flows and GDP of both exporters and importers reflects the consistency with the economic theory that the richer countries are, the more they trade. In addition, although the examination of geographical distance is irrelevant to the study, however, the negative coefficients of the nexus between geo-distance with export flows in the Random Effects estimation results across both cases of manufactured and non-manufactured goods are complying to previous studies[17].

Finally, the crucial purpose of this paper is to analyse the impacts of technological gap on the export flows to investigate the Comparative Advantage theory in this specific case. In fact, we find that technological gap is significantly negative correlated with manufactured export flows from developing to developed countries. This implies that the wider technological gap is, the less nations trade each other. This result may be contrast to the comparative advantage law that the difference in technology is the force for trade arising. Nonetheless, the researching results do enforce our observations that the more East Asian

[16] Mathyas, L., & Harris, M. (1998)
[17] Also see Mathyas, L., & Harris, M. (1998)

countries trade with OECD countries, the more percentage of manufactured goods in total exporting merchandise increases.

5.2 Further research

To sum up, efforts have been invested to investigate the typical nexus between technology and international trade, the results would have some limitations as stated previously. Besides these shortcomings, I suppose that this paper needs to carry out two further analysis. First, it would be essential to understand deeper on the causality relationship between trade and technological gap that we will be able to formulate more appropriate industry and trade policy. Last but not least, the sample should be enlarged to capture more concrete results.

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Appendix 1. Breusch-Pagan Lagrange multiplier test to not prefer Pooled OLS (in case of manufactured export flows)

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        Ln_manufactured[id,t] = Xb + u[id] + e[id,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
               Ln_manu~d |   4.505647       2.122651
                       e |    .090474        .300789
                       u |   .0047166       .0686773

        Test:   Var(u) = 0
                             chibar2(01) =   300.27
                          Prob > chibar2 =   0.0000
```

Appendix 2. Hausman test to prefer FE than RE (in case of manufactured export flows)

```
. hausman fixed random, sigmamore

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
Ln_manufac~1 |     .105102     .5403324       -.4352303        .0164653
    LnPOP_ex |   -3.798293    -.0940257       -3.704267        .6736921
    LnGDP_ex |    .8065526     .4150772        .3914754        .0626209
    LnPOP_im |   -5.396261    -.2692286       -5.127032        .9854556
    LnGDP_im |    .8881876     .8023976        .0857901        .1369785
  LnTech_dist|   -.2702458     .2205826       -.4908284        .2085236
------------------------------------------------------------------------------
                          b = consistent under Ho and Ha; obtained from xtreg
           B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =      786.74
                Prob>chi2 =      0.0000
```

Appendex 3. Detailed regression results for IV (in case of manufactured export flows)

```
. xtivreg2 Ln_manufactured LnPOP_ex LnGDP_ex LnPOP_im LnGDP_im LnDist LnTech_dist ( L
> ed_L2 ), fe
Warning - collinearities detected
Vars dropped:       LnDist

FIXED EFFECTS ESTIMATION
------------------------
Number of groups =        90                   Obs per group: min =        11
                                                              avg =      13.0
                                                              max =        13
Warning - collinearities detected
Vars dropped:  LnDist

IV (2SLS) estimation
--------------------

Estimates efficient for homoskedasticity only
Statistics consistent for homoskedasticity only

                                                      Number of obs =     1168
                                                      F(  6,  1072) =   191.73
                                                      Prob > F      =   0.0000
Total (centered) SS     =   207.753229                Centered R2   =   0.5274
Total (uncentered) SS   =   207.753229                Uncentered R2 =   0.5274
Residual SS             =  98.18720232                Root MSE      =    .3018

------------------------------------------------------------------------------------
   Ln_manufactured |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------------+----------------------------------------------------------------
Ln_manufactured_L1 |   .0602718    .020489     2.94   0.003     .0201141    .1004296
          LnPOP_ex |  -3.986848    .3916507  -10.18   0.000    -4.754469   -3.219227
          LnGDP_ex |   .8358871    .0417377   20.03   0.000     .7540827    .9176915
          LnPOP_im |  -5.304108    .5655805   -9.38   0.000    -6.412626   -4.195591
          LnGDP_im |   .8672202    .0903977    9.59   0.000      .690044    1.044396
            LnDist |          0  (omitted)
       LnTech_dist |  -.3093907    .1278392   -2.42   0.016     -.559951   -.0588304
------------------------------------------------------------------------------------
Underidentification test (Anderson canon. corr. LM statistic):         424.088
                                                   Chi-sq(1) P-val =    0.0000
------------------------------------------------------------------------------
Weak identification test (Cragg-Donald Wald F statistic):              695.235
Stock-Yogo weak ID test critical values: 10% maximal IV size             16.38
                                         15% maximal IV size              8.96
                                         20% maximal IV size              6.66
                                         25% maximal IV size              5.53
Source: Stock-Yogo (2005).  Reproduced by permission.
------------------------------------------------------------------------------
Sargan statistic (overidentification test of all instruments):           0.000
                                                 (equation exactly identified)
------------------------------------------------------------------------------
Instrumented:         Ln_manufactured_L1
Included instruments: LnPOP_ex LnGDP_ex LnPOP_im LnGDP_im LnTech_dist
Excluded instruments: Ln_manufactured_L2
Dropped collinear:    LnDist
------------------------------------------------------------------------------
```